GAUSS™ 14
Language Reference
Vol. 1
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<td>v</td>
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<tr>
<td>w</td>
</tr>
<tr>
<td>x</td>
</tr>
<tr>
<td>y</td>
</tr>
<tr>
<td>z</td>
</tr>
</tbody>
</table>

| 39 Obsolete Commands | 39-1 |
The GAUSS LANGUAGE REFERENCE describes each of the commands, procedures and functions available in the GAUSS™ programming language. These functions can be divided into four categories:

- Mathematical, statistical and scientific functions.
- Data handling routines, including data matrix manipulation and description routines, and file I/O.
- Programming statements, including branching, looping, display features, error checking, and shell commands.
- Graphics functions.

The first category contains those functions to be expected in a high level mathematical language: trigonometric functions and other transcendental functions, distribution functions, random number generators, numerical differentiation and integration routines, Fourier transforms, Bessel functions and polynomial evaluation routines. And, as a matrix programming language, GAUSS includes a variety of routines that perform standard matrix operations. Among these are routines to calculate determinants, matrix inverses, decompositions, eigenvalues and eigenvectors, and condition numbers.

Data handling routines include functions which return dimensions of matrices, and information about elements of data matrices, including functions to locate values lying in specific ranges or with certain values. Also under data handling routines fall all those functions that create, save, open and read from and write to GAUSS data sets and GAUSS Data Archives. A variety of sorting routines which will operate on both numeric and character data are also available.
Programming statements are all of the commands that make it possible to write complex programs in GAUSS. These include conditional and unconditional branching, looping, file I/O, error handling, and system-related commands to execute OS shells and access directory and environment information.

The graphics functions of GAUSS Publication Quality Graphics (PQG) are a set of routines built on the graphics functions in GraphiC by Scientific Endeavors Corporation. GAUSS PQG consists of a set of main graphing procedures and several additional procedures and global variables for customizing the output.

36.1 Documentation Conventions

The following table describes how text formatting is used to identify GAUSS programming elements:

<table>
<thead>
<tr>
<th>Text Style</th>
<th>Use</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>regular text</td>
<td>narrative</td>
<td>&quot;... text formatting is used ...&quot;</td>
</tr>
<tr>
<td>bold text</td>
<td>emphasis</td>
<td>&quot;...not supported under UNIX.&quot;</td>
</tr>
<tr>
<td><em>italics</em></td>
<td>variables</td>
<td>&quot;... If \textit{vnames} is a string or has fewer elements than \textit{x} has columns, it will be ...&quot;</td>
</tr>
<tr>
<td>monospace</td>
<td>code example</td>
<td>\texttt{if scalerr(cm);} \texttt{cm = inv(x);} \texttt{endif;}</td>
</tr>
<tr>
<td>monospace</td>
<td>filename, path, etc.</td>
<td>&quot;... is located in the examples subdirectory...&quot;</td>
</tr>
<tr>
<td>monospace</td>
<td>reference to a GAUSS</td>
<td>&quot;... as explained under&quot;</td>
</tr>
</tbody>
</table>
36.2 Command Components

The following list describes each of the components used in the Command Reference, Chapter 38.

**Purpose**

Describes what the command or function does.

**Library**

Lists the library that needs to be activated to access the function.

**Include**

Lists files that need to be included to use the function.

**Format**

Illustrates the syntax of the command or function.

**Input**

Describes the input parameters of the function.
Global Input
Describes the global variables that are referenced by the function.

Output
Describes the return values of the function.

Global Output
Describes the global variables that are updated by the function.

Portability
Describes differences under various operating systems.

Remarks
Explanatory material pertinent to the command.

Example
Sample code using the command or function.

Source
The source file in which the function is defined, if applicable.

Globals
Global variables that are accessed by the command.
36.3 Using This Manual

Users who are new to GAUSS should make sure they have familiarized themselves with LANGUAGE FUNDAMENTALS, Chapter 9, before proceeding here. That chapter contains the basics of GAUSS programming.

In all, there are over 800 routines described in this GAUSS LANGUAGE REFERENCE. We suggest that new GAUSS users skim through Commands by Category, Chapter 37, and then browse through Command Reference, Chapter 38, the main part of this manual. Here, users can familiarize themselves with the kinds of tasks that GAUSS can handle easily.

Chapter 37 gives a categorical listing of all functions in this GAUSS LANGUAGE REFERENCE and a short discussion of the functions in each category. Complete syntax, description of input and output arguments, and general remarks regarding each function are given in Chapter 38.

If a function is an "extrinsic" (that is, part of the Run-Time Library), its source code can be found on the src subdirectory. The name of the file containing the source code is given in Chapter 38 under the discussion of that function.
36.4 Global Control Variables

Several **GAUSS** functions use global variables to control various aspects of their performance. The files `gauss.ext`, `gauss.dec` and `gauss.lcg` contain the `external` statements, `declare` statements, and library references to these globals. All globals used by the **GAUSS Run-Time Library** begin with an underscore `_`.

Default values for these common globals can be found in the file `gauss.dec`, located on the src subdirectory. The default values can be changed by editing this file.

36.4.1 Changing the Default Values

To permanently change the default setting of a common global, two files need to be edited: `gauss.dec` and `gauss.src`.

To change the value of the common global `__output` from 1 to 0, for example, edit the file `gauss.dec` and change the statement

\[
\text{declare matrix } __\text{output} = 1;
\]

so it reads:

\[
\text{declare matrix } __\text{output} = 0;
\]

Also, edit the procedure `gausset`, located in the file `gauss.src`, and modify the statement

\[
__\text{output} = 1;
\]

similarly.
36.4.2 The Procedure `gausset`

The global variables affect your program, even if you have not set them directly in a particular command file. If you have changed them in a previous run, they will retain their changed values until you exit GAUSS or execute the `new` command.

The procedure `gausset` will reset the Run-Time Library globals to their default values.

```
gausset;
```

If your program changes the values of these globals, you can use `gausset` to reset them whenever necessary. `gausset` resets the globals as a whole; you can write your own routine to reset specific ones.
37 Commands by Category

37.1 Mathematical Functions

Scientific Functions

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abs</td>
<td>Returns absolute value of argument.</td>
</tr>
<tr>
<td>arccos</td>
<td>Computes inverse cosine.</td>
</tr>
<tr>
<td>arcsin</td>
<td>Computes inverse sine.</td>
</tr>
<tr>
<td>atan</td>
<td>Computes inverse tangent.</td>
</tr>
<tr>
<td>atan2</td>
<td>Computes angle given a point x,y.</td>
</tr>
<tr>
<td>besselj</td>
<td>Computes Bessel function, first kind.</td>
</tr>
<tr>
<td>bessely</td>
<td>Computes Bessel function, second kind.</td>
</tr>
<tr>
<td>beta</td>
<td>Computes the complete Beta function, also called the Euler integral.</td>
</tr>
<tr>
<td>boxcox</td>
<td>Computes the Box-Cox function.</td>
</tr>
<tr>
<td>cos</td>
<td>Computes cosine.</td>
</tr>
<tr>
<td>cosh</td>
<td>Computes hyperbolic cosine.</td>
</tr>
<tr>
<td>curve</td>
<td>Computes a one-dimensional smoothing curve.</td>
</tr>
</tbody>
</table>
 Commands by Category

- **digamma**: Computes the digamma function.
- **exp**: Computes the exponential function of $x$.
- **fmod**: Computes the floating-point remainder of $x/y$.
- **gamma**: Computes gamma function value.
- **gammacplx**: Computes gamma function for complex inputs.
- **gammaii**: Compute the inverse incomplete gamma function.
- **ln**: Computes the natural log of each element.
- **lnfact**: Computes natural log of factorial function.
- **lngammacplx**: Computes the natural log of the gamma function for complex inputs.
- **log**: Computes the log of each element.
- **mbesseli**: Computes modified and exponentially scaled modified Bessels of the first kind of the nth order.
- **nextn, nextnevn**: Returns allowable matrix dimensions for computing FFT's.
- **optn, optnevn**: Returns optimal matrix dimensions for computing FFT's.
- **pi**: Returns $\pi$.
- **polar**: Graphs data using polar coordinates.
- **polygamma**: Computes the polygamma function of order $n$. 


psi Computes the psi (or digamma) function.
sin Computes sine.
sinh Computes the hyperbolic sine.
spline Computes a two-dimensional interpolatory spline.
sqrt Computes the square root of each element.
tan Computes tangent.
tanh Computes hyperbolic tangent.
tocart Converts from polar to Cartesian coordinates.
topolar Converts from Cartesian to polar coordinates.
trigamma Computes trigamma function.
zeta Computes the Riemann zeta function.

All trigonometric functions take or return values in radian units.

**Differentiation and Integration**

gradMT Computes numerical gradient.
gradMTm Computes numerical gradient with mask.
gradMTT Computes numerical gradient using available threads.
gradMTTm Computes numerical gradient with mask using available threads.
gradp, gradcplx Computes first derivative of a function;
Commands by Category

`gradcplx` allows for complex arguments.

- `hessMT`: Computes numerical Hessian.
- `hessMTg`: Computes numerical Hessian using gradient procedure.
- `hessMTgw`: Computes numerical Hessian using gradient procedure with weights.
- `hessMTm`: Computes numerical Hessian with mask.
- `hessMTmw`: Computes numerical Hessian with mask and weights.
- `hessMTT`: Computes numerical Hessian using available threads.
- `hessMTTg`: Computes numerical Hessian using gradient procedure with available threads.
- `hessMTTgw`: Computes numerical Hessian using gradient procedure with weights and using available threads.
- `hessMTTm`: Computes numerical Hessian with mask and available threads.
- `hessMTw`: Computes numerical Hessian with weights.
- `hessp, hesscplx`: Computes second derivative of a function; `hesscplx` allows for complex arguments.
- `intgrat2`: Integrates a 2-dimensional function over an user-defined region.
- `intgrat3`: Integrates a 3-dimensional function over an
user-defined region.

`inthp1` Integrates an user-defined function over an infinite interval.

`inthp2` Integrates an user-defined function over the \([a, +\infty)\) interval.

`inthp3` Integrates an user-defined function over the \([a, +\infty)\) interval that is oscillatory.

`inthp4` Integrates an user-defined function over the \([a, b]\) interval.

`inthpControlCreate` Creates default `inthpControl` structure.

`intquad1` Integrates a 1-dimensional function.

`intquad2` Integrates a 2-dimensional function over an user-defined rectangular region.

`intquad3` Integrates a 3-dimensional function over an user-defined rectangular region.

`intsimp` Integrates by Simpson's method.

`gradp` and `hessp` use a finite difference approximation to compute the first and second derivatives. Use `gradp` to calculate a Jacobian.

`intquad1`, `intquad2`, and `intquad3` use Gaussian quadrature to calculate the integral of the user-defined function over a rectangular region.

To calculate an integral over a region defined by functions of \(x\) and \(y\), use `intgrat2` and `intgrat3`.

To get a greater degree of accuracy than that provided by `intquad1`, use `intsimp` for 1-dimensional integration.
**Linear Algebra**

- **balance**: Balances a matrix.
- **band**: Extracts bands from a symmetric banded matrix.
- **bandchol**: Computes the Cholesky decomposition of a positive definite banded matrix.
- **bandcholsol**: Solves the system of equations $Ax = b$ for $x$, given the lower triangle of the Cholesky decomposition of a positive definite banded matrix $A$.
- **bandltsol**: Solves the system of equations $Ax = b$ for $x$, where $A$ is a lower triangular banded matrix.
- **bandrv**: Creates a symmetric banded matrix, given its compact form.
- **bandsolpd**: Solves the system of equations $Ax = b$ for $x$, where $A$ is a positive definite banded matrix.
- **chol**: Computes Cholesky decomposition, $X = YY$.
- **choldn**: Performs Cholesky downdate on an upper triangular matrix.
- **cholsol**: Solves a system of equations given the Cholesky factorization of a matrix.
- **cholup**: Performs Cholesky update on an upper triangular matrix.
- **cond**: Computes condition number of a matrix.
- **crout**: Computes Crout decomposition, $X = LU$ (real
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>croutp</td>
<td>Computes Crout decomposition with row pivoting (real matrices only).</td>
</tr>
<tr>
<td>det</td>
<td>Computes determinant of square matrix.</td>
</tr>
<tr>
<td>delt</td>
<td>Computes determinant of decomposed matrix.</td>
</tr>
<tr>
<td>hess</td>
<td>Computes upper Hessenberg form of a matrix (real matrices only).</td>
</tr>
<tr>
<td>inv</td>
<td>Inverts a matrix.</td>
</tr>
<tr>
<td>invpd</td>
<td>Inverts a positive definite matrix.</td>
</tr>
<tr>
<td>invswp</td>
<td>Computes a generalized sweep inverse.</td>
</tr>
<tr>
<td>lapeighb</td>
<td>Computes eigenvalues only of a real symmetric or complex Hermitian matrix</td>
</tr>
<tr>
<td></td>
<td>selected by bounds.</td>
</tr>
<tr>
<td>lapeighi</td>
<td>Computes eigenvalues only of a real symmetric or complex Hermitian matrix</td>
</tr>
<tr>
<td></td>
<td>selected by index.</td>
</tr>
<tr>
<td>lapeighvb</td>
<td>Computes eigenvalues and eigenvectors of a real symmetric or complex Hermit</td>
</tr>
<tr>
<td></td>
<td>ian matrix selected by bounds.</td>
</tr>
<tr>
<td>lapeighvi</td>
<td>Computes selected eigenvalues and eigenvectors of a real symmetric or complex</td>
</tr>
<tr>
<td></td>
<td>Hermitian matrix.</td>
</tr>
<tr>
<td>lapgeig</td>
<td>Computes generalized eigenvalues for a pair of real or complex general</td>
</tr>
<tr>
<td></td>
<td>matrices.</td>
</tr>
<tr>
<td>lapgeigh</td>
<td>Computes generalized eigenvalues for a pair of</td>
</tr>
</tbody>
</table>
Hermitian matrices.

**lapgeighv** Computes generalized eigenvalues and eigenvectors for a pair of real symmetric or Hermitian matrices.

**lapgeigv** Computes generalized eigenvalues, left eigenvectors, and right eigenvectors for a pair of real or complex general matrices.

**lapgschur** Computes the generalized Schur form of a pair of real or complex general matrices.

**lapgsvdcest** Computes the generalized singular value decomposition of a pair of real or complex general matrices.

**lapgsvds** Computes the generalized singular value decomposition of a pair of real or complex general matrices.

**lapgsvdst** Computes the generalized singular value decomposition of a pair of real or complex general matrices.

**lapsvdcusv** Computes the singular value decomposition a real or complex rectangular matrix, returns compact $u$ and $v$.

**lapsvds** Computes the singular values of a real or complex rectangular matrix.

**lapsvduusv** Computes the singular value decomposition a real or complex rectangular matrix.

**lu** Computes LU decomposition with row pivoting
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>null</strong></td>
<td>Computes orthonormal basis for right null space.</td>
</tr>
<tr>
<td><strong>null1</strong></td>
<td>Computes orthonormal basis for right null space.</td>
</tr>
<tr>
<td><strong>orth</strong></td>
<td>Computes orthonormal basis for column space $x$.</td>
</tr>
<tr>
<td><strong>pinv</strong></td>
<td>Generalized pseudo-inverse: Moore-Penrose.</td>
</tr>
<tr>
<td><strong>pinvmt</strong></td>
<td>Generalized pseudo-inverse: Moore-Penrose.</td>
</tr>
<tr>
<td><strong>qqr</strong></td>
<td>QR decomposition: returns $Q_1$ and $R$.</td>
</tr>
<tr>
<td><strong>qqre</strong></td>
<td>QR decomposition: returns $Q_1$, $R$ and a permutation vector, $E$.</td>
</tr>
<tr>
<td><strong>qqrep</strong></td>
<td>QR decomposition with pivot control: returns $Q_1$, $R$, and $E$.</td>
</tr>
<tr>
<td><strong>qr</strong></td>
<td>QR decomposition: returns $R$.</td>
</tr>
<tr>
<td><strong>qre</strong></td>
<td>QR decomposition: returns $R$ and $E$.</td>
</tr>
<tr>
<td><strong>qrep</strong></td>
<td>QR decomposition with pivot control: returns $R$ and $E$.</td>
</tr>
<tr>
<td><strong>qrsol</strong></td>
<td>Solves a system of equations $R'x = b$ given an upper triangular matrix, typically the $R$ matrix from a QR decomposition.</td>
</tr>
<tr>
<td><strong>qrtsol</strong></td>
<td>Solves a system of equations $R'x = b$ given an upper triangular matrix, typically the $R$ matrix from a QR decomposition.</td>
</tr>
<tr>
<td><strong>qtyr</strong></td>
<td>QR decomposition: returns $Q'Y$ and $R$.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>qtyre</td>
<td>QR decomposition: returns $Q'Y$, $R$ and $E$.</td>
</tr>
<tr>
<td>qtyrep</td>
<td>QR decomposition with pivot control: returns $Q'Y$, $R$ and $E$.</td>
</tr>
<tr>
<td>qyr</td>
<td>QR decomposition: returns $QY$ and $R$.</td>
</tr>
<tr>
<td>qyre</td>
<td>QR decomposition: returns $QY$, $R$ and $E$.</td>
</tr>
<tr>
<td>qyrep</td>
<td>QR decomposition with pivot control: returns $QY$, $R$ and $E$.</td>
</tr>
<tr>
<td>rank</td>
<td>Computes rank of a matrix.</td>
</tr>
<tr>
<td>rref</td>
<td>Computes reduced row echelon form of a matrix.</td>
</tr>
<tr>
<td>schtoc</td>
<td>Reduces any 2x2 blocks on the diagonal of the real Schur matrix returned from schur. The transformation matrix is also updated.</td>
</tr>
<tr>
<td>schur</td>
<td>Computes Schur decomposition of a matrix (real matrices only).</td>
</tr>
<tr>
<td>solpd</td>
<td>Solves a system of positive definite linear equations.</td>
</tr>
<tr>
<td>svd</td>
<td>Computes the singular values of a matrix.</td>
</tr>
<tr>
<td>svd1</td>
<td>Computes singular value decomposition, $X = USV'$.</td>
</tr>
<tr>
<td>svd2</td>
<td>Computes svd1 with compact $U$.</td>
</tr>
<tr>
<td>svdcusv</td>
<td>Computes the singular value decomposition of a matrix so that: $x = u * s * v'$ (compact $u$).</td>
</tr>
<tr>
<td>svds</td>
<td>Computes the singular values of a matrix.</td>
</tr>
</tbody>
</table>
svdusv

Computes the singular value decomposition of a matrix so that: \( x = u * s * v' \).

The decomposition routines are **chol** for Cholesky decomposition, **crou** and **croup** for Crout decomposition, **qqr-qtyrep** for QR decomposition, and **svd-svdusv** for singular value decomposition.

**null**, **null1**, and **orth** calculate orthonormal bases.

**inv**, **invpd**, **solpd**, **cholsol**, **qrsol** and the ”/" operator can all be used to solve linear systems of equations.

**rank** and **rref** will find the rank and reduced row echelon form of a matrix.

**det**, **delt** and **cond** will calculate the determinant and condition number of a matrix.

### Eigenvalues

**eig**

Computes eigenvalues of general matrix.

**eigh**

Computes eigenvalues of complex Hermitian or real symmetric matrix.

**eighv**

Computes eigenvalues and eigenvectors of complex Hermitian or real symmetric matrix.

**eigv**

Computes eigenvalues and eigenvectors of general matrix.

There are four eigenvalue-eigenvector routines. Two calculate eigenvalues only, and two calculate eigenvalues and eigenvectors. The three types of matrices handled by these routines are:
<table>
<thead>
<tr>
<th>Commands by Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General:</strong></td>
</tr>
<tr>
<td><code>eig</code>, <code>eigv</code></td>
</tr>
<tr>
<td><strong>Symmetric or Hermitian:</strong></td>
</tr>
<tr>
<td><code>eigh</code>, <code>eighv</code></td>
</tr>
</tbody>
</table>

**Polynomial Operations**

- **polychar**: Computes characteristic polynomial of a square matrix.
- **polyeval**: Evaluates polynomial with given coefficients.
- **polyint**: Calculates Nth order polynomial interpolation given known point pairs.
- **polymake**: Computes polynomial coefficients from roots.
- **polymat**: Returns sequence powers of a matrix.
- **polymult**: Multiplies two polynomials together.
- **polyroot**: Computes roots of polynomial from coefficients.

See also `recserrc`, `recsercp`, and `conv`.

**Fourier Transforms**

- **dfft**: Computes discrete 1-D FFT.
- **dftti**: Computes inverse discrete 1-D FFT.
- **fft**: Computes 1- or 2-D FFT.
- **ftti**: Computes inverse 1- or 2-D FFT.
- **fftm**: Computes multi-dimensional FFT.
### Commands by Category

**fftn**
- Computes 1- or 2-D FFT using prime factor algorithm.

**rfftn**
- Computes real 1- or 2-D FFT using prime factor algorithm.

**rfftnp**
- Computes real 1- or 2-D FFT using prime factor algorithm, returns packed format FFT.

**rfft**
- Computes real 1- or 2-D FFT.

**rffti**
- Computes inverse real 1- or 2-D FFT.

**rfftip**
- Computes inverse real 1- or 2-D FFT from packed format FFT.

**rfftn**
- Computes real 1- or 2-D FFT using prime factor algorithm.

**rfftnp**
- Computes real 1- or 2-D FFT using prime factor algorithm, returns packed format FFT.

**rfftp**
- Computes real 1- or 2-D FFT, returns packed format FFT.

### Random Numbers

**rndBeta**
- Computes random numbers with beta distribution.

**rndCauchy**
- Computes Cauchy distributed random numbers with a choice of underlying random number generator.

**rndcon**
- Changes constant of the LC random number generator.

**rndCreateState**
- Creates a new random number stream for a specified generator type from a seed value.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>rndExp</code></td>
<td>Computes exponentially distributed random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><code>rndGamma</code></td>
<td>Computes gamma pseudo-random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><code>rndGeo</code></td>
<td>Computes geometric pseudo-random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><code>rndGumbel</code></td>
<td>Computes Gumbel distributed random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><code>rndi</code></td>
<td>Returns random integers, $0 \leq y &lt; 2^{32}$.</td>
</tr>
<tr>
<td><code>rndKMbeta</code></td>
<td>Computes beta pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMgam</code></td>
<td>Computes gamma pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMi</code></td>
<td>Returns random integers, $0 \leq y &lt; 2^{32}$.</td>
</tr>
<tr>
<td><code>rndKMn</code></td>
<td>Computes standard normal pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMnb</code></td>
<td>Computes negative binomial pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMp</code></td>
<td>Computes Poisson pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMu</code></td>
<td>Computes uniform pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndKMvm</code></td>
<td>Computes von Mises pseudo-random numbers.</td>
</tr>
<tr>
<td><code>rndLaplace</code></td>
<td>Computes Laplacian pseudo-random numbers.</td>
</tr>
</tbody>
</table>
with the choice of underlying random number generator.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>rndLogNorm</strong></td>
<td>Computes lognormal pseudo-random numbers with the choice of underlying random number generator.</td>
</tr>
<tr>
<td><strong>rndmult</strong></td>
<td>Changes multiplier of the LC random number generator.</td>
</tr>
<tr>
<td><strong>rndMVn</strong></td>
<td>Computes multivariate normal random numbers given a covariance matrix.</td>
</tr>
<tr>
<td><strong>rndn</strong></td>
<td>Computes normally distributed pseudo-random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><strong>rndnb</strong></td>
<td>Computes random numbers with negative binomial distribution.</td>
</tr>
<tr>
<td><strong>rndNegBinomial</strong></td>
<td>Computes negative binomial pseudo-random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><strong>rndp</strong></td>
<td>Computes random numbers with Poisson distribution.</td>
</tr>
<tr>
<td><strong>rndPoisson</strong></td>
<td>Computes Poisson pseudo-random numbers with a choice of underlying random number generator.</td>
</tr>
<tr>
<td><strong>rndseed</strong></td>
<td>Changes seed of the LC random number generator.</td>
</tr>
<tr>
<td><strong>rndStateSkip</strong></td>
<td>To advance a state vector by a specified number of values.</td>
</tr>
</tbody>
</table>
**Fuzzy Conditional Functions**

- `dotfeq`  
  Fuzzy `.==`

- `dotfeqmt`  
  Fuzzy `.==`

- `dotfge`  
  Fuzzy `.>=`

- `dotfgemt`  
  Fuzzy `.>`

- `dotfgt`  
  Fuzzy `.>`

- `dotfgtmt`  
  Fuzzy `.>`

- `dotfle`  
  Fuzzy `.<=`

- `dotflemt`  
  Fuzzy `.<=`

- `dotflt`  
  Fuzzy `<`

- `dotfltmt`  
  Fuzzy `<`

- `dotfne`  
  Fuzzy `./=`
The \texttt{mt} commands use an \texttt{fcmptol} argument to control the tolerance used for comparison.

The non-\texttt{mt} commands use the global variable \texttt{fcmptol} to control the tolerance used for comparison. By default, this is $1\times10^{-15}$. The default can be changed by editing the file \texttt{fcompare.dec}.

\subsection*{Statistical Functions}

\texttt{acf} \hspace{1cm} Computes sample autocorrelations.

\texttt{astd} \hspace{1cm} Computes the standard deviation of the
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>astds</td>
<td>Computes the 'sample' standard deviation of the elements across one dimension of an N-dimensional array.</td>
</tr>
<tr>
<td>ChiBarSquare</td>
<td>Computes probability of chi-bar-square statistic.</td>
</tr>
<tr>
<td>combinate</td>
<td>Computes combinations of $n$ things taken $k$ at a time.</td>
</tr>
<tr>
<td>combined</td>
<td>Writes combinations of $n$ things taken $k$ at a time to a GAUSS data set.</td>
</tr>
<tr>
<td>ConScore</td>
<td>Computes constrained score statistic and its probability.</td>
</tr>
<tr>
<td>conv</td>
<td>Computes convolution of two vectors.</td>
</tr>
<tr>
<td>corrm</td>
<td>Computes correlation matrix of a moment matrix.</td>
</tr>
<tr>
<td>corrms</td>
<td>Computes sample correlation matrix of a moment matrix.</td>
</tr>
<tr>
<td>corrvc</td>
<td>Computes correlation matrix from a variance-covariance matrix.</td>
</tr>
<tr>
<td>corrx</td>
<td>Computes correlation matrix.</td>
</tr>
<tr>
<td>corrxs</td>
<td>Computes sample correlation matrix.</td>
</tr>
<tr>
<td>crossprd</td>
<td>Computes cross product.</td>
</tr>
<tr>
<td>design</td>
<td>Creates a design matrix of 0's and 1's.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>dstat</td>
<td>Computes descriptive statistics of a data set or matrix.</td>
</tr>
<tr>
<td>dstatmt</td>
<td>Computes descriptive statistics of a data set or matrix.</td>
</tr>
<tr>
<td>dstatmtControlCreate</td>
<td>Creates default dstatmtControl structure.</td>
</tr>
<tr>
<td>gdaDStat</td>
<td>Computes descriptive statistics on multiple Nx1 variables in a GDA.</td>
</tr>
<tr>
<td>gdaDStatMat</td>
<td>Computes descriptive statistics on a selection of columns in a variable in a GDA.</td>
</tr>
<tr>
<td>loess</td>
<td>Computes coefficients of locally weighted regression.</td>
</tr>
<tr>
<td>loessmt</td>
<td>Computes coefficients of locally weighted regression.</td>
</tr>
<tr>
<td>loessmtControlCreate</td>
<td>Creates default loessmtControl structure.</td>
</tr>
<tr>
<td>meanc</td>
<td>Computes mean value of each column of a matrix.</td>
</tr>
<tr>
<td>median</td>
<td>Computes medians of the columns of a matrix.</td>
</tr>
<tr>
<td>moment</td>
<td>Computes moment matrix ($x'x$) with special handling of missing values.</td>
</tr>
<tr>
<td>momentd</td>
<td>Computes moment matrix from a data set.</td>
</tr>
<tr>
<td>movingave</td>
<td>Computes moving average of a series.</td>
</tr>
<tr>
<td>movingaveExpwgt</td>
<td>Computes exponentially weighted moving average of a series.</td>
</tr>
</tbody>
</table>
**Commands by Category**

- **movingaveWgt**: Computes weighted moving average of a series.
- **numCombinations**: Computes number of combinations of \( n \) things taken \( k \) at a time.
- **ols**: Computes least squares regression of data set or matrix.
- **olsmt**: Computes least squares regression of data set or matrix.
- **olsmtControlCreate**: Creates default `olsmtControl` structure.
- **olsqr**: Computes OLS coefficients using QR decomposition.
- **olsqr2**: Computes OLS coefficients, residuals, and predicted values using QR decomposition.
- **olsqrmt**: Computes OLS coefficients using QR decomposition.
- **pacf**: Computes sample partial autocorrelations.
- **princomp**: Computes principal components of a data matrix.
- **quantile**: Computes quantiles from data in a matrix, given specified probabilities.
- **quantiled**: Computes quantiles from data in a data set, given specified probabilities.
- **rndvm**: Computes von Mises pseudo-random numbers.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>stdc</code></td>
<td>Computes standard deviation of the columns of a matrix.</td>
</tr>
<tr>
<td><code>stdsc</code></td>
<td>Computes the 'sample' standard deviation of the elements in each column of a matrix.</td>
</tr>
<tr>
<td><code>toeplitz</code></td>
<td>Computes Toeplitz matrix from column vector.</td>
</tr>
<tr>
<td><code>varCovM</code></td>
<td>Computes the population variance-covariance matrix from a moment matrix.</td>
</tr>
<tr>
<td><code>varCovMS</code></td>
<td>Computes a sample variance-covariance matrix from a moment matrix.</td>
</tr>
<tr>
<td><code>varCovX</code></td>
<td>Computes the population variance-covariance matrix from a data matrix.</td>
</tr>
<tr>
<td><code>varCovXS</code></td>
<td>Computes a sample variance-covariance matrix from a data matrix.</td>
</tr>
<tr>
<td><code>varmall</code></td>
<td>Computes the log-likelihood of a Vector ARMA model.</td>
</tr>
<tr>
<td><code>varmares</code></td>
<td>Computes the residuals of a Vector ARMA model.</td>
</tr>
<tr>
<td><code>vcm</code></td>
<td>Computes a variance-covariance matrix from a moment matrix.</td>
</tr>
<tr>
<td><code>vcms</code></td>
<td>Computes a sample variance-covariance matrix from a moment matrix.</td>
</tr>
<tr>
<td><code>vcx</code></td>
<td>Computes a variance-covariance matrix from a data matrix.</td>
</tr>
<tr>
<td><code>vcxs</code></td>
<td>Computes a sample variance-covariance</td>
</tr>
</tbody>
</table>
matrix from a data matrix.

Advanced statistics and optimization routines are available in the GAUSS Applications programs. (Contact Aptech Systems for more information.)

### Optimization and Solution

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eqSolve</td>
<td>Solves a system of nonlinear equations.</td>
</tr>
<tr>
<td>eqSolvemt</td>
<td>Solves a system of nonlinear equations.</td>
</tr>
<tr>
<td>eqSolvemtControlCreate</td>
<td>Creates default eqSolvemtControl structure.</td>
</tr>
<tr>
<td>eqSolvemtOutCreate</td>
<td>Creates default eqSolvemtOut structure.</td>
</tr>
<tr>
<td>eqSolveSet</td>
<td>Sets global input used by eqSolve to default values.</td>
</tr>
<tr>
<td>linsolve</td>
<td>Solves $Ax = b$ using the inverse function.</td>
</tr>
<tr>
<td>ltrisol</td>
<td>Computes the solution of $Lx = b$ where $L$ is a lower triangular matrix.</td>
</tr>
<tr>
<td>lusol</td>
<td>Computes the solution of $LUx = b$ where $L$ is a lower triangular matrix and $U$ is an upper triangular matrix.</td>
</tr>
<tr>
<td>QNewton</td>
<td>Optimizes a function using the BFGS descent algorithm.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>QNewtonmt</strong></td>
<td>Minimizes an arbitrary function.</td>
</tr>
<tr>
<td><strong>QNewtonmtControlCreate</strong></td>
<td>Creates default <strong>QNewtonmtControl</strong> structure.</td>
</tr>
<tr>
<td><strong>QNewtonmtOutCreate</strong></td>
<td>Creates default <strong>QNewtonmtOut</strong> structure.</td>
</tr>
<tr>
<td><strong>QProg</strong></td>
<td>Solves the quadratic programming problem.</td>
</tr>
<tr>
<td><strong>QProgmt</strong></td>
<td>Solves the quadratic programming problem.</td>
</tr>
<tr>
<td><strong>QProgmtInCreate</strong></td>
<td>Creates an instance of a structure of type <strong>QProgmtInCreate</strong> with the <strong>maxit</strong> member set to a default value.</td>
</tr>
<tr>
<td><strong>sqpSolve</strong></td>
<td>Solves the nonlinear programming problem using a sequential quadratic programming method.</td>
</tr>
<tr>
<td><strong>sqpSolveMT</strong></td>
<td>Solves the nonlinear programming problem using a sequential quadratic programming method.</td>
</tr>
<tr>
<td><strong>sqpSolveMTControlCreate</strong></td>
<td>Creates an instance of a structure of type <strong>sqpSolveMTcontrol</strong> set to default values.</td>
</tr>
<tr>
<td><strong>sqpSolveMTlagrangeCreate</strong></td>
<td>Creates an instance of a structure of type <strong>sqpSolveMTlagrange</strong> set to default values.</td>
</tr>
<tr>
<td><strong>sqpSolveMToutCreate</strong></td>
<td>Creates an instance of a structure of type <strong>sqpSolveMTout</strong> set to default values.</td>
</tr>
</tbody>
</table>
Commands by Category

values.

\textbf{sqpSolveSet} \hspace{1cm} \text{Resets global variables used by sqpSolve to default values.}

\textbf{utrisol} \hspace{1cm} \text{Computes the solution of } Ux = b \text{ where } U \text{ is an upper triangular matrix.}

\section*{Statistical Distributions}

\textbf{cdfBeta} \hspace{1cm} \text{Computes integral of beta function.}

\textbf{cdfBetaInv} \hspace{1cm} \text{Computes the quantile or inverse of the beta cumulative distribution function.}

\textbf{cdfBinomial} \hspace{1cm} \text{Computes the binomial cumulative distribution function.}

\textbf{cdfBinomialInv} \hspace{1cm} \text{Computes the binomial quantile or inverse cumulative distribution function.}

\textbf{cdfBvn} \hspace{1cm} \text{Computes lower tail of bivariate Normal cdf.}

\textbf{cdfBvn2} \hspace{1cm} \text{Returns cdfbvn of a bounded rectangle.}

\textbf{cdfBvn2e} \hspace{1cm} \text{Returns cdfbvn of a bounded rectangle.}

\textbf{cdfCauchy} \hspace{1cm} \text{Computes the cumulative distribution function for the Cauchy distribution.}

\textbf{cdfCauchyinv} \hspace{1cm} \text{Computes the Cauchy inverse cumulative distribution function.}

\textbf{cdfChic} \hspace{1cm} \text{Computes complement of cdf of } \chi^2.

\textbf{cdfChii} \hspace{1cm} \text{Computes } \chi^2 \text{ abscissae values given probability and degrees of freedom.}
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdfChinc</td>
<td>Computes integral of noncentral $\chi^2$.</td>
</tr>
<tr>
<td>cdfExp</td>
<td>Computes the cumulative distribution function for the exponential distribution.</td>
</tr>
<tr>
<td>cdfExpInv</td>
<td>Computes the exponential inverse cumulative distribution function.</td>
</tr>
<tr>
<td>cdfFc</td>
<td>Computes complement of cdf of $F$.</td>
</tr>
<tr>
<td>cdfFnc</td>
<td>Computes integral of noncentral $F$.</td>
</tr>
<tr>
<td>cdfFncInv</td>
<td>Computes the quantile or inverse of noncentral $F$ cumulative distribution function.</td>
</tr>
<tr>
<td>cdfGam</td>
<td>Computes integral of incomplete $\Gamma$ function.</td>
</tr>
<tr>
<td>cdfGenPareto</td>
<td>Computes the cumulative distribution function for the Generalized Pareto distribution.</td>
</tr>
<tr>
<td>cdfLaplace</td>
<td>Computes the cumulative distribution function for the Laplace distribution.</td>
</tr>
<tr>
<td>cdfLaplaceInv</td>
<td>Computes the Laplace inverse cumulative distribution function.</td>
</tr>
<tr>
<td>cdfMvn</td>
<td>Computes multivariate Normal cdf.</td>
</tr>
<tr>
<td>cdfMvnce</td>
<td>Computes the complement of the multivariate Normal cumulative distribution function with error management</td>
</tr>
<tr>
<td>cdfMvne</td>
<td>Computes multivariate Normal cumulative distribution function with error management</td>
</tr>
<tr>
<td>cdfMvn2e</td>
<td>Computes the multivariate Normal cumulative distribution function with error management over</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>cdfMvtce</td>
<td>Computes complement of multivariate Student's t cumulative distribution function with error management</td>
</tr>
<tr>
<td>cdfMvte</td>
<td>Computes multivariate Student's t cumulative distribution function with error management</td>
</tr>
<tr>
<td>cdfMvt2e</td>
<td>Computes multivariate Student's t cumulative distribution function with error management over [a,b]</td>
</tr>
<tr>
<td>cdfN</td>
<td>Computes integral of Normal distribution: lower tail, or cdf.</td>
</tr>
<tr>
<td>cdfN2</td>
<td>Computes interval of Normal cdf.</td>
</tr>
<tr>
<td>cdfNc</td>
<td>Computes complement of cdf of Normal distribution (upper tail).</td>
</tr>
<tr>
<td>cdfNegBinomial</td>
<td>Computes the cumulative distribution function for the negative binomial distribution.</td>
</tr>
<tr>
<td>cdfNegBinomialInv</td>
<td>Computes the quantile or inverse negative binomial cumulative distribution function.</td>
</tr>
<tr>
<td>cdfNi</td>
<td>Computes the inverse of the cdf of the Normal distribution.</td>
</tr>
<tr>
<td>cdfRayleigh</td>
<td>Computes the Rayleigh cumulative distribution function.</td>
</tr>
<tr>
<td>cdfRayleighInv</td>
<td>Computes the Rayleigh inverse cumulative distribution function.</td>
</tr>
<tr>
<td>cdfTc</td>
<td>Computes complement of cdf of t-distribution.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>cdfTci</td>
<td>Computes the inverse of the complement of the Student's t cdf.</td>
</tr>
<tr>
<td>cdfTnc</td>
<td>Computes integral of noncentral ( t )-distribution.</td>
</tr>
<tr>
<td>cdfTvn</td>
<td>Computes lower tail of trivariate Normal cdf.</td>
</tr>
<tr>
<td>cdfWeibull</td>
<td>Computes the cumulative distribution function for the Weibull distribution.</td>
</tr>
<tr>
<td>cdfWeibullInv</td>
<td>Computes the Weibull inverse cumulative distribution function.</td>
</tr>
<tr>
<td>erf</td>
<td>Computes Gaussian error function.</td>
</tr>
<tr>
<td>erfc</td>
<td>Computes complement of Gaussian error function.</td>
</tr>
<tr>
<td>erfccplx</td>
<td>Computes complement of Gaussian error function for complex inputs.</td>
</tr>
<tr>
<td>erfcplx</td>
<td>Computes Gaussian error function for complex inputs.</td>
</tr>
<tr>
<td>lncdfbvn</td>
<td>Computes natural log of bivariate Normal cdf.</td>
</tr>
<tr>
<td>lncdfbvn2</td>
<td>Returns log of cdfbvn of a bounded rectangle.</td>
</tr>
<tr>
<td>lncdfmvn</td>
<td>Computes natural log of multivariate Normal cdf.</td>
</tr>
<tr>
<td>lncdfn</td>
<td>Computes natural log of Normal cdf.</td>
</tr>
<tr>
<td>lncdfn2</td>
<td>Computes natural log of interval of Normal cdf.</td>
</tr>
<tr>
<td>lncdfnc</td>
<td>Computes natural log of complement of Normal cdf.</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>lnpdfmvn</td>
<td>Computes multivariate Normal log-probabilities.</td>
</tr>
<tr>
<td>lnpdfmvt</td>
<td>Computes multivariate Student's t log-probabilities.</td>
</tr>
<tr>
<td>lnpdfn</td>
<td>Computes Normal log-probabilities.</td>
</tr>
<tr>
<td>lnpdfnt</td>
<td>Computes Student's t log-probabilities.</td>
</tr>
<tr>
<td>pdfCauchy</td>
<td>Computes the probability density function for the Cauchy distribution.</td>
</tr>
<tr>
<td>pdfexp</td>
<td>Computes the probability density function for the exponential distribution.</td>
</tr>
<tr>
<td>pdfgam</td>
<td>Computes the probability density function for the Gamma distribution.</td>
</tr>
<tr>
<td>pdfGenPareto</td>
<td>Computes the probability density function for the Generalized Pareto distribution.</td>
</tr>
<tr>
<td>pdfLaplace</td>
<td>Computes the probability density function for the Laplace distribution.</td>
</tr>
<tr>
<td>pdflogistic</td>
<td>Computes the probability density function for the logistic distribution.</td>
</tr>
<tr>
<td>pdfn</td>
<td>Computes standard Normal probability density function.</td>
</tr>
<tr>
<td>pdfPoisson</td>
<td>Computes the probability density function for the Poisson distribution.</td>
</tr>
<tr>
<td>pdfPoissonInv</td>
<td>Computes the quantile or inverse Poisson cumulative distribution function.</td>
</tr>
<tr>
<td>pdfRayleigh</td>
<td>Computes the probability density function of the</td>
</tr>
</tbody>
</table>
Rayleigh distribution.

pdfWeibull

Computes the probability density function of a Weibull random variable.

**Series and Sequence Functions**

recserar

Computes autoregressive recursive series.

recsercp

Computes recursive series involving products.

recserrc

Computes recursive series involving division.

seqa

Creates an additive sequence.

seqm

Creates a multiplicative sequence.

**Precision Control**

base10

Converts number to \(x.xxx\) and a power of 10.

ceil

Rounds up towards \(+\infty\).

floor

Rounds down towards \(-\infty\).

machEpsilon

Returns the smallest number such that \(1+\varepsilon>1\).

round

Rounds to the nearest integer.

trunc

Converts numbers to integers by truncating the fractional portion.

**round, trunc, ceil** and **floor** convert floating point numbers into integers. The internal representation for the converted integer is double
precision (64 bits).

Each matrix element in memory requires 8 bytes of memory.

37.2 Finance Functions

AmericanBinomCall
American binomial method Call.

AmericanBinomCall_Greeks
American binomial method call Delta, Gamma, Theta, Vega, and Rho.

AmericanBinomCall_ImpVol
Implied volatilities for American binomial method calls.

AmericanBinomPut
American binomial method Put.

AmericanBinomPut_Greeks
American binomial method put Delta, Gamma, Theta, Vega, and Rho.

AmericanBinomPut_ImpVol
Implied volatilities for American binomial method puts.

AmericanBSCall
American Black and Scholes Call.

AmericanBSCall_Greeks
American Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.

AmericanBSCall_ImpVol
Implied volatilities for American Black and Scholes calls.

AmericanBSPut
American Black and Scholes Put.

AmericanBSPut_Greeks
American Black and Scholes put Delta, Gamma, Omega, Theta, and Vega.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>AmericanBSPut_ImpVol</code></td>
<td>Implied volatilities for American Black and Scholes puts.</td>
</tr>
<tr>
<td><code>annualTradingDays</code></td>
<td>Computes number of trading days in a given year.</td>
</tr>
<tr>
<td><code>elapsedTradingDays</code></td>
<td>Computes number of trading days between two dates inclusively.</td>
</tr>
<tr>
<td><code>EuropeanBinomCall</code></td>
<td>European binomial method call.</td>
</tr>
<tr>
<td><code>EuropeanBinomCall_Greeks</code></td>
<td>European binomial method call Delta, Gamma, Theta, Vega and Rho.</td>
</tr>
<tr>
<td><code>EuropeanBinomCall_ImpVol</code></td>
<td>Implied volatilities for European binomial method calls.</td>
</tr>
<tr>
<td><code>EuropeanBinomPut</code></td>
<td>European binomial method Put.</td>
</tr>
<tr>
<td><code>EuropeanBinomPut_Greeks</code></td>
<td>European binomial method put Delta, Gamma, Theta, Vega, and Rho.</td>
</tr>
<tr>
<td><code>EuropeanBinomPut_ImpVol</code></td>
<td>Implied volatilities for European binomial method puts.</td>
</tr>
<tr>
<td><code>EuropeanBSCall</code></td>
<td>European Black and Scholes Call.</td>
</tr>
<tr>
<td><code>EuropeanBSCall_Greeks</code></td>
<td>European Black and Scholes call Delta, Gamma, Omega, Theta, and Vega.</td>
</tr>
<tr>
<td><code>EuropeanBSCall_ImpVol</code></td>
<td>Implied volatilities for European Black and Scholes calls.</td>
</tr>
<tr>
<td><code>EuropeanBSPut</code></td>
<td>European Black and Scholes Put.</td>
</tr>
<tr>
<td><code>EuropeanBSPut_Greeks</code></td>
<td>European Black and Scholes put</td>
</tr>
</tbody>
</table>
Delta, Gamma, Omega, Theta, and Vega.

**EuropeanBSPut_ImpVol**

Implied volatilities for European Black and Scholes puts.

**getNextTradingDay**

Returns the next trading day.

**getNextWeekDay**

Returns the next day that is not on a weekend.

**getPreviousTradingDay**

Returns the previous trading day.

**getPreviousWeekDay**

Returns the previous day that is not on a weekend.

### 37.3 Matrix Manipulation

#### Creating Vectors and Matrices

- **eye**
  - Creates identity matrix.

- **let**
  - Creates matrix from list of constants.

- **matalloc**
  - Allocates a matrix with unspecified contents.

- **matinit**
  - Allocates a matrix with specified fill value.

- **ones**
  - Creates a matrix of ones.

- **zeros**
  - Creates a matrix of zeros.
Use `zeros`, `ones`, or `matinit` to create a constant vector or matrix.

Matrices can also be loaded from an ASCII file, from a GAUSS matrix file, or from a GAUSS data set. (See File I/O, Chapter 1, for more information.)

**Loading and Storing Matrices**

- `asciiLoad` : Loads data from a delimited ASCII text file into an Nx1 vector.
- `dataload` : Loads matrices, N-dimensional arrays, strings and string arrays from a disk file.
- `datasave` : Saves matrices, N-dimensional arrays, strings and string arrays to a disk file.
- `load, loadm` : Loads matrix from ASCII or matrix file.
- `load` : Loads matrix from data set.
- `loadf` : Loads function from disk file.
- `loadk` : Loads keyword from disk file.
- `save` : Saves symbol to disk file.
- `saved` : Saves matrix to data set.

**Size, Ranking, and Range**

- `cols` : Returns number of columns in a matrix.
- `colsf` : Returns number of columns in an open data set.
## Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>counts</code></td>
<td>Returns number of elements of a vector falling in specified ranges.</td>
</tr>
<tr>
<td><code>countwts</code></td>
<td>Returns weighted count of elements of a vector falling in specified ranges.</td>
</tr>
<tr>
<td><code>cumprodc</code></td>
<td>Computes cumulative products of each column of a matrix.</td>
</tr>
<tr>
<td><code>cumsummc</code></td>
<td>Computes cumulative sums of each column of a matrix.</td>
</tr>
<tr>
<td><code>indexcat</code></td>
<td>Returns indices of elements falling within a specified range.</td>
</tr>
<tr>
<td><code>maxc</code></td>
<td>Returns largest element in each column of a matrix.</td>
</tr>
<tr>
<td><code>maxindc</code></td>
<td>Returns row number of largest element in each column of a matrix.</td>
</tr>
<tr>
<td><code>minc</code></td>
<td>Returns smallest element in each column of a matrix.</td>
</tr>
<tr>
<td><code>minindc</code></td>
<td>Returns row number of smallest element in each column of a matrix.</td>
</tr>
<tr>
<td><code>prodc</code></td>
<td>Computes the product of each column of a matrix.</td>
</tr>
<tr>
<td><code>rankindx</code></td>
<td>Returns rank index of Nx1 vector. (Rank order of elements in vector).</td>
</tr>
<tr>
<td><code>rows</code></td>
<td>Returns number of rows in a matrix.</td>
</tr>
<tr>
<td><code>rowsf</code></td>
<td>Returns number of rows in an open data set.</td>
</tr>
</tbody>
</table>
sumc Computes the sum of each column of a matrix.

sumr Computes the sum of each row of a matrix.

These functions are used to find the minimum, maximum and frequency counts of elements in matrices.

Use rows and cols to find the number of rows or columns in a matrix. Use rowsf and colsf to find the numbers of rows or columns in an open GAUSS data set.

Miscellaneous Matrix Manipulation

complex Creates a complex matrix from two real matrices.
delif Deletes rows from a matrix using a logical expression.
delrows Deletes rows from a matrix; the second argument contains the indices of the rows to be deleted.
diag Extracts the diagonal of a matrix.
diagrvc Puts a column vector into the diagonal of a matrix.
exctsmpl Creates a random subsample of a data set, with replacement.
imag Returns the imaginary part of a complex matrix.
indcv Checks one character vector against
another and returns the indices of the elements of the first vector in the second vector.

indnv
Checks one numeric vector against another and returns the indices of the elements of the first vector in the second vector.

intrsect
Returns the intersection of two vectors.

lowmat
Returns the main diagonal and lower triangle.

lowmat1
Returns a main diagonal of 1's and the lower triangle.

putvals
Inserts values into a matrix or N-dimensional array.

real
Returns the real part of a complex matrix.

reshape
Reshapes a matrix to new dimensions.

rev
Reverses the order of rows of a matrix.

rotater
Rotates the rows of a matrix, wrapping elements as necessary.

selif
Selects rows from a matrix using a logical expression.

setdif
Returns elements of one vector that are
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>shiftr</strong></td>
<td>Shifts rows of a matrix, filling in holes with a specified value.</td>
</tr>
<tr>
<td><strong>submat</strong></td>
<td>Extracts a submatrix from a matrix.</td>
</tr>
<tr>
<td><strong>subvec</strong></td>
<td>Extracts an Nx1 vector of elements from an NxK matrix.</td>
</tr>
<tr>
<td><strong>trimr</strong></td>
<td>Trims rows from top or bottom of a matrix.</td>
</tr>
<tr>
<td><strong>union</strong></td>
<td>Returns the union of two vectors.</td>
</tr>
<tr>
<td><strong>upmat</strong></td>
<td>Returns the main diagonal and upper triangle.</td>
</tr>
<tr>
<td><strong>upmat1</strong></td>
<td>Returns a main diagonal of 1's and the upper triangle.</td>
</tr>
<tr>
<td><strong>vec</strong></td>
<td>Stacks columns of a matrix to form a single column.</td>
</tr>
<tr>
<td><strong>vech</strong></td>
<td>Reshapes the lower triangular portion of a symmetric matrix into a column vector.</td>
</tr>
<tr>
<td><strong>vecr</strong></td>
<td>Stacks rows of a matrix to form a single column.</td>
</tr>
<tr>
<td><strong>vget</strong></td>
<td>Extracts a matrix or string from a data buffer constructed with <strong>vput</strong>.</td>
</tr>
<tr>
<td><strong>vlist</strong></td>
<td>Lists the contents of a data buffer constructed with <strong>vput</strong>.</td>
</tr>
</tbody>
</table>
Commands by Category

- **vnamecv**: Returns the names of the elements of a data buffer constructed with `vput`.

- **vput**: Inserts a matrix or string into a data buffer.

- **vread**: Reads a string or matrix from a data buffer constructed with `vput`.

- **vtypecv**: Returns the types of the elements of a data buffer constructed with `vput`.

- **xpnd**: Expands a column vector into a symmetric matrix.

**vech** and **xpnd** are complementary functions. **vech** provides an efficient way to store a symmetric matrix; **xpnd** expands the stored vector back to its original symmetric matrix.

**delif** and **selif** are complementary functions. **delif** deletes rows of a matrix based on a logical comparison; **selif** selects rows based on a logical comparison.

**lowmat**, **lowmat1**, **upmat**, and **upmat1** extract triangular portions of a matrix.

To delete rows which contain missing values from a matrix in memory, see **packr**.

### 37.4 Sparse Matrix Handling

- **denseToSp**: Converts a dense matrix to a sparse matrix.

- **denseToSpRE**: Converts a dense matrix to a sparse matrix using a relative epsilon.

- **packedToSp**: Creates a sparse matrix from a packed
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spBiconjGradSol</td>
<td>Solves the system of linear equations $Ax=b$ using the biconjugate gradient method.</td>
</tr>
<tr>
<td>spChol</td>
<td>Computes the $LL'$ decomposition of a sparse matrix.</td>
</tr>
<tr>
<td>spConjGradSol</td>
<td>Solves the system of linear equations $Ax=b$ for symmetric matrices using the conjugate gradient method.</td>
</tr>
<tr>
<td>spCreate</td>
<td>Creates a sparse matrix from vectors of non-zero values, row indices, and column indices.</td>
</tr>
<tr>
<td>spDenseSubmat</td>
<td>Returns a dense submatrix of a sparse matrix.</td>
</tr>
<tr>
<td>spDiagRvMat</td>
<td>Inserts submatrices along the diagonal of a sparse matrix.</td>
</tr>
<tr>
<td>spEigv</td>
<td>Computes a specified number of eigenvalues and eigenvectors of a square, sparse matrix.</td>
</tr>
<tr>
<td>spEye</td>
<td>Creates a sparse identity matrix.</td>
</tr>
<tr>
<td>spGetNZE</td>
<td>Returns the non-zero values in a sparse matrix, as well as their corresponding row and column indices.</td>
</tr>
<tr>
<td>spGetNumNZE</td>
<td>Returns the number of non-zero elements in a sparse matrix.</td>
</tr>
</tbody>
</table>
### Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spLDL</td>
<td>Computes the LDL decomposition of a symmetric sparse matrix.</td>
</tr>
<tr>
<td>spLU</td>
<td>Computes the LU decomposition of a sparse matrix with partial pivoting.</td>
</tr>
<tr>
<td>spOnes</td>
<td>Generates a sparse matrix containing only ones and zeros.</td>
</tr>
<tr>
<td>spSubmat</td>
<td>Returns a sparse submatrix of sparse matrix.</td>
</tr>
<tr>
<td>spToDense</td>
<td>Converts a sparse matrix to a dense matrix.</td>
</tr>
<tr>
<td>spTrTDense</td>
<td>Multiplies a sparse matrix transposed by a dense matrix.</td>
</tr>
<tr>
<td>spTScalar</td>
<td>Multiplies a sparse matrix by a scalar.</td>
</tr>
<tr>
<td>spZeros</td>
<td>Creates a sparse matrix containing no non-zero values.</td>
</tr>
</tbody>
</table>

### 37.5 N-Dimensional Array Handling

#### Creating Arrays

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>aconcat</td>
<td>Concatenates conformable matrices and arrays in a user-specified dimension.</td>
</tr>
<tr>
<td>aeye</td>
<td>Creates an N-dimensional array in which the planes described by the two trailing dimensions of the array are...</td>
</tr>
</tbody>
</table>
equal to the identity.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>areshape</td>
<td>Reshapes a scalar, matrix, or array into an array of user-specified size.</td>
</tr>
<tr>
<td>arrayalloc</td>
<td>Creates an N-dimensional array with unspecified contents.</td>
</tr>
<tr>
<td>arrayinit</td>
<td>Creates an N-dimensional array with a specified fill value.</td>
</tr>
<tr>
<td>mattoarray</td>
<td>Converts a matrix to a type array.</td>
</tr>
</tbody>
</table>

**Size, Ranking and Range**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>amax</td>
<td>Moves across one dimension of an N-dimensional array and finds the largest element.</td>
</tr>
<tr>
<td>amin</td>
<td>Moves across one dimension of an N-dimensional array and finds the smallest element.</td>
</tr>
<tr>
<td>asum</td>
<td>Computes the sum across one dimension of an N-dimensional array.</td>
</tr>
<tr>
<td>getdims</td>
<td>Gets the number of dimensions in an array.</td>
</tr>
<tr>
<td>getorders</td>
<td>Gets the vector of orders corresponding to an array.</td>
</tr>
</tbody>
</table>

**Setting and Retrieving Data in an Array**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>aconcat</td>
<td>Concatenates conformable matrices</td>
</tr>
</tbody>
</table>
and arrays in a user-specified dimension.

`areshape` Reshapes a scalar, matrix, or array into an array of user-specified size.

`arraytomat` Changes an array to type matrix.

`getarray` Gets a contiguous subarray from an N-dimensional array.

`getmatrix` Gets a contiguous matrix from an N-dimensional array.

`getmatrix4D` Gets a contiguous matrix from a 4-dimensional array.

`getscalar3D` Gets a scalar from a 3-dimensional array.

`getscalar4D` Gets a scalar from a 4-dimensional array.

`putarray` Puts a contiguous subarray into an N-dimensional array and returns the resulting array.

`setarray` Sets a contiguous subarray of an N-dimensional array.

**Miscellaneous Array Functions**

`amean` Computes the mean across one dimension of an N-dimensional array.

`amult` Performs matrix multiplication on the
planes described by the two trailing dimensions of N-dimensional arrays.

arrayindex

Saves a matrix of structures to a file on the disk.

atranpose

Transposes an N-dimensional array.

loopnextindex

Increments an index vector to the next logical index and jumps to the specified label if the index did not wrap to the beginning.

nextindex

Returns the index of the next element or subarray in an array.

previousindex

Returns the index of the previous element or subarray in an array.

singleindex

Converts a vector of indices for an N-dimensional array to a scalar vector index.

walkindex

Walks the index of an array forward or backward through a specified dimension.

### 37.6 Structures

**dsCreate**

Creates an instance of a structure of type DS set to default values.

**loadstruct**

Loads a structure into memory from a file on the disk.
### Commands by Category

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>pvCreate</code></td>
<td>Returns an initialized instance of structure of type <code>PV</code>.</td>
</tr>
<tr>
<td><code>pvGetIndex</code></td>
<td>Gets row indices of a matrix in a parameter vector.</td>
</tr>
<tr>
<td><code>pvGetParNames</code></td>
<td>Generates names for parameter vector stored in structure of type <code>PV</code>.</td>
</tr>
<tr>
<td><code>pvGetParVector</code></td>
<td>Retrieves parameter vector from structure of type <code>PV</code>.</td>
</tr>
<tr>
<td><code>pvLength</code></td>
<td>Returns the length of a parameter vector.</td>
</tr>
<tr>
<td><code>pvList</code></td>
<td>Retrieves names of packed matrices in structure of type <code>PV</code>.</td>
</tr>
<tr>
<td><code>pvPack</code></td>
<td>Packs general matrix into a structure of type <code>PV</code> with matrix name.</td>
</tr>
<tr>
<td><code>pvPacki</code></td>
<td>Packs general matrix or array into a <code>PV</code> instance with name and index.</td>
</tr>
<tr>
<td><code>pvPackm</code></td>
<td>Packs general matrix into a structure of type <code>PV</code> with a mask and matrix name.</td>
</tr>
<tr>
<td><code>pvPackmi</code></td>
<td>Packs general matrix or array into a <code>PV</code> instance with a mask, name, and index.</td>
</tr>
<tr>
<td><code>pvPacks</code></td>
<td>Packs symmetric matrix into a structure of type <code>PV</code>.</td>
</tr>
<tr>
<td><code>pvPacksi</code></td>
<td>Packs symmetric matrix into a <code>PV</code>.</td>
</tr>
</tbody>
</table>
instance with matrix name and index.

\textbf{pvPacksm} \hspace{2cm} Packs symmetric matrix into a structure of type \textbf{PV} with a mask.

\textbf{pvPacksmi} \hspace{2cm} Packs symmetric matrix into a \textbf{PV} instance with a mask, matrix name, and index.

\textbf{pvPutParVector} \hspace{2cm} Inserts parameter vector into structure of type \textbf{PV}.

\textbf{pvTest} \hspace{2cm} Tests an instance of structure of type \textbf{PV} to determine if it is a proper structure of type \textbf{PV}.

\textbf{pvUnpack} \hspace{2cm} Unpacks matrices stored in a structure of type \textbf{PV}.

\textbf{savestruct} \hspace{2cm} Saves a matrix of structures to a file on the disk.

\section*{37.7 Data File Reading/Writing}

\textbf{Spreadsheets}

\textbf{SpreadsheetReadM} \hspace{2cm} Reads and writes Excel files.

\textbf{SpreadsheetReadSA} \hspace{2cm} Reads and writes Excel files.

\textbf{SpreadsheetWrite} \hspace{2cm} Reads and writes Excel files.

\textbf{xlsGetSheetCount} \hspace{2cm} Gets the number of sheets in an Excel spreadsheet.
### Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xlsGetSheetSize</td>
<td>Gets the size (rows and columns) of a specified sheet in an Excel spreadsheet.</td>
</tr>
<tr>
<td>xlsGetSheetTypes</td>
<td>Gets the cell format types of a row in an Excel spreadsheet.</td>
</tr>
<tr>
<td>xlsMakeRange</td>
<td>Builds an Excel range string from a row/column pair.</td>
</tr>
<tr>
<td>xlsReadM</td>
<td>Reads from an Excel spreadsheet, into a GAUSS matrix.</td>
</tr>
<tr>
<td>xlsReadSA</td>
<td>Reads from an Excel spreadsheet, into a GAUSS string array or string.</td>
</tr>
<tr>
<td>xlsWrite</td>
<td>Writes a GAUSS matrix, string, or string array to an Excel spreadsheet.</td>
</tr>
<tr>
<td>xlsWriteM</td>
<td>Writes a GAUSS matrix to an Excel spreadsheet.</td>
</tr>
<tr>
<td>xlsWriteSA</td>
<td>Writes a GAUSS string or string array to an Excel spreadsheet.</td>
</tr>
</tbody>
</table>

### Text Files

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fcheckerr</td>
<td>Gets the error status of a file.</td>
</tr>
<tr>
<td>fclearerr</td>
<td>Gets the error status of a file, then clears it.</td>
</tr>
<tr>
<td>fflush</td>
<td>Flushes a file's output buffer.</td>
</tr>
<tr>
<td>fgets</td>
<td>Reads a line of text from a file.</td>
</tr>
</tbody>
</table>
### Commands by Category

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>fgetsa</code></td>
<td>Reads lines of text from a file into a string array.</td>
</tr>
<tr>
<td><code>fgetsat</code></td>
<td>Reads lines of text from a file into a string array.</td>
</tr>
<tr>
<td><code>fgets</code></td>
<td>Reads a line of text from a file.</td>
</tr>
<tr>
<td><code>fopen</code></td>
<td>Opens a file.</td>
</tr>
<tr>
<td><code>fputs</code></td>
<td>Writes strings to a file.</td>
</tr>
<tr>
<td><code>fputst</code></td>
<td>Writes strings to a file.</td>
</tr>
<tr>
<td><code>fseek</code></td>
<td>Positions the file pointer in a file.</td>
</tr>
<tr>
<td><code>fstrerror</code></td>
<td>Returns an error message explaining the cause of the most recent file I/O error.</td>
</tr>
<tr>
<td><code>ftell</code></td>
<td>Gets the position of the file pointer in a file.</td>
</tr>
</tbody>
</table>

### Database

This section summarizes all procedures within the GAUSS database module. A general usage description will be found in *Databases with GAUSS*, Section 1.

#### Database Setup

- **dbAddDatabase**: Adds a database to the list of database connections using the driver type or a connection URL.
- **dbGetDrivers**: Returns a list of available database drivers.
**Commands by Category**

**dbIsDriverAvailable**
- Returns 1 if a specified database driver is available.

**dbRemoveDatabase**
- Removes a database connection from the list of open database connections.
- Frees all related resources.

**Database Properties**

**dbGetConnectOptions**
- Returns the connection options string used for a database connection.

**dbGetDatabaseName**
- Returns the name of the database.

**dbGetDriverName**
- Returns the name of the connection's database driver.

**dbGetHostName**
- Returns the database connection's host name.

**dbGetPassword**
- Returns a connection's password.

**dbGetNumericalPrecPolicy**
- Returns the default numerical precision policy for a specified database connection.

**dbGetPort**
- Returns the database connection's port number if it has been set.

**dbIsOpen**
- Reports whether a specified database connection is open.

**dbIsValid**
- Reports whether a specified database connection has a valid driver.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbSetConnectOptions</td>
<td>Sets database-specific options.</td>
</tr>
<tr>
<td>dbSetDatabaseName</td>
<td>Sets the connection's database name to name.</td>
</tr>
<tr>
<td>dbSetHostName</td>
<td>Sets the specified database connection's host name.</td>
</tr>
<tr>
<td>dbSetNumericalPrecPolicy</td>
<td>Sets the default numerical precision policy used by queries created on this database connection.</td>
</tr>
<tr>
<td>dbSetPassword</td>
<td>Sets the database connection's password.</td>
</tr>
<tr>
<td>dbSetPort</td>
<td>Sets the specified database connection's port number.</td>
</tr>
</tbody>
</table>

### Database Information

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbGetPrimaryIndex</td>
<td>Returns the primary index for the specified table.</td>
</tr>
<tr>
<td>dbGetTableHeaders</td>
<td>Returns a string array populated with the names of all the fields in a specified table (or view).</td>
</tr>
<tr>
<td>dbGetTables</td>
<td>Returns the database's tables, system tables and views.</td>
</tr>
<tr>
<td>dbHasFeature</td>
<td>Returns a 1 if the database supports the specified feature.</td>
</tr>
</tbody>
</table>
Database Errors

- **dbGetLastErrorNum**
  Returns numerical information about the last error that occurred on the database.

- **dbGetLastErrorText**
  Returns text information about the last error that occurred on the database.

- **dbIsOpenError**
  Reports whether an error occurred while attempting to open the database connection.

- **dbQueryGetLastErrorNum**
  Returns numerical error information about the last error that occurred (if any) with the last executed query.

- **dbQueryGetLastErrorText**
  Returns text error information about the last error that occurred (if any) with the last executed query.

Database Connect

- **dbClose**
  Closes a database connection and destroys any remaining queries.

- **dbOpen**
  Opens a specified database connection using the current connection values.

Database Transaction

- **dbCommit**
  Commits a transaction to the database if the driver supports transactions and a `dbTransaction()` has been started.
dbCreateQuery  Process an SQL statement and prepare a query.

dbExecQuery  Executes an SQL statement and creates a query.

dbRollback  Rolls back a transaction on the database.

dbTransaction  Begins a transaction on the database.

**Query Building**

dbQueryBindValue  Set the placeholder placeholder to be bound to value val in the prepared statement.

dbQueryGetBoundValue  Returns the value for a placeholder in a query.

dbQueryGetBoundValues  Returns an Nx2 string array containing the placeholders and their corresponding values in a query.

dbQueryExecPrepared  Executes a previously created and prepared query.

dbQueryPrepare  Prepares a SQL query for execution.

**Query Manipulation**

dbQueryClear  Clears the result set and releases any resources held by the query. Sets the
 Commands by Category

**dbQueryFinish**
query state to inactive.

Instructs the database driver that no more data will be fetched from this query until it is re-executed.

**Query Information**

**dbQueryCols**
Returns the number of fields in the record.

**dbQueryGetLastInsertID**
Returns the object ID of the most recent inserted row if supported by the database.

**dbQueryGetLastQuery**
Returns the text of the current query being used.

**dbQueryGetNumRowsAffected**
Reports the number of rows affected by the result's SQL statement.

**dbQueryIsActive**
Returns 1 if the query is active.

**dbQueryIsForwardOnly**
Reports whether you can only scroll forward through a result set.

**dbQueryIsNull**
Reports whether the current field pointed at by an active query positioned on a valid record is NULL.

**dbQueryIsSelect**
Reports whether the specified query is a SELECT statement.

**dbQueryIsValid**
Reports whether the specified query is positioned on a valid record.
### dbQueryRows

Returns the size of the result (number of rows returned), or -1 if the size cannot be determined or if the database does not support reporting information about query sizes.

### dbQuerySetForwardOnly

Sets forward only mode to forward. If forward is true, only `dbQuerySeekNext()` and `dbQuerySeek()` with positive values, are allowed for navigating the results.

## Query Iteration

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbQueryGetPosition</code></td>
<td>Returns the current internal position of the query.</td>
</tr>
<tr>
<td><code>dbQuerySeek</code></td>
<td>Retrieves the record at a specified position, if available, and positions the query on the retrieved record.</td>
</tr>
<tr>
<td><code>dbQuerySeekFirst</code></td>
<td>Retrieves the first record in the result, if available, and positions the query on the retrieved record.</td>
</tr>
<tr>
<td><code>dbQuerySeekLast</code></td>
<td>Retrieves the last record in the result, if available, and positions the query on the retrieved record.</td>
</tr>
<tr>
<td><code>dbQuerySeekNext</code></td>
<td>Retrieves the next record in the result, if available, and positions the query on the retrieved record.</td>
</tr>
<tr>
<td><code>dbQuerySeekPrevious</code></td>
<td>Retrieves the previous record in the</td>
</tr>
</tbody>
</table>
result, if available, and positions the query on the retrieved record.

**Query Data Retrieval**

- **dbQueryFetchAllM**
  Returns the result set for the current query as a matrix.

- **dbQueryFetchAllSA**
  Returns the result set for the current query as a string array.

- **dbQueryFetchOneM**
  Returns a single row as an N x 1 matrix where N is the column count of the SELECT statement.

- **dbQueryFetchOneSA**
  Returns a single row as a string vector containing the field information for the current query.

- **dbQueryGetField**
  Returns the value of a specified field in the current record.

**GAUSS Data Archives**

- **gdaAppend**
  Appends data to a variable in a GDA.

- **gdaCreate**
  Creates a GDA.

- **gdaDStat**
  Computes descriptive statistics on multiple N x 1 variables in a GDA.

- **gdaDStatMat**
  Computes descriptive statistics on a selection of columns in a variable in a GDA.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>gdaGetIndex</td>
<td>Gets the index of a variable in a GDA.</td>
</tr>
<tr>
<td>gdaGetName</td>
<td>Gets the name of a variable in a GDA.</td>
</tr>
<tr>
<td>gdaGetNames</td>
<td>Gets the names of all the variables in a GDA.</td>
</tr>
<tr>
<td>gdaGetOrders</td>
<td>Gets the orders of a variable in a GDA.</td>
</tr>
<tr>
<td>gdaGetType</td>
<td>Gets the type of a variable in a GDA.</td>
</tr>
<tr>
<td>gdaGetTypes</td>
<td>Gets the types of all the variables in a GDA.</td>
</tr>
<tr>
<td>gdaGetVarInfo</td>
<td>Gets information about all of the variables in a GDA.</td>
</tr>
<tr>
<td>gdaIsCplx</td>
<td>Checks to see if a variable in a GDA is complex.</td>
</tr>
<tr>
<td>gdaLoad</td>
<td>Loads variables in a GDA into the workspace.</td>
</tr>
<tr>
<td>gdaPack</td>
<td>Packs the data in a GDA, removing all empty bytes.</td>
</tr>
<tr>
<td>gdaRead</td>
<td>Gets a variable from a GDA.</td>
</tr>
<tr>
<td>gdaReadByIndex</td>
<td>Gets a variable from a GDA, given a variable index.</td>
</tr>
<tr>
<td>gdaReadSome</td>
<td>Reads part of a variable from a GDA.</td>
</tr>
<tr>
<td>gdaReadSparse</td>
<td>Gets a sparse matrix from a GAUSS.</td>
</tr>
</tbody>
</table>
Commands by Category

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>gdaReadStruct</td>
<td>Gets a structure from a GAUSS Data Archive.</td>
</tr>
<tr>
<td>gdaReportVarInfo</td>
<td>Gets information about all of the variables in a GAUSS Data Archive and returns it in a string array formatted for printing.</td>
</tr>
<tr>
<td>gdaSave</td>
<td>Writes variables in a workspace to a GDA.</td>
</tr>
<tr>
<td>gdaUpdate</td>
<td>Updates a variable in a GDA.</td>
</tr>
<tr>
<td>gdaUpdateAndPack</td>
<td>Updates a variable in a GDA, leaving no empty bytes if the updated variable is smaller or larger than the variable it is replacing.</td>
</tr>
<tr>
<td>gdaWrite</td>
<td>Writes a variable to a GDA.</td>
</tr>
<tr>
<td>gdaWrite32</td>
<td>Writes a variable to a GDA using 32-bit system file write commands.</td>
</tr>
<tr>
<td>gdaWriteSome</td>
<td>Overwrites part of a variable in a GDA.</td>
</tr>
</tbody>
</table>

These functions all operate on GAUSS Data Archives (GDA's). For more information, see GAUSS Data Archives, Section 1.0.1.

**Data Sets**

- close

  Closes an open data set (.dat file).
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>closeall</td>
<td>Closes all open data sets.</td>
</tr>
<tr>
<td>create</td>
<td>Creates and opens a data set.</td>
</tr>
<tr>
<td>datacreate</td>
<td>Creates a \texttt{v96} real data set.</td>
</tr>
<tr>
<td>datacreatecomplex</td>
<td>Creates a \texttt{v96} complex data set.</td>
</tr>
<tr>
<td>datalist</td>
<td>Lists selected variables from a data set.</td>
</tr>
<tr>
<td>dataopen</td>
<td>Opens a data set.</td>
</tr>
<tr>
<td>eof</td>
<td>Tests for end of file.</td>
</tr>
<tr>
<td>getnr</td>
<td>Computes number of rows to read per iteration for a program that reads data from a disk file in a loop.</td>
</tr>
<tr>
<td>getnrmt</td>
<td>Computes number of rows to read per iteration for a program that reads data from a disk file in a loop.</td>
</tr>
<tr>
<td>iscplxf</td>
<td>Returns whether a data set is real or complex.</td>
</tr>
<tr>
<td>loadd</td>
<td>Loads a small data set.</td>
</tr>
<tr>
<td>open</td>
<td>Opens an existing data set.</td>
</tr>
<tr>
<td>readr</td>
<td>Reads rows from open data set.</td>
</tr>
<tr>
<td>saved</td>
<td>Creates small data sets.</td>
</tr>
<tr>
<td>seekr</td>
<td>Moves pointer to specified location in open data set.</td>
</tr>
<tr>
<td>tempname</td>
<td>Creates a temporary file with a unique</td>
</tr>
</tbody>
</table>
### Data Set Variable Names

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getname</td>
<td>Returns column vector of variable names in a data set.</td>
</tr>
<tr>
<td>getnamef</td>
<td>Returns string array of variable names in a data set.</td>
</tr>
<tr>
<td>indices</td>
<td>Retrieves column numbers and names from a data set.</td>
</tr>
<tr>
<td>indices2</td>
<td>Similar to indices, but matches columns with names for dependent and independent variables.</td>
</tr>
</tbody>
</table>

**typedef**

Returns the element size (2, 4 or 8 bytes) of data in open data set.

**writer**

Writes matrix to an open data set.

These functions all operate on GAUSS data sets (.dat files). For more information, see File I/O, Chapter 1.

To create a GAUSS data set from a matrix in memory, use saved. To create a data set from an existing one, use create. To create a data set from a large ASCII file, use the ATOG utility (see ATOG, Chapter 1.)

Data sets can be opened, read from, and written to using open, readr, seekr and writer. Test for the end of a file using eof, and close the data set using close or closeall.

The data in data sets may be specified as character or numeric. (See File I/O, Chapter 1.) See also create and vartypef.

**typedef** returns the element size of the data in an open data set.
indicesf
Retrieves column numbers and names from a data set.

indicesfn
Retrieves column numbers and names from a data set.

makevars
Decomposes matrix to create column vectors.

setvars
Creates globals using the names in a data set.

vartypef
Returns column vector of variable types (numeric/character) in a data set.

Use *getnamef* to retrieve the variable names associated with the columns of a GAUSS data set and *vartypef* to retrieve the variable types. Use *makevars* and *setvars* to create global vectors from those names. Use *indices* and *indices2* to match names with column numbers in a data set.

Data Coding

code
Codes the data in a vector by applying a logical set of rules to assign each data value to a category.

code (dataloop)
Creates new variables with different values based on a set of logical expressions.

dataloop (dataloop)
Specifies the beginning of a data loop.

delete (dataloop)
Removes specific rows in a data loop.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>drop (dataloop)</strong></td>
<td>Specifies columns to be dropped from the output data set in a data loop.</td>
</tr>
<tr>
<td><strong>dummy</strong></td>
<td>Creates a dummy matrix, expanding values in vector to rows with ones in</td>
</tr>
<tr>
<td></td>
<td>columns corresponding to true categories and zeros elsewhere.</td>
</tr>
<tr>
<td><strong>dummybr</strong></td>
<td>Similar to <strong>dummy</strong>.</td>
</tr>
<tr>
<td><strong>dummydn</strong></td>
<td>Similar to <strong>dummy</strong>.</td>
</tr>
<tr>
<td><strong>extern (dataloop)</strong></td>
<td>Allows access to matrices or strings in memory from inside a data loop.</td>
</tr>
<tr>
<td><strong>isinfnanmiss</strong></td>
<td>Returns true if the argument contains an infinity, NaN, or missing value.</td>
</tr>
<tr>
<td><strong>scalmiss</strong></td>
<td>Returns 1 if matrix has any missing values, 0 otherwise.</td>
</tr>
<tr>
<td><strong>keep (dataloop)</strong></td>
<td>Specifies columns (variables) to be saved to the output data set in a data</td>
</tr>
<tr>
<td></td>
<td>loop.</td>
</tr>
<tr>
<td><strong>lag (dataloop)</strong></td>
<td>Lags variables a specified number of periods.</td>
</tr>
<tr>
<td><strong>lag1</strong></td>
<td>Lags a matrix by one time period for time series analysis.</td>
</tr>
<tr>
<td><strong>lagn</strong></td>
<td>Lags a matrix a specified number of time periods for time series analysis.</td>
</tr>
<tr>
<td><strong>listwise (dataloop)</strong></td>
<td>Controls listwise deletion of missing</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>make</strong> (dataloop)</td>
<td>Specifies the creation of a new variable within a data loop.</td>
</tr>
<tr>
<td><strong>miss</strong></td>
<td>Changes specified values to missing value code.</td>
</tr>
<tr>
<td><strong>missex</strong></td>
<td>Changes elements to missing value using logical expression.</td>
</tr>
<tr>
<td><strong>missrv</strong></td>
<td>Changes missing value codes to specified values.</td>
</tr>
<tr>
<td><strong>msym</strong></td>
<td>Sets symbol to be interpreted as missing value.</td>
</tr>
<tr>
<td><strong>outtyp</strong> (dataloop)</td>
<td>Specifies the precision of the output data set.</td>
</tr>
<tr>
<td><strong>packr</strong></td>
<td>Delete rows with missing values.</td>
</tr>
<tr>
<td><strong>recode</strong></td>
<td>Similar to code, but leaves the original data in place if no condition is met.</td>
</tr>
<tr>
<td><strong>recode</strong> (dataloop)</td>
<td>Changes the value of a variable with different values based on a set of logical expressions.</td>
</tr>
<tr>
<td><strong>scalinfnanmiss</strong></td>
<td>Returns true if the argument is a scalar infinity, NaN, or missing value.</td>
</tr>
<tr>
<td><strong>scalmiss</strong></td>
<td>Tests whether a scalar is the missing value code.</td>
</tr>
<tr>
<td><strong>select</strong> (dataloop)</td>
<td>Selects specific rows (observations) in</td>
</tr>
</tbody>
</table>
a data loop based on a logical expression.

**subscat**
Simpler version of `recode`, but uses ascending bins instead of logical conditions.

**substute**
Similar to `recode`, but operates on matrices.

**vector (dataloop)**
Specifies the creation of a new variable within a data loop.

code, recode, and subscat allow the user to code data variables and operate on vectors in memory. substute operates on matrices, and dummy, dummybr and dummydn create matrices.

missex, missrv and miss should be used to recode missing values.

### Sorting and Merging

**intrleav**
Produces one large sorted data file from two smaller sorted files having the same keys.

**intrleavsa**
Interleaves the rows of two string arrays that have been sorted on a common column.

**mergeby**
Produces one large sorted data file from two smaller sorted files having a single key column in common.

**mergevar**
Accepts a list of names of global matrices, and concatenates the
corresponding matrices horizontally to form a single matrix.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sortc</td>
<td>Quick-sorts rows of matrix based on numeric key.</td>
</tr>
<tr>
<td>sortcc</td>
<td>Quick-sorts rows of matrix based on character key.</td>
</tr>
<tr>
<td>sortd</td>
<td>Sorts data set on a key column.</td>
</tr>
<tr>
<td>sorthc</td>
<td>Heap-sorts rows of matrix based on numeric key.</td>
</tr>
<tr>
<td>sorthcc</td>
<td>Heap-sorts rows of matrix based on character key.</td>
</tr>
<tr>
<td>sortind</td>
<td>Returns a sorted index of a numeric vector.</td>
</tr>
<tr>
<td>sortindc</td>
<td>Returns a sorted index of a character vector.</td>
</tr>
<tr>
<td>sortmc</td>
<td>Sorts rows of matrix on the basis of multiple columns.</td>
</tr>
<tr>
<td>sortr</td>
<td>Sorts rows of a matrix of numeric data.</td>
</tr>
<tr>
<td>sortrc</td>
<td>Sorts rows of a matrix of character data.</td>
</tr>
<tr>
<td>uniqindx</td>
<td>Returns a sorted unique index of a vector.</td>
</tr>
<tr>
<td>uniqindxs</td>
<td>Computes the sorted index of a string vector, omitting duplicate elements.</td>
</tr>
</tbody>
</table>
Commands by Category

**unique**
Removes duplicate elements of a vector.

**uniquesa**
Removes duplicate elements from a string vector.

**sortc, sorthc, and sortind** operate on numeric data only. **sortcc, sorthcc, and sortindc** operate on character data only.

**sortd, sortmc, unique, and uniqindx** operate on both numeric and character data.

Use **sortd** to sort the rows of a data set on the basis of a key column.

Both **intrleav** and **mergeby** operate on data sets.

### 37.8 Compiler Control

**#define**
Defines a case-insensitive text-replacement or flag variable.

**#definecs**
Defines a case-sensitive text-replacement or flag variable.

**#else**
Alternates clause for **#if-#else-#endif** code block.

**#endif**
End of **#if-#else-#endif** code block.

**#ifdef**
Compiles code block if a variable has been **#define'd**.

**#iflight**
Compiles code block if running **GAUSS** Light.
#ifndef
Compiles code block if a variable has not been #define'd.

#ifos2win
Compiles code block if running Windows.

#ifunix
Compiles code block if running UNIX.

#include
Includes code from another file in program.

#linesoff
Compiles program without line number and file name records.

#lineson
Compiles program with line number and file name records.

#srcfile
Inserts source file name record at this point (currently used when doing data loop translation).

#srcline
Inserts source file line number record at this point (currently used when doing data loop translation).

#undef
Undefines a text-replacement or flag variable.

These commands are compiler directives. That is, they do not generate GAUSS program instructions; rather, they are instructions that tell GAUSS how to process a program during compilation. They determine what the final compiled form of a program will be. They are not executable statements and have no effect at run-time. (See Compiler Directives, Chapter 1.1, for more information.)
### Commands by Category

#### 37.9 Multi-Threading

- **ThreadBegin**
  Marks beginning of a block of code to be executed as a thread.

- **ThreadEnd**
  Marks end of a block of code to be executed as a thread.

- **ThreadJoin**
  Completes definition of a set of threads, waits for their work.

- **ThreadStat**
  Marks a single statement to be executed as a thread.

Together, **ThreadBegin/ThreadEnd** and **ThreadStat** define a set of threads that will execute simultaneously. **ThreadJoin** completes the definition of that set. **ThreadJoin** waits for the threads in the set to finish their calculations, the results of which are then available for further use.

```plaintext
ThreadBegin; // Thread 1
  y = x'x;
  z = y'y;
ThreadEnd;
ThreadBegin; // Thread 2
  q = r'r;
  r = q'q;
ThreadEnd;
ThreadStat n = m'm; // Thread 3
ThreadStat p = o'o; // Thread 4
ThreadJoin; // waits for Threads 1-4 to finish

b = z + r + n'p; // Using the results
```
37.10 Program Control

Execution Control

- **call**: Calls function and discards return values.
- **end**: Terminates a program and closes all files.
- **pause**: Pauses for the specified time.
- **run**: Runs a program in a text file.
- **sleep**: Sleeps for the specified time.
- **stop**: Stops a program and leaves files open.
- **system**: Quits and returns to the OS.

Both `stop` and `end` will terminate the execution of a program; `end` will close all open files, and `stop` will leave those files open. Neither `stop` nor `end` is required in a GAUSS program.

Branching

- **goto**: Unconditional branching.
- **if...endif**: Conditional branching.
- **pop**: Retrieves `goto` arguments.

```plaintext
if iter > itlim;
    goto errout("Iteration limit exceeded");
elseif iter == 1;
    j = setup(x, y);
```
\begin{verbatim}
else;
    j = \texttt{iterate}(x,y);
endif;
.
.
errout:

\texttt{pop} \texttt{errmsg};
\texttt{print} \texttt{errmsg};
\texttt{end};
\end{verbatim}

**Looping**

- **break**
  - Jumps out the bottom of a \texttt{do} or \texttt{for} loop.

- **continue**
  - Jumps to the top of a \texttt{do} or \texttt{for} loop.

- **do while...endo**
  - Executes a series of statements in a loop as long as a given expression is TRUE (or FALSE).

- **do until...endo**
  - Loops if FALSE.

- **for...endfor**
  - Loops with integer counter.

```plaintext
iter = 0;
do while dif > tol;
    \{ x,x0 } = \texttt{eval}(x,x0);
dif = \texttt{abs}(x-x0);
iter = iter + 1;
if iter > maxits;
    break;
endif;
if not prtiter;
```
continue;
endif;
format /rdn 1,0;
print "Iteration: " iter;;
format /re 16,8;
print ", Error: " maxc(dif);
endo;

for i (1, cols(x), 1);
   for j (1, rows(x), 1);
      x[i,j] = x[i,j] + 1;
   endfor;
endfor;

**Subroutines**

- **gosub**
  
  Branches to subroutine.

- **pop**
  
  Retrieves `gosub` arguments.

- **return**
  
  Returns from subroutine.

Arguments can be passed to subroutines in the branch to the subroutine label and then popped, in first-in-last-out order, immediately following the subroutine label definition. See `gosub`.

Arguments can then be returned in an analogous fashion through the `return` statement.

**Procedures, Keywords, and Functions**

- **endp**
  
  Terminates a procedure definition.

- **fn**
  
  Allows user to create one-line functions.

- **keyword**
  
  Begins the definition of a keyword
procedure. Keywords are user-defined functions with local or global variables.

local
Declares variables local to a procedure.

proc
Begins definition of multi-line procedure.

retp
Returns from a procedure.

Here is an example of a GAUSS procedure:

```gauss
proc (3) = crosprod(x,y);
    local r1, r2, r3;
    r1 = x[2,.]*y[3,.]-x[3,.]*y[2,.];
    r2 = x[3,.]*y[1,.]-x[1,.]*y[3,.];
    r3 = x[1,.]*y[2,.]-x[2,.]*y[1,.];
    retp( r1, r2, r3);
endp;
```

The "(3) = " indicates that the procedure returns three arguments. All local variables, except those listed in the argument list, must appear in the `local` statement. Procedures may reference global variables. There may be more than one `retp` per procedure definition; none is required if the procedure is defined to return 0 arguments. The `endp` is always necessary and must appear at the end of the procedure definition. Procedure definitions cannot be nested. The syntax for using this example function is

```gauss
{ a1, a2, a3 } = crosprod(u,v);
```

See Procedures and Keywords, Chapter 1, and Libraries, Chapter 1, for details.
Libraries

- **declare**
  - Initializes variables at compile time.
- **external**
  - External symbol definitions.
- **lib**
  - Builds or updates a **GAUSS** library.
- **library**
  - Sets up list of active libraries.

**call** allows functions to be called when return values are not needed. This is especially useful if a function produces printed output (**dstat**, **ols** for example) as well as return values.

Compiling

- **compile**
  - Compiles and saves a program to a `.gcg` file.
- **#include**
  - Inserts code from another file into a **GAUSS** program.
- **loadp**
  - Loads compiled procedure.
- **save**
  - Saves the compiled image of a procedure to disk.
- **saveall**
  - Saves the contents of the current workspace to a file.
- **use**
  - Loads previously compiled code.

**GAUSS** procedures and programs may be compiled to disk files. By then using this compiled code, the time necessary to compile programs from scratch is eliminated. Use **compile** to compile a command file. All
procedures, matrices and strings referenced by that program will be compiled as well.

Stand-alone applications may be created by running compiled code under the GAUSS Run-Time Module. Contact Aptech Systems for more information on this product.

To save the compiled images of procedures that do not make any global references, use save. This will create an .fcg file. To load the compiled procedure into memory, use loadp. (This is not recommended because of the restriction on global references and the need to explicitly load the procedure in each program that references it. It is included here to maintain backward compatibility with previous versions.)

**Miscellaneous Program Control**

- **gausset**
  - Resets the global control variables declared in gauss.dec.

- **sysstate**
  - Gets or sets general system parameters.

### 37.11 OS Functions and File Management

- **cdir**
  - Returns current directory.

- **ChangeDir**
  - Changes directory in program.

- **chdir**
  - Changes directory interactively.

- **DeleteFile**
  - Deletes files.

- **dlibrary**
  - Dynamically links and unlinks shared libraries.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dllcall</td>
<td>Calls functions located in dynamic libraries.</td>
</tr>
<tr>
<td>dos</td>
<td>Provides access to the operating system from within GAUSS.</td>
</tr>
<tr>
<td>envget</td>
<td>Gets an environment string.</td>
</tr>
<tr>
<td>exec</td>
<td>Executes an executable program file.</td>
</tr>
<tr>
<td>execbg</td>
<td>Provides access to the operating system from within GAUSS.</td>
</tr>
<tr>
<td>fileinfo</td>
<td>Takes a file specification, returns names and information of files that match.</td>
</tr>
<tr>
<td>filesa</td>
<td>Takes a file specification, returns names of files that match.</td>
</tr>
<tr>
<td>getpath</td>
<td>Returns an expanded filename including the drive and path.</td>
</tr>
<tr>
<td>searchsourcepath</td>
<td>Searches the source path and (if specified) the src subdirectory of the GAUSS installation directory for a specified file.</td>
</tr>
<tr>
<td>shell</td>
<td>Shells to OS.</td>
</tr>
</tbody>
</table>

### 37.12 Workspace Management

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>Sets matrices equal to 0.</td>
</tr>
</tbody>
</table>
### Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>clearg</code></td>
<td>Sets global symbols to 0.</td>
</tr>
<tr>
<td><code>delete</code></td>
<td>Deletes specified global symbols.</td>
</tr>
<tr>
<td><code>hasimag</code></td>
<td>Examines matrix for nonzero imaginary part.</td>
</tr>
<tr>
<td><code>iscplx</code></td>
<td>Returns whether a matrix is real or complex.</td>
</tr>
<tr>
<td><code>maxbytes</code></td>
<td>Returns maximum memory to be read from a dataset at a time inside some GAUSS functions.</td>
</tr>
<tr>
<td><code>maxvec</code></td>
<td>Returns maximum allowed vector size.</td>
</tr>
<tr>
<td><code>new</code></td>
<td>Clears current workspace.</td>
</tr>
<tr>
<td><code>show</code></td>
<td>Displays global symbol table.</td>
</tr>
<tr>
<td><code>type</code></td>
<td>Returns type of argument (matrix or string).</td>
</tr>
<tr>
<td><code>typecv</code></td>
<td>Returns types of symbols (argument contains the names of the symbols to be checked).</td>
</tr>
</tbody>
</table>

When working with limited workspace, it is a good idea to clear large matrices that are no longer needed by your program.

### 37.13 Error Handling and Debugging

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>debug</code></td>
<td>Executes a program under the source level debugger.</td>
</tr>
</tbody>
</table>
### Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>error</strong></td>
<td>Creates user-defined error code.</td>
</tr>
<tr>
<td><strong>errorlog</strong></td>
<td>Sends error message to screen and log file.</td>
</tr>
<tr>
<td><strong>#linesoff</strong></td>
<td>Omits line number and file name records from program.</td>
</tr>
<tr>
<td><strong>#lineson</strong></td>
<td>Includes line number and file name records in program.</td>
</tr>
<tr>
<td><strong>scalerr</strong></td>
<td>Tests for a scalar error code.</td>
</tr>
<tr>
<td><strong>trace</strong></td>
<td>Traces program execution for debugging.</td>
</tr>
<tr>
<td><strong>trap</strong></td>
<td>Controls trapping of program errors.</td>
</tr>
<tr>
<td><strong>trapchk</strong></td>
<td>Examines the trap flag.</td>
</tr>
</tbody>
</table>

To trace the execution of a program, use **trace**.

User-defined error codes may be generated using **error**.

#### 37.14 String Handling

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>chrs</strong></td>
<td>Converts ASCII values to a string.</td>
</tr>
<tr>
<td><strong>convertsatostr</strong></td>
<td>Converts a 1x1 string array to a string.</td>
</tr>
<tr>
<td><strong>convertststrtos</strong></td>
<td>Converts a string to a 1x1 string array.</td>
</tr>
<tr>
<td><strong>cvtos</strong></td>
<td>Converts a character vector to a string.</td>
</tr>
<tr>
<td><strong>ftocv</strong></td>
<td>Converts an NxK matrix to a character matrix.</td>
</tr>
</tbody>
</table>
### Commands by Category

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ftos</strong></td>
<td>Converts a floating point scalar to a string.</td>
</tr>
<tr>
<td><strong>ftostrC</strong></td>
<td>Converts a matrix to a string array using a C language format specification.</td>
</tr>
<tr>
<td><strong>getf</strong></td>
<td>Loads ASCII or binary file into string.</td>
</tr>
<tr>
<td><strong>indsav</strong></td>
<td>Checks one string array against another and returns</td>
</tr>
<tr>
<td><strong>intrsectsa</strong></td>
<td>Returns the intersection of two string vectors, with duplicates removed.</td>
</tr>
<tr>
<td><strong>loads</strong></td>
<td>Loads a string file (.fst file).</td>
</tr>
<tr>
<td><strong>lower</strong></td>
<td>Converts a string to lowercase.</td>
</tr>
<tr>
<td><strong>ntos</strong></td>
<td>Converts a scalar or matrix to a string or string array. Simpler to use than <strong>ftos</strong>.</td>
</tr>
<tr>
<td><strong>parse</strong></td>
<td>Parses a string, returning a character vector of tokens.</td>
</tr>
<tr>
<td><strong>putf</strong></td>
<td>Writes a string to disk file.</td>
</tr>
<tr>
<td><strong>stocv</strong></td>
<td>Converts a string to a character vector.</td>
</tr>
<tr>
<td><strong>stof</strong></td>
<td>Converts a string to floating point numbers.</td>
</tr>
<tr>
<td><strong>strcombine</strong></td>
<td>Converts an NxM string array to an Nx1 string vector by combining each element in a column separated by a user-defined delimiter string.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>strindx</code></td>
<td>Finds starting location of one string in another string.</td>
</tr>
<tr>
<td><code>strlen</code></td>
<td>Returns length of a string.</td>
</tr>
<tr>
<td><code>strput</code></td>
<td>Lays a substring over a string.</td>
</tr>
<tr>
<td><code>strrindx</code></td>
<td>Finds starting location of one string in another string, searching from the end to the start of the string.</td>
</tr>
<tr>
<td><code>strsect</code></td>
<td>Extracts a substring of a string.</td>
</tr>
<tr>
<td><code>strsplit</code></td>
<td>Splits an Nx1 string vector into an NxK string array of the individual tokens.</td>
</tr>
<tr>
<td><code>strsplitPad</code></td>
<td>Splits an Nx1 string vector into an NxK string array of the individual tokens. Pads on the right with null strings.</td>
</tr>
<tr>
<td><code>strtof</code></td>
<td>Converts a string array to a numeric matrix.</td>
</tr>
<tr>
<td><code>strtofcplx</code></td>
<td>Converts a string array to a complex numeric matrix.</td>
</tr>
<tr>
<td><code>strtriml</code></td>
<td>Strips all whitespace characters from the left side of each element in a string array.</td>
</tr>
<tr>
<td><code>strtrimr</code></td>
<td>Strips all whitespace characters from the right side of each element in a string array.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>strtrunc</strong></td>
<td>Truncates all elements of a string array to not longer than the specified number of characters.</td>
</tr>
<tr>
<td><strong>strtrunc1</strong></td>
<td>Truncates the left side of all elements of a string array by a user-specified number of characters.</td>
</tr>
<tr>
<td><strong>strtruncpad</strong></td>
<td>Truncates all elements of a string array to the specified number of characters, adding spaces on the end as needed to achieve the exact length.</td>
</tr>
<tr>
<td><strong>strtruncr</strong></td>
<td>Truncates the right side of all elements of a string array by a user-specified number of characters.</td>
</tr>
<tr>
<td><strong>token</strong></td>
<td>Extracts the leading token from a string.</td>
</tr>
<tr>
<td><strong>upper</strong></td>
<td>Changes a string to uppercase.</td>
</tr>
<tr>
<td><strong>vals</strong></td>
<td>Converts a string to ASCII values.</td>
</tr>
<tr>
<td><strong>varget</strong></td>
<td>Accesses the global variable named by a string.</td>
</tr>
<tr>
<td><strong>vargetl</strong></td>
<td>Accesses the local variable named by a string.</td>
</tr>
<tr>
<td><strong>varput</strong></td>
<td>Assigns a global variable named by a string.</td>
</tr>
<tr>
<td><strong>varputl</strong></td>
<td>Assigns a local variable named by a string.</td>
</tr>
</tbody>
</table>
37.15 Time and Date Functions

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>date</td>
<td>Returns current system date.</td>
</tr>
<tr>
<td>datestr</td>
<td>Formats date as &quot;mm/dd/yy&quot;.</td>
</tr>
<tr>
<td>datestring</td>
<td>Formats date as &quot;mm/dd/yyyy&quot;.</td>
</tr>
<tr>
<td>datestrymd</td>
<td>Formats date as &quot;yyyyymmdd&quot;.</td>
</tr>
<tr>
<td>dayinyr</td>
<td>Returns day number of a date.</td>
</tr>
<tr>
<td>dayofweek</td>
<td>Returns day of week.</td>
</tr>
<tr>
<td>dtdate</td>
<td>Creates a matrix in DT scalar format.</td>
</tr>
<tr>
<td>dtday</td>
<td>Creates a matrix in DT scalar format containing only the year, month, and day. Time of day information is zeroed out.</td>
</tr>
<tr>
<td>dttime</td>
<td>Creates a matrix in DT scalar format containing only the hour, minute, and second. The date information is zeroed out.</td>
</tr>
<tr>
<td>dttodtv</td>
<td>Converts DT scalar format to DTV vector format.</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>dttostr</code></td>
<td>Converts a matrix containing dates in DT scalar format to a string array.</td>
</tr>
<tr>
<td><code>dttoutc</code></td>
<td>Converts DT scalar format to UTC scalar format.</td>
</tr>
<tr>
<td><code>dtvnormal</code></td>
<td>Normalizes a date and time (DTV) vector.</td>
</tr>
<tr>
<td><code>dtvtodt</code></td>
<td>Converts DTV vector format to DT scalar format.</td>
</tr>
<tr>
<td><code>dtvtoutc</code></td>
<td>Converts DTV vector format to UTC scalar format.</td>
</tr>
<tr>
<td><code>etdays</code></td>
<td>Difference between two times in days.</td>
</tr>
<tr>
<td><code>ethsec</code></td>
<td>Difference between two times in hundredths of a second.</td>
</tr>
<tr>
<td><code>etstr</code></td>
<td>Converts elapsed time to string.</td>
</tr>
<tr>
<td><code>hsec</code></td>
<td>Returns elapsed time since midnight in hundredths of a second.</td>
</tr>
<tr>
<td><code>strtodt</code></td>
<td>Converts a string array of dates to a matrix in DT scalar format.</td>
</tr>
<tr>
<td><code>time</code></td>
<td>Returns current system time.</td>
</tr>
<tr>
<td><code>timedt</code></td>
<td>Returns system date and time in DT scalar format.</td>
</tr>
<tr>
<td><code>timestr</code></td>
<td>Formats time as &quot;hh:mm:ss&quot;.</td>
</tr>
<tr>
<td><code>timeutc</code></td>
<td>Returns the number of seconds since January 1, 1970 Greenwich Mean.</td>
</tr>
</tbody>
</table>
Time.

**todaydt**
Returns system date in DT scalar format. The time returned is always midnight (00:00:00), the beginning of the returned day.

**utctodt**
Converts UTC scalar format to DT scalar format.

**utctodtv**
Converts UTC scalar format to DTV vector format.

Use **hsec** to time segments of code. For example,
```
et = hsec;
  x = y*y;
et = hsec - et;
```

will time the GAUSS multiplication operator.

### 37.16 Console I/O

**con**
Requests console input, creates matrix.

**cons**
Requests console input, creates string.

**key**
Gets the next key from the keyboard buffer. If buffer is empty, returns a 0.

**keyav**
Checks if keystroke is available.

**keyw**
Gets the next key from the keyboard buffer. If buffer is empty, waits for a
key.

wait
Waits for a keystroke.

waitc
Flushes buffer, then waits for a keystroke.

key can be used to trap most keystrokes. For example, the following loop will trap the ALT-H key combination:

\[
\begin{align*}
kk &= 0; \\
\text{do until } kk &= 1035; \\
\quad &kk = \text{key}; \\
\text{end};
\end{align*}
\]

Other key combinations, function keys and cursor key movement can also be trapped. See key.

cons and con can be used to request information from the console. keyw, wait, and waitc will wait for a keystroke.

### 37.17 Output Functions

#### Text Output

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cls</td>
<td>Clears the window.</td>
</tr>
<tr>
<td>comlog</td>
<td>Controls interactive command logging.</td>
</tr>
<tr>
<td>csrcol</td>
<td>Gets column position of cursor on window.</td>
</tr>
<tr>
<td>csrlin</td>
<td>Gets row position of cursor on window.</td>
</tr>
</tbody>
</table>
ed
Accesses an alternate editor.

edit
Edits a file with the GAUSS editor.

format
Defines format of matrix printing.

formatcv
Sets the character data format used by printfmt.

formatnv
Sets the numeric data format used by printfmt.

header
Prints a header for a report.

headermt
Prints a header for a report.

locate
Positions the cursor on the window.

output
Redirects print statements to auxiliary output.

outwidth
Sets line width of auxiliary output.

print
Prints to window.

printdos
Prints a string for special handling by the OS.

printfm
Prints matrices using a different format for each column.

printfmt
Prints character, numeric, or mixed matrix using a default format controlled by the functions formatcv and formatnv.

satostrC
Copies from one string array to
another using a C language format specifier string for each element.

\[
\text{screen [on | off]}
\]

Directs/suppresses print statements to window.

\[
\text{tab}
\]

Positions the cursor on the current line.

The results of all printing can be sent to an output file using output. This file can then be printed or ported as an ASCII file to other software.

To produces boxes, etc. using characters from the extended ASCII set, use chrs.

**DOS Compatibility Windows**

\[
\text{doswin}
\]

Opens the DOS compatibility window with default settings.

\[
\text{DOSWinCloseall}
\]

Closes the DOS compatibility window.

\[
\text{DOSWinOpen}
\]

Opens the DOS compatibility window and gives it the specified title and attributes.

**37.18 GAUSS Graphics**

This section summarizes all procedures available within the GAUSS graphics system. A general usage description will be found in GAUSS Graphics, Chapter 1.
Graph Types

- **plotBar**: Creates a bar plot.
- **plotBox**: Creates a box plot.
- **plotContour**: Creates a contour plot.
- **plotHist**: Calculates and creates a frequency histogram plot.
- **plotHistF**: Creates a histogram plot from a vector of frequencies.
- **plotHistP**: Calculates and creates a percentage frequency histogram plot.
- **plotLogLog**: Creates a 2-dimensional line plot with logarithmic scaling of the both the X and Y axes.
- **plotLogX**: Creates a 2-dimensional line plot with logarithmic scaling of the X axis.
- **plotLogY**: Creates a 2-dimensional line plot with logarithmic scaling of the Y axis.
- **plotPolar**: Creates a polar plot.
- **plotScatter**: Creates a 2-dimensional scatter plot.
- **plotSurface**: Creates a 3-dimensional surface plot.
- **plotTS**: Creates a graph of time series data.
- **plotXY**: Creates a 2-dimensional line plot.
# Commands by Category

## Adding Data to Existing Graphs

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>plotAddBar</td>
<td>Adds a bar or a set of bars to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddBox</td>
<td>Adds a box plot to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddHist</td>
<td>Adds a histogram to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddHistF</td>
<td>Adds a frequency histogram to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddHistP</td>
<td>Adds a percent frequency histogram to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddPolar</td>
<td>Adds a graph using polar coordinates to an existing polar graph.</td>
</tr>
<tr>
<td>plotAddScatter</td>
<td>Adds a set of points to an existing 2-D graph.</td>
</tr>
<tr>
<td>plotAddTS</td>
<td>Adds a curve of time series data to an existing time series plot.</td>
</tr>
<tr>
<td>plotAddXY</td>
<td>Adds an XY plot to an existing 2-D graph.</td>
</tr>
</tbody>
</table>

## Plot Control

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>plotClearLayout</td>
<td>Clears any previously set plot layouts.</td>
</tr>
<tr>
<td>plotCustomLayout</td>
<td>Plots a graph of user-specified size at a user-specified location.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>plotGetDefaults</td>
<td>Gets default settings for graph types.</td>
</tr>
<tr>
<td>plotLayout</td>
<td>Divides a plot into a grid of subplots and assigns the cell location in which to draw the next created graph.</td>
</tr>
<tr>
<td>plotOpenWindow</td>
<td>Opens a new, empty graph whicow to be used by the next drawn graph.</td>
</tr>
<tr>
<td>plotSave</td>
<td>Saves the last created graph to a user specified file type.</td>
</tr>
<tr>
<td>plotSetBar</td>
<td>Sets the fill style and format of bars in a histogram or bar graph.</td>
</tr>
<tr>
<td>plotSetBkdColor</td>
<td>Sets background color of a graph.</td>
</tr>
<tr>
<td>plotSetGrid</td>
<td>Controls the settings for the background grid of a plot.</td>
</tr>
<tr>
<td>plotSetLegend</td>
<td>Adds a legend to a graph.</td>
</tr>
<tr>
<td>plotSetLineColor</td>
<td>Sets line colors for a graph.</td>
</tr>
<tr>
<td>plotSetLineStyle</td>
<td>Sets line styles for a graph.</td>
</tr>
<tr>
<td>plotSetLineSymbol</td>
<td>Sets line symbols displayed on the plotted points of a graph.</td>
</tr>
<tr>
<td>plotSetLineThickness</td>
<td>Sets line thickness for a graph.</td>
</tr>
<tr>
<td>plotSetNewWindow</td>
<td>Sets whether or not graph should be drawn in the same window or a new window.</td>
</tr>
<tr>
<td>plotSetTitle</td>
<td>Controls the settings for the title for a graph.</td>
</tr>
</tbody>
</table>
plotSetXLabel
Controls the settings for the X-axis label on a graph.

plotSetXTicInterval
Controls the interval between X-axis tic labels and also allows the user to specify the first tic to be labeled for 2-D time series graphs.

plotSetXTicLabel
Controls the formatting and angle of X-axis tic labels for 2-D time series graphs.

plotSetYLabel
Controls the settings for the Y-axis label on a graph.

plotSetZLabel
Controls the settings for the Z-axis label on a graph.

37.19 PQG Graphics

This section summarizes all procedures and global variables available within the PUBLICATION QUALITY GRAPHICS (PQG) System. A general usage description will be found in PQG Graphics Colors, Chapter 1. Note that PUBLICATION QUALITY GRAPHICS (PQG) graphic functions are included as legacy code and have been replaced with new plot functions.

Graph Types

bar
Generates bar graph.

box
Graphs data using the box graph percentile method.

contour
Graphs contour data.
**Commands by Category**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>draw</strong></td>
<td>Supplies additional graphic elements to graphs.</td>
</tr>
<tr>
<td><strong>hist</strong></td>
<td>Computes and graphs frequency histogram.</td>
</tr>
<tr>
<td><strong>histf</strong></td>
<td>Graphs a histogram given a vector of frequency counts.</td>
</tr>
<tr>
<td><strong>histp</strong></td>
<td>Graphs a percent frequency histogram of a vector.</td>
</tr>
<tr>
<td><strong>loglog</strong></td>
<td>Graphs X,Y using logarithmic X and Y axes.</td>
</tr>
<tr>
<td><strong>logx</strong></td>
<td>Graphs X,Y using logarithmic X axis.</td>
</tr>
<tr>
<td><strong>logy</strong></td>
<td>Graphs X,Y using logarithmic Y axis.</td>
</tr>
<tr>
<td><strong>surface</strong></td>
<td>Graphs a 3-D surface.</td>
</tr>
<tr>
<td><strong>xy</strong></td>
<td>Graphs X,Y using Cartesian coordinate system.</td>
</tr>
<tr>
<td><strong>xyz</strong></td>
<td>Graphs X,Y,Z using 3-D Cartesian coordinate system.</td>
</tr>
</tbody>
</table>

**Axes Control and Scaling**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>paxes</em></td>
<td>Turns axes on or off.</td>
</tr>
<tr>
<td><em>pcross</em></td>
<td>Controls where axes intersect.</td>
</tr>
<tr>
<td><em>pgrid</em></td>
<td>Controls major and minor grid lines.</td>
</tr>
<tr>
<td><em>pticout</em></td>
<td>Controls direction of tick marks on axes.</td>
</tr>
</tbody>
</table>
Commands by Category

**_pxpmax**
Controls precision of numbers on X axis.

**_pxsci**
Controls use of scientific notation on X axis.

**_pypmax**
Controls precision of numbers on Y axis.

**_pysci**
Controls use of scientific notation on Y axis.

**_pzpmax**
Controls precision of numbers on Z axis.

**_pzsci**
Controls use of scientific notation on Z axis.

**scale**
Scales X,Y axes for 2-D plots.

**scale3d**
Scales X,Y, and Z axes for 3-D plots.

**xtics**
Scales X axis and controls tick marks.

**ytics**
Scales Y axis and controls tick marks.

**ztics**
Scales Z axis and controls tick marks.

### Text, Labels, Titles, and Fonts

**_paxht**
Controls size of axes labels.

**_pdate**
Controls date string contents.

**_plegctl**
Sets location and size of plot legend.

**_plegstr**
Specifies legend text entries.
Commands by Category

_pmmsgctl
 Controls message position.

_pmmsgstr
 Specifies message text.

_pnum
 Controls axes numeric labels and orientation.

_pnumht
 Controls size of axes numeric labels.

_ptitlht
 Controls main title size.

asclabel
 Defines character labels for tick marks.

fonts
 Loads fonts for labels, titles, messages, and legend.

title
 Specifies main title for graph.

xlabel
 Specifies X axis label.

ylabel
 Specifies Y axis label.

zlabel
 Specifies Z axis label.

Main Curve Lines and Symbols

_pboxctl
 Controls box plotter.

_pboxlim
 Outputs percentile matrix from box plotter.

_pcolor
 Controls line color for main curves.

_plctrl
 Controls main curve and frequency of data symbols.

_pltype
 Controls line style for main curves.
Commands by Category

_plwidth
 Controls line thickness for main curves.

_pstype
 Controls symbol type for main curves.

_psymsiz
 Controls symbol size for main curves.

_pzclr
 Z level color control for contour and surface.

Extra Lines and Symbols

_parrow
 Creates arrows.

_parrow3
 Creates arrows for 3-D graphs.

_perrbar
 Plots error bars.

_pline
 Plots extra lines and circles.

_pline3d
 Plots extra lines for 3-D graphs.

_psym
 Plots extra symbols.

_psym3d
 Plots extra symbols for 3-D graphs.

Graphic Panel, Page, and Plot Control

_pageshf
 Shifts the graph for printer output.

_pagesiz
 Controls size of graph for printer output.

_plotshf
 Controls plot area position.

_plotsiz
 Controls plot area size.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_protate</td>
<td>Rotates the graph 90 degrees.</td>
</tr>
<tr>
<td>axmargin</td>
<td>Controls axes margins and plot size.</td>
</tr>
<tr>
<td>begwind</td>
<td>Graphic panel initialization procedure.</td>
</tr>
<tr>
<td>endwind</td>
<td>Ends graphic panel manipulation; displays graphs.</td>
</tr>
<tr>
<td>getwind</td>
<td>Gets current graphic panel number.</td>
</tr>
<tr>
<td>loadwind</td>
<td>Loads a graphic panel configuration from a file.</td>
</tr>
<tr>
<td>makewind</td>
<td>Creates graphic panel with specified size and position.</td>
</tr>
<tr>
<td>margin</td>
<td>Controls graph margins.</td>
</tr>
<tr>
<td>nextwind</td>
<td>Sets to next available graphic panel number.</td>
</tr>
<tr>
<td>savewind</td>
<td>Saves graphic panel configuration to a file.</td>
</tr>
<tr>
<td>setwind</td>
<td>Sets to specified graphic panel number.</td>
</tr>
<tr>
<td>window</td>
<td>Creates tiled graphic panels of equal size.</td>
</tr>
</tbody>
</table>

**axmargin** is preferred to the older *plotsiz* and *plotshf* globals for establishing an absolute plot size and position.
**Output Options**

- `pscreen`  
  Controls graphics output to window.

- `psilent`  
  Controls final beep.

- `ptek`  
  Controls creation and name of `graphics.tkf` file.

- `pzoom`  
  Specifies zoom parameters.

- `graphpRT`  
  Generates print, conversion file.

- `pggwin`  
  Sets the graphics viewer mode.

- `setvwrmode`  
  Sets the graphics viewer mode.

- `tkf2eps`  
  Converts `.tkf` file to Encapsulated PostScript file.

- `tkf2ps`  
  Converts `.tkf` file to PostScript file.

**Miscellaneous**

- `pbox`  
  Draws a border around graphic panel/window.

- `pcrop`  
  Controls cropping of graphics data outside axes area.

- `pframe`  
  Draws a frame around 2-D, 3-D plots.

- `pmcolor`  
  Controls colors to be used for axes, title, x and y labels, date, box, and background.

- `graphset`  
  Resets all PQG globals to default.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rerun</td>
<td>Displays most recently created graph.</td>
</tr>
<tr>
<td>view</td>
<td>Sets 3-D observer position in workbox units.</td>
</tr>
<tr>
<td>viewxyz</td>
<td>Sets 3-D observer position in plot coordinates.</td>
</tr>
<tr>
<td>volume</td>
<td>Sets length, width, and height ratios of 3-D workbox.</td>
</tr>
</tbody>
</table>
a

abs

**Purpose**

Returns the absolute value or complex modulus of $x$.

**Format**

$$y = \text{abs}(x);$$

**Input**

$x$  
N$x$K matrix or sparse matrix or N-dimensional array.

**Output**

$y$  
N$x$K matrix or sparse matrix or N-dimensional array containing absolute values of $x$. 
Example

```c
//Set rng seed for repeatable
//random numbers
rndseed 929212;

dx = rndn(2,2);
y = abs(x);
```

The code above assigns the variables as follows:

```plaintext
x = -0.23061709 0.054931120
   0.88863202 -0.82246522

y = 0.23061709 0.054931120
   0.88863202 0.82246522
```

In this example, a 2x2 matrix of Normal random numbers is generated and the absolute value of the matrix is computed.

**acf**

**Purpose**

Computes sample autocorrelations.

**Format**

```plaintext
rk = acf(y, k, d);
```
**Input**

<table>
<thead>
<tr>
<th>symbol</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Nx1 vector, data.</td>
</tr>
<tr>
<td>k</td>
<td>scalar, maximum number of autocorrelations to compute.</td>
</tr>
<tr>
<td>d</td>
<td>scalar, order of differencing.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>symbol</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rk</td>
<td>Kx1 vector, sample autocorrelations.</td>
</tr>
</tbody>
</table>

**Example**

```plaintext
x = { 20.80,
      18.58,
      23.39,
      20.47,
      21.78,
      19.56,
      19.58,
      18.91,
      20.08,
      21.88 };

rk = acf(x,4,2);
print rk;
```

The code above produces the following output:
**Source**

tsutil.src

**aconcat**

**Purpose**

Concatenates conformable matrices and arrays in a user-specified dimension.

**Format**

\[ y = \text{aconcat}(a, b, \text{dim}); \]

**Input**

\( a \)  
matrix or N-dimensional array.

\( b \)  
matrix or K-dimensional array, conformable with \( a \).

\( \text{dim} \)  
scalar, dimension in which to concatenate.

**Output**

\( y \)  
M-dimensional array, the result of the concatenation.
Remarks

\(a\) and \(b\) are conformable only if all of their dimensions except \(dim\) have the same sizes. If \(a\) or \(b\) is a matrix, then the size of dimension 1 is the number of columns in the matrix, and the size of dimension 2 is the number of rows in the matrix.

Example

```plaintext
//Create a 2x3x4 array with each element set to 0
a = arrayinit(2|3|4, 0);

//Create a 3x4 matrix with each element set to 3
b = 3*ones(3, 4);
y = aconcat(a, b, 3);
```

\(y\) will be a 3x3x4 array, where \([1,1,1]\) through \([2,3,4]\) are zeros and \([3,1,1]\) through \([3,2,4]\) are threes.

```plaintext
//Create an additive sequence from 1-20 and 'reshape' it into a 4x5 matrix
a = reshape(seqa(1, 1, 20), 4, 5);

b = zeros(4, 5);
y = aconcat(a, b, 3);
```

\(y\) will be a 2x4x5 array, where \([1,1,1]\) through \([1,4,5]\) are sequential integers beginning with 1, and \([2,1,1]\) through \([2,4,5]\) are zeros.

```plaintext
//The pipe operator '|' causes vertical concatenation so
//that the statement 2|3|4 creates a 3x1 column vector
//equal to \{ 2, 3, 4 \}
a = arrayinit(2|3|4, 0);
b = seqa(1, 1, 24);
```
// 'Reshape' the vector 'b' into a 2x3x4 dimensional array
b = areshape(b, 2|3|4);
y = aconcat(a, b, 5);

\[ y \] will be a 2x1x2x3x4 array, where \([1,1,1,1,1]\) through \([1,1,2,3,4]\) are zeros, and \([2,1,1,1,1]\) through \([2,1,2,3,4]\) are sequential integers beginning with 1.

\begin{verbatim}
a = arrayinit(2|3|4, 0);
b = seqa(1, 1, 6);
b = areshape(b, 2|3|1);
y = aconcat(a, b, 1);
\end{verbatim}

\[ y \] will be a 2x3x5 array, such that:

\[
[1,1,1] \text{ through } [1,3,5] = \\
\begin{bmatrix}
0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 2 \\
0 & 0 & 0 & 0 & 3
\end{bmatrix}
\]

\[
[2,1,1] \text{ through } [2,3,5] = \\
\begin{bmatrix}
0 & 0 & 0 & 0 & 4 \\
0 & 0 & 0 & 0 & 5 \\
0 & 0 & 0 & 0 & 6
\end{bmatrix}
\]

**See Also**

areshape
aeye

Purpose

Creates an N-dimensional array in which the planes described by the two trailing dimensions of the array are equal to the identity.

Format

\[ a = \text{aeye}(ord); \]

Input

\( ord \)       \( \text{N} \times 1 \) vector of orders, the sizes of the dimensions of \( a \).

Output

\( a \)       N-dimensional array, containing 2-dimensional identity arrays.

Remarks

If \( ord \) contains numbers that are not integers, they will be truncated to integers.

The planes described by the two trailing dimensions of \( a \) will contain 1's down the diagonal and 0's everywhere else.

Example

\[ v = \{ 2, 3, 3 \}; \]
a = aeye(v); 

a will be a 2x3x3 array, such that:

[1,1,1] through [1,3,3] = 

```
1 0 0
0 1 0
0 0 1
``` 

[2,1,1] through [2,3,3] = 

```
1 0 0
0 1 0
0 0 1
``` 

See Also

eye

amax

Purpose

Moves across one dimension of an N-dimensional array and finds the largest element.

Format

```
y = amax(x, dim);
```
**Input**

\( x \)  
N-dimensional array.

\( dim \)  
scalar, number of dimension across which to find the maximum value.

**Output**

\( y \)  
N-dimensional array.

**Remarks**

The output \( y \), will have the same sizes of dimensions as \( x \), except that the dimension indicated by \( dim \) will be collapsed to 1.

**Example**

```plaintext
rndseed 9823432;

//Create random normal numbers with a standard deviation
//of 10 and round them to the nearest integer
x = round(10*rndn(24,1));

//Reshape them from a 24x1 vector into 2x3x4 array
x = areshape(x,2|3|4);

// Calculate the max across the second dimension
dim = 2;
 y = amax(x,dim);
```
After this calculation:

\( x[1,1,1] \text{ through } x[1,3,4] = \)

\[
\begin{array}{cccc}
-14.000000 & 4.0000000 & 6.0000000 & -4.0000000 \\
1.0000000 & 8.0000000 & 10.0000000 & 9.0000000 \\
-3.0000000 & 12.0000000 & 5.0000000 & -26.0000000 \\
\end{array}
\]

\( x[2,1,1] \text{ through } x[2,3,4] = \)

\[
\begin{array}{cccc}
4.0000000 & 6.0000000 & 4.0000000 & 2.0000000 \\
1.0000000 & 16.0000000 & 9.0000000 & -4.0000000 \\
-4.0000000 & -8.0000000 & -10.0000000 & 8.0000000 \\
\end{array}
\]

\( y[1,1,1] \text{ through } y[1,1,4] = \)

\[
\begin{array}{cccc}
1.0000000 & 12.0000000 & 10.0000000 & 9.0000000 \\
\end{array}
\]

\( y[2,1,1] \text{ through } y[2,1,4] = \)

\[
\begin{array}{cccc}
\end{array}
\]

Use the same \( x \) array and calculate the max across dimension 1:

\[
y2 = \text{amax}(x, 1);
\]

After this calculation, \( x \) remains the same, but \( y2 \) is:

\( y2[1,1,1] \text{ through } y2[1,3,1] = \)

\[
\begin{array}{cccc}
6.0000000 \\
10.0000000 \\
12.0000000 \\
\end{array}
\]

\( y2[2,1,1] \text{ through } y2[2,3,1] = \)
See Also

amin, maxc

amean

Purpose

Computes the mean across one dimension of an N-dimensional array.

Format

\[ y = \text{amean}(x, \ dim); \]

Input

\( x \)  
N-dimensional array.

\( dim \)  
scalar, number of dimension to compute the mean across.

Output

\( y \)  
[N-1]-dimensional array.
Remarks

The output $y$, will have the same sizes of dimensions as $x$, except that the dimension indicated by $dim$ will be collapsed to 1.

Example

```c
//Create an additive sequence from 1-24
x = seqa(1,1,24);

//'Reshape' this 24x1 vector into a 2x3x4 dimensional array
x = areshape(x,2|3|4);

y = amean(x,3);
```

$x$ is a 2x3x4 array, such that:

$[1,1,1]$ through $[1,3,4] =$

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000000</td>
<td>2.0000000</td>
<td>3.0000000</td>
<td>4.0000000</td>
</tr>
<tr>
<td>5.0000000</td>
<td>6.0000000</td>
<td>7.0000000</td>
<td>8.0000000</td>
</tr>
<tr>
<td>9.0000000</td>
<td>10.000000</td>
<td>11.000000</td>
<td>12.000000</td>
</tr>
</tbody>
</table>

$[2,1,1]$ through $[2,3,4] =$

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13.000000</td>
<td>14.000000</td>
<td>15.000000</td>
<td>16.000000</td>
</tr>
<tr>
<td>17.000000</td>
<td>18.000000</td>
<td>19.000000</td>
<td>20.000000</td>
</tr>
<tr>
<td>21.000000</td>
<td>22.000000</td>
<td>23.000000</td>
<td>24.000000</td>
</tr>
</tbody>
</table>

$y$ will be a 1x3x4 array, such that:

$[1,1,1]$ through $[1,3,4] =$
Using the same array \( x \) as the above example, this example computes the mean across the first dimension. \( y \) will be a 2x3x1 array, such that:

\[
\begin{align*}
\text{[1,1,1]} & \text{ through } \text{[1,3,1]} = \\
2.500000 & \ \\
6.500000 & \\
10.500000 & \\
\text{[2,1,1]} & \text{ through } \text{[2,3,1]} = \\
14.500000 & \\
18.500000 & \\
22.500000 &
\end{align*}
\]

**See Also**

asum

**AmericanBinomCall**

**Purpose**

Prices American call options using binomial method.
Format

\[ c = \text{AmericanBinomCall}(S_0, K, r, \text{div}, \tau, \sigma, N); \]

Input

- \( S_0 \): scalar, current price.
- \( K \): Mx1 vector, strike prices.
- \( r \): scalar, risk free rate.
- \( \text{div} \): continuous dividend yield.
- \( \tau \): scalar, elapsed time to exercise in annualized days of trading.
- \( \sigma \): scalar, volatility.
- \( N \): number of time segments.

Output

- \( c \): Mx1 vector, call premiums.

Remarks


Example

\[ S_0 = 718.46; \]
K = { 720, 725, 730 };  
r = .0498;  
sigma = .2493;  

t0 = dtday(2001, 1, 30);  
t1 = dtday(2001, 2, 16);  
tau = elapsedTradingDays(t0,t1) /  
    annualTradingDays(2001);  

c = AmericanBinomCall(S0,K,r,0,tau,sigma,60);  
print c;  

produces the output:

17.344044
15.058486
12.817427

Source
finprocs.src

AmericanBinomCall_Greeks

Purpose
Computes Delta, Gamma, Theta, Vega, and Rho for American call options using binomial method.
Format

\[
\{ d, g, t, v, rh \} = \text{AmericanBinomCall_Greeks}(S0, K, r, \\
\text{div}, \tau, \sigma, N);
\]

Input

- **$S0$**
  - scalar, current price.
- **$K$**
  - Mx1 vector, strike prices.
- **$r$**
  - scalar, risk free rate.
- **$\text{div}$**
  - continuous dividend yield.
- **$\tau$**
  - scalar, elapsed time to exercise in annualized days of trading.
- **$\sigma$**
  - scalar, volatility.
- **$N$**
  - number of time segments.

Global Input

- **$_\text{fin_thetaType}$**
  - scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
- **$_\text{fin_epsilon}$**
  - scalar, finite difference stepsize. Default = $1e^{-8}$.

Output

- **$d$**
  - Mx1 vector, delta.
- **$g$**
  - Mx1 vector, gamma.
$t$  Mx1 vector, theta.

$v$  Mx1 vector, vega.

$rh$  Mx1 vector, rho.

**Remarks**


**Example**

```plaintext
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
div = 0;

print AmericanBinomCall_Greeks(S0,K,r,0,tau,sigma,30);
```

produces:

```
0.70631204
0.00076381912
-17.400851
68.703851
76.691829
```
Source
finprocs.src

See Also
AmericanBinomCall_ImpVol, AmericanBinomCall, AmericanBinomPut_Greeks, AmericanBS_Call_Greeks

AmericanBinomCall_ImpVol

Purpose
Computes implied volatilities for American call options using binomial method.

Format
\[ \sigma = \text{AmericanBinomCall}_\text{ImpVol}(c, S_0, K, r, \text{div}, \tau, N); \]

Input
- \( c \)
  Mx1 vector, call premiums
- \( S_0 \)
  scalar, current price.
- \( K \)
  Mx1 vector, strike prices.
- \( r \)
  scalar, risk free rate.
- \( \text{div} \)
  continuous dividend yield.
\[ \text{tau} \quad \text{scalar, elapsed time to exercise in annualized days of trading.} \]

\[ N \quad \text{number of time segments.} \]

**Output**

\[ \text{sigma} \quad \text{Mx1 vector, volatility.} \]

**Remarks**


**Example**

```plaintext
c = \{ 13.70, 11.90, 9.10 \};
S0 = 718.46;
K = \{ 720, 725, 730 \};
r = .0498;
div = 0;

t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) / annualTradingDays(2001);

sigma = AmericanBinomCall_ImpVol(c,S0,K,r,0,tau,30);
print sigma;
```

produces:
AmericanBinomPut

Purpose

Prices American put options using binomial method.

Format

\[ c = \text{AmericanBinomPut}(S0, K, r, \text{div}, \tau, \text{sigma}, N); \]

Input

- **S0**: scalar, current price.
- **K**: Mx1 vector, strike prices.
- **r**: scalar, risk free rate.
- **div**: continuous dividend yield.
- **tau**: scalar, elapsed time to exercise in annualized days of trading.
- **sigma**: scalar, volatility.
- **N**: number of time segments.
Output

\[ c \] Mx1 vector, put premiums.

Remarks


Example

\[
\begin{align*}
S0 &= 718.46; \\
K &= \{ 720, 725, 730 \}; \\
r &= .0498; \\
sigma &= .2493; \\

t0 &= \text{dtday}(2001, 1, 30); \\
t1 &= \text{dtday}(2001, 2, 16); \\
tau &= \text{elapsedTradingDays}(t0, t1) / \text{annualTradingDays}(2001); \\
c &= \text{AmericanBinomPut}(S0, K, r, 0, tau, sigma, 60); \\
\text{print } c;
\end{align*}
\]

produces:

\[
\begin{align*}
16.986117 \\
19.729923 \\
22.548538
\end{align*}
\]
**Source**
finprocs.src

**AmericanBinomPut_Greeks**

**Purpose**
Computes Delta, Gamma, Theta, Vega, and Rho for American put options using binomial method.

**Format**

\[
\{ d, g, t, v, rh \} = \text{AmericanBinomPut\_Greeks}(S0, K, r, \text{div}, \tau, \sigma, N);
\]

**Input**

- **S0**
  scalar, current price.

- **K**
  Mx1 vector, strike prices.

- **r**
  scalar, risk free rate.

- **div**
  continuous dividend yield.

- **tau**
  scalar, elapsed time to exercise in annualized days of trading.

- **sigma**
  scalar, volatility.

- **N**
  number of time segments.
Global Input

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
_fin_epsilon scalar, finite difference stepsize. Default = 1e-8.

Output

\[d\] Mx1 vector, delta.
\[g\] Mx1 vector, gamma.
\[t\] Mx1 vector, theta.
\[v\] Mx1 vector, vega.
\[rh\] Mx1 vector, rho.

Remarks

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach," Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

Example

\[
\begin{align*}
S0 &= 305; \\
K &= 300; \\
r &= .08; \\
\text{div} &= 0;
\end{align*}
\]
sigma = .25;
tau = .33;

print AmericanBinomPut_Greeks(S0,K,r,0,tau,sigma,60);
produces

-0.38324908
0.00076381912
8.1336630
68.337294
-27.585043

Source
finprocs.src

See Also
AmericanBinomPut_ImpVol, AmericanBinomPut, AmericanBinomCall_Greeks, AmericanBSPut_Greeks

AmericanBinomPut_ImpVol

Purpose

Computes implied volatilities for American put options using binomial method.

Format

sigma = AmericanBinomPut_ImpVol(c, S0, K, r, div, tau, N);
**Input**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c$</td>
<td>Mx1 vector, put premiums</td>
</tr>
<tr>
<td>$S0$</td>
<td>scalar, current price.</td>
</tr>
<tr>
<td>$K$</td>
<td>Mx1 vector, strike prices.</td>
</tr>
<tr>
<td>$r$</td>
<td>scalar, risk free rate.</td>
</tr>
<tr>
<td>$\text{div}$</td>
<td>continuous dividend yield.</td>
</tr>
<tr>
<td>$\tau$</td>
<td>scalar, elapsed time to exercise in annualized days of trading.</td>
</tr>
<tr>
<td>$N$</td>
<td>number of time segments.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>Mx1 vector, volatility.</td>
</tr>
</tbody>
</table>

**Remarks**


**Example**

```plaintext
p = { 14.60, 17.10, 20.10 };  
S0 = 718.46;  
K = { 720, 725, 730 };  
```
\begin{verbatim}
r = .0498;
div = 0;

t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0, t1) / 
     annualTradingDays(2001);

sigma = AmericanBinomPut_ImpVol(p, S0, K, r, 0, tau, 30);
print sigma;
\end{verbatim}

produces:

\begin{verbatim}
0.12466064
0.16583252
0.21203735
\end{verbatim}

**Source**

finprocs.src

**AmericanBSCall**

**Purpose**

Prices American call options using Black, Scholes, and Merton method.

**Format**

\begin{verbatim}
c = AmericanBSCall(S0, K, r, div, tau, sigma);
\end{verbatim}
**Input**

\( S_0 \)  
scalar, current price.

\( K \)  
Mx1 vector, strike prices.

\( r \)  
scalar, risk free rate.

\( \text{div} \)  
continuous dividend yield.

\( \tau \)  
scalar, elapsed time to exercise in annualized days of trading.

\( \sigma \)  
scalar, volatility.

**Output**

\( c \)  
Mx1 vector, call premiums.

**Example**

\[
\begin{align*}
S_0 &= 718.46; \\
K &= \{ 720, 725, 730 \}; \\
r &= .0498; \\
\sigma &= .2493; \\
t_0 &= \text{dtday}(2001, 1, 30); \\
t_1 &= \text{dtday}(2001, 2, 16); \\
\tau &= \text{elapsedTradingDays}(t_0, t_1) / \text{annualTradingDays}(2001); \\
c &= \text{AmericanBSCall}(S_0, K, r, 0, \tau, \sigma); \\
\text{print} & \ c;
\end{align*}
\]
produces:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>32.005720</td>
<td>31.083232</td>
<td>30.367548</td>
<td></td>
</tr>
</tbody>
</table>

**Source**
finprocs.src

**AmericanBSCall_Greeks**

**Purpose**
Computes Delta, Gamma, Theta, Vega, and Rho for American call options using Black, Scholes, and Merton method.

**Format**

\[
\{ d, g, t, v, \text{rh} \} = \text{AmericanBSCall\_Greeks}(S0, K, r, \text{div}, \tau, \sigma);
\]

**Input**

- \( S0 \) scalar, current price.
- \( K \) Mx1 vector, strike prices.
- \( r \) scalar, risk free rate.
- \( \text{div} \) continuous dividend yield.
\[\tau\] scalar, elapsed time to exercise in annualized days of trading.
\[\sigma\] scalar, volatility.

**Global Input**

\_[fin\_thetaType] scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.

**Output**

\[d\] Mx1 vector, delta.
\[g\] Mx1 vector, gamma.
\[t\] Mx1 vector, theta.
\[v\] Mx1 vector, vega.
\[rh\] Mx1 vector, rho.

**Example**

```plaintext
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
print AmericanBSCall_Greeks(S0,K,r,0,tau,sigma);
```
produces:

```
0.40034039
0.016804021
-55.731079
115.36906
46.374528
```

**Source**

`finprocs.src`

**See Also**

AmericanBSCall_ImpVol, AmericanBSCall, AmericanBSPut_Greeks, AmericanBinomCall_Greeks

**AmericanBSCall_ImpVol**

**Purpose**

Computes implied volatilities for American call options using Black, Scholes, and Merton method.

**Format**

```
sigma = AmericanBSCall_ImpVol(c, S0, K, r, div, tau);
```
Input

\[ c \quad \text{Mx1 vector, call premiums.} \]
\[ S0 \quad \text{scalar, current price.} \]
\[ K \quad \text{Mx1 vector, strike prices.} \]
\[ r \quad \text{scalar, risk free rate.} \]
\[ \text{div} \quad \text{continuous dividend yield.} \]
\[ \tau \quad \text{scalar, elapsed time to exercise in annualized days of trading.} \]

Output

\[ \sigma \quad \text{Mx1 vector, volatility.} \]

Example

```plaintext
\[ c = \{ \ 13.70, 11.90, 9.10 \ }; \]
\[ S0 = 718.46; \]
\[ K = \{ \ 720, 725, 730 \ }; \]
\[ r = .0498; \]

\[ t0 = \text{dtday}(2001, 1, 30); \]
\[ t1 = \text{dtday}(2001, 2, 16); \]
\[ \tau = \text{elapsedTradingDays}(t0,t1) / \]
\[ \quad \text{annualTradingDays}(2001); \]

\[ \sigma = \text{AmericanBS\textunderscore Call\_ImpVol}(c,S0,K,r,0,\tau); \]
\[ \text{print} \ \sigma; \]
```
produces:

```
0.10259888
0.088370361
0.066270752
```

**Source**

`finprocs.src`

---

**AmericanBSPut**

**Purpose**

Prices American put options using Black, Scholes, and Merton method.

**Format**

```
c = AmericanBSPut(S0, K, r, div, tau, sigma);
```

**Input**

- `S0` scalar, current price.
- `K` Mx1 vector, strike prices.
- `r` scalar, risk free rate.
- `div` continuous dividend yield.
- `tau` scalar, elapsed time to exercise in annualized days of trading.
- `sigma` scalar, volatility.
Output

\[ c \]
Mx1 vector, put premiums.

Example

\[
S_0 = 718.46; \\
K = \{ 720, 725, 730 \}; \\
r = .0498; \\
sigma = .2493; \\

t_0 = \text{dtday}(2001, 1, 30); \\
t_1 = \text{dtday}(2001, 2, 16); \\
tau = \text{elapsedTradingDays}(t_0, t_1) / \text{annualTradingDays}(2001); \\

c = \text{AmericanBSPut}(S_0, K, r, 0, tau, sigma); \\
\text{print } c; \\
\]
produces:

\[
16.870783 \\
19.536842 \\
22.435487 \\
\]

Source

finprocs.src
AmericanBSPut_Greeks

**Purpose**

Computes Delta, Gamma, Theta, Vega, and Rho for American put options using Black, Scholes, and Merton method.

**Format**

\[
\{d, g, t, v, rh\} = \text{AmericanBSPut\_Greeks}(S0, K, r, div, tau, sigma); 
\]

**Input**

- **$S0$** scalar, current price.
- **$K$** Mx1 vector, strike prices.
- **$r$** scalar, risk free rate.
- **$div$** continuous dividend yield.
- **$tau$** scalar, elapsed time to exercise in annualized days of trading.
- **$sigma$** scalar, volatility.

**Global Input**

- **$_\text{fin\_thetaType}$** scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
- **$_\text{fin\_epsilon}$** scalar, finite difference stepsize. Default = 1e-8.
Output

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>Mx1 vector, delta.</td>
</tr>
<tr>
<td>g</td>
<td>Mx1 vector, gamma.</td>
</tr>
<tr>
<td>t</td>
<td>Mx1 vector, theta.</td>
</tr>
<tr>
<td>v</td>
<td>Mx1 vector, vega.</td>
</tr>
<tr>
<td>rh</td>
<td>Mx1 vector, rho.</td>
</tr>
</tbody>
</table>

Example

```plaintext
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;

print AmericanBSPut_Greeks(S0,K,r,0,tau,sigma);
```

produces:

```
-0.33296721
0.0091658294
-17.556118
77.614237
-40.575963
```

Source

finprocs.src
See Also

AmericanBSCall_ImpVol, AmericanBSCall_Greeks, AmericanBSPut_ImpVol

AmericanBSPut_ImpVol

Purpose

Computes implied volatilities for American put options using Black, Scholes, and Merton method.

Format

\[ \sigma = \text{AmericanBSPut}_\text{ImpVol}(c, S_0, K, r, \text{div}, \tau) ; \]

Input

- \( c \) Mx1 vector, put premiums.
- \( S_0 \) scalar, current price.
- \( K \) Mx1 vector, strike prices.
- \( r \) scalar, risk free rate.
- \( \text{div} \) continuous dividend yield.
- \( \tau \) scalar, elapsed time to exercise in annualized days of trading.

Output

- \( \sigma \) Mx1 vector, volatility.
Example

\[
p = \{ 14.60, 17.10, 20.10 \};
S0 = 718.46;
K = \{ 720, 725, 730 \};
r = .0498;
\]

\[
t0 = \text{dtday}(2001, 1, 30);
t1 = \text{dtday}(2001, 2, 16);
tau = \text{elapsedTradingDays}(t0, t1) / \text{annualTradingDays}(2001);
\]

\[
sigma = \text{AmericanBSPut_ImpVol}(p, S0, K, r, 0, \tau);
\]

\[
\text{print} \ \sigma;
\]

produces:

\[
0.12753662
0.16780029
0.21396729
\]

Source

finprocs.src

amin

Purpose

Moves across one dimension of an N-dimensional array and finds the smallest element.
**Format**

\[ y = \text{amin}(x, \ dim) ; \]

**Input**

- \( x \) : N-dimensional array.
- \( \text{dim} \) : scalar, number of dimension across which to find the minimum value.

**Output**

- \( y \) : N-dimensional array.

**Remarks**

The output \( y \), will have the same sizes of dimensions as \( x \), except that the dimension indicated by \( \text{dim} \) will be collapsed to 1.

**Example**

```markdown
// Setting the rng seed allows for repeatable random numbers
rndseed 8237348;

// Create a 24x1 vector of random normal numbers with a standard deviation of 10 and then round to the nearest integer value
x = round(10*rndn(24,1));

// Reshape the 24x1 vector into a 2x3x4 dimensional array
```
//NOTE: The pipe operator '|' is for vertical concatenation
x = reshape(x,2|3|4);

dim = 2;
y = amin(x,dim);

x is a 2x3x4 array, such that:

\[
\begin{array}{cccc}
[1,1,1] \text{ through } [1,3,4] = \\
1.0000000 & -11.000000 & 9.0000000 & -8.0000000 \\
-2.0000000 & -10.000000 & -6.0000000 & -5.0000000 \\
-5.0000000 & 17.000000 & 9.0000000 & -2.0000000 \\
\end{array}
\]

\[
\begin{array}{cccc}
[2,1,1] \text{ through } [2,3,4] = \\
-4.0000000 & -2.0000000 & 7.0000000 & -2.0000000 \\
4.0000000 & 13.0000000 & -16.000000 & 11.000000 \\
2.0000000 & -1.0000000 & 12.0000000 & -16.000000 \\
\end{array}
\]

y will be a 2x1x4 array, such that:

\[
\begin{array}{cccc}
[1,1,1] \text{ through } [1,1,4] = \\
-5.0000000 & -11.000000 & -6.0000000 & -8.0000000 \\
\end{array}
\]

\[
\begin{array}{cccc}
[2,1,1] \text{ through } [2,1,4] = \\
-4.0000000 & -2.0000000 & -16.000000 & -16.000000 \\
\end{array}
\]

\[y = amin(x,1);\]

Using the same array x as the above example, this example finds the minimum value across the first dimension.
\( y \) will be a 2x3x1 array, such that:

\[
\begin{align*}
[1,1,1] \text{ through } [1,3,1] &= \\
&= -11.000000 \\
&-10.000000 \\
&-5.0000000 \\
\end{align*}
\]

\[
\begin{align*}
[2,1,1] \text{ through } [2,3,1] &= \\
&= -4.000000 \\
&-16.000000 \\
&-16.0000000 \\
\end{align*}
\]

**See Also**

`amax`, `minc`

**amult**

**Purpose**

Performs matrix multiplication on the planes described by the two trailing dimensions of N-dimensional arrays.

**Format**

\[
y = \text{amult}(a, b);
\]
### Input

- **a** N-dimensional array.
- **b** N-dimensional array.

### Output

- **y** N-dimensional array, containing the product of the matrix multiplication of the planes described by the two trailing dimensions of **a** and **b**.

### Remarks

All leading dimensions must be strictly conformable, and the two trailing dimensions of each array must be matrix-product conformable.

### Example

```plaintext
//Create an additive sequence from 1-12 and reshape it into
//a 2x3x2 dimensional array
a = areshape(seqa(1,1,12),2|3|2);

b = areshape(seqa(1,1,16),2|2|4);

//Multiply the two 3x2 matrices in 'a' by the corresponding
//2x4 matrices in 'b'
y = amult(a,b);
```

*a* is a 2x3x2 array, such that:
\[ \begin{bmatrix} 1,1,1 \righttext{ through } [1,3,2] \righttext{=} \\
1.0000000 & 2.0000000 \\
3.0000000 & 4.0000000 \\
5.0000000 & 6.0000000 \\
\end{bmatrix} \]

\[ \begin{bmatrix} 2,1,1 \righttext{ through } [2,3,2] \righttext{=} \\
7.0000000 & 8.0000000 \\
9.0000000 & 10.000000 \\
11.000000 & 12.000000 \\
\end{bmatrix} \]

\[ b \] is a 2x2x4 array, such that:

\[ \begin{bmatrix} 1,1,1 \righttext{ through } [1,2,4] \righttext{=} \\
1.0000000 & 2.0000000 & 3.0000000 & 4.0000000 \\
5.0000000 & 6.0000000 & 7.0000000 & 8.0000000 \\
\end{bmatrix} \]

\[ \begin{bmatrix} 2,1,1 \righttext{ through } [2,2,4] \righttext{=} \\
9.0000000 & 10.000000 & 11.000000 & 12.000000 \\
13.000000 & 14.000000 & 15.000000 & 16.000000 \\
\end{bmatrix} \]

\[ y \] will be a 2x3x4 array, such that:

\[ \begin{bmatrix} 1,1,1 \righttext{ through } [1,3,4] \righttext{=} \\
11.000000 & 14.000000 & 17.000000 & 20.000000 \\
23.000000 & 30.000000 & 37.000000 & 44.000000 \\
35.000000 & 46.000000 & 57.000000 & 68.000000 \\
\end{bmatrix} \]

\[ \begin{bmatrix} 2,1,1 \righttext{ through } [2,3,4] \righttext{=} \\
\end{bmatrix} \]
annualTradingDays

Purpose

Computes number of trading days in a given year.

Format

\[ n = \text{annualTradingDays}(a); \]

Input

\( a \)  
scalar, year.

Output

\( n \)  
number of trading days in year.

Remarks

A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2012. Holidays are defined in holidays.asc. You
may edit that file to modify or add holidays.

Source
finutils.src

Globals
_fin_annualTradingDays, _fin_holidays

See Also
eTD, gNTD, gPTD, gNWD, gPWD

arccos

Purpose
Computes the inverse cosine.

Format

\[ y = \text{arccos}(x); \]

Input

\[ x \quad \text{NxK matrix or N-dimensional array.} \]

Output

\[ y \quad \text{NxK matrix or N-dimensional array containing the angle in} \]
radians whose cosine is \( x \).

**Remarks**

If \( x \) is complex or has any elements whose absolute value is greater than 1, complex results are returned.

**Example**

```plaintext
//Format print statements to show 3 digits
//after the decimal point
format /rd 6,3;

x = { -1, -0.5, 0, 0.5, 1 };
y = arccos(x);

print "x = " x;
print "y = " y;
```

The code above, produces the following output:

```
x =
  -1.000
  -0.500
   0.000
   0.500
   1.000
y =
  3.142
  2.094
  1.571
```
arcsin

**Purpose**

Computes the inverse sine.

**Format**

\[ y = \text{arcsin}(x); \]

**Input**

\[ x \quad \text{NxK matrix or N-dimensional array.} \]

**Output**

\[ y \quad \text{NxK matrix or N-dimensional array, the angle in radians whose sine is } x. \]

**Remarks**

If \( x \) is complex or has any elements whose absolute value is greater than 1, complex
results are returned.

**Example**

```plaintext
//Set 'x' to be the sequence -1, -0.5, 0, 0.5, 1
x = seqa(-1, 0.5, 5);
y = arcsin(x);
```

Assigns $y$ to be equal to:

-1.5707963
-0.52359878
0.00000000
0.52359878
1.5707963

**Source**

trig.src

**areshape**

**Purpose**

Reshapes a scalar, matrix, or array into an array of user-specified size.

**Format**

```plaintext
y = areshape(x, o);
```
**Input**

- $x$ scalar, matrix, or N-dimensional array.
- $o$ Mx1 vector of orders, the sizes of the dimensions of the new array.

**Output**

- $y$ M-dimensional array, created from data in $x$.

**Remarks**

If there are more elements in $x$ than in $y$, the remaining elements are discarded. If there are not enough elements in $x$ to fill $y$, then when `areshape` runs out of elements, it goes back to the first element of $x$ and starts getting additional elements from there.

**Example**

```plaintext
x = 3;
orders = { 2,3,4 };
y = areshape(x,orders);
```

$y$ will be a 2x3x4 array of threes.

```plaintext
x = reshape(seqa(1,1,90),30,3);
orders = { 2,3,4,5 };
y = areshape(x,orders);
```

$y$ will be a 2x3x4x5 array. Since $y$ contains 120 elements and $x$ contains only 90, the first 90 elements of $y$ will be set to the sequence of integers from 1 to 90 that are
contained in \( x \), and the last 30 elements of \( y \) will be set to the sequence of integers from 1 to 30 contained in the first 30 elements of \( x \).

\[
\begin{align*}
x &= \texttt{reshape(seqa(1,1,60),20,3)}; \\
o &= \{3,2,4\}; \\
y &= \texttt{areshape(x,orders)};
\end{align*}
\]

\( y \) will be a 3x2x4 array. Since \( y \) contains 24 elements, and \( x \) contains 60, the elements of \( y \) will be set to the sequence of integers from 1 to 24 contained in the first 24 elements of \( x \).

See Also

\texttt{aconcat}

\texttt{arrayalloc}

Purpose

Creates an N-dimensional array with unspecified contents.

Format

\[
y = \texttt{arrayalloc} (o, cf);
\]

Input

- \( o \) \( \) Nx1 vector of orders, the sizes of the dimensions of the array.
- \( cf \) \( \) scalar, 0 to allocate real array, or 1 to allocate complex array.
Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>N-dimensional array.</td>
</tr>
</tbody>
</table>

Remarks

The contents are unspecified. This function is used to allocate an array that will be written to in sections using `setarray`.

Example

```gauss
orders = { 2, 3, 4 };
y = arrayalloc(orders, 1);
```

`y` will be a complex 2x3x4 array with unspecified contents.

```gauss
//Tell GAUSS to replace all instances of 'REAL' with a 0
#define REAL 0
orders = { 7, 5, 3 };

//Create a real 7x5x3 dimensional array; before GAUSS
//interprets this statement it will replace 'REAL' with
//a scalar 0
y = arrayalloc(orders, REAL);
```

See Also

`arrayinit`, `setarray`
**arrayindex**

**Purpose**

Converts a scalar vector index to a vector of indices for an N-dimensional array.

**Format**

\[ i = \text{arrayindex}(si, o); \]

**Input**

- \( si \) : scalar, index into vector or 1-dimensional array.
- \( o \) : Nx1 vector of orders of an N-dimensional array.

**Output**

- \( i \) : Nx1 vector of indices, index of corresponding element in N-dimensional array.

**Remarks**

This function and its opposite, **singleindex**, allow you to easily convert between an N-dimensional index and its corresponding location in a 1-dimensional object of the same size.
Example

//Set the rng seed for repeatable random numbers
rndseed 982348;

orders = { 2,3,4,5 }; 

//Create 120x1 vector of uniform random numbers
//(2*3*4*5 = 120)
v = rndu(prodc(orders),1);

//Reshape the 120x1 random vector into a 2x3x4x5
//dimensional array
a = areshape(v,orders);

vi = 50;
ai = arrayindex(vi,orders);

print "vi = " vi;
print "ai = " ai;
print "v[vi] = " v[vi];
//The double semi-colon below suppresses the
//new-line allowing the string and the data to be
//printed on the same line
print "getarray(a, ai) = "; getarray(a,ai);

The code above, produces the following output:

vi = 50.000
ai =
 1.000
 3.000
 2.000
 5.000
This example allocates a vector of random numbers and creates a 4-dimensional array using the same data. The 50th element of the vector \( v \) corresponds to the element of array \( a \) that is indexed with \( a_i \).

**See Also**

- `singleindex`

**arrayinit**

**Purpose**

Creates an N-dimensional array with a specified fill value.

**Format**

\[
y = \text{arrayinit}(o, \ v);
\]

**Input**

- \( o \): Nx1 vector of orders, the sizes of the dimensions of the array.
- \( v \): scalar, value to initialize. If \( v \) is complex the result will be complex.
Output

\[ y \]  
N-dimensional array with each element equal to the value of \( v \).

Example

```plaintext
val = 3.14;
orders = { 2, 100, 9 };
y = arrayinit(orders, val);
```

\( y \) will be a 2x100x9 array with each element equal to 3.14.

See Also

arrayalloc

arraytomat

Purpose

Converts an array to type matrix.

Format

\[ y = \text{arraytomat}(a); \]

Input

\[ a \]  
N-dimensional array.
Output

\[ y \]

KxL or 1xL matrix or scalar, where L is the size of the fastest moving dimension of the array and K is the size of the second fastest moving dimension.

Remarks

`arraytomat` will take an array of 1 or 2 dimensions or an N-dimensional array, in which the N-2 slowest moving dimensions each have a size of 1.

Example

```plaintext
//Create 25x1 vector containing the sequence 0.5, 1, //1.5...12.5
x = seqa(0.5, 0.5, 25);

//Reshape into a 1x6x4 array, discarding the 25th element //of 'x'
a = areshape(x, 1|6|4);

//Set 'y' to be a 6x4 variable of type matrix, with the //same contents as 'a'
y = arraytomat(a);
```

The code above sets \( y \) equal to:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>4.5</td>
<td>5.0</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>6.5</td>
<td>7.0</td>
<td>7.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>
See Also

mattoarray

asciiload

Purpose

Loads data from a delimited ASCII text file into an N x 1 vector.

Format

\[ y = \text{asciiload}(\text{filename}); \]

Input

filename  string, name of data file.

Output

y  N x 1 vector.

Remarks

The file extension must be included in the file name.

Numbers in ASCII files must be delimited with spaces, commas, tabs, or newlines.
This command loads as many elements as possible from the file into an Nx1 vector. This allows you to verify if the load was successful by calling `rows(y)` after `asciiload` to see how many elements were actually loaded. You may then `reshape` the Nx1 vector to the desired form. You could, for instance, put the number of rows and columns of the matrix right in the file as the first and second elements and `reshape` the remainder of the vector to the desired form using those values.

**Example**

To load the file `myfile.asc`, containing the following data:

```
  2.805  16.568
  -4.871  3.399
  17.361 -12.725
```

you may use any of the following commands:

```matlab
//This statement assumes 'myfile.asc' is in the current //working directory
y = asciiload("myfile.asc");
```

```matlab
//This code assumes that 'myfile.asc' is //located in the C:\gauss13 directory //Note the double backslashes for path separators
fpath = "C:\\gauss13\\myfile.asc";
y = asciiload(fpath);
```

```matlab
path = "C:\\gauss13\";
fname = "myfile.asc";
//The '$+' operator adds two strings together into one //string
y = asciiload(path$+fname);
```

All of the above commands will set `y` to be equal to:
2.805
16.568
-4.871
3.399
17.361
-12.725

See Also
load, dataload

asclabel

Purpose

To set up character labels for the X and Y axes. NOTE: This function is for
the deprecated PQG graphics.

Library
pgraph

Format

asclabel(xl, yl); 

Input

xl string or Nx1 character vector, labels for the tick marks on
the X axis. Set to 0 if no character labels for this axis are
desired.
$y_l$  string or Mx1 character vector, labels for the tick marks on the Y axis. Set to 0 if no character labels for this axis are desired.

**Example**

This illustrates how to label the X axis with the months of the year:

```plaintext
let lab = JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC;
asclabel(lab,0);
```

This will also work:

```plaintext
lab = "JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DE
C";
asclabel(lab,0);
```

If the string format is used, then escape characters may be embedded in the labels. For example, the following produces character labels that are multiples of $\lambda$. The font Simgrma must be previously loaded in a **fonts** command.

```plaintext
fonts("simplex simgrma");
lab = "\2010.25\202l \2010.5\202l \2010.75\202l 1";
asclabel(lab,0);
```

Here, the "\202l" produces the "$\lambda$" symbol from Simgrma.

**Source**

pgraph.src

**See Also**

xtics, ytics, scale, scale3d, fonts
astd

**Purpose**

Computes the standard deviation of the elements across one dimension of an N-dimensional array.

**Format**

\[ y = \text{astd}(x, \ dim); \]

**Input**

- \( x \)  
  N-dimensional array.
- \( dim \)  
  scalar, number of dimension to sum across.

**Output**

- \( y \)  
  N-dimensional array, standard deviation across specified dimension of \( x \).

**Remarks**

The output \( y \), will have the same sizes of dimensions as \( x \), except that the dimension indicated by \( dim \) will be collapsed to 1.

This function essentially computes:

\[ \sqrt{\frac{1}{N-1} \sum_{c} ((x - \text{meanc}(x))')^2} \]
Thus, the divisor is N-1 rather than N, where N is the number of elements being summed. See `astds` for the alternate definition.

**Example**

```matlab
//Create a 1e6x1 vector of random normal numbers with a
//standard deviation of 25 and reshape it into a
//2e5x3x2 array
a = reshape(25*rndn(2e6,1),2e5|3|2);
y = std(a,3);
```

The code above should produce a 3x2 matrix with all elements close to 25 similar to what we see below. Since the example uses random numbers, your answer may vary slightly.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>24.997</td>
<td>25.030</td>
</tr>
<tr>
<td>25.012</td>
<td>24.986</td>
</tr>
<tr>
<td>24.978</td>
<td>25.000</td>
</tr>
</tbody>
</table>

**See Also**

`astds`, `stdc`

**astds**

**Purpose**

Computes the 'sample' standard deviation of the elements across one dimension of an N-dimensional array.
**Format**

\[ y = \text{astds}(x, \ dim); \]

**Input**

- **x**
  - N-dimensional array.
- **dim**
  - scalar, number of dimension to sum across.

**Output**

- **y**
  - N-dimensional array, standard deviation across specified dimension of \( x \).

**Remarks**

The output \( y \), will have the same sizes of dimensions as \( x \), except that the dimension indicated by \( \text{dim} \) will be collapsed to 1.

This function essentially computes:

\[
\sqrt{\frac{1}{N} \sum \left( (x - \text{mean}(x))' \right)^2}
\]

Thus, the divisor is \( N \) rather than \( N-1 \), where \( N \) is the number of elements being summed. See \text{astd} for the alternate definition.

**Example**

- \( a = \text{areshape}(25\cdot\text{rndn}(16,1),4|2|2); \)
- \( y = \text{astds}(a,3); \)
print "a = " a;
print "y = " y;

The code above produces the following output (due to the use of random data in this example your answers will be different):

a =

Plane [1,..,]
  12.538  -56.786
  -40.283  -58.287

Plane [2,..,]
  4.047  -0.325
  17.617  -9.248

Plane [3,..,]
  17.908  40.048
   8.916 -37.247

Plane [4,..,]
  -0.977  16.058
 -38.189   0.984

y =

Plane [1,..,]
In this example, 16 standard Normal random variables are generated. They are multiplied by 25 and `reshape`d into a 4x2x2 array, and the standard deviation is computed across the third dimension of the array.

### See Also

`astd`, `stdsc`

### asum

#### Purpose

Computes the sum across one dimension of an N-dimensional array.

#### Format

\[
y = \text{asum}(x, \ dim);
\]

#### Input

- `x`  
  N-dimensional array.
- `dim`  
  scalar, number of dimension to sum across.

#### Output

- `y`  
  N-dimensional array.
**Remarks**

The output \( y \), will have the same sizes of dimensions as \( x \), except that the dimension indicated by \( \text{dim} \) will be collapsed to 1.

**Example**

\[
x = \text{seqa}(1,1,24); \\
dims = \{ 2, 3, 4 \}; \\
x = \text{areshape}(x,dims); \\
y = \text{asum}(x,3); 
\]

\( x \) is a 2x3x4 array, such that:

**Plane [1,..,]**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>2.000</td>
<td>3.000</td>
<td>4.000</td>
<td></td>
</tr>
<tr>
<td>5.000</td>
<td>6.000</td>
<td>7.000</td>
<td>8.000</td>
<td></td>
</tr>
<tr>
<td>9.000</td>
<td>10.000</td>
<td>11.000</td>
<td>12.000</td>
<td></td>
</tr>
</tbody>
</table>

**Plane [2,..,]**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13.000</td>
<td>14.000</td>
<td>15.000</td>
<td>16.000</td>
<td></td>
</tr>
<tr>
<td>17.000</td>
<td>18.000</td>
<td>19.000</td>
<td>20.000</td>
<td></td>
</tr>
<tr>
<td>21.000</td>
<td>22.000</td>
<td>23.000</td>
<td>24.000</td>
<td></td>
</tr>
</tbody>
</table>

and \( y \) is equal to:

**Plane [1,..,]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14.000</td>
<td>16.000</td>
<td>18.000</td>
<td>20.000</td>
</tr>
</tbody>
</table>
22.000  24.000  26.000  28.000  
30.000  32.000  34.000  36.000

\[ y = \text{asum}(x,1); \]

Using the same array \( x \) as the above example, this example computes the sum across the first dimension. \( y \) will be a 2x3x1 array, such that:

Plane [1,..,]  
10.000  
26.000  
42.000  

Plane [2,..,]  
58.000  
74.000  
90.000

See Also
amean
atan

Purpose

Returns the arctangent of its argument.

Format

\[ y = \text{atan}(x); \]
Input

\( x \)  
NxK matrix or N-dimensional array.

Output

\( y \)  
NxK matrix or N-dimensional array containing the arctangents of \( x \) in radians.

Remarks

\( y \) will be the same size as \( x \), containing the arctangents of the corresponding elements of \( x \).

For real \( x \), the arctangent of \( x \) is the angle whose tangent is \( x \). The result is a value in radians in the range \(-\pi/2\) to \(+\pi/2\). To convert radians to degrees, multiply by \(180/\pi\).

For complex \( x \), the arctangent is defined everywhere except \( i \) and \(-i\). If \( x \) is complex, \( y \) will be complex.

Example

```plaintext
//Create a sequence with 5 elements starting at -pi and //increasing by pi/2
x = seqa(-pi, pi/2, 5)
y = atan(x);
```

After the code above:

\[
\begin{array}{cc}
-3.142 & -1.263 \\
-1.571 & -1.004
\end{array}
\]
atan2

Purpose

Computes an angle from an \( x, y \) coordinate.

Format

\[
z = \text{atan2}(y, x);
\]

Input

\( y \)  
NxK matrix or P-dimensional array where the last two dimensions are NxK, the \( y \) coordinate.

\( x \)  
LxM matrix or P-dimensional array where the last two dimensions are LxM, ExE conformable with \( y \), the \( x \) coordinate.

Output

\( z \)  
max(N,L) by max(K,M) matrix or P-dimensional array

See Also

atan2, sin, cos, pi, tan
where the last two dimensions are \( \max(N,L) \) by \( \max(K,M) \).

**Remarks**

Given a point \( x, y \) in a Cartesian coordinate system, \texttt{atan2} will give the correct angle with respect to the positive X axis. The answer will be in radians from \(-\pi\) to \(+\pi\).

To convert radians to degrees, multiply by \(180/\pi\).

\texttt{atan2} operates only on the real component of \( x \), even if \( x \) is complex.

**Example**

```plaintext
//Create the sequence -\pi, -\pi/2, 0, \pi/2, \pi
x = seqa(-pi, pi/2, 5);
y = 1;

zpol = atan2(y, x);
zdeg = zpol*(180/pi);
```

After the code above:

<table>
<thead>
<tr>
<th>x</th>
<th>zpol</th>
<th>zdeg</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.142</td>
<td>2.833</td>
<td>162.343</td>
</tr>
<tr>
<td>-1.571</td>
<td>2.575</td>
<td>147.518</td>
</tr>
<tr>
<td>0.000</td>
<td>1.571</td>
<td>90.000</td>
</tr>
<tr>
<td>1.571</td>
<td>0.567</td>
<td>32.482</td>
</tr>
<tr>
<td>3.142</td>
<td>0.308</td>
<td>17.657</td>
</tr>
</tbody>
</table>

**See Also**

\texttt{atan, sin, cos, pi, tan, arcsin, arccos}
# atranspose

## Purpose

Transposes an N-dimensional array.

## Format

\[
y = \text{transpose}(x, \ nd);
\]

## Input

- \(x\): N-dimensional array.
- \(nd\): Nx1 vector of dimension indices, the new order of dimensions.

## Output

- \(y\): N-dimensional array, transposed according to \(nd\).

## Remarks

The vector of dimension indices must be a unique vector of integers, 1-N, where 1 corresponds to the first element of the vector of orders.

## Example

```matlab
x = seqa(1,1,24);
x = areshape(x,2|3|4);
```
\[
\text{nd} = \{2, 1, 3\}; \\
y = \text{atranspose}(x, \text{nd}); \\
\]

This example transposes the dimensions of \(x\) that correspond to the first and second elements of the vector of orders. \(x\) is a 2x3x4 array, such that:

<table>
<thead>
<tr>
<th>Plane [1,..,]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000 2.000 3.000 4.000</td>
</tr>
<tr>
<td>5.000 6.000 7.000 8.000</td>
</tr>
<tr>
<td>9.000 10.000 11.000 12.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [2,..,]</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.000 14.000 15.000 16.000</td>
</tr>
<tr>
<td>17.000 18.000 19.000 20.000</td>
</tr>
<tr>
<td>21.000 22.000 23.000 24.000</td>
</tr>
</tbody>
</table>

\(y\) is a 3x2x4 array, such that:

<table>
<thead>
<tr>
<th>Plane [1,..,]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000 2.000 3.000 4.000</td>
</tr>
<tr>
<td>13.000 14.000 15.000 16.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [2,..,]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.000 6.000 7.000 8.000</td>
</tr>
<tr>
<td>17.000 18.000 19.000 20.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [3,..,]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.000 10.000 11.000 12.000</td>
</tr>
<tr>
<td>21.000 22.000 23.000 24.000</td>
</tr>
</tbody>
</table>
nd = { 2,3,1 };  
y = atranspose(x,nd);

Using the same array $x$ as the example above, this example transposes all three dimensions of $x$, returning a 3x4x2 array $y$, such that:

Plane [1,..,]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>13.000</td>
<td></td>
</tr>
<tr>
<td>2.000</td>
<td>14.000</td>
<td></td>
</tr>
<tr>
<td>3.000</td>
<td>15.000</td>
<td></td>
</tr>
<tr>
<td>4.000</td>
<td>16.000</td>
<td></td>
</tr>
</tbody>
</table>

Plane [2,..,]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.000</td>
<td>17.000</td>
<td></td>
</tr>
<tr>
<td>6.000</td>
<td>18.000</td>
<td></td>
</tr>
<tr>
<td>7.000</td>
<td>19.000</td>
<td></td>
</tr>
<tr>
<td>8.000</td>
<td>20.000</td>
<td></td>
</tr>
</tbody>
</table>

Plane [3,..,]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.000</td>
<td>21.000</td>
<td></td>
</tr>
<tr>
<td>10.000</td>
<td>22.000</td>
<td></td>
</tr>
<tr>
<td>11.000</td>
<td>23.000</td>
<td></td>
</tr>
<tr>
<td>12.000</td>
<td>24.000</td>
<td></td>
</tr>
</tbody>
</table>

**See Also**

areshape
**axmargin**

**Purpose**

Sets absolute margins for the plot axes which control placement and size of plot. NOTE: This function is for the deprecated PQG graphics.

**Library**

pgraph

**Format**

```
axmargin(l, r, t, b);
```

**Input**

- **l**
  - scalar, the left margin in inches.
- **r**
  - scalar, the right margin in inches.
- **t**
  - scalar, the top margin in inches.
- **b**
  - scalar, the bottom margin in inches.

**Remarks**

`axmargin` sets an absolute distance from the axes to the edge of the graphic panel. Note that the user is responsible for allowing enough space in the margin if axes labels, numbers and title are used on the graph, since `axmargin` does not size the plot automatically as in the case of `margin`.
All input inch values for this procedure are based on a full size window of 9x6.855 inches. If this procedure is used within a graphic panel, the values will be scaled to window inches automatically.

If both margin and axmargin are used for a graph, axmargin will override any sizes specified by margin.

**Example**

The statement:

```plaintext
axmargin(1,1,.5,.855);
```

will create a plot area of 7 inches horizontally by 5.5 inches vertically, and positioned 1 inch right and .855 up from the lower left corner of the graphic panel/page.

**Source**

pgraph.src
**b**

**balance**

**Purpose**

Balances a square matrix.

**Format**

\[
\{ b, z \} = \text{balance}(x);
\]

**Input**

\( x \) KxK matrix or N-dimensional array where the last two dimensions are KxK.

**Output**

\( b \) KxK matrix or N-dimensional array where the last two dimensions are KxK, balanced matrix.

\( z \) KxK matrix or N-dimensional array where the last two dimensions are KxK, diagonal scale matrix.

**Remarks**

*balance* returns a balanced matrix \( b \) and another matrix \( z \) with scale factors in
powers of two on its diagonal. $b$ is balanced in the sense that the absolute sums of the magnitudes of elements in corresponding rows and columns are nearly equal.

**balance** is most often used to scale matrices to improve the numerical stability of the calculation of their eigenvalues. It is also useful in the solution of matrix equations.

In particular,\[ b = z^{-1} x z \]

**balance** uses the BALANC function from EISPACK..

**Example**

```plaintext
let x[3,3] = 100 200 300
40  50  60
7   8   9;
{ b, z } = balance(x);

b = 100.0 100.0 37.5
  80.0  50.0  15.0
  56.0  32.0   9.0

z = 4.0  0.0  0.0
  0.0   2.0  0.0
  0.0   0.0  0.5
```

**band**

**Purpose**

Extracts bands from a symmetric banded matrix.
Format

\[ a = \text{band}(y, n); \]

Input

- \( y \) : KxK symmetric banded matrix.
- \( n \) : scalar, number of subdiagonals.

Output

- \( a \) : Kx(N+1) matrix, 1 subdiagonal per column.

Remarks

\( y \) can actually be a rectangular PxQ matrix. \( K \) is then defined as \( \min(P,Q) \). It will be assumed that \( a \) is symmetric about the principal diagonal for \( y[1:K,1:K] \).

The subdiagonals of \( y \) are stored right to left in \( a \), with the principal diagonal in the rightmost or \( (N+1) \)th column of \( a \). The upper left corner of \( a \) is unused; it is set to 0.

This compact form of a banded matrix is what \texttt{bandchol} expects.

Example

\[
 x = \begin{bmatrix}
 1 & 2 & 0 & 0 \\
 2 & 8 & 1 & 0 \\
 0 & 1 & 5 & 2 \\
 0 & 0 & 2 & 3 \\
\end{bmatrix};
\]

\[ //\text{Extract only the principal diagonal} \]
b0 = \texttt{band}(x,0);

//Extract the principal diagonal and the first subdiagonal
b1 = \texttt{band}(x,1);

//Extract the principal diagonal and the first two subdiagonals
b2 = \texttt{band}(x,2);

After the code above:

\[
\begin{pmatrix}
1 & 0 & 1 & 0 & 0 & 1 \\
5 & 1 & 5 & 0 & 1 & 5 \\
3 & 2 & 3 & 0 & 2 & 3 \\
\end{pmatrix}
\]
\[
\begin{pmatrix}
b0 & 8 \\
b1 & 2 & 8 \\
b2 & 0 & 2 & 8 \\
\end{pmatrix}
\]

\textbf{See Also}

\texttt{bandchol}, \texttt{bandcholsol}, \texttt{bandltsol}, \texttt{band}, \texttt{bandsolp}

\textbf{bandchol}

\textbf{Purpose}

Computes the Cholesky decomposition of a positive definite banded matrix.

\textbf{Format}

\[
l = \texttt{bandchol}(a);
\]
**Input**

\( a \)  
KxN compact form matrix.

**Output**

\( l \)  
KxN compact form matrix, lower triangle of the Cholesky decomposition of \( a \).

**Remarks**

Given a positive definite banded matrix \( A \), there exists a matrix \( L \), the lower triangle of the Cholesky decomposition of \( A \), such that \( A = LL' \). \( a \) is the compact form of \( A \); see \texttt{band} for a description of the format of \( a \).

\( l \) is the compact form of \( L \). This is the form of matrix that \texttt{bandcholsol} expects.

**Example**

\[
\begin{align*}
x &= \begin{bmatrix}
1 & 2 & 0 & 0 \\
2 & 8 & 1 & 0 \\
0 & 1 & 5 & 2 \\
0 & 0 & 2 & 3
\end{bmatrix}; \\
\end{align*}
\]

\[
\begin{align*}
\text{bx} &= \texttt{band}(x, 1); \\
\text{bl} &= \texttt{bandchol}(\text{bx}); \\
\text{l} &= \texttt{chol}(x);
\end{align*}
\]

After the code above:
See Also

band, bandcholsol, bandltsol, bandrv, bandsolpd

bandcholsol

Purpose

Solves the system of equations $Ax = b$ for $x$, given the lower triangle of the Cholesky decomposition of a positive definite banded matrix $A$.

Format

$x = \text{bandcholsol}(b, \ l);$ 

Input

$b$  KxM matrix.

$l$  KxN compact form matrix.

Output

$x$  KxM matrix.
Remarks

Given a positive definite banded matrix $A$, there exists a matrix $L$, the lower triangle of the Cholesky decomposition of $A$, such that $A = LL'$. $l$ is the compact form of $L$; see band for a description of the format of $l$.

$b$ can have more than one column. If so, $Ax = b$ is solved for each column. That is,

$$A\times[.,i] = b[.,i]$$

Example

//Create matrix 'A' and right-hand side 'b'
A = [ 1 2 0 0,
     2 8 1 0,
     0 1 5 2,
     0 0 2 3 ];
b = [ 1.3, 2.1, 0.7, 1.8 ];

//Create banded matrix form of 'A'
Aband = band(A,1);

//Cholesky factorization of the banded 'A'
Lband = bandchol(Aband);

//Solve the system of equations
x = bandcholsol(b, Lband);

After the code above is run:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>1.000</td>
<td>1.495</td>
<td>1.300</td>
<td>1.300</td>
</tr>
<tr>
<td>Lband = 2.000</td>
<td>2.000</td>
<td>x = -0.098</td>
<td>b = 2.100</td>
<td>A\times x = 2.100</td>
</tr>
<tr>
<td>0.500</td>
<td>2.179</td>
<td>-0.110</td>
<td>0.700</td>
<td>0.700</td>
</tr>
<tr>
<td>0.918</td>
<td>1.469</td>
<td>0.673</td>
<td>1.800</td>
<td>1.800</td>
</tr>
</tbody>
</table>
See Also

band, bandchol, bandltsol, bandrv, bandsolpd

bandltsol

Purpose

Solves the system of equations $Ax = b$ for $x$, where $A$ is a lower triangular banded matrix.

Format

$$x = \text{bandltsol}(b, A);$$

Input

<table>
<thead>
<tr>
<th>$b$</th>
<th>KxM matrix.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>KxN compact form matrix.</td>
</tr>
</tbody>
</table>

Output

| $x$ | KxM matrix. |

Remarks

$A$ is a lower triangular banded matrix in compact form. See band for a description of the format of $A$.

$b$ can have more than one column. If so, $Ax = b$ is solved for each column. That is,
A*x[.,i] = b[.,i];

Example

//Create matrix 'A' and right-hand side 'b'
A = [ 1 2 0 0,
     2 8 1 0,
     0 1 5 2,
     0 0 2 3 ];
b = [ 1.3, 2.1, 0.7, 1.8 ];

//Create a matrix containing the lower triangular part
//of 'A'
Alower = lowmat(A);

//Create banded matrix from of 'Alower'
Abandlow = band(Alower, 1);

//Solve the system of equations
x = bandltsol(b, Abandlow);

After the code above:

1 0 0 0 0 1 1.300 1.3
1.3

Alower = 2 8 0 0 Aband = 2 8 x = -0.063 b = 2.1 Alower*
x = 2.1

0 1 5 0 1 5 0.153 0.7
0.7
0 0 2 3 2 3 0.498 1.8
1.8

See Also

band, bandchol, bandcholsol, bandrv, bandsolpd
**bandrv**

**Purpose**

Creates a symmetric banded matrix, given its compact form.

**Format**

\[ y = \text{bandrv}(a); \]

**Input**

\( a \)  
KxN compact form matrix.

**Output**

\( y \)  
KxK symmetric banded matrix.

**Remarks**

\( a \) is the compact form of a symmetric banded matrix, as generated by \text{band}. \( a \) stores subdiagonals right to left, with the principal diagonal in the rightmost (Nth) column. The upper left corner of \( a \) is unused. \text{bandchol} expects a matrix of this form.

\( y \) is the fully expanded form of \( a \), a KxK matrix with N-1 subdiagonals.

**Example**

\[
 x = \{ 1 2 0 0,
\]

38-84
//Create a version of 'x' in band format
xBand = band(x,1);

//Expand the banded version of 'x' back to a full matrix
xNew = bandrv(xBand);

After the code above:

xBand = 2 8 1 0, 0 1 5 2, 0 0 2 3 ;
x = 2 8 1 0
xNew = 2 8 1 0

See Also
band, bandchol, bandcholsol, bandltsol, bandsolpd

bandsolpd

Purpose
Solves the system of equations \( Ax = b \) for \( x \), where \( A \) is a positive definite
banded matrix.

Format
\[
x = \text{bandsolpd}(b, A);
\]
**Input**

- $b$: KxM matrix.
- $A$: KxN compact form matrix.

**Output**

- $x$: KxM matrix.

**Remarks**

$A$ is a positive definite banded matrix in compact form. See `band` for a description of the format of $A$.

$b$ can have more than one column. If so, $Ax = b$ is solved for each column. That is,

$$A\times[.,i] = b[.,i]$$

**See Also**

`band`, `bandchol`, `bandcholsol`, `bandltsol`, `bandrv`

**bar**

**Purpose**

Generates a bar graph. NOTE: This function is for the deprecated PQG graphics, use `plotBar` instead.
Library
pgraph

Format

```
bar(val, ht);
```

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>val</strong></td>
<td>Nx1 numeric vector, bar labels. If scalar 0, a sequence from 1 to <strong>rows(ht)</strong> will be created.</td>
</tr>
<tr>
<td><strong>ht</strong></td>
<td>NxK numeric vector, bar heights.</td>
</tr>
</tbody>
</table>

Global Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>pbarwid</em></td>
<td>scalar, width and type of bars in bar graphs and histograms. The valid range is 0-1. If this is 0, the bars will be a single pixel wide. If this is 1, the bars will touch each other. If this value is positive, the bars will overlap. If negative, the bars will be plotted side-by-side. The default is 0.5.</td>
</tr>
</tbody>
</table>
| _pbartyp_ | Kx2 matrix. The first column controls the bar shading:  
  0 no shading.  
  1 dots.  
  2 vertical cross-hatch.  
  3 diagonal lines with positive slope. |
diagonal lines with negative slope.

5 diagonal cross-hatch.

6 solid.

The second column controls the bar color.

**Remarks**

Use `scale` or `ytics` to fix the scaling for the bar heights.

**Example**

In this example, three overlapping sets of bars will be created. The three heights for the $i$th bar are stored in $x[i]$. 

```r
library pgraph;
graphset;

t = seqa(0,1,10);
x = (t^2/2).* (1~0.7~0.3);

_plcgctl = { 1 4 };
_plcstr = "Accnt #1\000Accnt #2\000Accnt #3";
title("Theoretical Savings Balance");
xlabel("Years");
ylabel("Dollars x 1000");
_pbartyp = { 1 10 }; /* Set color of the bars */
_pnum = 2;

bar(t,x); /* Use t vector to label X axis. */
```
Source
pbar.src

See Also
asclabel, xy, logx, logy, loglog, scale, hist

base10

Purpose
Breaks number into a number of the form #.#... and a power of 10.

Format
{ M, P } = base10(x);

Input
x     scalar, number to break down.

Output
M     scalar, in the range -10 < M < 10.
P     scalar, integer power such that:
M*10^P = x
Example

\[
\{ b, e \} = \textit{base10}(4500);
\]

After the code above:

\[
b = 4.5 \quad e = 3
\]

and

\[
b \times 10^e = 4.5 \times 10^3 = 4500
\]

Source

base10.src

begwind

Purpose

Initializes global graphic panel variables. NOTE: This function is for the deprecated PQG graphics.

Library

pgraph

Format

begwind;
Remarks

This procedure must be called before any other graphic panel functions are called.

Source

pwindow.src

See Also

endwind, window, makewind, nextwind, getwind

besselj

Purpose

Computes a Bessel function of the first kind, $J_n(x)$.

Format

$$y = \text{besselj}(n, x);$$

Input

<table>
<thead>
<tr>
<th>$n$</th>
<th>NxK matrix or P-dimensional array where the last two dimensions are NxK, the order of the Bessel function. Nonintegers will be truncated to an integer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>LxM matrix or P-dimensional array where the last two dimensions are LxM, ExE conformable with $n$.</td>
</tr>
</tbody>
</table>
Output

$Y$ \hspace{1cm} \text{max}(N,L)$ by \text{max}(K,M)$ matrix or P-dimensional array where the last two dimensions are \text{max}(N,L)$ by \text{max}(K,M)$.

Example

```plaintext
//Create the sequence 0.1, 0.2, 0.3,...,19.9
x = seqa(0, 0.1, 200);

//Calculate a first order Bessel function
ord = 1;
y0 = besselj(ord, x);

//Calculate the first and second order Bessel function
ord = {1 2};
y = besselj(ord, x);

//Plot the output of the first and third order Bessel
//functions
plotXY(x, y);
```

In the code above, the calculation of both the first and second order Bessel functions assigns the return from the first order calculation to be the first column of $y$ and the return from the calculation of the second order function to be the second column of $y$.

The `plotXY` function treats each incoming column as a separate line.

See Also

`bessely, mbesseli`
**bessely**

**Purpose**

Computes a Bessel function of the second kind (Weber's function), \( Y_n(x) \).

**Format**

\[ y = \text{bessely}(n, x); \]

**Input**

- \( n \)  
  NxK matrix or P-dimensional array where the last two dimensions are NxK, the order of the Bessel function. Nonintegers will be truncated to an integer.

- \( x \)  
  LxM matrix or P-dimensional array where the last two dimensions are LxM, ExE conformable with \( n \).

**Output**

- \( y \)  
  max(N,L) by max(K,M) matrix or P-dimensional array where the last two dimensions are max(N,L) by max(K,M).

**Example**

```plaintext
//Create the sequence 0.1, 0.2, 0.3, 0.4, 0.5
x = seqa(0.1, 0.1, 5);

//Create the sequence 1, 1.1, 1.2, 1.3, 1.4
```
x2 = seqa(1, 0.1, 5);

//Calculate a first order bessel function against 'x' and
//calculate a third order bessel function against 'x2'
//NOTE: The '~' provides horizontal concatenation
ord = { 1 3 };
y = bessely(ord, x~x2);

After the code above:

<table>
<thead>
<tr>
<th></th>
<th>0.100</th>
<th>1.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6.459</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3.324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2.293</td>
<td>0.300</td>
<td>1.200</td>
</tr>
<tr>
<td>-1.781</td>
<td>0.400</td>
<td>1.300</td>
</tr>
<tr>
<td>-1.471</td>
<td>0.500</td>
<td>1.400</td>
</tr>
</tbody>
</table>

See Also

bessel, mbesseli

beta

Purpose

Computes the standard Beta function, also called the Euler integral. The beta function is defined as:

\[ B(x, y) = \int_0^1 t^{x-1}(1 - t)^{y-1} \, dt \]

Format

\[ f = \text{beta}(x, y); \]

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**Input**

- $x$: scalar or NxK matrix; $x$ may be real or complex.
- $y$: LxM matrix, ExE conformable with $x$.

**Output**

- $f$: NxK matrix.

**Technical Notes**

The Beta function's relationship with the Gamma function is:

\[
\frac{\gamma(x) \times \gamma(y)}{\gamma(x + y)}
\]

**See Also**

cdfBeta, gamma, gammacplx, zeta

box

**Purpose**

Graphs data using the box graph percentile method. NOTE: This function uses the deprecated PQG graphics. Use `plotBox` instead.

**Library**

pgraph
Format

\texttt{box(grp, y);}

Input

\begin{itemize}
\item \textit{grp} 1xM vector. This contains the group numbers corresponding to each column of \textit{y} data. If scalar 0, a sequence from 1 to \texttt{cols(y)} will be generated automatically for the X axis.
\item \textit{y} NxM matrix. Each column represents the set of \textit{y} values for an individual percentiles box symbol.
\end{itemize}

Global Input

\begin{itemize}
\item \texttt{pboxctl} 5x1 vector, controls box style, width, and color.
\begin{itemize}
\item [1] box width between 0 and 1. If zero, the box plot is drawn as two vertical lines representing the quartile ranges with a filled circle representing the 50th percentile.
\item [2] box color. If this is set to 0, the colors may be individually controlled using the global variable \texttt{pcolor}.
\item [3] Min/max style for the box symbol. One of the following:
\begin{itemize}
\item [1] Minimum and maximum taken from the actual limits of the data. Elements 4 and 5 are ignored.
\end{itemize}
\end{itemize}
\end{itemize}
2 Statistical standard with the minimum and maximum calculated according to interquartile range as follows:

\[ \text{intqrang}e = 75\text{th} - 25\text{th} \]
\[ \text{min} = 25\text{th} - 1.5 \text{intqrang}e \]
\[ \text{max} = 75\text{th} + 1.5 \text{intqrang}e \]

Elements 4 and 5 are ignored.

3 Minimum and maximum percentiles taken from elements 4 and 5.


\_plctrl

1xM vector or scalar as follows:
0 Plot boxes only, no symbols.
1 Plot boxes and plot symbols which lie outside the \text{min} and \text{max} box values.
2 Plot boxes and all symbols.
-1 Plot symbols only, no boxes.

These capabilities are in addition to the usual line control capabilities of \_plctrl.

\_pcolor

1xM vector or scalar for symbol colors. If scalar, all symbols will be one color.
**Remarks**

If missing values are encountered in the $y$ data, they will be ignored during calculations and will not be plotted.

**Source**

pbox.src

**boxcox**

**Purpose**

Computes the Box-Cox function.

**Format**

$$y = \text{boxcox}(x, \lambda);$$

**Input**

- $x$  
  MxN matrix or P-dimensional array where the last two dimensions are MxN.

- $\lambda$  
  KxL matrix or P-dimensional array where the last two dimensions are KxL, ExE conformable to $x$.

**Output**

- $y$  
  max(M,L)xmax(N,K) or P-dimensional array where the last two dimensions are max(M,L)xmax(N,K).
Remarks

Allowable range for $x$ is: $x > 0$

The `boxcox` function computes:

$$\text{boxcox}(x) = \frac{x^\lambda - 1}{\lambda}$$

Example

```r
x = c(.2, .4, .8, 1, 1.2, 1.4);
lambda = .4;
y = boxcox(x, lambda);
```

After the code above:

```
-1.187
-0.767
y = -0.213
  0.000
  0.189
  0.360
```

break

Purpose

Breaks out of a `do` or `for` loop.

Format

```
break;
```
Example

```matlab
x = rndn(4, 4);

// Loop through each row of 'x' using 'r' as the loop // counter
for r(1, rows(x), 1);
    // For each row, loop through its elements
    for c(1, cols(x), 1);
        if c == r;  /* Set the diagonal to 1 */
            x[r, c] = 1;
        elseif c > r;  /* leave upper triangle as it is */
            break;  /* terminate inner loop */
        else;
            x[r, c] = 0;  /* set lower triangle elements to 0 */
        endif;
    endfor;
endfor;  /* break jumps to the statement after this endfor */
```

After running the code above, `x` should be a lower triangular matrix similar to below. Due to the use of random data, your matrix will have different non-zero elements above the diagonal.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>1.288</td>
<td>-0.060</td>
<td>1.801</td>
</tr>
<tr>
<td>0.000</td>
<td>1.000</td>
<td>1.609</td>
<td>1.474</td>
</tr>
<tr>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
<td>-0.768</td>
</tr>
<tr>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Remarks

This command works just like in C.

See Also

continue, do, for
call

Purpose

Calls a function or procedure when the returned value is not needed and can be ignored, or when the procedure is defined to return nothing.

Format

```
call function_name(argument_list);
call function_name;
```

Remarks

This is useful when you need to execute a function or procedure and do not need the value that it returns. It can also be used for calling procedures that have been defined to return nothing.

`function_name` can be any intrinsic GAUSS function, a procedure (proc), or any valid expression.

Example

```
call chol(x);
y = det1;
```
The above example is the fastest way to compute the determinant of a positive definite matrix. The result of **chol** is discarded and **detl** is used to retrieve the determinant that was computed during the call to **chol**.

**See Also**

**proc**

**cdfBeta**

**Purpose**

Computes the incomplete Beta function (i.e., the cumulative distribution function of the Beta distribution).

**Format**

\[ y = \text{cdfBeta}(x, a, b); \]

**Input**

\[ x \]  
NxK matrix.

\[ a \]  
LxM matrix, ExE conformable with \( x \).

\[ b \]  
PxQ matrix, ExE conformable with \( x \) and \( a \).

**Output**

\[ y \]  
max(N,L,P) by max(K,M,Q) matrix.
Remarks

*y* is the integral from 0 to *x* of the beta distribution with parameters *a* and *b*. Allowable ranges for the arguments are:

\[
0 \leq x \leq 1 \\
a > 0 \\
b > 0
\]

A -1 is returned for those elements with invalid inputs.

Example

```
x = { .1, .2, .3, .4 }; 
 a = 0.5; 
b = 0.3; 
y = cdfBeta(x,a,b); 
 0.1423 
y = 0.2066 
 0.2606 
 0.3109
```

See Also

cdfChic, cdfFc, cdfN, cdfNc, cdfTc, gamma

Technical Notes

cdfBeta has the following approximate accuracy:

\[
\begin{align*}
\text{max}(a, b) & \leq 500 & \text{absolute error is} & \approx \pm 5e-13 \\
500 & < \text{max}(a, b) & \leq 10,000 & \text{absolute error is} & \approx \pm 5e-11 \\
10,000 & < \text{max}(a, b) & \leq 200,000 & \text{absolute error is} & \approx \pm 1e-9
\end{align*}
\]
References


cdfBetaInv

Purpose

Computes the quantile or inverse of the Beta cumulative distribution function.

Format

\[ x = \text{cdfBetaInv}(p, a, b); \]

Input

- \( p \): NxK matrix, Nx1 vector or scalar. 0 < \( p \) < 1.
- \( a \): ExE conformable with \( p \). 0 < \( a \).
- \( b \): ExE conformable with \( p \). 0 < \( b \).
Output

$x$  
NxK matrix, Nx1 vector or scalar.

Remarks

For invalid inputs, cdfBetaInv will return a scalar error code which, when its value is assessed by function scalerr, corresponds to the invalid input. If the first input is out of range, scalerr will return a 1; if the second is out of range, scalerr will return a 2; etc.

See Also

cdfBeta, cdfBinomial, cdfNegBinomial

cdfBinomial

Purpose

Computes the binomial cumulative distribution function.

Format

$p = \text{cdfBinomial}(\text{successes, trials, prob});$

Input

$successes$  
NxK matrix, Nx1 vector or scalar. successes must be a positive number and < trials

$trials$  
ExE conformable with successes. trials must be >
successes.

prob
The probability of success on any given trial. ExE conforms with successes. $0 < \text{prob} < 1$.

Output

$p$
N$xK$ matrix, N$1$ vector or scalar.

Example

What are the chances that a baseball player with a long-term batting average of .317 could break Ichiro Suzuki's record of 270 hits in a season if he had as many at bats as Ichiro had that year, 704?

```p = \text{cdfBinomial}(270,704,.317); /* The cumulative probability of our player getting 270 or fewer hits in the season */```

$$p = 0.9999199430052614$$

Therefore the odds of this player breaking Ichiro's record:

$$= 1-p$$
$$= 0.0000000000037863 \text{ or } 0.0000000003786305\%$$

Remarks

For invalid inputs, \text{cdfBinomial} will return a scalar error code which, when its value is assessed by function \text{scalerr}, corresponds to the invalid input. If the first input is out of range, \text{scalerr} will return a 1; if the second is out of range, \text{scalerr} will return a 2; etc.
See Also

cdfBinomialInv, cdfNegBinomial

cdfBinomialInv

Purpose

Computes the binomial quantile or inverse cumulative distribution function.

Format

\[ s = \text{cdfBinomialInv}(p,\text{trials},\text{prob}); \]

Input

- \( p \) : NxK matrix, Nx1 vector or scalar. \( 0 < p < 1 \).
- \( \text{trials} \) : ExE conformable with \( p \). \( \text{trials} > 0 \).
- \( \text{prob} \) : The probability of success on any given trial. ExE conformable with \( p \). \( 0 < \text{prob} < 1 \).

Output

- \( s \) : The number of successes. NxK matrix, Nx1 vector or scalar.

Example

What is a reasonable range of wins for a basketball team playing 82 games in a
season, with a 60% chance of winning any game? For our example we will define a reasonable range as falling between the top and bottom deciles.

\[
\text{range} = \{ 0.10, 0.9 \};
\]
\[
s = \text{cdfBinomialInv}(\text{range}, 82, 0.6);
\]
\[
s = 43 \text{ to } 55
\]

This means that a team with a 60% chance of winning any one game would win between 43 and 55 games in 80% of seasons.

**Remarks**

For invalid inputs, \( \text{cdfBinomialInv} \) will return a scalar error code which, when its value is assessed by function \( \text{scalerr} \), corresponds to the invalid input. If the first input is out of range, \( \text{scalerr} \) will return a 1; if the second is out of range, \( \text{scalerr} \) will return a 2; etc.

**See Also**

\( \text{cdfBinomial} \), \( \text{cdfNegBinomial} \), \( \text{cdfNegBinomialInv} \)

**cdfBvn**

**Purpose**

Computes the cumulative distribution function of the standardized bivariate Normal density (lower tail).

**Format**

\[
c = \text{cdfBvn}(h, k, r);
\]
**Input**

- **h**: NxK matrix, the upper limits of integration for variable 1.
- **k**: LxM matrix, ExE conformable with **h**, the upper limits of integration for variable 2.
- **r**: PxQ matrix, ExE conformable with **h** and **k**, the correlation coefficients between the two variables.

**Output**

- **c**: max(N,L,P) by max(K,M,Q) matrix, the result of the double integral from $-\infty$ to $h$ and $-\infty$ to $k$ of the standardized bivariate Normal density $f(x, y, r)$.

**Remarks**

The function integrated is:

$$f(x, y, r) = \frac{e^{-0.5w}}{2\pi \sqrt{1-r^2}}$$

with

$$w = \frac{x^2 - 2rxy + y^2}{1 - r^2}$$

Thus, $x$ and $y$ have 0 means, unit variances, and correlation $= r$.

Allowable ranges for the arguments are:
\[ -\infty \leq h \leq +\infty \\
-\infty \leq k \leq +\infty \\
-1 < r < 1 \]

A -1 is returned for those elements with invalid inputs.

To find the integral under a general bivariate density, with \( x \) and \( y \) having nonzero means and any positive standard deviations, use the transformation equations:

\[
\begin{align*}
h &= (ht - ux) \div sx; \\
k &= (kt - uy) \\
\end{align*}
\]

where \( ux \) and \( uy \) are the (vectors of) means of \( x \) and \( y \), \( sx \) and \( sy \) are the (vectors of) standard deviations of \( x \) and \( y \), and \( ht \) and \( kt \) are the (vectors of) upper integration limits for the untransformed variables, respectively.

**See Also**

`cdfN`, `cdfTvn`

**Technical Notes**

The absolute error for `cdfBvn` is approximately \( \pm 5.0e-9 \) for the entire range of arguments.

**References**

**cdfBvn2**

**Purpose**

Returns the bivariate Normal cumulative distribution function of a bounded rectangle.

**Format**

\[ y = \text{cdfBvn2}(h, dh, k, dk, r); \]

**Input**

- \( h \)  \( \text{Nx1 vector, starting points of integration for variable 1.} \)
- \( dh \)  \( \text{Nx1 vector, increments for variable 1.} \)
- \( k \)  \( \text{Nx1 vector, starting points of integration for variable 2.} \)
- \( dk \)  \( \text{Nx1 vector, increments for variable 2.} \)
- \( r \)  \( \text{Nx1 vector, correlation coefficients between the two variables.} \)

**Output**

- \( y \)  \( \text{Nx1 vector, the integral over the rectangle bounded by } h, h + dh, k, \text{ and } k + dk \text{ of the standardized bivariate Normal distribution.} \)
Remarks

Scalar input arguments are okay; they will be expanded to Nx1 vectors.

\[ \text{cdfBvn2 computes:} \]
\[ \text{cdfBvn}(h + dh, k + dk, r) + \text{cdfBvn}(h, k, r) - \text{cdfBvn}(h, k + dk, r) - \text{cdfBvn}(h + dh, k, r) \]

\text{cdfBvn2} computes an error estimate for each set of inputs. The size of the error depends on the input arguments. If \text{trap 2} is set, a warning message is displayed when the error reaches 0.01*abs(y). For an estimate of the actual error, see \text{cdfBvn2e}.

Example

Example 1

```c
print cdfBvn2(1,-1,1,-1,0.5);
1.4105101488974692e-001
```

Example 2

```c
print cdfBvn2(1,-1e-15,1,-1e-15,0.5);
4.9303806576313238e-32
```

Example 3

```c
print cdfBvn2(1,-1e-45,1,-1e-45,0.5);
0.0000000000000000e+000
```

Example 4

```c
trap 2,2;
print cdfBvn2(1,-1e-45,1,1e-45,0.5);
```
WARNING: Dubious accuracy from cdfBvn2:
0.000e+000 +/- 2.8e-060
0.0000000000000000e+000

Source
lncdfn.src

See Also
cdfBvn2e, lncdfbvn2

cdfBvn2e

Purpose

Returns the bivariate Normal cumulative distribution function of a bounded rectangle.

Format

\[
\{ y, e \} = \text{cdfBvn2e}(h, dh, k, dk, r);
\]

Input

- **h**: Nx1 vector, starting points of integration for variable 1.
- **dh**: Nx1 vector, increments for variable 1.
- **k**: Nx1 vector, starting points of integration for variable 2.
- **dk**: Nx1 vector, increments for variable 2.
$r$  
Nx1 vector, correlation coefficients between the two variables.

**Output**

$y$  
Nx1 vector, the integral over the rectangle bounded by $h$, $h + dh$, $k$, and $k + dk$ of the standardized bivariate Normal distribution.

$e$  
Nx1 vector, an error estimate.

**Remarks**

Scalar input arguments are okay; they will be expanded to Nx1 vectors. cdfBvn2e computes:

\[
\text{cdfBvn}(h + dh, k + dk, r) + \text{cdfBvn}(h, k, r) - \text{cdfBvn}(h, k + dk, r) - \text{cdfBvn}(h + dh, k, r)
\]

The real answer is $y \pm e$. The size of the error depends on the input arguments.

**Example**

**Example 1**

```
print cdfBvn2e(1,-1,1,-1,0.5);
```

```
1.4105101488974692e-001
1.9927918166193113e-014
```

**Example 2**
Example 3

```
print cdfBvn2e(1,-1e-15,1,-1e-15,0.5);

7.3955709864469857e-032
2.8306169312687801e-030
```

**See Also**

cdfBvn2, lncdfbvn2

cdfCauchy

**Purpose**

Computes the cumulative distribution function for the Cauchy distribution.

**Format**

```
y = cdfCauchy(x,a,b);
```

**Input**

- `x`  
  N x K matrix, an N x 1 vector or scalar.

- `a`  
  Location parameter; N x K matrix, N x 1 vector or scalar, ExE conformable with `x`. 
\( b \)  Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \).  \( b \) must be greater than 0.

**Output**

\( y \)  NxK matrix, Nx1 vector or scalar.

**Remarks**

The cumulative distribution function for the Cauchy distribution is defined as:

\[
\frac{1}{2} + \frac{1}{\pi} \arctan \left( \frac{x - a}{b} \right)
\]

**See Also**

pdfCauchy

cdfCauchyInv

**Purpose**

Computes the Cauchy inverse cumulative distribution function.

**Format**

\[
y = \text{cdfCauchyInv}(p, a, b);
\]
**Input**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p )</td>
<td>NxK matrix, Nx1 vector or scalar. ( p ) must be greater than zero and less than 1.</td>
</tr>
<tr>
<td>( a )</td>
<td>Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( p ).</td>
</tr>
<tr>
<td>( b )</td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( p ). ( b ) must be greater than 0.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>NxK matrix, Nx1 vector or scalar.</td>
</tr>
</tbody>
</table>

**See Also**

pdfCauchy, cdfCauchy

cdfChic

**Purpose**

Computes the complement of the cdf of the chi-square distribution.

**Format**

\[ y = \text{cdfChic}(x, \ n); \]
### Input

- \( x \): NxK matrix.
- \( n \): LxM matrix, ExE conformable with \( x \).

### Output

- \( y \): max(N,L) by max(K,M) matrix.

### Remarks

- \( y \) is the integral from \( x \) to \( \infty \) of the chi-square distribution with \( n \) degrees of freedom.

The elements of \( n \) must all be positive integers. The allowable ranges for the arguments are:

- \( x > 0 \)
- \( n > 0 \)

A -1 is returned for those elements with invalid inputs.

This equals \( 1 - X_n^2(x) \), Thus, to get the chi-squared cdf, subtract \( \text{cdfChic}(x, n) \) from 1. The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

### Example

```c
x = { .1, .2, .3, .4 };
n = 3;
```
$y = \text{cdfChic}(x, n);$

0.991837
$y = 0.977589$
0.960028
0.940242

**See Also**

`cdfBeta`, `cdfFc`, `cdfNc`, `cdfTc`, `gamma`

**Technical Notes**

For $n \leq 1000$, the incomplete gamma function is used and the absolute error is approx. ±6e-13.

For $n > 1000$, a Normal approximation is used and the absolute error is ±2e-8.

For higher accuracy when $n > 1000$, use:

$$1 - \text{cdfGam}(0.5 \times x, 0.5 \times n);$$

**References**


cdfChii

**Purpose**

Compute chi-square abscissae values given probability and degrees of freedom.

**Format**

\[ c = \text{cdfChii}(p, n); \]

**Input**

- \( p \) : MxN matrix, probabilities.
- \( n \) : LxK matrix, ExE conformable with \( p \), degrees of freedom.

**Output**

- \( c \) : max(M,L) by max(N,K) matrix, abscissae values for chi-squared distribution.

**Example**

The following generates a 3x3 matrix of pseudo-random numbers with a chi-squared distribution with expected value of 4:

```plaintext
//Set the rng seed for repeatable random numbers
rndseed 464578;

//Set the 'probabilities' input equal to a 3x3 matrix of
```
//uniform random numbers and the degrees of freedom' input
//to be a 3x3 matrix with each element equal to '4'
x = cdfChii(rndu(3,3),4+zeros(3,3));

After the code above:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.934227</td>
<td>6.231914</td>
<td>4.227479</td>
<td></td>
</tr>
<tr>
<td>x = 2.647158</td>
<td>1.203957</td>
<td>10.559593</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.868060</td>
<td>1.368600</td>
<td>1.963283</td>
</tr>
</tbody>
</table>

**Source**
cdfchii.src

**See Also**
gammaii

cdfChinc

**Purpose**
Computes the cumulative distribution function for the noncentral chi-square distribution.

**Format**

\[ y = cdfChinc(x, \nu, d); \]

**Input**

\[ x \]

N\times1 vector, values of upper limits of integrals, must be
greater than 0.

\(v\) scalar, degrees of freedom, \(v > 0\).

\(d\) scalar, noncentrality parameter, \(d > 0\).

This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV, 1959.)

### Output

\(y\) Nx1 vector.

### Remarks

\(y\) is the integral from 0 to \(x\) of the noncentral chi-square distribution with \(v\) degrees of freedom and noncentrality \(d\).

\(\text{cdfChinc}\) can return a vector of values, but the degrees of freedom and noncentrality parameter must be the same for all values of \(x\).

For invalid inputs, \(\text{cdfChinc}\) will return a scalar error code which, when its value is assessed by function \(\text{scalerr}\), corresponds to the invalid input. If the first input is out of range, \(\text{scalerr}\) will return a 1; if the second is out of range, \(\text{scalerr}\) will return a 2; etc.

Relation to \(\text{cdfChic}\):

\[
\text{cdfChic}(x, v) = 1 - \text{cdfChinc}(x, v, 0);
\]
Example

```matlab
x = [.5, 1, 5, 25];
print cdfChinc(x, 4, 2);
```

The code above returns:

```
0.0042086234
0.016608592
0.30954232
0.99441140
```

See Also

cdfFnc, cdfTnc

cdfChincInv

Purpose

Computes the quantile or inverse of noncentral chi-square cumulative distribution function.

Format

```matlab
x = cdfChincInv(y, df, nonc);
```

Input

- **y**: NxK matrix, Nx1 vector or scalar. The integral from 0 to x.
### Output

**x**

NxK matrix, Nx1 vector or scalar. The upper limit of the integrals of the noncentral chi-square distribution with $df$ degrees of freedom and noncentrality $nonc$.

### Remarks

Note: Input $nonc$ is the square root of the noncentrality parameter that sometimes goes under the symbol lambda.

For invalid inputs, `cdfChinc` will return a scalar error code which, when its value is assessed by function `scalerr`, corresponds to the invalid input. If the first input is out of range, `scalerr` will return a 1; if the second is out of range, `scalerr` will return a 2; etc.

### See Also

`cdfChinc`, `cdfChic`, `cdfFnc`, `cdfTnc`
cdfExp

Purpose
Computes the cumulative distribution function for the exponential distribution.

Format

\[ y = \text{cdfExp}(x, a, m); \]

Input

- \( x \)  
  NxK matrix, an Nx1 vector or scalar.
- \( a \)  
  Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( a \) must be less than \( x \).
- \( m \)  
  Mean parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( m \) must be greater than 0.

Output

- \( y \)  
  NxK matrix, Nx1 vector or scalar.

Remarks
The cumulative distribution function for the exponential distribution is defined as
\[ 1 - \exp\left(-\frac{x-a}{b}\right) \]

**See Also**

pdfExp

cdfExpInv

**Purpose**

Computes the exponential inverse cumulative distribution function.

**Format**

\[ y = \text{cdfExpInv}(p, a, b); \]

**Input**

- **p**
  - NxK matrix, Nx1 vector or scalar. \( p \) must be greater than zero and less than 1.

- **a**
  - Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( p \).

- **b**
  - Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( p \). \( b \) must be greater than 0.
Output

\( y \)  
NxK matrix, Nx1 vector or scalar.

See Also

pdfExp, cdfExp

cdfFc

Purpose

Computes the complement of the cumulative distribution function of the \( F \) distribution.

Format

\[ y = \text{cdfFc}(x, n1, n2); \]

Input

\( x \)  
NxK matrix.

\( n1 \)  
LxM matrix, ExE conformable with \( x \).

\( n2 \)  
PxQ matrix, ExE conformable with \( x \) and \( n1 \).

Output

\( y \)  
max(N,L,P) by max(K,M,Q) matrix
Remarks

y is the integral from x to $\infty$ of the $F$ distribution with $n1$ and $n2$ degrees of freedom.

This equals

$$1 - G(x, n1, n2)$$

where $G$ is the $F$ cdf with $n1$ and $n2$ degrees of freedom. Thus, to get the $F$ cdf, use:

$$1 - \text{cdfFc}(x, n1, n2);$$

The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

Allowable ranges for the arguments are:

- $x > 0$
- $n1 > 0$
- $n2 > 0$

A -1 is returned for those elements with invalid inputs.

For max($n1,n2$) $\leq$ 1000, the absolute error is approx. $\pm5e-13$. For max($n1,n2$) $>$ 1000, Normal approximations are used and the absolute error is approx. $\pm2e-6$.

For higher accuracy when max($n1,n2$) $>$ 1000, use

$$\text{cdfBeta}(n2/(n2 + n1*x), n2/2, n1/2);$$

Example

```c
x = { .1, .2, .3, .4 };```

n1 = 0.5;
n2 = 0.3;
print cdfFc(x,n1,n2);

The code above, produces:

0.751772
0.708152
0.680365
0.659816

See Also
cdfBeta, cdfChic, cdfN, cdfNc, cdfTc, gamma

References


7. Pike, M.C. and I.D. Hill, "Remark on Algorithm 179 Incomplete Beta Ratio."
cdfFnc

Purpose

Computes the cumulative distribution function of the noncentral $F$ distribution.

Format

$$y = \text{cdfFnc}(x, \ n1, \ n2, \ d);$$

Input

- $x$ \hspace{1cm} Nx1 vector, values of upper limits of integrals, $x > 0$.
- $v1$ \hspace{1cm} scalar, degrees of freedom of numerator, $n1 > 0$.
- $v2$ \hspace{1cm} scalar, degrees of freedom of denominator, $n2 > 0$.
- $d$ \hspace{1cm} scalar, noncentrality parameter, $d > 0$.

This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV, 1959.)

Output

- $y$ \hspace{1cm} Nx1 vector.
Remarks

For invalid inputs, \texttt{cdfFnc} will return a scalar error code which, when its value is assessed by function \texttt{scalerr}, corresponds to the invalid input. If the first input is out of range, \texttt{scalerr} will return a 1; if the second is out of range, \texttt{scalerr} will return a 2; etc.

Technical Notes

Relation to \texttt{cdfFc}:

\[
\texttt{cdfFc}(x, n1, n2) = 1 - \texttt{cdfFnc}(x, n1, n2, 0);
\]

See Also

cdfTnc, cdfChinc

cdfFncInv

Purpose

Computes the quantile or inverse of noncentral \textit{F} cumulative distribution function.

Format

\[
x = \texttt{cdfFncInv}(y, dfn, dfd, nonc);
\]

Input

\[
y \quad \text{NxK matrix, Nx1 vector or scalar.}
\]
dfn: ExE conformable with $y$. The degrees of freedom numerator. $dfn > 0$.

dfd: ExE conformable with $y$. The degrees of freedom denominator. $dfd > 0$.

nonc: ExE conformable with $y$. The noncentrality parameter. Note: This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. $nonc > 0$.

Output

$x$: NxK matrix, Nx1 vector or scalar. The upper limit of the integrals of the noncentral $F$ distribution.

Remarks

Note: Input $nonc$ is the square root of the noncentrality parameter that sometimes goes under the symbol lambda.

For invalid inputs, $cdfFncInv$ will return a scalar error code which, when its value is assessed by function $scalerr$, corresponds to the invalid input. If the first input is out of range, $scalerr$ will return a 1; if the second is out of range, $scalerr$ will return a 2; etc.

See Also

cdfFnc, cdfChinc, cdfChic, cdfTnc
**cdfGam**

**Purpose**

Computes the incomplete gamma function.

**Format**

\[ g = \text{cdfGam}(x, \ intlim); \]

**Input**

- **x** \( \text{NxK matrix of data.} \)
- **intlim** \( \text{LxM matrix, ExE compatible with x, containing the integration limit.} \)

**Output**

- **g** \( \text{max(N,L) by max(K,M) matrix.} \)

**Remarks**

The incomplete gamma function returns the integral

\[ \int_{0}^{\int lim} \frac{e^{-t}t^{x-1}}{\Gamma(x)} dt \]

The allowable ranges for the arguments are:
\[ x > 0 \]
\[ \text{intlim} > 0 \]

A -1 is returned for those elements with invalid inputs.

**Example**

```matlab
x = [0.5 1 3 10];
intlim = seqa(0,.2,6);
g = cdfGam(x,intlim);
```

After the code above:

<table>
<thead>
<tr>
<th>x</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>0.200000</td>
<td>0.472911</td>
</tr>
<tr>
<td>intlim = 0.400000</td>
<td>g = 0.628907</td>
</tr>
<tr>
<td>0.600000</td>
<td>0.726678</td>
</tr>
<tr>
<td>0.800000</td>
<td>0.794097</td>
</tr>
<tr>
<td>1.000000</td>
<td>0.842701</td>
</tr>
</tbody>
</table>

This computes the integrals over the range from 0 to 1, in increments of 0.2, at the parameter values 0.5, 1, 3, 10.

**Technical Notes**

`cdfGam` has the following approximate accuracy:

- \( x < 500 \) : the absolute error is approx. ±6e-13
- \( 500 \leq x \leq 10,000 \) : the absolute error is approx. ±3e-11
- \( 10,000 < x \) : a Normal approximation is used and the absolute error is approx. ±3e-10
References


cdfGenPareto

Purpose

Computes the cumulative distribution function for the Generalized Pareto distribution.

Format

\[ y = \text{cdfGenPareto}(x, a, o, k); \]

Input

- **x**: NxK matrix, an Nx1 vector or scalar.
- **a**: Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x.
- **o**: Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x. o must be greater than 0.
$k$  
Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with $x$.

**Output**

$y$  
NxK matrix, Nx1 vector or scalar.

**Remarks**

The cumulative distribution function for the Generalized Pareto distribution is defined as:

$$f(x) = \begin{cases} 1 - \left(1 + k \frac{(x-\mu)}{\sigma}\right)^{-1/k} & k \neq 0 \\ \frac{1}{1 - \exp\left(-\frac{(x-\mu)}{\sigma}\right)} & k = 0 \end{cases}$$

**See Also**

pdfGenPareto

cdfLaplace

**Purpose**

Computes the cumulative distribution function for the Laplace distribution.

**Format**

$$y = \text{cdfLaplace}(x,a,b);$$
**Input**

- **x**: NxK matrix, an Nx1 vector or scalar.
- **a**: Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x.
- **b**: Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x. b must be greater than 0.

**Output**

- **y**: NxK matrix, Nx1 vector or scalar.

**Remarks**

The cumulative distribution function for the Laplace distribution is defined as

\[ F(x) = \begin{cases} \frac{1}{2} \exp(-\lambda(\mu - x)) & X \leq \mu \\ 1 - \frac{1}{2} \exp(-\lambda(\mu - x)) & X > \mu \end{cases} \]

**See Also**

- cdfLaplaceInv
**Purpose**

Computes the Laplace inverse cumulative distribution function.

**Format**

\[ y = \text{cdfLaplaceInv}(p, a, b); \]

**Input**

- **p**: NxK matrix, Nx1 vector or scalar. \( p \) must be greater than 0 and less than 1.
- **a**: Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( p \).
- **b**: Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( p \). \( b \) must be greater than 0.

**Output**

- **y**: NxK matrix, Nx1 vector or scalar.

**See Also**

- [cdfLaplace](#)
cdfLogistic

Purpose

Computes the cumulative distribution function for the logistic distribution.

Format

\[ y = \text{cdfLogistic}(x, a, b); \]

Input

<table>
<thead>
<tr>
<th>( x )</th>
<th>NxK matrix, an Nx1 vector or scalar.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( x ).</td>
</tr>
<tr>
<td>( b )</td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( x ). ( b ) must be greater than 0.</td>
</tr>
</tbody>
</table>

Output

| \( y \)  | NxK matrix, Nx1 vector or scalar. |

Remarks

The cumulative distribution function for the logistic distribution is defined as:

\[ F(x) = \frac{1}{1 + \exp(-z)} \]
where

\[ z \equiv \frac{x - \mu}{\sigma} \]

**See Also**

pdfLogistic

cdfLogisticInv

**Purpose**

Computes the logistic inverse cumulative distribution function.

**Format**

\[
y = \text{cdfLogisticInv}(p, a, b);
\]

**Input**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>p</strong></td>
<td>NxK matrix, Nx1 vector or scalar.  ( p ) must be greater than 0 and less than 1.</td>
<td></td>
</tr>
<tr>
<td><strong>a</strong></td>
<td>Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( p ).</td>
<td></td>
</tr>
<tr>
<td><strong>b</strong></td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( p ). ( b ) must be greater than 0.</td>
<td></td>
</tr>
</tbody>
</table>
# Output

| $y$ | NxK matrix, Nx1 vector or scalar. |

## See Also

pdfLogistic, cdfLogistic

# cdfMvn

## Purpose

Computes multivariate Normal cumulative distribution function.

## Format

$$y = \text{cdfMvn}(x, r);$$

## Input

| $x$ | KxL matrix, abscissae. |
| $r$ | KxK matrix, correlation matrix. |

## Output

| $y$ | Lx1 vector, $Pr(X < x|r)$ |

## Source

lncdfn.src
See Also

cdfBvn, cdfN, lncdfmvn

cdfMvnce

Purpose

Computes the complement of the multivariate Normal cumulative distribution function with error management.

Format

\[ \{y, err, retcode\} = \text{cdfMvnce}(ctl, x, r, m); \]

Input

\[ ctl \]
instance of a \texttt{cdfmControl} structure with members.

\[ ctl\.maxEvaluations \]
scalar, maximum number of evaluations.

\[ ctl\.absErrorTolerance \]
scalar absolute error tolerance.

\[ ctl\.relative \]
error tolerance.

\[ x \]
\( N \times K \) matrix, abscissae.

\[ r \]
\( K \times K \) matrix, correlation matrix.

\[ m \]
\( K \times 1 \) vector, means.
Output

| y | Lx1 vector, $Pr(X > x| r, m)$. |
|---|--------------------------------|
| err | Lx1 vector, estimates of absolute error. |
| retcode | Lx1 vector, return codes, |
| 0 | normal completion with $err < ctl.absErrorTolerance$. |
| 1 | $err > ctl.absErrorTolerance$ and $ctl.maxEvaluations$ exceeded; increase $ctl.maxEvaluations$ to decrease error. |
| 2 | $K > 100$ or $K < 1$. |
| 3 | $R$ not positive semi-definite. |
| missing | $R$ not properly defined. |

Remarks

cdfMvne evaluates the following integral

$$
\phi(x \in R, m) = \frac{1}{\sqrt{|R|} (2\pi)^m} \int_{-\infty}^{\infty} \ldots \int_{-\infty}^{\infty} e^{-\frac{1}{2} (x-m)^T R^{-1} (x-m)} dz
$$

Source
cdfm.src

See Also
cdfMvn2e, cdfMvnce, cdfMvte
References


cdfMvne

Purpose

Computes multivariate Normal cumulative distribution function with error management.

Format

\[
\{y, \text{err, retcode}\} = \text{cdfMvne}(\text{ctl}, x, r, m);
\]

Input

- **ctl** instance of a **cdfmControl** structure with members.
  - *ctl.maxEvaluations* scalar, maximum number of evaluations.
  - *ctl.absErrorTolerance* scalar absolute error tolerance.
  - *ctl.relative* error tolerance.
- **x** NxK matrix, abscissae.
\( r \) \( \) KxK matrix, correlation matrix.

\( m \) \( \) Kx1 vector, means.

**Output**

\( y \) \( \) Lx1 vector, \( Pr(X < x|r,m) \).

\( err \) \( \) Lx1 vector, estimates of absolute error.

\( retcode \) \( \) Lx1 vector, return codes.

\[
\begin{array}{ll}
0 & \text{normal completion with } err < \text{ctl.absErrorTolerance.} \\
1 & \text{err} > \text{ctl.absErrorTolerance and } \\
 & \text{ctl.maxEvaluations exceeded; increase } \\
 & \text{ctl.maxEvaluations to decrease error} \\
2 & K > 100 \text{ or } K < 1 \\
3 & R \text{ not positive semi-definite} \\
\text{missing} & R \text{ not properly defined}
\end{array}
\]

**Example**

```c
x = { 0.5 -0.5, \
    0.1  0.7, \
    1.3 -0.9 }; \\

cor = { 1 0, \
       0 1 }; \\
```
\[
m = \{ 0, 0, 0 \};
\]

//Declare cdfmControl structure
struct cdfmControl ctl;

//Fill in control structure
//with default values
ctl = cdfmControlCreate();

\{ y, err, ret \} = cdfmvne(ctl, x, cor, m);

After the code above:

\[
y = \\
0.21334213 \\
0.40920912 \\
0.16624302
\]

**Remarks**

cdfMvne evaluates the following integral

\[
\Phi(x_i, R, m) = \frac{1}{\sqrt{|R| (2\pi)^m}} \int_{-\infty}^{x_{i1}} \int_{-\infty}^{x_{i2}} \ldots \int_{-\infty}^{x_{ik}} e^{-\frac{1}{2}(z-m)^T R^{-1}(z-m)} \, dz
\]

**Source**
cdfm.src

**See Also**
cdfmControlCreate, cdfMvn2e, cdfMvte
References


cdfMvn2e

**Purpose**

Computes the multivariate Normal cumulative distribution function with error management over the range [a,b].

**Format**

\[
\{y, err, retcode\} = \text{cdfMvn2e}(ctl, a, b, r, m);
\]

**Input**

<table>
<thead>
<tr>
<th>ctl</th>
<th>instance of a cdfmControl structure with members.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctl.maxEvaluations</td>
<td>scalar, maximum number of evaluations.</td>
</tr>
<tr>
<td>ctl.absErrorTolerance</td>
<td>scalar absolute error tolerance.</td>
</tr>
<tr>
<td>ctl.relative</td>
<td>error tolerance.</td>
</tr>
<tr>
<td>a</td>
<td>NxK matrix, lower limits.</td>
</tr>
</tbody>
</table>
\( b \)  
N\times K matrix, upper limits.

\( r \)  
K\times K matrix, correlation matrix.

\( m \)  
K\times 1 vector, means.

**Output**

\( y \)  
L\times 1 vector, \( Pr(X > a \text{ and } X < b | r, m) \).

\( err \)  
L\times 1 vector, estimates of absolute error.

\( retcode \)  
L\times 1 vector, return codes.

0  
normal completion with \( err < \) \( ctl.absErrorTolerance \).

1  
\( err > \) \( ctl.absErrorTolerance \) and \( ctl.maxEvaluations \) exceeded; increase \( ctl.maxEvaluations \) to decrease error.

2  
K > 100 or K < 1.

3  
\( R \) not positive semi-definite.

missing  
\( R \) not properly defined.

**Remarks**

\texttt{cdfMvne} evaluates the following integral

\[
\Phi(a_i, b_i, R, m) = \frac{1}{\sqrt{|R| (2\pi)^m}} \int_{a_{i1}}^{b_{i1}} \int_{a_{i2}}^{b_{i2}} \ldots \int_{a_{iK}}^{b_{iK}} e^{-\frac{1}{2}(z-m')'R(z-m')} \, dz
\]
Source

cdfm.src

See Also

cdfmControlCreate, cdfMvne, cdfMvnce, cdfMvt2e

References


cdfMvtce

Purpose

Computes complement of multivariate Student's t cumulative distribution function with error management.

Format

\[
\{y, \ err, \ retcode\} = \text{cdfMvtce}(ctl, x, R, m, n);
\]

Input

- **ctl** instance of a *cdfmControl* structure with members.
  - `ctl.maxEvaluations` scalar, maximum number of
Evaluations.

- `ctl.absErrorTolerance`: scalar absolute error tolerance.
- `ctl.relErrorTolerance`: tolerance.

**Input**

- `x`: NxK matrix, abscissae.
- `R`: KxK matrix, correlation matrix.
- `m`: Kx1 vector, noncentralities.
- `n`: scalar, degrees of freedom.

**Output**

- `y`: Lx1 vector, \( Pr(X > x | r, m) \).
- `err`: Lx1 vector, estimates of absolute error.
- `retcode`: Lx1 vector, return codes.
  - 0: normal completion with \( err < ctl.absErrorTolerance \).
  - 1: \( err > ctl.absErrorTolerance \) and \( ctl.maxEvaluations \) exceeded; increase \( ctl.maxEvaluations \) to decrease error.
  - 2: \( K > 100 \) or \( K < 1 \).
  - 3: \( R \) not positive semi-definite.
  - missing: \( R \) not properly defined.
Remarks

The central multivariate Student's t cdf for the i-th row of \( x \) is defined by

\[
T(x_i, R, n) = \frac{\Gamma\left(\frac{n+K}{2}\right)}{\Gamma\left(\frac{n}{2}\right)} \left| R \right|^{-\frac{n}{2}} \int_{x_{i1}}^{\infty} \int_{x_{i2}}^{\infty} \cdots \int_{x_{iK}}^{\infty} \left(1 + \frac{z' \Sigma^{-1} z}{n}\right)^{-\frac{n+K}{2}} dz
\]

\[
= \frac{2^{1-n}}{\Gamma\left(\frac{m}{2}\right)} \int_{x_{i1}}^{\infty} s^{n-1} e^{-\frac{s^2}{2}} \Phi\left(-\infty, \frac{sx_i}{\sqrt{m}}, R\right) ds
\]

where

\[
\Phi(x_i, R, m) = \frac{1}{\sqrt{|R| (2\pi)^m}} \int_{x_{i1}}^{\infty} \int_{x_{i2}}^{\infty} \cdots \int_{x_{iK}}^{\infty} e^{-\frac{1}{2}(z-m)'R^{-1}(z-m)'} dz
\]

For the noncentral cdf we have

\[
T(x_i, R, n, m) = \frac{2^{1-n}}{\Gamma\left(\frac{m}{2}\right)} \int_{0}^{\infty} s^{n-1} e^{-\frac{s^2}{2}} \Phi\left(\frac{sx_i}{\sqrt{m}} - m', \infty, R\right) ds
\]

Source

cdfm.src

See Also

cdfMvt2e, cdfMvtc, cdfMvne


### cdfMvte

#### Purpose

Computes multivariate Student's t cumulative distribution function with error management.

#### Format

\[
\{y, \text{err}, \text{retcode}\} = \text{cdfMvte}(\text{ctl}, x, R, m, n);
\]

#### Input

- **ctl**: instance of a `cdfmControl` structure with members.
  - `ctl.maxEvaluations`: scalar, maximum number of evaluations.
  - `ctl.absErrorTolerance`: scalar absolute error tolerance.
  - `ctl.relErrorTolerance`: tolerance.
- **x**: NxK matrix, abscissae.
- **R**: KxK matrix, correlation matrix.
- **m**: Kx1 vector, noncentralities.
- **n**: scalar, degrees of freedom.
Output

\[ y \]  \ Lx1 \ vector, \Pr(X < x|r,m).

\[ err \]  \ Lx1 \ vector, \ estimates \ of \ absolute \ error.

\[ retcode \]  \ Lx1 \ vector, \ return \ codes.

\( 0 \)  \ normal \ completion \ with \ \text{err} < \text{ctl.absErrorTolerance}.

\( 1 \)  \ \text{err} > \text{ctl.absErrorTolerance} \ and \ \text{ctl.maxEvaluations} \ exceeded; \ increase \ \text{ctl.maxEvaluations} \ to \ decrease \ \text{error}.

\( 2 \)  \ K > 100 \ or \ K < 1.

\( 3 \)  \ R \ not \ positive \ semi-definite.

\textit{missing}  \ R \ not \ properly \ defined.

Remarks

The central multivariate Student's t cdf for the i-th row of \( x \) is defined by

\[
T(x_i, R, n) = \frac{\Gamma\left(\frac{n+K}{2}\right)}{\Gamma\left(\frac{n}{2}\right)\sqrt{|R|(n\pi)^K}} \int_{x_{i1}}^{\infty} \int_{x_{i2}}^{\infty} \cdots \int_{x_{iK}}^{\infty} \left(1 + z'\Sigma^{-1}z\right)^{-\frac{n+K}{2}} \, dz
\]

\[
= 2^{1-\frac{n}{2}} \Gamma\left(\frac{m}{2}\right) \int_{x_{i1}}^{\infty} e^{-\frac{x_i^2}{2}} \Phi\left(-\infty, \frac{sx_i}{\sqrt{m}}, R\right) \, ds
\]

where
\[ \Phi(x_i, R, m) = \frac{1}{\sqrt{|R|} (2\pi)^m} \int_{x_{i1}}^{\infty} \cdots \int_{x_{iK}}^{\infty} e^{-\frac{1}{2}z'R^{-1}z} \, dz \]

For the noncentral cdf we have

\[ T(x_i, R, n, m) = 2^{\frac{i-\frac{n}{2}}{2}} \int_0^{\infty} s^{n-1} e^{-\frac{s^2}{2}} \Phi\left(-\infty, \frac{sx_i}{\sqrt{n}} - m', R\right) \, ds \]

### Source

cdfm.src

### See Also

cdfMvte, cdfMvt2e, cdfMvnce


### cdfMvt2e

#### Purpose

Computes multivariate Student's t cumulative distribution function with error management over [a,b].

#### Format

\[
\{y, \text{err, retcode}\} = \text{cdfMvt2e} (ctl, a, b, R, m, n);
\]
Input

<table>
<thead>
<tr>
<th>ctl</th>
<th>instance of a <code>cdfmControl</code> structure with members.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>ctl.maxEvaluations</code> scalar, maximum number of evaluations.</td>
</tr>
<tr>
<td></td>
<td><code>ctl.absErrorTolerance</code> scalar absolute error tolerance.</td>
</tr>
<tr>
<td></td>
<td><code>ctl.relErrorTolerance</code> tolerance.</td>
</tr>
<tr>
<td>a</td>
<td>NxK matrix, lower limits.</td>
</tr>
<tr>
<td>b</td>
<td>NxK matrix, upper limits.</td>
</tr>
<tr>
<td>R</td>
<td>KxK matrix, correlation matrix.</td>
</tr>
<tr>
<td>m</td>
<td>Kx1 vector, noncentralities.</td>
</tr>
<tr>
<td>n</td>
<td>scalar, degrees of freedom.</td>
</tr>
</tbody>
</table>

Output

| y   | Lx1 vector, a $\Pr(X > a \text{ and } X < b|r,m)$.
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>err</td>
<td>Lx1 vector, estimates of absolute error.</td>
</tr>
<tr>
<td>retcode</td>
<td>Lx1 vector, return codes.</td>
</tr>
<tr>
<td>0</td>
<td>normal completion with $\text{err} &lt; \text{ctl.absErrorTolerance}$.</td>
</tr>
<tr>
<td>1</td>
<td>$\text{err} &gt; \text{ctl.absErrorTolerance}$ and $\text{ctl.maxEvaluations}$ exceeded; increase $\text{ctl.maxEvaluations}$ to decrease error.</td>
</tr>
</tbody>
</table>
2 \quad K > 100 \text{ or } K < 1.

3 \quad R \text{ not positive semi-definite.}

missing \quad R \text{ not properly defined.}

**Remarks**

The central multivariate Student's t cdf for the i-th row of $x$ is defined by

$$T(x_i, R, n) = \frac{\Gamma\left(\frac{n + K}{2}\right)}{\Gamma\left(\frac{n}{2}\right)\sqrt{|R| (n\pi)^K}} \int_{x_i1}^{\infty} \int_{x_i2}^{\infty} \cdots \int_{x_iK}^{\infty} \frac{(1 + \frac{z' \Sigma^{-1} z}{n})^{-\frac{n + K}{2}}}{s} ds$$

$$\equiv 2^{l - \frac{n}{2}} \frac{n}{\Gamma\left(\frac{n}{2}\right)} \int_0^{\infty} s^{n-1} e^{-\frac{x^2}{2}} \Phi\left(-\infty, \frac{sx_i}{\sqrt{n}}, R\right) ds$$

where

$$\Phi(x_i, R, m) = \frac{1}{\sqrt{|R| (2\pi)^m}} \int_{x_i1}^{\infty} \int_{x_i2}^{\infty} \cdots \int_{x_iK}^{\infty} e^{-\frac{1}{2} z' R^{-1} z} dz$$

For the noncentral cdf we have

$$T(x_i, R, n, m) = \frac{2^{l - \frac{n}{2}}}{\Gamma\left(\frac{n}{2}\right)} \int_{0}^{\infty} s^{n-1} e^{-\frac{x^2}{2}} \Phi\left(-\infty, \frac{sx_i}{\sqrt{n}} - m', R\right) ds$$

**See Also**

cdfMvte, cdfMvtce, cdfMvn2e
**Source**
cdfm.src


**cdfN, cdfNc**

**Purpose**

`cdfN` computes the cumulative distribution function (cdf) of the Normal distribution. `cdfNc` computes 1 minus the cdf of the Normal distribution.

**Format**

```matlab
n = cdfN(x);
nc = cdfNc(x);
```

**Input**

`x`  
NxK matrix.

**Output**

`n`  
NxK matrix.

`nc`  
NxK matrix.
Remarks

\( n \) is the integral from \(-\infty\) to \(x\) of the Normal density function, and \( n_c \) is the integral from \(x\) to \(+\infty\).

Note that:

\[
\text{cdf}_N(x) + \text{cdf}_N(x) = 1
\]

However, many applications expect \( \text{cdf}_N(x) \) to approach 1, but never actually reach it. Because of this, we have capped the return value of \( \text{cdf}_N \) at 1 - machine epsilon, or approximately 1 - 1.11e-16. As the relative error of \( \text{cdf}_N \) is about \( \pm5e-15 \) for \( \text{cdf}_N(x) \) around 1, this does not invalidate the result. What it does mean is that for \( \text{abs}(x) \) > (approx.) 8.2924, the identity does not hold true. If you have a need for the uncapped value of \( \text{cdf}_N \), the following code will return it:

```c
n = cdfN(x);
if n >= 1-eps;
    n = 1;
endif;
```

where the value of machine epsilon is obtained as follows:

```c
x = 1;
do while 1-x /= 1;
    eps = x;
    x = x/2;
endo;
```

Note that this is an alternate definition of machine epsilon. Machine epsilon is usually defined as the smallest number such that \(1 + \text{machine epsilon} > 1\), which is about \(2.23e-16\). This defines machine epsilon as the smallest number such that \(1 - \text{machine epsilon} < 1\), or about \(1.11e-16\).
The \texttt{erf} and \texttt{erfc} functions are also provided, and may sometimes be more useful than \texttt{cdfN} and \texttt{cdfNc}.

**Example**

```plaintext
x = { -2 -1 0 1 2 };
n = cdfN(x);
nc = cdfNc(x);

x = -2.0000000 -1.0000000 0.0000000 1.0000000 2.0000000
n = 0.0227501 0.15865525 0.5000000 0.8413447 0.9772498
nc = 0.9772498 0.84134475 0.5000000 0.1586552 0.0227501
```

**See Also**

\texttt{erf}, \texttt{erfc}, \texttt{cdfBeta}, \texttt{cdfChic}, \texttt{cdfTc}, \texttt{cdfFc}, \texttt{gamma}

**Technical Notes**

For the integral from $\infty$ to $x$:

\[
\begin{align*}
x & \leq -37 & \text{cdfN underflows and 0.0 is returned} \\
-36 & < x < -10 & \text{cdfN has a relative error of approx. } \pm 5\times10^{-12}
\end{align*}
\]
-10 < x < 0 \quad \text{cdfN has a relative error of approx. } \pm 1e-13

0 < x \quad \text{cdfN has a relative error of approx. } \pm 5e-15

For \text{cdfNc}, i.e., the integral from x to +\infty, use the above accuracies but change x to -x.

References


cdfNegBinomial

Purpose
Computes the cumulative distribution function for the negative binomial distribution.

Format
\[ p = \text{cdfNegBinomial}(f, s, \text{prob}); \]

Input
- \( f \): NxK matrix, Nx1 vector or scalar. \( 0 < f \).
- \( s \): ExE conformable with \( f.0 < s \).
- \( \text{prob} \): The probability of success on any given trial. ExE conformable with \( f.0 < \text{prob} < 1 \).

Output
- \( p \): NxK matrix, Nx1 vector or scalar. The probability of observing \( f \) failures before observing \( s \) successes.

Remarks
For invalid inputs, \text{cdfNegBinomial} will return a scalar error code which, when its value is assessed by function \text{scalerr}, corresponds to the invalid input. If the first input is out of range, \text{scalerr} will return a 1; if the second is out of range, \text{scalerr} will return a 2; etc.
See Also

cdfBinomial, cdfBinomialInv, cdfNegBinomialInv

cdfNegBinomialInv

Purpose

Computes the quantile or inverse negative binomial cumulative distribution function.

Format

\[ f = \text{cdfNegBinomialInv}(p, s, \text{prob}); \]

Input

\( p \)  
NxK matrix, Nx1 vector or scalar. 0 < \( f < 1 \).
\( s \)  
ExE conformable with \( p \). 0 < \( s \).
\( \text{prob} \)  
The probability of success on any given trial. ExE conformable with \( p \). 0 < \( \text{prob} < 1 \).

Output

\( f \)  
NxK matrix, Nx1 vector or scalar.

Remarks

For invalid inputs, \text{cdfNegBinomialInv} will return a scalar error code which,
when its value is assessed by function \texttt{scalerr}, corresponds to the invalid input. If the first input is out of range, \texttt{scalerr} will return a 1; if the second is out of range, \texttt{scalerr} will return a 2; etc.

\textbf{See Also}

\texttt{cdfBinomial, cdfBinomialInv, cdfNegBinomial}

\textbf{cdfN2}

\textbf{Purpose}

Computes interval of Normal cumulative distribution function.

\textbf{Format}

\begin{verbatim}
y = cdfN2(x, dx);
\end{verbatim}

\textbf{Input}

\begin{itemize}
  \item \textbf{x} \hspace{1cm} MxN matrix, abscissae.
  \item \textbf{dx} \hspace{1cm} KxL matrix, ExE conformable to \textbf{x}, intervals.
\end{itemize}

\textbf{Output}

\begin{itemize}
  \item \textbf{y} \hspace{1cm} max(M,K) by max(N,L) matrix, the integral from \textbf{x} to \textbf{x} + \textbf{dx} of the Normal distribution, i.e., \( Pr(x < X < x + dx) \). 
\end{itemize}
Remarks

The relative error is:

\[
|x| \leq 1 \quad \text{and} \quad dx \leq 1 \quad \pm 1 \cdot 10^{-14}
\]

\[
1 < |x| < 37 \quad \text{and} \quad |dx| < 1/|x| \quad \pm 1 \cdot 10^{-13}
\]

\[
\min(x, x + dx) > -37 \quad \text{and} \quad y > 10^{-300} \quad \pm 1 \cdot 10^{-11} \text{ or better}
\]

A relative error of \(\pm 10^{-14}\) implies that the answer is accurate to better than \(\pm 1\) in the 14th digit.

Example

```c
print cdfN2(1,0.5);
9.1848052662599017e-02
print cdfN2(20,0.5);
2.7535164718736454e-89
print cdfN2(20,1e-2);
5.0038115018684521e-90
print cdfN2(-5,2);
1.3496113800582164e-03
print cdfN2(-5,0.15);
```
Source
lncdfn.src

See Also
lncdfn2

cdfNi

Purpose
Computes the inverse of the cdf of the Normal distribution.

Format
\[ x = \text{cdfNi}(p); \]

Input
\[ p \]      NxK real matrix, Normal probability levels, 0 <= p <= 1.

Output
\[ x \]      NxK real matrix, Normal deviates, such that:
\[ \text{cdfN}(x) = p. \]
Remarks

\[ cdfN(cdfNi(p)) = p \] to within the errors given below:

\[ p \leq 4.6e-308 \quad \text{-37.5 is returned} \]

\[ 4.6e-308 < p < 5e-24 \quad \text{accurate to } \pm 5 \text{ in 12th digit} \]

\[ 5e-24 < p < 0.5 \quad \text{accurate to } \pm 1 \text{ in 13th digit} \]

\[ 0.5 < p < 1 - 2.22045e-16 \quad \text{accurate to } \pm 5 \text{ in 15th digit} \]

\[ p \geq 1 - 2.22045e-16 \quad 8.12589 \text{ is returned} \]

See Also

*cdfN*

*cdfPoisson*

Purpose

Computes the Poisson cumulative distribution function.

Format

\[
p = \text{cdfPoisson}(x, \lambda);\]

Input

* x \quad \text{NxK matrix, Nx1 vector or scalar. } x \text{ must be a positive whole number.}

* \lambda \quad \text{ExE conformable with } x. \text{ The mean parameter.}
Output

\[ p \]

NxK matrix, Nx1 vector or scalar.

Remarks

For invalid inputs, \texttt{cdfPoisson} will return a scalar error code which, when its value is assessed by function \texttt{scalerr}, corresponds to the invalid input. If the first input is out of range, \texttt{scalerr} will return a 1; if the second is out of range, \texttt{scalerr} will return a 2; etc.

Example

Suppose that a hospital emergency department sees an average of 200 patients during the Friday evening shift. What is the probability that they will see fewer than 250 patients during any one Friday evening shift.

\[
p = \texttt{cdfPoisson}(250, 200);
p = 0.99971538 \text{ or } 99.715\%
\]

See Also

\texttt{cdfPoissonInv}, \texttt{cdfBinomial}, \texttt{cdfNegBinomial}

\textbf{cdfPoissonInv}

Purpose

Computes the quantile or inverse Poisson cumulative distribution function.
Format

\[ x = \text{cdfPoissonInv}(p, \lambda); \]

Input

\( p \) \hspace{1cm} \text{NxK matrix, Nx1 vector or scalar.} \hspace{0.5cm} 0 < p < 1. \\
\( \lambda \) \hspace{1cm} \text{ExE conformable with} \ p. \text{ The mean parameter.}

Output

\( x \) \hspace{1cm} \text{NxK matrix, Nx1 vector or scalar.}

Example

Suppose that a hospital emergency department sees an average of 200 patients during the Friday evening shift. If the hospital wants to have enough staff on hand to handle the patient load on 95% of Friday evenings, how many patients do they need staff on hand for?

\[ x = \text{cdfPoissonInv}(.95, 200); \]
\[ p = 224 \]

The hospital should expect to see 224 or few patients on 95% of Friday evenings.

Remarks

For invalid inputs, \textit{cdfPoissoninv} will return a scalar error code which, when its value is assessed by function \textit{scalerr}, corresponds to the invalid input. If the first input is out of range, \textit{scalerr} will return a 1; if the second is out of range,
**See Also**

cdfPoisson, cdfBinomial, cdfNegBinomial,

cdfRayleigh

**Purpose**

Computes the Rayleigh cumulative distribution function.

**Format**

\[ y = \text{cdfRayleigh}(x,b); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>NxK matrix, an Nx1 vector or scalar. (x) must be greater than 0.</td>
</tr>
<tr>
<td>(b)</td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with (x). (b) must be greater than 0.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>NxK matrix, Nx1 vector or scalar.</td>
</tr>
</tbody>
</table>

**Remarks**

The Rayleigh cumulative distribution function is defined as
\[ 1 - \exp\left(\frac{-x^2}{2\sigma^2}\right) \]

**See Also**

cdfRayleighInv, pdfRayleigh

cdfRayleighInv

**Purpose**

Computes the Rayleigh inverse cumulative distribution function.

**Format**

\[ y = \text{cdfRayleighInv}(p, b); \]

**Input**

- \( p \): NxK matrix, Nx1 vector or scalar. \( p \) must be greater than 0 and less than 1.
- \( b \): Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( p \). \( b \) must be greater than 0.

**Output**

- \( y \): NxK matrix, Nx1 vector or scalar.
See Also

\texttt{pdfRayleigh}, \texttt{cdfRayleigh}

cdfTc

Purpose

Computes the complement of the cdf of the Student's \( t \) distribution.

Format

\[ y = \text{cdfTc}(x, \ n); \]

Input

\begin{itemize}
  \item \( x \) \quad \text{NxK matrix.}
  \item \( n \) \quad \text{LxM matrix, ExE conformable with } x.
\end{itemize}

Output

\begin{itemize}
  \item \( y \) \quad \text{max(N,L) by max(K,M) matrix.}
\end{itemize}

Remarks

\( y \) is the integral from \( x \) to \( \infty \) of the \( t \) distribution with \( n \) degrees of freedom.

Allowable ranges for the arguments are:
\[-\infty \leq x \leq +\infty\]
\[n > 0\]

A -1 is returned for those elements with invalid inputs.

This equals:
\[1 - F(x, n)\]

where \(F\) is the \(t\) cdf with \(n\) degrees of freedom. Thus, to get the \(t\) cdf, subtract \(\text{cdfTc}(x, n)\) from 1. The complement of the cdf is computed because this is what is most commonly needed in statistical applications, and because it can be computed with fewer problems of roundoff error.

**Example**

```matlab
x = { .1, .2, .3, .4 };
n = 3;
y = \text{cdfTc}(x,n);
```

0.46332617
0.42713516

\[y = 0.39188165\]
\[0.35796758\]

**See Also**

\(\text{cdfTci}\)

**Technical Notes**

For results greater than 0.5e-30, the absolute error is approx. \(\pm 1e-14\) and the relative error is approx. \(\pm 1e-12\). If you multiply the relative error by the result, then take the minimum of that and the absolute error, you have the maximum actual error for any
result. Thus, the actual error is approx. ±1e-14 for results greater than 0.01. For results less than 0.01, the actual error will be less. For example, for a result of 0.5e-30, the actual error is only ±0.5e-42.

References


**cdfTci**

*Purpose*

Computes the inverse of the complement of the Student's $t$ cdf.

*Format*

\[ x = \text{cdfTci}(p, n); \]

*Input*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$p$</td>
<td>NxK real matrix, complementary Student's $t$ probability levels, $0 \leq p \leq 1$.</td>
</tr>
<tr>
<td>$n$</td>
<td>LxM real matrix, degrees of freedom, $n &gt; 1$, $n$ need not be integral. ExE conformable with $p$.</td>
</tr>
</tbody>
</table>
Output

\[ x \quad \text{max}(N,L) \text{ by } \text{max}(K,M) \text{ real matrix, Student's } t \text{ deviates,} \]
\[ \text{such that } \text{cdfTc}(x, n) = p. \]

Remarks

\[ \text{cdfTc(cdfTci}(p, n)) = p \text{ to within the errors given below:} \]
\[
\begin{align*}
0.5e-30 & < p & < 0.01 & \text{ accurate to } \pm 1 \text{ in 12th digit} \\
0.01 & < p & & \text{ accurate to } \pm 1e-14
\end{align*}
\]

Extreme values of arguments can give rise to underflows, but no overflows are generated.

See Also

cdfTc

cdfTnc

Purpose

The integral under noncentral Student's \( t \) distribution, from \( -\infty \) to \( x \). It can return a vector of values, but the degrees of freedom and noncentrality parameter must be the same for all values of \( x \).

Format

\[ y = \text{cdfTnc}(x, v, d); \]
**Input**

- $x$: Nx1 vector, values of upper limits of integrals.
- $v$: scalar, degrees of freedom, $v > 0$.
- $d$: scalar, noncentrality parameter.

This is the square root of the noncentrality parameter that sometimes goes under the symbol lambda. (See Scheffe, *The Analysis of Variance*, App. IV, 1959.)

**Output**

- $y$: Nx1 vector, integrals from $-\infty$ to $x$ of noncentral $t$.

**Remarks**

$$\text{cdfTc}(x, \ v) = 1 - \text{cdfTnc}(x, \ v, 0).$$

**See Also**

cdfFnc, cdfChinc

cdfTvn

**Purpose**

Computes the cumulative distribution function of the standardized trivariate Normal density (lower tail).
### Format

\[ c = \text{cdfTvn}(x_1, x_2, x_3, \rho_{12}, \rho_{23}, \rho_{13}); \]

### Input

- **x1**: Nx1 vector of upper limits of integration for variable 1.
- **x2**: Nx1 vector of upper limits of integration for variable 2.
- **x3**: Nx1 vector of upper limits of integration for variable 3.
- **\rho_{12}**: scalar or Nx1 vector of correlation coefficients between the two variables \( x_1 \) and \( x_2 \).
- **\rho_{23}**: scalar or Nx1 vector of correlation coefficients between the two variables \( x_2 \) and \( x_3 \).
- **\rho_{13}**: scalar or Nx1 vector of correlation coefficients between the two variables \( x_1 \) and \( x_3 \).

### Output

- **c**: Nx1 vector containing the result of the triple integral from \(-\infty\) to \( x_1 \), \(-\infty\) to \( x_2 \), and \(-\infty\) to \( x_3 \) of the standardized trivariate Normal density.

### Remarks

Allowable ranges for the arguments are:
In addition, $\rho_{12}$, $\rho_{23}$ and $\rho_{13}$ must come from a legitimate positive definite matrix. A -1 is returned for those rows with invalid inputs.

A separate integral is computed for each row of the inputs.

The first 3 arguments ($x_1$, $x_2$, $x_3$) must be the same length, N. The second 3 arguments ($\rho_{12}$, $\rho_{23}$, $\rho_{13}$) must also be the same length, and this length must be N or 1. If it is 1, then these values will be expanded to apply to all values of $x_1$, $x_2$, $x_3$. All inputs must be column vectors.

To find the integral under a general trivariate density, with $x_1$, $x_2$, and $x_3$ having nonzero means and any positive standard deviations, transform by subtracting the mean and dividing by the standard deviation. For example:

$$x_1 = \left( \frac{x_1 - \text{meanc}(x_1)}{\text{stdc}(x_1)} \right)$$

The absolute error for `cdfTvn` is approximately $\pm 2.5\times10^{-8}$ for the entire range of arguments.

**See Also**

cdfN, cdfBvn

**References**


### cdfWeibull

**Purpose**

Computes the cumulative distribution function for the Weibull distribution.

**Format**

\[ y = \text{cdfWeibull}(x,k,\lambda) \]

**Input**

- \( x \) \: NxK matrix, Nx1 vector or scalar. \( x \) must be greater than 0.
- \( k \) \: Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( k \) must be greater than 0.
- \( \lambda \) \: Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( \lambda \) must be greater than 0.

**Output**

- \( y \) \: NxK matrix, Nx1 vector or scalar.

**Remarks**

The Weibull cumulative distribution function is defined as:
\[ f(x;k,\lambda) = 1 - e^{-(x/\lambda)k} \]

**See Also**

pdfWeibull, cdfWeibullInv

**cdfWeibullInv**

**Purpose**

Computes the Weibull inverse cumulative distribution function.

**Format**

\[ y = \text{cdfWeibullInv}(p,k,\lambda); \]

**Input**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p )</td>
<td>NxK matrix, Nx1 vector or scalar. ( p ) must be greater than 0 and less than 1.</td>
</tr>
<tr>
<td>( k )</td>
<td>Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( x ). ( k ) must be greater than 0.</td>
</tr>
<tr>
<td>( \lambda )</td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with ( x ). ( \lambda ) must be greater than 0.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>NxK matrix, Nx1 vector or scalar.</td>
</tr>
</tbody>
</table>
See Also

pdfWeibull, cdfWeibull

cdir

Purpose

Returns the current directory.

Format

\[ y = \text{cdir}(s); \]

Input

\( s \)  
string, if the first character is 'A'-'Z' and the second character is a colon ':' then that drive will be used. If not, the current default drive will be used.

Output

\( y \)  
string containing the drive and full path name of the current directory on the specified drive.

Remarks

If the current directory is the root directory, the returned string will end with a backslash, otherwise it will not.
A null string or scalar zero can be passed in as an argument to obtain the current drive and path name.

**Example**

If the current working directory is C:\gauss12:

```plaintext
x = cdir(0);
y = cdir("d:");
print x;
print y;
```

The code above will return:

```
C:\gauss12
d:
```

**ceil**

**Purpose**

Round up toward $+\infty$.

**Format**

```
y = ceil(x);
```

**Input**

- \(x\) : NxK matrix.
Output

\[ y \text{ NxK matrix.} \]

Remarks

This rounds every element in the matrix \( x \) to an integer. The elements are rounded up toward \( +\infty \).

Example

\[
\begin{align*}
  x &= 10 \times \text{rndn}(2,2); \\
  y &= \text{ceil}(x);
\end{align*}
\]

After the code above, the matrices \( x \) and \( y \) should hold values similar to below. Answers will vary due to the use of random numbers as the input to the \texttt{ceil} function.

\[
\begin{align*}
  x &= 8.73383 \ -0.783488 \ 13.1106 \\
  y &= 9.000000 \ 0.000000 \ 14.000000 \\
  &\quad 7.155113 \ 8.000000
\end{align*}
\]

See Also

\texttt{floor, trunc}

ChangeDir

Purpose

Changes the working directory within a program.
Format

\[ d = \text{ChangeDir}(s); \]

Input

\[ s \]
string, directory to change to.

Output

\[ d \]
string, new working directory, or null string if change failed.

See Also

chdir, cdir

chdir

Purpose

Changes working directory in interactive mode..

Format

```
chdir dirstr;
```

Input

\[ dirstr \]
literal or ^string, directory to change to.
Remarks

This is for interactive use. Use `ChangeDir` in a program.

If the directory change fails, `chdir` prints an error message.

The working directory is listed in the status report on UNIX.

See Also

`changedir`, `cdir`

chiBarSquare

Purpose

Compute the probability for a chi-bar square statistic from an hypothesis involving parameters under constraints.

Format

\[ SL\text{prob} = \text{chiBarSquare}(SL, H, a, b, c, d, bounds); \]

Input

- \( SL \): scalar, chi-bar square statistic
- \( H \): KxK matrix, positive covariance matrix
- \( a \): MxK matrix, linear equality constraint coefficients
- \( b \): Mx1 vector, linear equality constraint constants

These arguments specify the linear equality constraints of the
following type:

\[
\begin{align*}
\mathbf{a} \times \mathbf{x} &= \mathbf{b} \\
\end{align*}
\]

where \( \mathbf{x} \) is the \( K \times 1 \) parameter vector.

\( \mathbf{c} \)

\( M \times K \) matrix, linear inequality constraint coefficients.

\( \mathbf{d} \)

\( M \times 1 \) vector, linear inequality constraint constants.

These arguments specify the linear inequality constraints of the following type:

\[
\begin{align*}
\mathbf{c} \times \mathbf{x} &\geq \mathbf{d} \\
\end{align*}
\]

where \( \mathbf{x} \) is the \( K \times 1 \) parameter vector.

\( \text{bounds} \)

\( K \times 2 \) matrix, bounds on parameters. The first column contains the lower bounds, and the second column the upper bounds.

**Output**

\( \text{SLprob} \)

scalar, probability of \( SL \).

**Remarks**

See Silvapulle and Sen, *Constrained Statistical Inference*, page 75 for further details about this function. Let

\[
\begin{align*}
\mathbf{Z}_{p \times 1} &\sim N(0, \mathbf{V}) \\
\end{align*}
\]

where \( \mathbf{V} \) is a positive definite covariance matrix. Define
\[ x^{-2} (V, C) = Z'V^{-1}Z - \min_{\theta \in C} (Z - \theta)'V^{-1}(Z - \theta) \]

\( C \) is a closed convex cone describing a set of constraints. \texttt{ChiBarSquare} computes the probability of this statistic given \( V \) and \( C \).

**Example**

\[
V = \{ 0.0005255598 -0.0006871606 -0.0003191342, \\
-0.0006871606 0.0037466205 0.0012285813, \\
-0.0003191342 0.0012285813 0.0009081412 \};
\]

\[
SL = 3.860509;
\]

\[
\text{Bounds} = \{ 0 200, 0 200, 0 200 \};
\]

\[
\text{vi} = \text{invpd}(v);
\]

\[
\text{SLprob} = \text{chiBarSquare}(\text{SL}, \text{Vi}, 0, 0, 0, 0, \text{bounds});
\]

\[
\text{slprob} = 0.10885000
\]

**Source**

hypotest.src

**chol**

**Purpose**

Computes the Cholesky decomposition of a symmetric, positive definite square matrix.
**Format**

\[ y = \text{chol}(x); \]

**Input**

\[ x \quad \text{NxN matrix.} \]

**Output**

\[ y \quad \text{NxN matrix containing the Cholesky decomposition of } x. \]

**Remarks**

\[ y \text{ is the "square root" matrix of } x. \text{ That is, it is an upper triangular matrix such that } x = y'y. \]

\texttt{chol} does not check to see that the matrix is symmetric. \texttt{chol} will look only at the upper half of the matrix including the principal diagonal.

If the matrix \( x \) is symmetric but not positive definite, either an error message or an error code will be generated, depending on the lowest order bit of the trap flag:

- **trap 0** \quad Print error message and terminate program.
- **trap 1** \quad Return scalar error code 10.

See \texttt{scalerr} and \texttt{trap} for more details about error codes.

**Example**

```c
// 'moment' calculates x'\times x with options for handling missing data
```
x = moment(randn(100,4),0);
y = chol(x);

// y'y is equivalent to y'*y
ypy = y'y;

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>95.2801</td>
<td>8.6983</td>
<td>3.7248</td>
<td>1.5449</td>
<td>9.7612</td>
<td>0.8911</td>
<td>0.3816</td>
</tr>
<tr>
<td>8.6983</td>
<td>83.4547</td>
<td>-6.1455</td>
<td>-12.5551</td>
<td>y = 0.0000</td>
<td>9.0918</td>
<td>-0.7133</td>
</tr>
<tr>
<td>3.7248</td>
<td>-6.1455</td>
<td>87.6666</td>
<td>-3.0284</td>
<td>0.0000</td>
<td>0.0000</td>
<td>9.3280</td>
</tr>
<tr>
<td>1.5449</td>
<td>-12.5551</td>
<td>-3.0284</td>
<td>90.8311</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

See Also

crout, solpd

choldn

Purpose

Performs a Cholesky downdate of one or more rows on an upper triangular matrix.

Format

`r = choldn(C, x);`

Input

<table>
<thead>
<tr>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>KxK upper triangular matrix.</td>
</tr>
</tbody>
</table>
x

NxK matrix, the rows to downdate $C$ with.

Output

$r$

KxK upper triangular matrix, the downdated matrix.

Remarks

If `trap 1` is set, `choldn` returns scalar error code 60, otherwise it terminates the program with an error message.

$C$ should be a Cholesky factorization.

```
choldn(C, x);
```

is equivalent to

```
chol(C'C - x'x);
```

but `choldn` is numerically much more stable.

WARNING: it is possible to render a Cholesky factorization non-positive definite with `choldn`. You should keep an eye on the ratio of the largest diagonal element of $r$ to the smallest--if it gets very large, $r$ may no longer be positive definite. This ratio is a rough estimate of the condition number of the matrix.

Example

```
  0 11.16601462 2.97761666
  0 0 11.65496052;
let x[2,3] = 1.76644971 7.49445820 9.79114666
  6.87691156 4.41961438 4.32476921;
```
\[
  r = \text{choldn}(C, x);
\]

\[
\begin{bmatrix}
  18.8706 & 15.3229 & 8.0495 \\
  0.0000 & 9.3068 & -2.1201 \\
  0.0000 & 0.0000 & 7.6288
\end{bmatrix}
\]

**See Also**

cholup, chol

**cholsol**

**Purpose**

Solves a system of linear equations given the Cholesky factorization of the system.

**Format**

\[
  x = \text{cholsol}(b, C);
\]

**Input**

- \( b \) : NxK matrix.
- \( C \) : NxN matrix.

**Output**

- \( x \) : NxK matrix.
Remarks

$C$ is the Cholesky factorization of a linear system of equations $A$. $x$ is the solution for $Ax = b$. $b$ can have more than one column. If so, the system is solved for each column, i.e., $A^i x[ , , i ] = b[ , , i ]$.

Since $A^{-1} = I/A$ and $	extbf{eye}(N)$ creates an identity matrix of size $N$:

```plaintext
cholsol(eye(N), C);
```

is equivalent to:

```plaintext
invpd(A);
```

Thus, if you have the Cholesky factorization of $A$, $	extbf{cholsol}$ is the most efficient way to obtain the inverse of $A$.

Example

```plaintext
//Assign the right-hand side 'b' and the Cholesky //factorization 'C'
b = [ 0.03177513, 0.41823100, 1.70129375 ];
C = [ 1.73351215 1.53201723 1.78102499,
     0 1.09926365 0.63230050,
     0 0 0.67015361 ];

//Solve the system of equations
x = cholsol(b,C);

//Note: C'C is equivalent to C'*C
A = C'C;

//Solve the system of equations
x2 = b/A;
```
See Also

chol

cholup

Purpose

Performs a Cholesky update of one or more rows on an upper triangular matrix.

Format

\[ r = \text{cholup}(C, x); \]

Input

- **C**: KxK upper triangular matrix.
- **x**: NxK matrix, the rows to update \( C \) with.

Output

- **r**: KxK upper triangular matrix, the updated matrix.
Remarks

C should be a Cholesky factorization.

\(\text{cholup}(C, x)\) is equivalent to \(\text{chol}(C'C + x'x)\), but \text{cholup} is numerically much more stable.

Example

```plaintext
let C[3,3] = 18.87055964 15.3229443 8.04947012
  0 9.30682813 -2.12009339
  0 0 7.62878355;
let x[2,3] = 1.76644971 7.49445820 9.79114666
  6.87691156 4.41961438 4.32476921;
    r = cholup(C,x);

  20.162100 16.505444 9.8667614
r = 0.000000 11.166015 2.9776167
  0.000000 11.654961
```

See Also

- choldn
- chrs

Purpose

Converts a matrix of ASCII values into a string containing the appropriate characters.
Format

\[ y = \text{chs}(x); \]

Input

\( x \) \hspace{1cm} \text{NxK matrix.}

Output

\( y \) \hspace{1cm} \text{string of length N*K containing the characters whose ASCII values are equal to the values in the elements of } x.

Remarks

This function is useful for embedding control codes in strings and for creating variable length strings when formatting printouts, reports, etc.

Example

```c
//42 is the ascii value for an asterisk '*'
print chrs(42);
```

The code above returns:

```
*
```

\texttt{chs} can be used to create an interactive program in which the user is prompted for keyboard input which the code uses to make decisions.

```c
//Print a string to prompt the user for input
print "Choose a parameter: Enter [a,b,c]";
```
//Wait for the user to enter a keystroke and assign the
//ASCII value of that key to 'param'
param = keyw;

//Convert the ASCII value to a string
paramString = chrs(param);

if paramString == "a"
    print "You have chosen:" "a";
    //execute code for this choice
elseif paramString == "b"
    print "You have chosen:" "b";
    //execute code for this choice
elseif paramString == "c"
    print "You have chosen:" "c";
    //execute code for this choice
endif;

See Also
vals, ftos, stof

clear

Purpose

Clears space in memory by setting matrices equal to scalar zero.

Format

clear x, y;
Remarks

If your program is running out of memory, or uses considerable system resources, using `clear` to deallocate large matrices after they are no longer needed may allow it to run more efficiently.

```matlab
clear x;
```

is equivalent to

```matlab
x = 0;
```

Matrix names are retained in the symbol table after they are cleared.

Matrices can be `clear'ed even though they have not previously been defined. `clear` can be used to initialize matrices to scalar 0.

Example

```matlab
A = rndn(1000, 1000);
//Code that uses 'A' would be here
//Free memory holding 'A'
clear A;
```

See Also

`clearg`, `new`, `show`, `delete`

See Also

`clearg`

Purpose

Clears global symbols by setting them equal to scalar zero.
**Format**

`clearg a, b, c;`

**Output**

```
a, b, c  scalar global matrices containing 0.
```

**Remarks**

It is considered a best practice to avoid using global variables inside of procedures when possible.

```
clearg x;
```

is equivalent to

```
x = 0;
```

where \( x \) is understood to be a global symbol. `clearg` can be used to initialize symbols not previously referenced. This command can be used inside of procedures to clear global matrices. It will ignore any locals by the same name.

**Example**

Let us suppose there is a procedure that takes in a large global matrix, but only uses the LU factorization for the majority of the calculation. If the computer is memory limited compared to the size of the data, you could do something like this:

```
//Create a 1000x1000 matrix of Cauchy random deviates
X = \texttt{rndCauchy}(1000, 1000, 0, 1);

//Call the procedure which is defined below
out = \texttt{myProc}(X);
```
proc (1) = myProc(A);
    local l, u, ans;

    //Calculate LU factors of 'A'
    { l, u } = lu(A);

    //Code no longer needs 'A', or global 'x', so free them
    clearg X;
    clear A;

    //Main work of proc would go here, including assignment
    //of 'ans'
    retp(ans);
endp;

See Also

clear, delete, new, show, local

close

Purpose

Closes a GAUSS file.

Format

    y = close(handle);
**Input**

*handle* scalar, the file handle given to the file when it was opened with the *open*, *create*, or *fopen* command.

**Output**

*y* scalar, 0 if successful, -1 if unsuccessful.

**Remarks**

*handle* is the scalar file handle created when the file was opened. It will contain an integer which can be used to refer to the file.

*close* will close the file specified by handle, and will return a 0 if successful and a -1 if not successful. The handle itself is not affected by *close* unless the return value of *close* is assigned to it.

If *f1* is a file handle and it contains the value 7, then after:

```c
    call close(f1);
```

the file will be closed but *f1* will still have the value 7. The best procedure is to do the following:

```c
    f1 = close(f1);
```

This will set *f1* to 0 upon a successful close.

It is important to set unused file handles to zero because both *open* and *create* check the value that is in a file handle before they proceed with the process of opening a file. During *open* or *create*, if the value that is in the file handle matches that of
an already open file, the process will be aborted and a File already open error message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happened, you would no longer be able to access the first file.

An advantage of the close function is that it returns a result which can be tested to see if there were problems in closing a file. The most common reason for having a problem in closing a file is that the disk on which the file is located is no longer in the disk drive--or the handle was invalid. In both of these cases, close will return a -1.

Files are not automatically closed when a program terminates. This allows users to run a program that opens files, and then access the files from interactive mode after the program has been run. Files are automatically closed when GAUSS exits to the operating system or when a program is terminated with the end statement. stop will terminate a program but not close files.

As a rule it is good practice to make end the last statement in a program, unless further access to the open files is desired from interactive mode. You should close files as soon as you are done writing to them to protect against data loss in the case of abnormal termination of the program due to a power or equipment failure.

The danger in not closing files is that anything written to the files may be lost. The disk directory will not reflect changes in the size of a file until the file is closed and system buffers may not be flushed.

**Example**

```
open f1 = dat1 for append;
y = writer(f1,x);
f1 = close(f1);
```

**See Also**

closeall
**closeall**

**Purpose**

Closes all currently open GAUSS files.

**Format**

\[
\text{closeall}; \\
\text{closeall list_of_handles};
\]

**Remarks**

*list_of_handles* is a comma-delimited list of file handles.

`closeall` with no specified list of handles will close all files. The file handles will not be affected. The main advantage of using `closeall` is ease of use; the file handles do not have to be specified, and one statement will close all files.

When a list of handles follows `closeall`, all files are closed and the file handles listed are set to scalar 0. This is safer than `closeall` without a list of handles because the handles are cleared.

It is important to set unused file handles to zero because both `open` and `create` check the value that is in a file handle before they proceed with the process of opening a file. During `open` or `create`, if the value that is in the file handle matches that of an already open file, the process will be aborted and a File already open error message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happened, you would no longer be able to access the first file.

Files are not automatically closed when a program terminates. This allows users to run a program that opens files, and then access the files from interactive mode after the program has been run. Files are automatically closed when **GAUSS** exits to the
operating system or when a program is terminated with the `end` statement. `stop` will terminate a program but not close files.

As a rule it is good practice to make `end` the last statement in a program, unless further access to the open files is desired from interactive mode. You should close files as soon as you are done writing to them to protect against data loss in the case of abnormal termination of the program due to a power or equipment failure.

The danger in not closing files is that anything written to the files may be lost. The disk directory will not reflect changes in the size of a file until the file is closed and system buffers may not be flushed.

### Example

```plaintext
open f1 = dat1 for read;
open f2 = dat1 for update;
x = `readr(f1, rowsf(f1));
x = `sqrt(x);
call `writer(f2, x);
closeall f1, f2;
```

### See Also

- `close`
- `open`

### cls

**Purpose**

Clears the program input/output window.
**Format**

```
cls;
```

**Remarks**

This command clears the window and locates the cursor at the upper left hand corner of the window. It is sometimes useful to put a `cls` statement at the beginning of a program that prints a report to the screen so that you have fewer lines of data to look at.

**See Also**

`locate`

**code**

**Purpose**

Allows a new variable to be created (coded) with different values depending upon which one of a set of logical expressions is true.

**Format**

```
y = code(e, v);
```

**Input**

- `e` : NxK matrix of 1's and 0's. Each column of this matrix is created by a logical expression using "dot" conditional and boolean operators. Each of these expressions should return a
column vector result. The columns are horizontally 
concatenated to produce e. If more than one of these vectors 
contains a 1 in any given row, the code function will 
terminate with an error message.

\[ v \] 

(K+1)x1 vector containing the values to be assigned to the 
new variable.

**Output**

\[ y \] 

Nx1 vector containing the new values.

**Remarks**

If none of the K expressions is true, the new variable is assigned the default value, 
which is given by the last element of \( v \).

**Example**

```c
let x1 = 0 /* column vector of original values */
    5
    10
    15
    20;

let v = 1 /* column vector of new values */
    2
    3; /* the last element of v is the "default" */

e1 = (0 .lt x1) .and (x1 .le 5); /* expression 1 */
e2 = (5 .lt x1) .and (x1 .le 25); /* expression 2 */
```
\[ e = e_1 \sim e_2; \quad /* \text{concatenate } e_1 \& e_2 \text{ to make a 1,0 mask with one less column than the number of new values in } v. */ \]

\[ y = \text{code}(e,v); \]

After the code above:

<table>
<thead>
<tr>
<th>x1</th>
<th>v</th>
<th>e</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0 0</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1 0</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>0 1</td>
<td>2</td>
</tr>
</tbody>
</table>

For every row in \( e \), if a 1 is in the first column, the first element of \( v \) is used. If a 1 is in the second column, the second element of \( v \) is used, and so on. If there are only zeros in the row, the last element of \( v \) is used. This is the default value.

If there is more than one 1 in any row of \( e \), the function will terminate with an error message.

**Source**

datatran.src

**See Also**

recode, substitute
code (dataloop)

**Purpose**

Creates new variables with different values based on a set of logical expressions.

**Format**

```
code [[#]] [[$]] var [[default defval]] with
val_1 for expression_1,
val_2 for expression_2,
.
.
val_n for expression_n;
```

**Input**

- `var` literal, the new variable name.
- `defval` scalar, the default value if none of the expressions are TRUE.
- `val` scalar, value to be used if corresponding expression is TRUE.
- `expression` logical scalar-returning expression that returns nonzero TRUE or zero FALSE.
Remarks

If '.Selenium' is specified, the new variable will be considered a character variable. If '#.' or nothing is specified, the new variable will be considered numeric.

The logical expressions must be mutually exclusive, i.e., only one may return TRUE for a given row (observation).

Any variables referenced must already exist, either as elements of the source data set, as externs, or as the result of a previous make, vector, or code statement.

If no default value is specified, 999 is used.

Example

```plaintext
code agecat default 5 with
  1 for age < 21,
  2 for age >= 21 and age < 35,
  3 for age >= 35 and age < 50,
  4 for age >= 50 and age < 65;

code $ sex with
  "MALE" for gender == 1,
  "FEMALE" for gender == 0;
```

See Also

recode (dataloop)

cols

Purpose

Returns the number of columns in a matrix.
Format

\[ y = \texttt{cols}(x); \]

Input

\[ x \]  
N x K matrix or sparse matrix.

Output

\[ y \]  
number of columns in \( x \).

Remarks

If \( x \) is an empty matrix, \texttt{rows}(x) and \texttt{cols}(x) both return 0.

Example

```matlab
// Create a 100x3 matrix of uniform random numbers
x = \texttt{rndu}(100, 3);

y = \texttt{cols}(x);
```

After the code above:

\[ y = 3 \]

See Also

\texttt{rows}, \texttt{colsf}, \texttt{show}
colsf

**Purpose**

Returns the number of columns in a **GAUSS** data (.dat) file or **GAUSS** matrix (.fmt) file.

**Format**

\[ yf = \text{colsf}(fh); \]

**Input**

- \( fh \)
  
  file handle of an open file.

**Output**

- \( yf \)
  
  number of columns in the file that has the handle \( fh \).

**Remarks**

In order to call `colsf` on a file, the file must be open.

**Example**

```gauss
//Create a file with 10 columns
create fp = myfile with x,10,4;

//Calculate the number of rows of the file created above
```
nCols = \texttt{colsf}(fp);

The result will be

nCols = 10

\textbf{See Also}

\texttt{rowsf}, \texttt{cols}, \texttt{show}

\textbf{combine}

\textbf{Purpose}

Computes combinations of \( N \) things taken \( K \) at a time.

\textbf{Format}

\[ y = \texttt{combine}(N, \ K); \]

\textbf{Input}

\begin{itemize}
  \item \( N \) scalar.
  \item \( K \) scalar.
\end{itemize}

\textbf{Output}

\begin{itemize}
  \item \( y \) MxK matrix, where M is the number of combinations of \( N \) things taken \( K \) at a time.
\end{itemize}
Remarks

"Things" are represented by a sequence of integers from 1 to \( N \), and the integers in each row of \( y \) are the combinations of those integers taken \( K \) at a time.

Example

```plaintext
//Calculate all combinations of 4 items chosen 2 at a time
n = 4;
k = 2;
y = combine(n,k);

print y;
```

The code above will create the following output:

```
1.0000 2.0000
1.0000 3.0000
1.0000 4.0000
2.0000 3.0000
2.0000 4.0000
3.0000 4.0000
```

See Also

combined, numCombinations

combinated

Purpose

Writes combinations of \( N \) things taken \( K \) at a time to a GAUSS data set.
**Format**

\[ ret = \text{combined}(fname, vnames, N, K); \]

**Input**

- **fname**
  - string, file name.

- **vname**
  - 1x1 or Kx1 string array, names of columns in data set. If 1x1 string, names will have column number appended. If null string, names will be X1, X2, ...

- **N**
  - scalar.

- **K**
  - scalar.

**Output**

- **ret**
  - scalar, if data set was successfully written, \( ret = \) number of rows written to data set. Otherwise, one of the following:
  
  - 0  \( \text{file already exists}. \)
  
  - -1 \( \text{data set couldn't be created}. \)
  
  - -n \( \text{the (n-1)th write to the data set failed}. \)

**Remarks**

The rows of the data set in \( fname \) contain sequences of the integers from 1 to \( N \) in combinations taken \( K \) at a time.
Example

//Note: The '|' operator vertically concatenates strings
vnames = "Jim"|"Harry"|"Susan"|"Wendy";

//Create a dataset file named 'couples', containing all
//combinations of the names in 'vnames' taken 2 at a time
k = 2;
m = combined("couples",vnames, rows(vnames),k);

print m "rows were written to the dataset";

6.0000 rows were written to the dataset

Continuing from the code above:

//Open the file written above
open f0 = "couples";

//Read in m=6 rows of the dataset into 'y'
y = readr(f0,m);

//Get the variable names from the dataset and assign them
//to 'names'
names = getnamef(f0);
f0=close(f0);

for i(1, rows(y),1);
   print names[y[i,.]]';
endfor;

will produce the following output:
The first row of the print output 'Jim Harry' is the first and second element of \textit{vnames}, because the first row of \textit{y} is equal to '1 2'. The fourth row of the print output is 'Harry Susan', because the fourth row of \textit{y} is '2 3' and 'Harry' is the second element of \textit{vnames} while 'Susan' is the third element.

\textbf{See Also}

\textit{combinate}, \textit{numCombinations}

\textbf{comlog}

\textbf{Purpose}

Controls logging of interactive mode commands to a disk file.

\textbf{Format}

\begin{verbatim}
comlog [[file=filename]] [[on|off|reset]];
\end{verbatim}

\textbf{Input}

\begin{verbatim}
filename      literal or ^string.
\end{verbatim}
Remarks

comlog on turns on command logging to the current file. If the file already exists, subsequent commands will be appended.

comlog off closes the log file and turns off command logging.

comlog reset turns on command logging to the current log file, resetting the log file by deleting any previous commands.

Interactive mode statements are always logged into the file specified in the log_file configuration variable, regardless of the state of comlog.

The command comlog file= filename selects the file but does not turn on logging.

The command comlog off will turn off logging. The filename will remain the same. A subsequent comlog on will cause logging to resume. A subsequent comlog reset will cause the existing contents of the log file to be destroyed and a new file created.

The command comlog by itself will cause the name and status of the current log file to be printed in the window.

compile

Purpose

Compiles a source file to a compiled code file. See also Compiler, Chapter 1.

Format

compile source fname;
Input

| Source  | literal or ^string, the name of the file to be compiled. |
|         |                                                          |
| Fname   | literal or ^string, optional, the name of the file to be created. If not given, the file will have the same filename and path as source. It will have a .gcg extension. |

Remarks

The source file will be searched for in the src_path if the full path is not specified and it is not present in the current directory.

The source file is a regular text file containing a GAUSS program. There can be references to global symbols, Run-Time Library references, etc.

If there are library statements in source, they will be used during the compilation to locate various procedures and symbols used in the program. Since all of these library references are resolved at compile time, the library statements are not transferred to the compiled file. The compiled file can be run without activating any libraries.

If you do not want extraneous stuff saved in the compiled image, put a new at the top of the source file or execute a new in interactive mode before compiling.

The program saved in the compiled file can be run with the run command. If no extension is given, the run command will look for a file with the correct extension for the version of GAUSS. The src_path will be used to locate the file if the full path name is not given and it is not located on the current directory.

When the compiled file is run, all previous symbols and procedures are deleted before the program is loaded. It is therefore unnecessary to execute a new before run'ning a compiled file.
If you want line number records in the compiled file you can put a `#lineson` statement in the `source` file or turn line tracking on from the Options menu.

Don't try to include compiled files with `#include`.

**Example**

```c
compile qxy.e;
```

In this example, the `src_path` would be searched for `qxy.e`, which would be compiled to a file called `qxy.gcg` on the same subdirectory `qxy.e` was found.

```c
compile qxy.e xy;
```

In this example, the `src_path` would be searched for `qxy.e` which would be compiled to a file called `xy.gcg` on the current subdirectory.

**See Also**

`run`, `use`, `saveall`

**complex**

**Purpose**

Converts a pair of real matrices to a complex matrix.

**Format**

```
z = complex(xr, xi);
```
### Input

- \(xr\)  
  NxK real matrix, the real elements of \(z\).
- \(xi\)  
  NxK real matrix or scalar, the imaginary elements of \(z\).

### Output

- \(z\)  
  NxK complex matrix.

### Example

```plaintext
x = [ 4 6,
      9 8 ];

y = [ 3 5,
      1 7 ];

t = complex(x,y);
```

After the code above, \(t\) will be equal to:

```
 4 + 3i  6 + 5i
 9 + 1i  8 + 7i
```

### See Also

- [imag](#), [real](#)
con

**Purpose**

Requests input from the keyboard (console), and returns it in a matrix.

**Format**

\[ x = \text{con}(r, c); \]

**Input**

- \( r \) scalar, row dimension of matrix.
- \( c \) scalar, column dimension of matrix.

**Output**

\( x \) \( r \times c \) matrix.

**Remarks**

\textbf{con} gets input from the active window. \textbf{GAUSS} will not "see" any input until you press ENTER, so follow each entry with an ENTER.

\( r \) and \( c \) may be any scalar-valued expressions. Nonintegers will be truncated to an integer.

If \( r \) and \( c \) are both set to 1, \textbf{con} will cause a question mark to appear in the window, indicating that it is waiting for a scalar input.

Otherwise, \textbf{con} will cause the following prompt to appear in the window:
indicating that it is waiting for the [1,1] element of the matrix to be inputted. The \( - \) means that \textbf{con} will move horizontally through the matrix as you input the matrix elements. To change this or other options, or to move to another part of the matrix, use the following commands:

- \texttt{u} up one row
- \texttt{d} down one row
- \texttt{l} left one column
- \texttt{r} right one column
- \texttt{t} first element
- \texttt{b} last element
- \texttt{g \#, \#} goto element
- \texttt{g \#} goto element of vector
- \texttt{h} move horizontally, default
- \texttt{v} move vertically, default
- \texttt{exttt\} move diagonally, default
- \texttt{s} show size of matrix
- \texttt{n} display element as numeric,
default
c  display element as character
e  exp(1)
p  pi.
.  missing value

?  show help screen
x  exit

If the desired matrix is 1xN or Nx1, then con will automatically exit after the last element has been entered, allowing you to input the vector quickly.

If the desired matrix is NxK, you will need to type 'x' to exit when you have finished entering the matrix data. If you exit before all elements have been entered, unspecified elements will be zeroed out.

Use a leading single quote for character input.

**Example**

```plaintext
n = con(1,1);
print rndn(n,n);
```

If you enter 2 at the con generated prompt:

```plaintext
? 2
```

the code above will return a 2x2 random matrix, similar to:
In this example, the `con` function is used to obtain the size of a square matrix of Normal random variables which is to be printed out.

**See Also**

`cons`, `let`, `load`

**cond**

**Purpose**

Computes the condition number of a matrix using the singular value decomposition.

**Format**

```matlab
    c = cond(x);
```

**Input**

- `x` 
  NxK matrix.

**Output**

- `c` 
  scalar, an estimate of the condition number of `x`. This equals the ratio of the largest singular value to the smallest. If the smallest singular value is zero or not all of the singular values
can be computed, the return value is $10^{300}$.

**Example**

```plaintext
x = { 4 2 6,
     8 5 7,
     3 8 9 }

y = cond(x);
```

will assign $y$ to equal:

```plaintext
y = 9.8436943
```

**Source**

`svd.src`

**conj**

**Purpose**

Returns the complex conjugate of a matrix.

**Format**

```plaintext
y = conj(x);
```

**Input**

$x$  NxK matrix.
**Output**

\[ y \quad \text{NxK matrix, the complex conjugate of } x. \]

**Remarks**

Compare `conj` with the transpose (’) operator.

**Example**

\[
\begin{align*}
&x = \{ 1+9i \quad 2, \\
&\quad 4+4i \quad 5i, \\
&\quad 7i \quad 8-2i \}; \\
&y = \text{conj}(x); \\
\end{align*}
\]

\[
\begin{align*}
x & = 1 + 9i \quad 2 \\
y & = 1 - 9i \quad 2 \\
\end{align*}
\]

\[
\begin{align*}
x & = 4 + 4i \quad 0 + 5i \\
y & = 4 - 4i \quad 0 - 5i \\
\end{align*}
\]

\[
\begin{align*}
x & = 0 + 7i \quad 8 - 2i \\
y & = 0 - 7i \quad 8 + 2i \\
\end{align*}
\]

**cons**

**Purpose**

Retrieves a character string from the keyboard.

**Format**

\[ x = \text{cons}(); \]
Output

\[ x \text{ string, the characters entered from the keyboard} \]

Remarks

\[ x \text{ is assigned the value of a character string typed in at the keyboard. The program will pause to accept keyboard input. The maximum length of the string that can be entered is 254 characters. The program will resume execution when the ENTER key is pressed.} \]

Example

\[ x = \text{cons}(); \]

At the cursor enter:

\[ \text{probability} \]

Now \( x \) will be equal to:

\[ x = "\text{probability}"; \]

See Also

\[ \text{con} \]
**ConScore**

**Purpose**

Compute local score statistic and its probability for hypotheses involving parameters under constraints

**Format**

\[
\{ SL, SLprob \} = \text{ConScore}(H, G, \text{grad}, a, b, c, d, \text{bounds}, psi);
\]

**Input**

- **H**: KxK matrix, Hessian of loglikelihood with respect to parameters.
- **G**: KxK matrix, cross-product matrix of the first derivatives by observation. If not available set to \( H \).
- **grad**: Kx1 vector, gradient of loglikelihood with respect to parameters.
- **a**: MxK matrix, linear equality constraint coefficients.
- **b**: Mx1 vector, linear equality constraint constants.

These arguments specify the linear equality constraints of the following type:

\[
a * X = b
\]

where \( X \) is the Kx1 parameter vector.
\( c \)  \( M \times K \) matrix, linear inequality constraint coefficients.

\( d \)  \( M \times 1 \) vector, linear inequality constraint constants.

These arguments specify the linear inequality constraints of the following type:

\[ c \times X \geq d \]

where \( X \) is the \( K \times 1 \) parameter vector.

\( bounds \)  \( K \times 2 \) matrix, bounds on parameters. The first column contains the lower bounds, and the second column the upper bounds.

\( psi \)  indices of the set of parameters in the hypothesis.

**Output**

\( SL \)  scalar, local score statistic of hypothesis.

\( SLprob \)  scalar, probability of \( SL \).

**Remarks**

\textbf{ConScore} computes the local score statistic for the hypothesis \( H(\Theta) = 0 \) vs. \( H(\Theta) \geq 0 \), where \( \Theta \) is the vector of estimated parameters, and \( H() \) is a constraint function of the parameters.

First, the model with \( H(\Theta) = 0 \) is estimated, and the Hessian and optionally the cross-product of the derivatives is computed. Also, the gradient vector is computed.

Next, the constraint arguments are set to \( H(\Theta) \geq 0 \).
Example

This example is from Silvapulle and Sen, *Constrained Statistical Inference*, page 181-3. It computes the local score statistic and probability for an ARCH model. It tests the null hypothesis of no arch effects against the alternative of arch effects subject to their being constrained to be positive.

The Hessian, H, cross-product matrix, G, and the gradient vector, grad, are generated by an estimation using `sqpsolvemt` where the model is an ARCH model with the arch parameters constrained to be zero.

```c
#include sqpsolvemt.sdf
/* data */
struct DS d0;
d0 = reshape(dsCreate,2,1);

load z0[] = aoi.asc;
z = packr(lagn(251*ln(trimr(z0,1,0)./trimr(z0,0,1)),0|1|2|3|4));
d0[1].dataMatrix = z[.,1];
d0[2].dataMatrix = z[.,2:5];

/* control structure */
struct sqpsolvemtControl c0;
c0 = sqpSolveMTcontrolCreate;

/* constraints setting arch parameter equal to zero for H(theta) = 0 */
c0.A = zeros(3,6) ~ eye(3);
c0.B = zeros(3,1);
c0.covType = 2; /* causes cross-product of Jacobian to be computed which
```
is needed for ConScore */

```c
struct PV p0;
p0 = pvPack(pvCreate,.08999, "constant");
p0 = pvPack(p0,.25167|-.12599|.09164|.07517, "phi");
p0 = pvPack(p0,3.22713, "omega");
p0 = pvPack(p0,0|0|0, "arch");
```

```c
struct sqpsolvemtOut out0;
out0 = sqpsolvemt(&lpr,p0,d0,c0);
```

/* set up constraints for H(theta) >= 0 */
```c
bounds = { -1e256 1e256, 
          -1e256 1e256, 
          -1e256 1e256, 
          -1e256 1e256, 
          -1e256 1e256, 
          -1e256 1e256, 
          -1e256 1e256, 
          0 1e256, 
          0 1e256, 
          0 1e256 };
```

```c
H = out0.hessian;
G = out0.xproduct;
// minus because -logl in log-likelihood
grad = -out0.gradient;
```

```c
psi = { 7, 8, 9 };
```

```c
{ SL, SLprob } = ConScore(H,G,grad,0,0,0,0,bounds,psi);
```

will assign the variables `SL` and `SLprob` as follows:
Source

hypotest.src

**continue**

**Purpose**

Jumps to the top of a `do` or `for` loop.

**Format**

```
continue;
```

**Example**

```c
x = rndn(4,4);

//Loop through each row of 'x' using 'r' as the loop
//counter
for r(0, rows(x), 1);
    //Loop through each element in our current row
    for c(0, cols(x), 1); /* continue jumps here */
        //If we are on the diagonal skip the rest of the
        //inner loop
        if c == r;
            continue;
```
```c
endif;
// Set the non-diagonal elements to 0
x[r,c] = 0;
endfor;
endfor;
```

Before the loops, \( x \) looks like:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.4400255</td>
<td>0.15389012</td>
<td>-0.90423208</td>
<td>-0.62402330</td>
</tr>
<tr>
<td>2.1330276</td>
<td>0.95605712</td>
<td>-1.2353752</td>
<td>1.1276577</td>
</tr>
<tr>
<td>1.1526412</td>
<td>0.36105374</td>
<td>1.1462596</td>
<td>1.1907549</td>
</tr>
<tr>
<td>0.41986542</td>
<td>1.0603897</td>
<td>-0.19616276</td>
<td>2.8940323</td>
</tr>
</tbody>
</table>

After the loops above, \( x \) looks like:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.4400255</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>0.0000000</td>
<td>0.95605712</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td>0.0000000</td>
<td>0.0000000</td>
<td>1.1462596</td>
<td>0.0000000</td>
</tr>
<tr>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>2.8940323</td>
</tr>
</tbody>
</table>

**Remarks**

This command works just as in C.

**contour**

**Purpose**

Graphs a matrix of contour data. Note: This function is for the deprecated PQG graphics.

**Library**

pgraph
Format

\texttt{contour(x, y, z);} 

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{x}</td>
<td>1xK vector, the X axis data. K must be odd.</td>
</tr>
<tr>
<td>\texttt{y}</td>
<td>Nx1 vector, the Y axis data. N must be odd.</td>
</tr>
<tr>
<td>\texttt{z}</td>
<td>NxK matrix, the matrix of height data to be plotted.</td>
</tr>
</tbody>
</table>

Global Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{_plev}</td>
<td>Kx1 vector, user-defined contour levels for \texttt{contour}. Default 0.</td>
</tr>
<tr>
<td>\texttt{_pzclr}</td>
<td>Nx1 or Nx2 vector. This controls the Z level colors. See \texttt{surface} for a complete description of how to set this global.</td>
</tr>
</tbody>
</table>

Remarks

A vector of evenly spaced contour levels will be generated automatically from the \texttt{z} matrix data. Each contour level will be labeled. For unlabeled contours, use \texttt{ztics}. To specify a vector of your own unequal contour levels, set the vector \texttt{_plev} before calling \texttt{contour}. To specify your own evenly spaced contour levels, see \texttt{ztics}. 

Source

\texttt{pcontour.src}
See Also

surface

conv

Purpose

Computes the convolution of two vectors.

Format

\[ c = \text{conv}(b, x, f, l); \]

Input

- \( b \) : Nx1 vector.
- \( x \) : Lx1 vector.
- \( f \) : scalar, the first convolution to compute.
- \( l \) : scalar, the last convolution to compute.

Output

- \( c \) : Qx1 result, where: \( Q = (l - f + 1) \)

If \( f \) is 0, the first to the \( l \)'th convolutions are computed. If \( l \) is 0, the \( f \)'th to the last convolutions are computed. If \( f \) and \( l \) are both zero, all the convolutions are computed.
Remarks

If $x$ and $b$ are vectors of polynomial coefficients, this is the same as multiplying the two polynomials.

See Also

polymult

convertsatostr

Purpose

Converts a 1x1 string array to a string.

Format

$$str = \text{convertsatostr}(sa);$$

Input

$sa$  
1x1 string array.

Output

$str$  
string, $sa$ converted to a string.

See Also

convertstrtosa
**convertstrtos**

**Purpose**
Converts a string to a 1x1 string array.

**Format**

```plaintext
sa = convertstrtos(str);
```

**Input**

| str | string. |

**Output**

| sa | 1x1 string array, str converted to a string array. |

**Example**

```plaintext
str = "This is a string";
z = convertstrtos(str);
```

You can check the types of your variables by viewing them on the GAUSS data page, or by using the `show` command. If the code above was executed at startup, running the `show` command would return:

<table>
<thead>
<tr>
<th>24 bytes</th>
<th>str</th>
<th>STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 char</td>
<td>str</td>
<td>1</td>
</tr>
</tbody>
</table>
See Also

corvertsatostr

corrm, corrvc, corrx

Purpose

Computes an unbiased estimate of a correlation matrix.

Format

\[ cx = \text{corrm}(m); \]
\[ cx = \text{corrvc}(vc); \]
\[ cx = \text{corrx}(x); \]

Input

\( m \)  
KxK moment (\( x'x \)) matrix. A constant term MUST have been the first variable when the moment matrix was computed.

\( vc \)  
KxK variance-covariance matrix (of data or parameters).

\( x \)  
NxK matrix of data.
Output

\[ cx \]  
PxP correlation matrix. For \texttt{corrm}, \( P = K-1 \). For \texttt{corrvc} and \texttt{corrx}, \( P = K \).

Remarks

The correlation matrix is the standardized version of the unbiased estimator of the population variance-covariance matrix. It is computed using the moment matrix of deviations about the mean divided by the number of observations minus one \( N - 1 \). For the observed correlation/covariance matrix which uses \( N \) rather than \( N - 1 \), see \texttt{corrms} and \texttt{corrxs}.

Source

\texttt{corr.src}

See Also

\texttt{momentd}, \texttt{corrms}, \texttt{corrxs}

\texttt{corrms,corrxs}

Purpose

Computes the observed correlation matrix.

Format

\[
\begin{align*}
  cx & = \texttt{corrms}(m); \\
  cx & = \texttt{corrxs}(x);
\end{align*}
\]
**Input**

\[ m \]
KxK moment \((x'x)\) matrix. A constant term MUST have been the first variable when the moment matrix was computed.

\[ x \]
NxK matrix of data.

**Output**

\[ cx \]
PxP correlation matrix. For `corrms`, \( P = K-1 \). For `corrxs`, \( P = K \).

**Remarks**

The correlation matrix is the standardized version of the correlation/covariance matrix computed from the input data, that is, it divides the sample size, \( N \), rather than \( N - 1 \). For an unbiased estimate correlation/covariance matrix which uses \( N - 1 \), use `corrm` or `corrx`.

**Source**
`corrs.src`

**See Also**
`momentd`, `corrm`, `corrx`
**cos**

**Purpose**

Returns the cosine of its argument.

**Format**

\[ y = \cos(x); \]

**Input**

\( x \) \quad \text{NxK matrix.}

**Output**

\( y \) \quad \text{NxK matrix containing the cosines of the elements of } x.

**Remarks**

For real matrices, \( x \) should contain angles measured in radians.

To convert degrees to radians, multiply the degrees by \( \pi/180 \).

**Example**

```c
//Create a sequence starting at 0 and increasing by pi/4
x = seqa(0, pi/4, 5);
y = cos(x);
```
### cosh

#### Purpose

Computes the hyperbolic cosine.

#### Format

\[ y = \cosh(x); \]

#### Input

\[ x \quad \text{NxK matrix.} \]

#### Output

\[ y \quad \text{NxK matrix containing the hyperbolic cosines of the elements of } x. \]

---

### See Also

atan, atan2, pi
Example

```matlab
x = { -0.5, -0.25, 0, 0.25, 0.5, 1 };
x = x * pi;
y = cosh(x);
```

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5708</td>
<td>2.5092</td>
</tr>
<tr>
<td>-0.7854</td>
<td>1.3246</td>
</tr>
<tr>
<td>0.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>0.7854</td>
<td>1.3246</td>
</tr>
<tr>
<td>1.5708</td>
<td>2.5092</td>
</tr>
<tr>
<td>3.1416</td>
<td>11.5920</td>
</tr>
</tbody>
</table>

Source

trig.src

counts

Purpose

Counts the numbers of elements of a vector that fall into specified ranges.

Format

```matlab
c = counts(x, v);
```

Input

- `x`: Nx1 vector containing the numbers to be counted.
- `v`: Px1 vector containing breakpoints specifying the ranges
within which counts are to be made. The vector \( v \) MUST be sorted in ascending order.

**Output**

\( c \)  
\( \text{P} \times 1 \text{ vector, the counts of the elements of } x \text{ that fall into the regions:} \)

\[
\begin{align*}
x & \leq v[1], \\
v[1] < x & \leq v[2], \\
& \quad \vdots \\
v[p-1] < x & \leq v[p]
\end{align*}
\]

**Remarks**

If the maximum value of \( x \) is greater than the last element (the maximum value) of \( v \), the sum of the elements of the result, \( c \), will be less than \( N \), the total number of elements in \( x \).

If

\[
\begin{array}{cccc}
1 \\
2 \\
3 \\
4 & 4 \\
5 & v & = & 5 \\
6 & 8 \\
7 \\
8 \\
9
\end{array}
\]

then
The first category can be a missing value if you need to count missings directly. Also $+\infty$ or $-\infty$ are allowed as breakpoints. The missing value must be the first breakpoint if it is included as a breakpoint and infinities must be in the proper location depending on their sign. $-\infty$ must be in the $[2,1]$ element of the breakpoint vector if there is a missing value as a category as well, otherwise it has to be in the $[1,1]$ element. If $+\infty$ is included, it must be the last element of the breakpoint vector.

**Example**

**Example 1**

```latex
\begin{verbatim}
x = { 1.5, 3, 5, 4, 1, 3 }; 
v = { 0, 2, 4 }; 
c = counts(x,v);
\end{verbatim}
```

```
1.5
  3   0   0
x = 2  v = 2  c = 2
  4   4   3
  1
  3
```

**Example 2**

```latex
\begin{verbatim}
x = { -3, -2.5, -2, 0, -9, 18 }; 
v = __infn|-2|__infp; 
c = counts(x,v);
\end{verbatim}
```

```
  -INF   0
v =   -2  c = 4
  +INF   2
```

**Example 3**
x = { -2.3, -0.4, -3.1, -0.2, 1.9, -1.4 };

//Change all values in 'x' equal to -0.2 to be a missing value
x = miss(x, -0.2);

v = { ., -2, 0, 2 }; c = counts(x,v);

-2.3     .     1
-0.4     -2    2
x = -3.1  v =  0   c = 2
     .     2   1
     1.9
     -1.4

countwts

Purpose

Returns a weighted count of the numbers of elements of a vector that fall into specified ranges.

Format

\[ c = \text{countwts}(x, \ v, \ w); \]

Input

\( x \)\n\( \) Nx1 vector, the numbers to be counted.
\( v \)\n\( \) Px1 vector, the breakpoints specifying the ranges within
which counts are to be made. This MUST be sorted in ascending order (lowest to highest).

\[ w \]

Nx1 vector, containing weights.

**Output**

\[ c \]

Px1 vector containing the weighted counts of the elements of \( x \) that fall into the regions:

\[
\begin{align*}
  x & \leq v[1], \\
  v[1] & < x \leq v[2], \\
  \vdots & \\
  \vdots & \\
  v[p-1] & < x \leq v[p]
\end{align*}
\]

That is, when \( x[i] \) falls into region \( j \), the weight \( w[i] \) is added to the \( j \)th counter.

**Remarks**

If any elements of \( x \) are greater than the last element of \( v \), they will not be counted.

Missing values are not counted unless there is a missing in \( v \). A missing value in \( v \) MUST be the first element in \( v \).

**Example**

\[
\begin{align*}
  x & = \{ 1, 3, 2, 4, 1, 3 \}; \\
  w & = \{ .25, 1, .333, .1, .25, 1 \}; \\
  v & = \{ 0, 1, 2, 3, 4 \};
\end{align*}
\]
\begin{verbatim}
c = countwts(x,v,w);
c = 0.000000
0.500000
0.333000
2.000000
0.100000
\end{verbatim}

\textbf{create}

\textbf{Purpose}

Creates and opens a GAUSS data set for subsequent writing.

\textbf{Format}

\begin{verbatim}
create [[vflag]] [[-w32]] [[complex]] fh = filename with
vnames, col, dtyp, vtyp;
create [[vflag]] [[-w32]] [[complex]] fh = filename using comfile;
\end{verbatim}

\textbf{Input}

\begin{verbatim}
vflag literal, version flag.
-v89 obsoleted, use -v96.
-v92 obsoleted, use -v96.
-v96 supported on all platforms.
\end{verbatim}

For details on the various versions, see \textbf{Foreign Language}
Interface, Chapter 1. The default format can be specified in gauss.cfg by setting the `dat_fmt_version` configuration variable. The default, v96, should be used.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>filename</strong></td>
<td>literal or ^string</td>
</tr>
<tr>
<td>filename is the name to be given to the file on the disk. The name can include a path if the directory to be used is not the current directory. This file will automatically be given the extension .dat. If an extension is specified, the .dat will be overridden. If the name of the file is to be taken from a string variable, the name of the string must be preceded by the ^ (caret) operator.</td>
<td></td>
</tr>
<tr>
<td><strong>create... with...</strong></td>
<td></td>
</tr>
<tr>
<td><strong>vnames</strong></td>
<td>literal or ^string or ^character matrix.</td>
</tr>
<tr>
<td>vnames controls the names to be given to the columns of the data file. If the names are to be taken from a string or character matrix, the ^ (caret) operator must be placed before the name of the string or character matrix. The number of columns parameter, col, also has an effect on the way the names will be created. See below and see the examples for details on the ways names are assigned to a data file.</td>
<td></td>
</tr>
<tr>
<td><strong>col</strong></td>
<td>scalar expression.</td>
</tr>
<tr>
<td>col is a scalar expression containing the number of columns in the data file. If <code>col</code> is 0, the number of columns will be controlled by the contents of vnames. If <code>col</code> is positive, the file will contain <code>col</code> columns and the names to be given each column will be created as necessary depending on the vnames parameter. See the examples.</td>
<td></td>
</tr>
<tr>
<td><strong>dtyp</strong></td>
<td>scalar expression.</td>
</tr>
</tbody>
</table>
$dtyp$ is the precision used to store the data. This is a scalar expression containing 2, 4, or 8, which is the number of bytes per element.

2  
signed integer

4  
single precision

8  
double precision

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Digits</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer</td>
<td>4</td>
<td>-32768 &lt; X &lt; 32768</td>
</tr>
<tr>
<td>single</td>
<td>6-7</td>
<td>8.43 x 10^{-37} &lt;</td>
</tr>
<tr>
<td>double</td>
<td>15-16</td>
<td>4.19 x 10^{-307} &lt;</td>
</tr>
</tbody>
</table>

If the integer type is specified, numbers will be rounded to the nearest integer as they are written to the data set. If the data to be written to the file contains character data, the precision must be 8 or the character information will be lost.

$vtyp$  
matrix, types of variables.

The types of the variables in the data set. If $\text{rows}(vtyp)^*$ $\text{cols}(vtyp) < col$, only the first element is used. Otherwise nonzero elements indicate a numeric variable and zero elements indicate character variables.

create... using...

$comfile$  
literal or ^string.

$comfile$ is the name of a command file that contains the information needed to create the file. The default extension for
the command file is `.gcf`, which can be overridden.

There are three possible commands in this file:

```
numvar  n  str;
outvar  varlist;
outtyp  dtyp;
```

`numvar` and `outvar` are alternate ways of specifying the number and names of the variables in the data set to be created.

When `numvar` is used, `n` is a constant which specifies the number of variables (columns) in the data file and `str` is a string literal specifying the prefix to be given to all the variables. Thus:

```
numvar 10  xx;
```

says that there are 10 variables and that they are to be named `xx01` through `xx10`. The numeric part of the names will be padded on the left with zeros as necessary so the names will sort correctly:

<table>
<thead>
<tr>
<th>xx01,</th>
<th>...</th>
<th>xx9</th>
<th>1-9 names</th>
</tr>
</thead>
<tbody>
<tr>
<td>xx001,</td>
<td>...</td>
<td>xx10</td>
<td>10-99 names</td>
</tr>
<tr>
<td>xx0001,</td>
<td>...</td>
<td>xx100</td>
<td>100-999 names</td>
</tr>
<tr>
<td></td>
<td>...</td>
<td>xx1000</td>
<td>1000-8100 names</td>
</tr>
</tbody>
</table>

If `str` is omitted, the variable prefix will be "x".

When `outvar` is used, `varlist` is a list of variable names, separated by spaces or commas. For instance:

```
outvar  x1, x2, zed;
```
specifies that there are to be 3 variables per row of the data set, and that they are to be named \( X_1, X_2, ZED \), in that order.

\textbf{outtyp} specifies the precision. It can be a constant: 2, 4, or 8, or it can be a literal: I, F, or D. For an explanation of the available data types, see \texttt{dtyp} in \texttt{create... with...} previously.

The \textbf{outtyp} statement does not have to be included. If it is not, then all data will be stored in 4 bytes as single precision floating point numbers.

\section*{Output}

\textit{fh} scalar.

\textit{fh} is the file handle which will be used by most commands to refer to the file within \texttt{GAUSS}. This file handle is actually a scalar containing an integer value that uniquely identifies each file. This value is assigned by \texttt{GAUSS} when the \texttt{create} (or \texttt{open}) command is executed.

\section*{Remarks}

If the \texttt{complex} flag is included, the new data set will be initialized to store complex number data. Complex data is stored a row at a time, with the real and imaginary halves interleaved, element by element.

The \texttt{--w32} flag is an optimization for Windows. It is ignored on all other platforms. \texttt{GAUSS} 7.0 and later use Windows system file write commands that support 64-bit file sizes. These commands are slower on Windows XP than the 32-bit file write commands that were used in \texttt{GAUSS} 6.0 and earlier. If you include the \texttt{--w32} flag, successive writes to the file indicated by \textit{fh} will use 32-bit Windows write
commands, which will be faster on Windows XP. Note, however, that the \texttt{-w32} flag does not support 64-bit file sizes.

**Example**

```plaintext
let vnames = age sex educat wage occ;
create f1 = simdat with ^vnames,0,8;

obs = 0; nr = 1000;
do while obs < 10000;
   data = rndn(nr,cols(f1));
   if writer(f1,data) /= nr;
      print "Disk Full";
   end;
endif;
obs = obs+nr;
endo;

closeall f1;
```

This example uses \texttt{create... with...} to create a double precision data file called \texttt{simdat.dat} on the default drive with 5 columns. The \texttt{writer} command is used to write 10000 rows of Normal random numbers into the file. The variables (columns) will be named: \texttt{AGE, SEX, EDUCAT, WAGE, OCC}.

Here are some examples of the variable names that will result when using a character vector of names in the argument to the \texttt{create} function.

```plaintext
vnames = { AGE PAY SEX JOB };
typ = { 1, 1, 0, 0 };
create fp = mydata with ^vnames,0,8,typ;
```

The names in the this example will be: \texttt{AGE, PAY, SEX, JOB}.

\texttt{AGE} and \texttt{PAY} are numeric variables, \texttt{SEX} and \texttt{JOB} are character variables.
create fp = mydata with ^vnames,3,2;

The names will be: AGE, PAY, SEX.

create fp = mydata with ^vnames,8,2;

The names will now be: AGE, PAY, SEX, JOB1, JOB2, JOB3, JOB4, JOB5.

If a literal is used for the vnames parameter, the number of columns should be explicitly given in the col parameter and the names will be created as follows:

create fp = mydata with var,4,2;

Giving the names: VAR1, VAR2, VAR3, VAR4.

The next example assumes a command file called comd.gcf containing the following lines, created using a text editor:

```
outvar age, pay, sex;
outtyp i;
```

Then the following program could be used to write 100 rows of random integers into a file called smpl.dat in the subdirectory called /gauss/data:

```
filename = "/gauss/data/smpl";
create fh = ^filename using comd;
x = rndn(100,3)*10;
if writer(fh,x) /= rows(x);
   print "Disk Full";
   end;
endif;
closeall fh;
```

For platforms using the backslash as a path separator, remember that two backslashes ("\") are required to enter one backslash inside of double quotes. This is because a backslash is the escape character used to embed special characters in strings.
See Also
datacreate, datacreatecomplex, open, readr, writer, eof, close, output, iscplxf

crossprd

Purpose

Computes the cross-products (vector products) of sets of 3x1 vectors.

Format

\[ z = \text{crossprd}(x, y); \]

Input

- \( x \) 3xK matrix, each column is treated as a 3x1 vector.
- \( y \) 3xK matrix, each column is treated as a 3x1 vector.

Output

- \( z \) 3xK matrix, each column is the cross-product (sometimes called vector product) of the corresponding columns of \( x \) and \( y \).

Remarks

The cross-product vector \( z \) is orthogonal to both \( x \) and \( y \). \[ \text{sumc}(x .* z) \] and \[ \text{sumc}(y .* z) \] will be Kx1 vectors, all of whose elements are 0 (except for rounding error).
**Example**

```plaintext
x = { 10  4,
     11 13,
     14 13 }; 
y = { 3 11,
     5 12,
     7  9 }; 
z = crossprd(x,y);
```

<table>
<thead>
<tr>
<th>7</th>
<th>-39</th>
</tr>
</thead>
<tbody>
<tr>
<td>-28</td>
<td>107</td>
</tr>
<tr>
<td>17</td>
<td>-95</td>
</tr>
</tbody>
</table>

**Source**

crossprd.src

**crout**

**Purpose**

Computes the Crout decomposition of a square matrix without row pivoting, such that: \( X = LU \).

**Format**

```plaintext
y = crout(x);
```

**Input**

\( x \)  

N\( x \) square nonsingular matrix.
Output

$y$  
NxN matrix containing the lower ($L$) and upper ($U$) matrices of the Crout decomposition of $x$. The main diagonal of $y$ is the main diagonal of the lower matrix $L$. The upper matrix has an implicit main diagonal of ones. Use `lowmat` and `upmat1` to extract the $L$ and $U$ matrices from $y$.

Remarks

Since it does not do row pivoting, it is intended primarily for teaching purposes. See `croutp` for a decomposition with pivoting.

Example

```c
X = { 1 2 -1,
     2 3 -2,
     1 -2 1 }

//Perform crout decomposition
y = crout(x);

//Extract lower triangle of 'y' and assign it to 'L'
L = lowmat(y);

//Extract upper triangle of 'y', fill the diagonal with ones and assign it to 'L'
U = upmat1(y);
```

After the code above:


\[
\begin{array}{ccc}
1.0 & 2.0 & -1.0 \\
1.0 & 0.0 & 0.0 \\
1.0 & 2.0 & -1.0 \\
y = 2.0 & -1.0 & 0.0 \\
L = 2.0 & -1.0 & 0.0 \\
U = 0.0 & 1.0 & 0.0 \\
1.0 & -4.0 & 2.0 \\
1.0 & -4.0 & 2.0 \\
0.0 & 0.0 & 1.0
\end{array}
\]

**See Also**

croutp, chol, lowmat, lowmat1, lu, upmat, upmat1

**croutp**

**Purpose**

Computes the Crout decomposition of a square matrix with partial (row) pivoting.

**Format**

\[
y = \text{croutp}(x);
\]

**Input**

\[
x \quad \text{N} \times \text{N} \text{ square nonsingular matrix.}
\]

**Output**

\[
y \quad \text{(N+1)} \times \text{N} \text{ matrix containing the lower (}L\text{) and upper (}U\text{) matrices of the Crout decomposition of a permuted } x. \text{ The N+1 row of the matrix } y \text{ gives the row order of the } y \text{ matrix. The matrix must be reordered prior to extracting the } L \text{ and } U \text{ matrices. Use } \text{lowmat} \text{ and } \text{upmat1} \text{ to extract the } L \text{ and}
\]
$U$ matrices from the reordered $y$ matrix.

**Example**

This example illustrates a procedure for extracting $L$ and $U$ of the permuted $x$ matrix. It continues by sorting the result of $LU$ to compare with the original matrix $x$.

$$X = \{ 1 2 -1, \\
2 3 -2, \\
1 -2 1 \};$$

$$y = \text{croutp}(x);$$

If we view 'y', we will see:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
<td>0.50000</td>
<td>0.28571</td>
</tr>
<tr>
<td>2.0000</td>
<td>1.5000</td>
<td>-1.0000</td>
</tr>
<tr>
<td>1.0000</td>
<td>-3.5000</td>
<td>-0.57142</td>
</tr>
<tr>
<td>2.0000</td>
<td>3.0000</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

//This bottom row is the permutation index vector
//Calculate how many rows in 'y'
$$r = \text{rows}(y);$$

//Extract the index row and transpose it into a column
//vector
$$indx = y[r,.]';$$

Viewing 'indx' will reveal:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
</tr>
<tr>
<td>indx = 3</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
//Rearrange the rows of 'y' based upon the index vector
z = y[inds, .];

// obtain L and U of permuted matrix X
L = lowmat(z);
U = upmat1(z);

// Horizontally concatenate the index vector and the product
// of L*U then pass that result into the 'sortc' function
// (which will sort this result based upon the first column
q = sortc(indx~(L*U), 1);

// Remove the index vector, which we added by way of
// horizontal concatenation in the statement just above
x2 = q[., 2:cols(q)];

Now at the end of this example, x2 is equal to x.

See Also

crout, chol, lowmat, lowmat1, upmat, upmat1

csrcol, csrlin

Purpose

Returns the position of the cursor.

Format

\[
y = \text{csrcol};
\]

\[
y = \text{csrlin};
\]
Output

\( y \) scalar, row or column value.

Remarks

\( y \) will contain the current column or row position of the cursor on the screen. The upper left corner is (1,1).

\texttt{csrcol} returns the column position of the cursor. \texttt{csrlin} returns the row position.

The \texttt{locate} command allows the cursor to be positioned at a specific row and column.

\texttt{csrcol} returns the cursor column with respect to the current output line, i.e., it will return the same value whether the text is wrapped or not. \texttt{csrlin} returns the cursor line with respect to the top line in the window.

Example

\begin{verbatim}
    r = csrlin;
c = csrcol;

    //Clear the program input/output window
    cls;

    //Re-position the cursor to its location before the program
    //input/output window was cleared
    locate r,c;
\end{verbatim}

In this example the screen is cleared without affecting the cursor position.

See Also

\texttt{cls}, \texttt{locate}
**cumprodc**

**Purpose**

Computes the cumulative products of the columns of a matrix.

**Format**

\[ y = \text{cumprodc}(x); \]

**Input**

\( x \quad \text{NxK matrix.} \)

**Output**

\( y \quad \text{NxK matrix containing the cumulative products of the columns of } x. \)

**Remarks**

This is based on the recursive series \texttt{recsercp}. \texttt{recsercp} could be called directly as follows:

\[ \text{recsercp}(x, \text{zeros}(1, \text{cols}(x))); \]

to accomplish the same thing.

**Example**

\[ x = \{ 1 \ -3, \]

\[ 3 \ -2 \}; \]

38-260
2  2,
3 -1 );
y = cumprodc(x);  

Now if you view y, you will see:

1.000 -3.000
y = 2.000 -6.000
6.000  6.000

Source

cumprodc.src

See Also

cumsumc, recsercp, recserar

cumsumc

Purpose

Computes the cumulative sums of the columns of a matrix.

Format

y = cumsumc(x);

Input

x N x K matrix.
Output

\( y \) \hspace{1cm} \text{NxK matrix containing the cumulative sums of the columns of} \ x.

Remarks

This is based on the recursive series function \textit{recserar}. \textit{recserar} could be called directly as follows:

\[
\text{recserar}(x, x[1,.], \text{ones}(1, \text{cols}(x)))
\]

to accomplish the same thing.

Example

\[
\begin{align*}
x &= \{ 1 & -3, \\
& 2 & 2, \\
& 3 & -1 \}; \\
\end{align*}
\]

\[
y = \text{cumsumc}(x);
\]

Now if you view \( y \), you will see:

\[
\begin{array}{cc}
1.000 & -3.000 \\
y &= 3.000 & -1.000 \\
6.000 & -2.000
\end{array}
\]

Source

cumsumc.src
See Also

cumprodc, recsercp, recserar

curve

Purpose

Computes a one-dimensional smoothing curve.

Format

\[
\{ u, v \} = \text{curve}(x, y, d, s, \text{sigma}, G);
\]

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>Kx1 vector, x-abscissae (X-axis values).</td>
</tr>
<tr>
<td>(y)</td>
<td>Kx1 vector, y-ordinates (Y-axis values).</td>
</tr>
<tr>
<td>(d)</td>
<td>Kx1 vector or scalar, observation weights.</td>
</tr>
<tr>
<td>(s)</td>
<td>scalar, smoothing parameter. If (s = 0), curve performs an interpolation. If (d) contains standard deviation estimates, a reasonable value for (s) is K.</td>
</tr>
<tr>
<td>(\text{sigma})</td>
<td>scalar, tension factor.</td>
</tr>
<tr>
<td>(G)</td>
<td>scalar, grid size factor.</td>
</tr>
</tbody>
</table>
Output

\textbf{u} \quad (K*G)x1 vector, x-abscissae, regularly spaced.
\textbf{v} \quad (K*G)x1 vector, y-ordinates, regularly spaced.

Remarks

\textit{sigma} contains the tension factor. This value indicates the curviness desired. If \textit{sigma} is nearly zero (e.g. .001), the resulting curve is approximately the tensor product of cubic curves. If \textit{sigma} is large, (e.g. 50.0) the resulting curve is approximately bi-linear. If \textit{sigma} equals zero, tensor products of cubic curves result. A standard value for \textit{sigma} is approximately 1.

\textit{G} is the grid size factor. It determines the fineness of the output grid. For \textit{G} = 1, the input and output vectors will be the same size. For \textit{G} = 2, the output grid is twice as fine as the input grid, i.e., \textit{u} and \textit{v} will have twice as many rows as \textit{x} and \textit{y}.

Source

\texttt{spline.src}

\texttt{cvtos}

\textbf{Purpose}

Converts a character vector to a string.

\textbf{Format}

\texttt{s = cvtos(v);}
**Input**

$\mathbf{v}$  
Nx1 character vector, to be converted to a string.

**Output**

$s$  
string, contains the contents of $\mathbf{v}$.

**Remarks**

$cvtos$ in effect appends the elements of $\mathbf{v}$ together into a single string.

$cvtos$ was written to operate in conjunction with stocv. If you pass it a character vector that does not conform to the output of stocv, you may get unexpected results. For example, cvtos does NOT look for 0 terminating bytes in the elements of $\mathbf{v}$; it assumes every element except the last is 8 characters long. If this is not true, there will be 0's in the middle of $s$.

If the last element of $\mathbf{v}$ does not have a terminating 0 byte, cvtos supplies one for $s$.

**Example**

```c
let v = { "Now is t" "he time " "for all " "good men"
};
s = cvtos(v);
```

Now the variable $s$ is a string with the following contents.

```c
s = "Now is the time for all good men"
```
See Also

stocv, vget, vlist, vput, vread
datacreate

**Purpose**

Creates a real data set.

**Format**

\[ fh = \text{datacreate}(\text{filename}, \text{vnames}, \text{col}, \text{dtyp}, \text{vtyp}); \]

**Input**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>filename</code></td>
<td>string, name of data file.</td>
</tr>
<tr>
<td><code>vnames</code></td>
<td>string or Nx1 string array, names of variables.</td>
</tr>
<tr>
<td><code>col</code></td>
<td>scalar, number of variables.</td>
</tr>
<tr>
<td><code>dtyp</code></td>
<td>scalar, data precision, one of the following:</td>
</tr>
<tr>
<td>2</td>
<td>2-byte, signed integer.</td>
</tr>
<tr>
<td>4</td>
<td>4-byte, single precision.</td>
</tr>
<tr>
<td>8</td>
<td>8-byte, double precision.</td>
</tr>
<tr>
<td><code>vtyp</code></td>
<td>scalar or Nx1 vector, types of variables, may contain one or both of the following:</td>
</tr>
<tr>
<td>0</td>
<td>character variable.</td>
</tr>
</tbody>
</table>
Output

fh scalar, file handle.

Remarks

The file handle returned by `datacreate` is a scalar containing a positive integer value that uniquely identifies each file. This value is assigned by GAUSS when the `create`, `datacreate`, `datacreatecomplex`, `open` or `dataopen` commands are executed. The file handle is used to reference the file in the commands `readr` and `writer`. If `datacreate` fails, it returns a -1.

If `filename` does not include a path, then the file is placed on the current directory. The file is given a .dat extension if no extension is specified.

If `col` is set to 0, then the number of columns in the data set is controlled by the contents of `vnames`. If `col` is positive, then the file will contain `col` columns.

If `vnames` contains `col` elements, then each column is given the name contained in the corresponding row of `vnames`. If `col` is positive and `vnames` is a string, then the columns are given the names `vnames1`, `vnames2`, ..., `vnamesN` (or `vnames01`, `vnames02`, ..., `vnamesN`), where N = `col`. The numbers appended to `vnames` are padded on the left with zeros to the same length as N.

The `dtyp` argument allows you to specify the precision to use when storing your data. Keep in mind the following range restrictions when selecting a value for `dtyp`:

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Digits</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>38-268</td>
</tr>
</tbody>
</table>
If the integer type is specified, numbers are rounded to the nearest integer as they are written to the data set. If the data to be written to the file contains character data, the precision must be 8 or the character information will be lost.

If \( vtyp \) is a scalar, then the value in \( vtyp \) controls the types of all of the columns in the data set. If it is an \( \text{Nx1} \) vector, then the type of each column is controlled by the value in the corresponding row of \( vtyp \).

**Example**

```plaintext
fh = datacreate("myfile.dat", "V",100,8,1);
x = rdn(500,100);
r = writer(fh,x);
ret = close(fh);
```

This example creates a double precision data file called `myfile.dat`, which is placed in the current directory. The file contains 100 columns with 500 observations (rows), and the columns are given the names 'V001', 'V002', ..., 'V100'.

**Source**

datafile.src

**See Also**

datacreatecomplex, create, dataopen, writer
**datacreatecomplex**

**Purpose**

Creates a complex data set.

**Format**

\[ fh = \text{datacreatecomplex}(filename, \text{vnames, col, dtyp, vtyp}); \]

**Input**

- **filename**
  - string, name of data file.

- **vnames**
  - string or Nx1 string array, names of variables.

- **col**
  - scalar, number of variables.

- **dtyp**
  - scalar, data precision, one of the following:
    - 2  2-byte, signed integer.
    - 4  4-byte, single precision.
    - 8  8-byte, double precision.

- **vtyp**
  - scalar or Nx1 vector, types of variables, may contain one or both of the following:
    - 0  character variable.
    - 1  numeric variable.
Output

\( fh \) scalar, file handle.

Remarks

The file handle returned by `datacreatecomplex` is a scalar containing a positive integer value that uniquely identifies each file. This value is assigned by GAUSS when the `create`, `datacreate`, `datacreatecomplex`, `open` or `dataopen` commands are executed. The file handle is used to reference the file in the commands `readr` and `writer`. If `datacreatecomplex` fails, it returns a -1.

Complex data is stored a row at a time, with the real and imaginary halves interleaved, element by element. For columns containing character data, the imaginary parts are zeroed out.

If `filename` does not include a path, then the file is placed on the current directory. The file is given a `.dat` extension if no extension is specified.

If `col` is set to 0, then the number of columns in the data set is controlled by the contents of `vnames`. If `col` is positive, then the file will contain `col` columns.

If `vnames` contains `col` elements, then each column is given the name contained in the corresponding row of `vnames`. If `col` is positive and `vnames` is a string, then the columns are given the names `vnames1`, `vnames2`, ..., `vnamesN` (or `vnames01`, `vnames02`, ..., `vnamesN`), where N = `col`. The numbers appended to `vnames` are padded on the left with zeros to the same length as N.

The `dtyp` argument allows you to specify the precision to use when storing your data. Keep in mind the following range restrictions when selecting a value for `dtyp`:
<table>
<thead>
<tr>
<th>Data Type</th>
<th>Digits</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer</td>
<td>4</td>
<td>-32768 &lt; X &lt; 32767</td>
</tr>
<tr>
<td>single</td>
<td>6-7</td>
<td>$8.43 \times 10^{-37} &lt;</td>
</tr>
<tr>
<td>double</td>
<td>15-16</td>
<td>$4.19 \times 10^{-307} &lt;</td>
</tr>
</tbody>
</table>

If the integer type is specified, numbers are rounded to the nearest integer as they are written to the data set. If the data to be written to the file contains character data, the precision must be 8 or the character information will be lost.

If \( vtyp \) is a scalar, then the value in \( vtyp \) controls the types of all of the columns in the data set. If it is an Nx1 vector, then the type of each column is controlled by the value in the corresponding row of \( vtyp \).

**Example**

```matlab
string vnames = { "random1", "random2" };  
fh = datacreatecomplex("myfilecplx.dat", vnames, 2, 8, 1);  
x = complex(rndn(1000,2), rndn(1000,2));  
r = writer(fh, x);  
ret = close(fh);
```

This example creates a complex double precision data file called `myfilecplx.dat`, which is placed in the current directory. The file contains 2 columns with 1000 observations (rows), and the columns are given the names 'random1' and 'random2'.

**Source**

datafile.src

**See Also**

datacreate, create, dataopen, writer
# datalist

## Purpose

List selected variables from a data set.

## Format

```
datalist dataset [[var 1 [var 2 ...]]];
```

## Input

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dataset</code></td>
<td>literal, name of the data set.</td>
</tr>
<tr>
<td><code>var#</code></td>
<td>literal, the names of the variables to list.</td>
</tr>
</tbody>
</table>

## Global Input

<table>
<thead>
<tr>
<th>Scalar</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>__range</code></td>
<td>scalar, the range of rows to list. The default is all rows.</td>
</tr>
<tr>
<td><code>__miss</code></td>
<td>scalar, controls handling of missing values.</td>
</tr>
<tr>
<td></td>
<td>0  display rows with missing values.</td>
</tr>
<tr>
<td></td>
<td>1  do not display rows with missing values.</td>
</tr>
</tbody>
</table>

The default is 0.

<table>
<thead>
<tr>
<th>Scalar</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>__prec</code></td>
<td>scalar, the number of digits to the right of the decimal point to display. The default is 3.</td>
</tr>
</tbody>
</table>
Remarks

The variables are listed in an interactive mode. As many rows and columns as will fit on the screen are displayed. You can use the cursor keys to pan and scroll around in the listing.

Example

```
   datalist freq age sex pay;
```

This command will display the variables age, sex, and pay from the data set freq.dat.

Source

datalist.src

dataload

Purpose

Loads matrices, N-dimensional arrays, strings and string arrays from a disk file.

Format

```
y = dataload(filename);
```

Input

```
filename    string, name of data file.
```
Output

\[ y \]

matrix, array, string or string array, data retrieved from the file.

Remarks

The proper extension must be included in the file name. Valid extensions are as follows:

- `.fmt` matrix file
- array file
- `.fst` string file
- string array file

See Foreign Language Interface, Chapter 1, for details on these file types.

Example

```plaintext
y = dataload("myfile.fmt");
```

See Also

`load`, `datasave`
**dataloop (dataloop)**

**Purpose**

Specifies the beginning of a data loop.

**Format**

```
dataloop infile outfile;
```

**Input**

`infile` string variable or literal, the name of the source data set.

**Output**

`outfile` string variable or literal, the name of the output data set.

**Remarks**

The statements between the `dataloop`... `endata` commands are assumed to be metacode to be translated at compile time. The data from `infile` is manipulated by the specified statements, and stored to the data set `outfile`. Case is not significant within the `dataloop`... `endata` section, except for within quoted strings. Comments can be used as in any GAUSS code.

**Example**

```
src = "source";
dataloop ^src dest;
make newvar = x1 + x2 + log(x3);
```
Here, \texttt{src} is a string variable requiring the caret (^) operator, while \texttt{dest} is a string literal.

\textbf{dataopen}

\textbf{Purpose}

Opens a data set.

\textbf{Format}

\begin{equation*}
    fh = \texttt{dataopen}(\texttt{filename, mode});
\end{equation*}

\textbf{Input}

- \texttt{filename}: string, name of data file.
- \texttt{mode}: string containing one of the following:
  - \texttt{read}: open file for read.
  - \texttt{append}: open file for append.
  - \texttt{update}: open file for update.

\textbf{Output}

- \texttt{fh}: scalar, file handle.
Remarks

The file must exist before it can be opened with the `dataopen` command (to create a new file, see `datacreate` or `datasave`).

The file handle returned by `dataopen` is a scalar containing a positive integer value that uniquely identifies each file. This value is assigned by GAUSS when the `create`, `datacreate`, `datacreatecomplex`, `open` or `dataopen` commands are executed. The file handle is used to reference the file in the commands `readr` and `writer`. If `dataopen` fails, it returns a -1.

A file can be opened simultaneously under more than one handle. If the value that is in the file handle when the `dataopen` command begins to execute matches that of an already open file, the process will be aborted and a File already open error message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happens, you would no longer be able to access the first file.

It is important to set unused file handles to zero because both `dataopen` and `datacreate` check the value that is in a file handle to see if it matches that of an open file before they proceed with the process of opening a file. You may set unused file handles to zero with the `close` or `closeall` commands.

If `filename` does not have an extension, `dataopen` appends a .dat extension before searching for the file. If the file is an .fmt matrix file, the extension must be explicitly given. If no path information is included, then `dataopen` searches for the file in the current directory.

Files opened in `read` mode cannot be written to. The pointer is set to the beginning of the file and the `writer` function is disabled for files opened in this way. This is the only mode available for matrix files (.fmt), which are always written in one piece with the `save` command.

Files opened in `append` mode cannot be read. The pointer is set to the end of the file so that a subsequent write to the file with the `writer` function will add data to the end of the file without overwriting any of the existing data in the file. The `readr`
function is disabled for files opened in this way. This mode is used to add additional rows to the end of a file.

Files opened in update mode can be read from and written to. The pointer is set to the beginning of the file. This mode is used to make changes in a file.

**Example**

```c
fh = dataopen("myfile.dat","read");
y = readr(fh,100);
ret = close(fh);
```

This example opens the data file `myfile.dat` in the current directory and reads 100 observations (rows) from the file into the global variable `y`.

**Source**

datafile.src

**See Also**

open, datacreate, writer, readr

**datasave**

**Purpose**

Saves matrices, N-dimensional arrays, strings and string arrays to a disk file.

**Format**

```c
ret = datasave(filename,x);
```
**Input**

- **filename** string, name of data file.
- **x** matrix, array, string or string array, data to write to disk.

**Output**

- **ret** scalar, return code, 0 if successful, or -1 if it is unable to write the file.

**Remarks**

`datasave` can be used to save matrices, N-dimensional arrays, strings and string arrays. The following extensions are given to files that are saved with `datasave`:

- matrix `.fmt`
- array `.fmt`
- string `.fst`
- string array `.fst`

See **Foreign Language Interface**, Chapter 1, for details on these file types.

Use `dataload` to load a data file created with `datasave`.

**Example**

```matlab
x = rndn(1000,100);
```
ret = datasave("myfile.fmt",x);

See Also
save, dataload

date

Purpose

Returns the current date in a 4-element column vector, in the order: year, month, day, and hundredths of a second since midnight.

Format

\[ y = \text{date}; \]

Remarks

The hundredths of a second since midnight can be accessed using hsec.

Example

\[
\begin{align*}
\text{print } \text{date}; \\
2012.0 \\
7.0 \\
16.0 \\
4571524.7
\end{align*}
\]
### See Also

time, timestr, ethsec, hsec, etstr

### datestr

#### Purpose

Returns a date in a string.

#### Format

\[
str = \text{datestr}(d);
\]

#### Input

- \(d\) 4x1 vector, like the `date` function returns. If this is 0, the `date` function will be called for the current system date.

#### Output

- \(str\) 8 character string containing current date in the form: \(mo/du/yr\)

#### Example

```plaintext
d = { 2012, 10, 09, 0 };  
y = datestr(d);  
print y;
```
produces the following output:

10/09/12

**Source**

time.src

**See Also**

date, datestring, datestrymd, time, timestr, ethsec

**datestring**

**Purpose**

Returns a date in a string with a 4-digit year.

**Format**

\[ str = \text{datestring}(d); \]

**Input**

\[ d \] 4x1 vector, like the `date` function returns. If this is 0, the `date` function will be called for the current system date.

**Output**

\[ str \] 10 character string containing current date in the form: `mm/dd/yyyy`
Example

```matlab
dt = { 2012, 12, 18, 0 }; y = datestring(dt); print y;
```

produces the following output:

```
12/18/2012
```

Source
time.src

See Also
date, datestr, datestrymd, time, timestr, ethsec

datestrymd

Purpose

Returns a date in a string in the form \texttt{yyymmdd}.

Format

```
str = datestrymd(d);
```

Input

```
d 4x1 vector, like the \texttt{date} function returns. If this is 0, the
```
The `date` function will be called for the current system date.

### Output

| `str` | 8 character string containing current date in the form: `yyyyymmdd` |

### Example

```c
d = { 2012, 11, 16, 0 };  
y = datestrymd(d);  
print y;
```

returns:

```
20121116
```

### Source

time.src

### See Also

date, datestr, datestring, time, timestr, ethsec

dayinyr

### Purpose

Returns day number in the year of a given date.
Format

\[ \text{daynum} = \text{dayinyr}(\text{dt}); \]

Input

\( \text{dt} \) 3x1 or 4x1 vector, date to check. The date should be in the form returned by \text{date}.

Output

\( \text{daynum} \) scalar, the day number of that date in that year.

Example

```plaintext
x = { 1973, 8, 31, 0 };  
\text{y} = \text{dayinyr}(x);  
\text{print} \ y;
```

produces:

\[ \text{y} = 243.00000 \]

Source
time.src

Globals

_isleap
**dayofweek**

**Purpose**

Returns day of week.

**Format**

\[ d = \text{dayofweek}(a); \]

**Input**

\[ a \]

Nx1 vector, dates in DT format.

**Output**

\[ d \]

Nx1 vector, integers indicating day of week of each date:

1. Sunday
2. Monday
3. Tuesday
4. Wednesday
5. Thursday
6. Friday
7. Saturday
Remarks

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

20120401183207


Source

time.src

dbAddDatabase

Purpose

Adds a database to the list of database connections using the driver type or a connection URL.

Format

\[
\begin{align*}
  db_id &= \text{dbAddDatabase}(driver\_type); \\
  db_id &= \text{dbAddDatabase}(connection\_url);
\end{align*}
\]

Input

\[
\begin{align*}
  driver\_type & \quad \text{string, supported options include:} \\
                 & \quad \text{MYSQL,} \\
                 & \quad \text{OCI,} \\
                 & \quad \text{ODBC,}
\end{align*}
\]
PSQL,
SQLITE

`connection_url` string, with the following format:

driver://username:password@hostname:port/database_name

Output

- `db_id` scalar, index into a table of all opened database connections, or 0 on failure.

Example

```plaintext
db_id = dbAddDatabase("MYSQL");
url = "mysql://webuser:pswd@localhost:3306/dev";
db_id = dbAddDatabase(url);
```

Remarks

Before using the connection, it must be initialized. E.g., call some or all of `dbSetDatabaseName()`, `dbSetUserName()`, `dbSetPassword()`, `dbSetHostName()`, `dbSetPort()`, and `dbSetConnectOptions()`, and, finally, `dbOpen()`.

The exception to this is using a connection URL, since this performs the above mentioned steps. Omitting portions of the connection URL is allowed, but the syntax must remain the same. For example:

```plaintext
id = dbAddDatabase("oci://root:@localhost:/testing");
```
is a valid connection URL, but will not set the password or port number fields.

### dbClose

#### Purpose

Closes a database connection and destroys any remaining queries.

#### Format

```
dbClose(db_id);
```

#### Input

- **db_id**: scalar, database connection index number.

#### Remarks

`dbClose()` does not remove the database connection from the list of available database connections. The connection can be opened again without repeating the database initialization and setup steps.

### dbCommit

#### Purpose

Commits a transaction to the database if the driver supports transactions and a `dbTransaction()` has been started.
Format

\[ ret = \text{dbCommit}(db\_id); \]

Input

\textit{db\_id}  
scalar, database connection index number.

Output

\textit{ret}  
scalar, 1 for success or 0 for failure.

Example

\begin{verbatim}
  db_id = \text{dbAddDatabase}("SQLITE");
  \text{dbTransaction}(db\_id);
  \text{dbExecQuery}(db\_id, "INSERT INTO PEOPLE
    (first, last) VALUES ('John', 'Doe');");
  \text{dbCommit}(db\_id);
  \text{dbClose}(db\_id);
\end{verbatim}

Remarks

Note: For some databases, the commit will fail and return 0 if there is an active query using the database for a SELECT statement. Make the query inactive before doing the commit to resolve this problem.

Call \text{dbGetLastErrorText}() to get information about errors.
dbCreateQuery

**Purpose**

Process an SQL statement and prepare a query. If `placeholders` is present, these values are bound sequentially to ODBC style parameters.

**Format**

```
qid = dbCreateQuery(db_id);
qid = dbCreateQuery(db_id, query);
qid = dbCreateQuery(db_id, query, placeholders);
```

**Input**

- `db_id` scalar, database connection index number.
- `query` string, database query to construct.
- `placeholders` string, or string array containing bind value(s).

**Output**

- `qid` scalar, query id to be used for result retrieval.
Example

Example 1

```c
qid = dbCreateQuery("SELECT * FROM GDP
   WHERE COUNTRY = ?", "USA");
   dbQueryExecPrepared(qid);

   // Results as a matrix
   results = dbQueryFetchAllM(qid);
```

Example 2

```c
qid = dbCreateQuery("INSERT INTO
   PEOPLE(id, fname, lname) VALUES
   (NULL, ?, ?);");
   dbQueryAddBindValue(qid, "Joe");
   dbQueryAddBindValue(qid, "Smith");
   dbQueryExecPrepared(qid);
```

Remarks

If the placeholders parameter is passed in, the values are bound sequentially to ODBC style parameters.

See also

dbQueryPrepare
**dbExecQuery**

**Purpose**

Executes an SQL statement and creates a query. If `placeholders` is present, these values are bound sequentially to ODBC style parameters.

**Format**

```
qid = dbExecQuery(db_id, sql_statement);
qid = dbExecQuery(db_id, sql_statement, placeholders);
```

**Input**

- `db_id` scalar, database connection index number.
- `sql_statement` string containing a valid SQL statement.
- `placeholders` string (array) containing bind value(s).

**Output**

- `qid` scalar, query id to be used for result retrieval.

**Example**

In the examples below, `db_id` is a previously created database id.
**Example 1**

```plaintext
def qid = dbExecQuery(db_id, "SELECT * FROM GDP
   WHERE COUNTRY = ?", "USA");

// Results as a matrix
results = dbQueryFetchAllM(qid);
```

**Example 2**

```plaintext
bd_vals = "Joe"|"Smith";
qid = dbExecQuery(db_id, "INSERT INTO PEOPLE(id,
   fname, lname); VALUES (NULL, ?, ?);", bd_vals);
```

**Example 3**

```plaintext
qid = dbExecQuery("SELECT * FROM PEOPLE
   p WHERE p.FNAME = ?", "Joe");

// Results as a string array
results = dbQueryFetchAllSA(qid);
```

**dbGetConnectOptions**

**Purpose**

Returns the connection options string used for a database connection.

**Format**

```plaintext
options = dbGetConnectOptions(db_id);
```
### Input

\[ db_{id} \]  
Scalar, database connection index number.

### Output

\[ options \]  
String, containing the connection options for the specified database connection.

### See Also

*dbSetConnectOptions*

### Remarks

If you have not set any connection options with *dbSetConnectOptions*, then this function will return an empty string. For a full list of options see *dbSetConnectOptions*.

### dbGetDatabaseName

#### Purpose

Returns the name of the database.

#### Format

\[
db_{name} = \text{dbGetDatabaseName}(db_{id});
\]
**Input**

\[ db_id \]  
scalar, database connection index number.

**Output**

\[ db_name \]  
string, name of the database.

**dbGetDriverName**

**Purpose**

Returns the name of the connection's database driver.

**Format**

\[ driver_name = \text{dbGetDriverName}(db_id); \]

**Input**

\[ db_id \]  
scalar, database connection index number.

**Output**

\[ driver_name \]  
string, name of the database driver.
### Example

```java
   db_id = dbAddDatabase("SQLITE");
   print "Driver = " dbGetDriverName(db_id);
```

will print the following output

```
   Driver = SQLITE
```

### dbGetDrivers();

### Purpose

Returns a list of available database drivers.

### Format

```
   drivers = dbGetDrivers();
```

### Output

```
   drivers  N x 1 string array, list of available database drivers.
```

### Example

```java
   print dbGetDrivers();
```

```
   MYSQL
   OCI
   ODBC
```
**dbGetHostName**

**Purpose**

Returns the database connection's host name

**Format**

```
host_name = dbGetHostName(db_id);
```

**Input**

- **db_id**: scalar, database connection index number.

**Output**

- **host_name**: string, name of database connection.

**dbGetLastErrorNum**

**Purpose**

Returns information about the last error that occurred on the database.
**Format**

\[ \text{last\_error} = \text{dbGetLastErrorNum}(\text{db\_id}); \]

**Input**

- \text{db\_id} scalar, database connection index number.

**Output**

- \text{last\_error} scalar, number of last error on the specified database.

**dbGetLastErrorText**

**Purpose**

Returns information about the last error that occurred on the database.

**Format**

\[ \text{last\_error} = \text{dbGetLastErrorText}(\text{db\_id}); \]

**Input**

- \text{db\_id} scalar, database connection index number.
Output

last_error  string, details of last error on the specified database.

**dbGetNumericalPrecPolicy**

**Purpose**

Returns the default numerical precision policy for a specified database connection.

**Format**

\[
prec_policy = \text{dbGetNumericalPrecPolicy}(db\_id);
\]

**Input**

\[
\text{db}_id  \quad \text{scalar, database connection index number.}
\]

**Output**

\[
prec_policy  \quad \text{scalar:}
\]

- DB_HIGH_  strings will be used to preserve precision
- PRECISION
- DB_LOW_  Force 32-bit integer values
- PRECISION_
- INT32
DB_LOWPRECISIONINT64
Force 64-bit integer values

DB_LOWPRECISIONDOUBLE
Force double values. This is the default policy.

**dbGetPassword**

**Purpose**

Returns a connection's password.

**Format**

```
db_password = dbGetPassword(db_id);
```

**Input**

*db_id* scalar, database connection index number.

**Output**

*db_password* string containing the password for the specified database connection or a null string.
Remarks

dbGetPassword() will only return passwords set with dbSetPassword() or specified in the URL string for dbAddDatabase().

dbGetPort

Purpose

Returns the database connection's port number if it has been set.

Format

\[
d_{port} = \text{dbGetPort}(db_{id});
\]

Input

\( db_{id} \) scalar, database connection index number.

Output

\( db_{port} \) scalar, the port number of the specified database connection.

Remarks

dbGetPort() will only return the port number if it was previously set with dbSetPort().
dbGetTableHeaders

**Purpose**

Returns a string array populated with the names of all the fields in a specified table (or view).

**Format**

```
field_names = dbGetTableHeaders(db_id, table_name);
```

**Input**

- `db_id` scalar, database connection index number.
- `table_name` string, name of table or view.

**Output**

- `field_names` string array containing the column names for the specified table or view.

**Remarks**

The order in which the fields appear in the record is undefined.
**dbGetTables**

**Purpose**

Returns the database's tables, system tables and views.

**Format**

```plaintext
tables = dbGetTables(db_id, type);
tables = dbGetTables(db_id);
```

**Input**

- **db_id**
  - scalar, database connection index number.
- **type**
  - scalar:
    - **DB_TABLES**
      - All tables visible to the user. This is the default value.
    - **DB_SYSTEM_TABLES**
      - Internal tables used by the database.
    - **DB_VIEWS**
      - All views visible to the user.
    - **DB_ALL_TABLES**
      - All of the above.

**Output**

- **tables**
  - Nx1 string array containing the information specified by the 'type' parameter.
**dbGetUserName**

**Purpose**

Returns the database connection's user name.

**Format**

```
user_name = dbGetUserName(db_id);
```

**Input**

- `db_id` scalar, database connection index number.

**Output**

- `user_name` string containing the user name associated with the specified database connection.

**See Also**

- `dbSetUserName`

**dbHasFeature**

**Purpose**

Returns a 1 if the database supports the specified feature.
Format

\[ ret = \text{dbHasFeature}(db\_id, \text{feature}); \]

Input

\( db\_id \) scalar, database connection index number.

\( \text{feature} \) scalar or define:

<table>
<thead>
<tr>
<th>Define</th>
<th>Scalar</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB_TRANSACTIONS</td>
<td>0</td>
<td>Whether the driver supports SQL transactions.</td>
</tr>
<tr>
<td>DB_QUERY_SIZE</td>
<td>1</td>
<td>Whether the database is capable of reporting the size of a query. Note that some databases do not support returning the size (i.e. number</td>
</tr>
</tbody>
</table>
of rows returned) of a query, in which case `dbQueryRows()` will return -1.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB_BLOB</td>
<td>2</td>
</tr>
<tr>
<td>DB_UNICODE</td>
<td>3</td>
</tr>
<tr>
<td>DB_PREPARED_QUERIES</td>
<td>4</td>
</tr>
<tr>
<td>DB_NAMED_PLACEHOLDERS</td>
<td>5</td>
</tr>
</tbody>
</table>

Whether the driver supports Binary Large Object fields.

Whether the driver supports Unicode strings if the database server does.

Whether the driver supports prepared query execution.

Whether the driver supports the use of named
<table>
<thead>
<tr>
<th>Feature</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB_POSITIONAL_PLACEHOLDERS</td>
<td>6</td>
</tr>
<tr>
<td>DB_LAST_INSERT_ID</td>
<td>7</td>
</tr>
<tr>
<td>DB_BATCH_OPERATIONS</td>
<td>8</td>
</tr>
<tr>
<td>DB_SIMPLE_LOCKING</td>
<td>9</td>
</tr>
<tr>
<td>DB_LOW_PRECISION_NUMBERS</td>
<td>10</td>
</tr>
</tbody>
</table>

- **DB_POSITIONAL_PLACEHOLDERS**: Whether the driver supports the use of positional placeholders.
- **DB_LAST_INSERT_ID**: Whether the driver supports returning the Id of the last touched row.
- **DB_BATCH_OPERATIONS**: Whether the driver supports batched operations. (Not supported)
- **DB_SIMPLE_LOCKING**: Whether the driver disallows a write lock on a table while other queries have a read lock on it.
the driver allows fetching numerical values with low precision.

Whether the driver supports database event notifications.

Whether the driver can do any low-level resource cleanup when `dbQueryFinish()` is called.

Whether the driver can access multiple result sets returned from batched statements.
or stored procedures. (Not supported)

Output

\[ ret \]
Scalar, 1 if the database supports the specified feature, or 0 if not.

Example

```c
db_id = dbAddDatabase("MYSQL");

// Create empty query
qid = dbCreateQuery(db_id);

if dbHasFeature(db_id, DB_NAMED_PLACEHOLDERS);
    dbQueryPrepare(qid, "SELECT * FROM GDP WHERE COUNTRY = :country");
    dbQueryBindValue(qid, ":country", "USA");
else;
    dbQueryPrepare(qid, "SELECT * FROM GDP WHERE COUNTRY = ?");
    dbQueryBindValue(qid, 1, "USA");
endif;

dbQueryExecPrepared(qid);
```
Remarks

Note that some databases need to be opened with `dbOpen()` before this can be determined.

dbIsDriverAvailable

Purpose

Returns 1 if a specified database driver is available.

Format

```
ret = dbIsDriverAvailable(name);
```

Input

`name` string, name of driver to check

Output

`ret` scalar, 1 if the specified driver is available, or 0 if not.

dbIsOpen

Purpose

Reports whether a specified database connection is open.
**Format**

\[
ret = \text{dbIsOpen}(db\_id);
\]

**Input**

- \( db\_id \) scalar, database connection index number.

**Output**

- \( ret \) scalar, 1 if the connection is open or 0 if it is closed.

**dbIsOpenError**

**Purpose**

Reports whether an error occurred while attempting to open the database connection.

**Format**

\[
ret = \text{dbIsOpenError}(db\_id);
\]

**Input**

- \( db\_id \) scalar, database connection index number.
Output

\textit{ret} scalar, 1 if there was an error or 0 if not.

\textbf{dbNumericalPrecPolicy}

\textbf{Purpose}

Returns the default numerical precision policy for a specified database connection.

\textbf{Format}

\begin{verbatim}
prec_policy = dbNumericalPrecPolicy(db_id);
\end{verbatim}

\textbf{Input}

\begin{verbatim}
db_id scalar, database connection index number.
\end{verbatim}

\textbf{Output}

\begin{verbatim}
prec_policy scalar:
0 strings will be used to preserve precision
1 Force 32-bit integer values
2 Force 64-bit integer values
4 Force double values. This is the default policy.
\end{verbatim}
**dbOpen**

**Purpose**

Opens a specified database connection using the current connection values.

**Format**

```
ret = dbOpen(db_id, user_name, password);
ret = dbOpen(db_id);
```

**Input**

- **db_id**: scalar, database connection index number.
- **user_name**: string, user name for the database being connected to.
- **password**: string, password associated with the specified user name for this database.

**Output**

- **ret**: scalar, 1 for success.

**Example**

Set driver and host

```
  db_id = dbAddDatabase("MYSQL");
dbSetHostName(db_id, "localhost");
```

then, either
dbSetUserName(db_id, "test");
dbSetPassword(db_id, "secret_passw0rd");
ret = dbOpen(db_id);

or

ret = dbOpen(db_id, "test", "secret_passw0rd");

**dbQueryBindValue**

**Purpose**

Set the placeholder placeholder to be bound to value val in the prepared statement. Note that the placeholder mark (e.g. :) must be included when specifying the placeholder name.

**Format**

\[ \text{dbQueryBindValue}(qid, \text{placeholder}, \text{val}); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>qid</strong></td>
<td>scalar, query number.</td>
</tr>
<tr>
<td><strong>placeholder</strong></td>
<td>string, Oracle style (:value_name) or integer, index of ODBC style (?) placeholder.</td>
</tr>
<tr>
<td><strong>val</strong></td>
<td>valid type, the value to be bound.</td>
</tr>
</tbody>
</table>
**Remarks**

Values cannot be bound to multiple locations in the query.

**Example**

**Oracle style**

```
    db_id = dbAddDatabase("MYSQL");
    qid = dbCreateQuery(db_id);
    dbQueryPrepare(qid, "SELECT * FROM
        PEOPLE WHERE FIRST = :fname AND
        LAST = :lname");
    dbQueryBindValue(qid, ":fname", "John");
    dbQueryBindValue(qid, ":lname", "Doe");
    dbQueryExecPrepared(qid);
```

**ODBC Style**

```
    db_id = dbAddDatabase("MYSQL");
    qid = dbCreateQuery(db_id);
    dbQueryPrepare(qid, "SELECT * FROM
        PEOPLE WHERE FIRST = ? AND
        LAST = ?");
    dbQueryBindValue(qid, 1, "John");
    dbQueryBindValue(qid, 2, "Doe");
    dbQueryExecPrepared(qid);
```
**dbQueryClear**

**Purpose**

Clears the result set and releases any resources held by the query. Sets the query state to inactive.

**Format**

```
dbQueryClear(qid);
```

**Input**

- `qid` scalar, query number.

**Remarks**

You should rarely if ever need to call this function.

---

**dbQueryCols**

**Purpose**

Returns the number of fields in the record.

**Format**

```
num_fields = dbQueryCols(qid);
```
**Input**

$qid$ scalar, query number.

**Output**

$num\_fields$ scalar, number of fields.

---

**dbQueryExecPrepared**

**Purpose**

Executes a previously created and prepared query.

**Format**

```
ret = dbQueryExecPrepared(qid);
```

**Input**

$qid$ scalar, query number.

**Output**

$ret$ scalar, 1 for success and 0 for failure.
Example

```plaintext
qid = dbCreateQuery(db_id);
dbQueryPrepare(qid, "SELECT * FROM USERS WHERE ID = :id");
dbQueryBindValue(qid, ":id", 5);
dbQueryExecPrepared(qid);

results = dbQueryFetchAllSA(qid);

dbQueryBindValue(qid, ":id", 10);

// Re-execute the query with new value
dbQueryExecPrepared(qid);

results = dbQueryFetchAllSA(qid);
```

dbQueryFetchAllM

Purpose

Returns the result set for the current query as a matrix.

Format

```plaintext
result = dbQueryFetchAllM(qid);
result = dbQueryFetchAllM(qid, columns);
```

Input

```plaintext
qid          scalar, query number.
```
**columns**

string or string array, specific columns to pull out from result matrix. Must be a subset of fields from SELECT statement.

**Output**

**result**

matrix, the result set; or if the result set is empty, a scalar error code.

**Remarks**

For string results, or to treat numerical results as strings, use `dbQueryFetchAllSA()` to return a string array. This function retrieves all rows at once. You can process rows in an iterative manner by using the `dbQueryFetchOneM()` and `dbQueryFetchOneSA()` functions.

**Example**

**Example 1**

```plaintext
qid = dbExecQuery(db_id, "SELECT * FROM GDP");

gdp = dbQueryFetchAllM(qid);

// If 'gdp' is a scalar error code
if scalmiss(gdp);
    print "No results";
else;
    // do something with gdp
endif;
```
Example 2

```sql
qid = dbExecQuery(db_id, "SELECT * FROM PEOPLE WHERE COUNTRY = ?", "USA");

// specify zipcode as column of interest
zipcodes = dbQueryFetchAllM(qid, "ZIPCODE");

if not scalmiss(zipcodes);
    print "zip codes = " zipcodes;
endif;
```

See Also

dbQueryFetchAllSA, dbQueryFetchOneM, dbQueryFetchOneSA

dbQueryFetchAllSA

Purpose

Returns the result set for the current query as a string array.

Format

```sql
result = dbQueryFetchAllSA(qid);
result = dbQueryFetchAllSA(qid, columns);
```

Input

- **qid**: scalar, query number.
- **columns**: string or string array, specific columns to pull out from result.
matrix. Must be a subset of fields from SELECT statement.

**Output**

`result` string array, containing the result set for the current query. If the result set is empty, a scalar error code is returned.

**Remarks**

For numerical only results, use `dbQueryFetchAllM()` to return a matrix. This function retrieves all rows at once. You can process rows in an iterative manner by using the `dbQueryFetchOneM()` and `dbQueryFetchOneSA()` functions.

**Example**

```php
$qid = dbExecQuery(db_id, "SELECT * FROM PEOPLE WHERE COUNTRY = ?", "USA");

// specify names as columns of interest
names = dbQueryFetchAllSA(qid,
   "FIRST_NAME"|$"LAST_NAME");

// If 'names' is not a scalar error code
if not scalmiss(names);
   print "People in the USA = " names;
endif;
```

**See Also**

dbQueryFetchAllM, dbQueryFetchOneSA, dbQueryFetchOneM
dbQueryFetchOneM

Purpose

Returns a single row as an Nx1 matrix where N is the column count of the SELECT statement containing the field information for the current query.

Format

```plaintext
record = dbQueryFetchOneM(qid);
record = dbQueryFetchOneM(qid, columns);
```

Input

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>qid</td>
<td>scalar, query number.</td>
</tr>
<tr>
<td>columns</td>
<td>string or string array, specific columns to pull from the result matrix. Must be a subset of fields from the SELECT statement.</td>
</tr>
</tbody>
</table>

Output

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>record</td>
<td>matrix, if the query points to a valid row (dbQueryIsValid() returns true), the record is populated with the row's values. An empty record (scalmiss (record) is true) is returned when there is no active query (dbQueryIsActive() returns false).</td>
</tr>
</tbody>
</table>

Remarks

This function is only useful in an iterative context. You can easily retrieve all the
results at once by using the `dbQueryFetchAllM()` and `dbQueryFetchAllSA()` functions.

For string results, or to treat numerical results as a string, using `dbQueryFetchOneSA()` will return a string array.

**Example**

```c
qid = dbExecQuery(db_id, "SELECT YTD, TOTAL FROM GDP");

do while dbQuerySeekNext(qid);
    record = dbQueryFetchOneM(qid);
    ytd = record[1];
    total = record[2];
endo;
```

**See Also**

`dbQueryFetchOneSA`, `dbQueryFetchAllM`, `dbQueryFetchAllSA`, `dbQueryGetField`

**dbQueryFetchOneSA**

**Purpose**

Returns a single row as a string vector containing the field information for the current query.

**Format**

```c
record = dbQueryFetchOneSA(qid);
record = dbQueryFetchOneSA(qid, columns);
```
Input

**qid**
scalar, query number.

**columns**
string or string array, specific columns to pull from the result matrix. Must be a subset of fields from the SELECT statement.

Output

**record**
string array, if the query points to a valid row (dbQueryIsValid() returns true), the record is populated with the row's values. An empty record (scalmiss (record) is true) is returned when there is no active query dbQueryIsActive() returns false).

Remarks

This function is only useful in an iterative context. You can easily retrieve all the results at once by using the dbQueryFetchAllM() and dbQueryFetchAllSA() functions.

For numerical only results, using dbQueryFetchOneM() will return a matrix instead of a string array.

Example

```plaintext
qid = dbExecQuery(db_id, "SELECT COUNTRY, TOTAL FROM GDP");
do while dbQuerySeekNext(qid);
    record = dbQueryFetchOneSA(qid);
```
country = record[1];
total = record[2];
end;
**dbQueryGetBoundValue**

**Purpose**

Returns the value for a placeholder in a query.

**Format**

```plaintext
val = dbQueryGetBoundValue(qid, placeholder);
```

**Input**

<table>
<thead>
<tr>
<th>qid</th>
<th>scalar, query number.</th>
</tr>
</thead>
<tbody>
<tr>
<td>placeholder</td>
<td>string, Oracle style (:value_name) or integer, index of ODBC style (?) placeholder.</td>
</tr>
</tbody>
</table>

**Output**

| val       | string, bound value if previously set. |

**Example**

```plaintext
db_id = dbAddDatabase("MYSQL");
qid = dbCreateQuery(db_id);
dbQueryPrepare(qid, "SELECT * FROM PEOPLE WHERE FIRST = :fname AND LAST = :lname");
dbQueryBindValue(qid, "fname", "John");
dbQueryBindValue(qid, "lname", "Doe");
```
```plaintext
print "Name = ";
print dbQueryGetBoundValue(qid, ":fname");
print dbQueryGetBoundValue(qid, ":lname");
```

_or_

```plaintext
db_id = dbAddDatabase("MYSQL");
args = "John"|"Doe";
qid = dbCreateQuery(db_id, "SELECT * FROM PEOPLE WHERE FIRST = ? AND LAST = ?", args);
```

```plaintext
print "Name = ";
print dbQueryGetBoundValue(qid, 1);
print dbQueryGetBoundValue(qid, 2);
```

results in

```
Name = John Doe
```

**dbQueryGetBoundValues**

**Purpose**

Returns an Nx2 string array containing the placeholders and their corresponding values in a query.

**Format**

```plaintext
bound_values = dbQueryGetBoundValues(qid);
```
**Input**

$qid$ scalar, query number.

**Output**

$bound_values$ Nx2 string array. The first column contains the placeholders and the second column contains the corresponding values.

**Example**

```plaintext
db_id = dbAddDatabase("MYSQL");
qid = dbCreateQuery(db_id);
dbQueryPrepare(qid, "SELECT * FROM
    PEOPLE WHERE FIRST = :fname AND
   LAST = :lname");
dbQueryBindValue(qid, ":fname", "John");
dbQueryBindValue(qid, ":lname", "Doe");

print "Vars = " dbQueryGetBoundValues(qid);
```

will print

```
Vars =
    :fname   John
    :lname   Doe
```
dbQueryGetField

Purpose

Returns the value of a specified field in the current record. An overloaded version that accepts a column name as input is available, but not as efficient.

Format

\[
\text{field\_value} = \text{dbQueryGetField}(\text{qid}, \text{idx});
\]
\[
\text{field\_value} = \text{dbQueryGetField}(\text{qid}, \text{name});
\]

Input

\begin{itemize}
\item \textit{qid} \hspace{1cm} scalar, query number.
\item \textit{idx} \hspace{1cm} scalar, index of the field whose value should be returned.
\end{itemize}

Remarks

The fields are numbered from left to right using the text of the SELECT statement, e.g. in

\[
\text{qid} = \text{dbExecQuery}("\text{SELECT forename, surname FROM people"});
\]
\[
\text{do while dbQuerySeekNext(qid);
    forename = dbQueryGetField(qid, 1);
    // Using field index
    surname = dbQueryGetField(qid, 2);
    // Using field index
    forename = dbQueryGetField(qid, "forename");
\]
Field 1 is *forename* and field 2 is *surname*. Using SELECT * is not recommended because the order of the fields in the query is undefined.

**See Also**
dbQueryFetchOneM, dbQueryFetchOneSA

dbQueryGetLastErrorNum

**Purpose**

Returns error information about the last error that occurred (if any) with the last executed query.

**Format**

```
err_num = dbQueryGetLastErrorNum();
```

**Output**

```
err_num  scalar, number of last error.
```

**Remarks**

Because a failed query will not have a valid handle (id), this function retrieves stored error information about the last executed query.
See also

dbQueryGetLastErrorText

dbQueryGetLastErrorText

Purpose

Returns error information about the last error that occurred (if any) with the last executed query.

Format

```
err_txt = dbQueryGetLastErrorText();
```

Output

```
err_txt
```
2x1 string array, database and driver text of last error.

Remarks

Because a failed query will not have a valid handle (id), this function retrieves stored error information about the last executed query.

See also

dbQueryGetLastErrorNum
dbQueryGetLastInsertID

**Purpose**

Returns the object ID of the most recent inserted row if supported by the database.

**Format**

```plaintext
last_insert = dbQueryGetLastInsertID(qid);
```

**Input**

- **qid**: scalar, query number.

**Output**

- **last_insert**: scalar, object id

**Remarks**

If more than one row was touched by the insert, the behavior is undefined.

For MySQL databases the row's auto-increment field will be returned.

With a PSQL database, the table must contain OID's which were not created by default. Check the `default_with_oids` configuration variable to be sure.

**Example**

38-334
// Given NAMES is an empty MySQL
// table with the *id* column
// auto-incrementing.
db_id = dbAddDatabase("MYSQL");
qid = dbCreateQuery(db_id, "INSERT
  INTO NAMES (first, last) VALUES
  ('John', 'Doe');");

if dbHasFeature(db_id, DB_LAST_INSERT_ID);
  last_id = dbQueryGetLastInsertID(qid);
endif;

See Also
dbHasFeature
dbQueryGetLastQuery

Purpose
Returns the text of the current query being used.

Format

query_string = dbQueryGetLastQuery(qid);

Input

qid scalar, query number.
Output

| query_string | string, text of the current query, or empty string if there is no current query. |

**dbQueryGetPosition**

**Purpose**

Returns the current internal position of the query.

**Format**

\[
\text{index} = \text{dbQueryGetPosition}(qid)
\]

**Input**

| qid | scalar, query number. |

**Output**

| index | scalar, query position |

**Remarks**

The first record is at position zero. If the position is invalid, the function returns DB_BEFORE_FIRST_ROW or DB_AFTER_LAST_ROW, which are special negative values.
Example

```plaintext
qid = dbCreateQuery(db_id, "SELECT * 
FROM PEOPLE");
do while dbQuerySeekNext(qid);
    print "Current index = "
    dbQueryGetPosition(qid);
endo;
```

dbQueryIsActive

**Purpose**

Returns 1 if the query is active.

**Format**

```plaintext
ret = dbQueryIsActive(qid);
```

**Input**

| qid | scalar, query number. |

**Output**

| ret | scalar, 1 if the query is active or 0 if not. |

**Remarks**

An active query is one that has been `dbQueryExecPrepared()`'d successfully, but
not yet finished with. When you are finished with an active query, you can make the query inactive by calling `dbQueryFinish()` or `dbQueryClear()`.

Note: Of particular interest is an active query that is a SELECT statement. For some databases that support transactions, an active query that is a SELECT statement can cause a `dbCommit()` or a `dbRollback()` to fail, so before committing or rolling back, you should make your active SELECT statement query inactive using one of the methods listed above.

**Example**

```c
qid = dbCreateQuery(db_id);
dbQueryIsActive(qid); // False

dbQueryPrepare(qid, "INSERT INTO TEST (foo, bar) VALUES (1, 2);"神通);
dbQueryIsActive(qid); // False

dbQueryExecPrepared(qid);
dbQueryIsActive(qid); // True

dbQueryFinish(qid);
dbQueryIsActive(qid); // False
```

**dbQueryIsForwardOnly**

**Purpose**

Reports whether you can only scroll forward through a result set.

**Format**

```c
ret = dbQueryIsForwardOnly(qid);
```
Input

$qid$ scalar, query number.

Output

$ret$ scalar, 1 if the result set can only be scrolled through forward, otherwise a 0.

Remarks

Setting a query to "forward only" will usually improve performance. By default, queries are created with "forward only" off.

See Also

dbQuerySetForwardOnly, dbQuerySeekNext

dbQueryIsNull

Purpose

Returns 1 if the query is active, positioned on a valid record and the field is NULL; otherwise returns 0. Reports whether the current field pointed at by an active query positioned on a valid record is NULL.

Format

\[ ret = \text{dbQueryIsNull}(qid, field); \]
Input

qid  scalar, query number.
field  scalar, index into result set.

Output

ret  scalar, 1 if the field is NULL or 0 otherwise.

Remarks

Note that for some drivers, dbQueryIsNull() will not return accurate information until after an attempt is made to retrieve data.

See Also

dbQueryIsActive, dbQueryIsValid

dbQueryIsSelect

Purpose

Reports whether the specified query is a SELECT statement.

Format

\[ ret = \text{dbQueryIsSelect}(qid); \]
**Input**

$qid$ scalar, query number.

**Output**

$ret$ scalar, 1 if the query is a SELECT statement or 0 otherwise.

**Example**

```c
qid = dbExecQuery(db_id, "SELECT * FROM PEOPLE");

dbQueryIsSelect(qid); // True

qid = dbExecQuery(db_id, "INSERT INTO PEOPLE (fname, lname) VALUES ('John', 'Doe');");

dbQueryIsSelect(qid); // False
```

**dbQueryIsValid**

**Purpose**

Reports whether the specified query is positioned on a valid record.

**Format**

```c
ret = dbQueryIsValid(qid);
```
### Input

| qid   | scalar, query number. |

### Output

| ret   | scalar, 1 if the query is positioned on a valid record or 0 otherwise. |

### Example

```plaintext
qid = dbExecQuery(db_id, "SELECT * FROM PEOPLE");

dbQueryIsValid(qid); // False
// Give it a valid position
dbQuerySeekFirst(qid);
// Iterate until no longer valid.
do while dbQueryIsValid(qid);
    // dbQueryIsValid = True
dbQuerySeekNext(qid);
endo;

dbQueryIsValid(qid); // False
```

### dbQueryPrepare

#### Purpose

Prepares a SQL query for execution.
**Format**

\[ ret = \texttt{dbQueryPrepare}(qid, \texttt{query}); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>qid</strong></td>
<td>scalar, query index number.</td>
</tr>
<tr>
<td><strong>query</strong></td>
<td>string, database query to prepare.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ret</strong></td>
<td>scalar, 1 for success and 0 for failure.</td>
</tr>
</tbody>
</table>

**Example**

```c
db_id = \texttt{dbAddDatabase}("MYSQL");
qid = \texttt{dbCreateQuery}(db_id);
ret = \texttt{dbQueryPrepare}(qid, "SELECT *
FROM STOCKS WHERE SYMBOL = :sym");
dbQueryBindValue(qid, ":sym", "GOOG");
ret = \texttt{dbQueryExecPrepared}(qid);
```

**Remarks**

The query may contain placeholders for binding values. Both Oracle style colon-name (e.g., :surname), and ODBC style (?) placeholders are supported; but they cannot be mixed in the same query.
Portability note: Some databases choose to delay preparing a query until it is executed the first time. In this case, preparing a syntactically incorrect query succeeds, but every consecutive `dbQueryExecPrepared()` will fail.

For SQLite, the query string can contain only one statement at a time. If more than one statement is given, the function returns 0.

**See also**

`dbQueryBindValue`

**dbQueryRows**

**Purpose**

Returns the size of the result (number of rows returned), or -1 if the size cannot be determined or if the database does not support reporting information about query sizes.

**Format**

```
result_size = dbQueryRows(qid);
```  

**Input**

`qid` scalar, query number.

**Output**

`result_size` scalar, number of rows in the current result set of the active query. If the number of rows cannot be determined a -1 is
Remarks

Note that if the query is not active, a -1 is returned. This property can be checked with `dbQueryIsActive()`.

Example

```c
// Given a table with US States.
qid = dbCreateQuery(db_id, "SELECT * FROM STATES");

count = dbQueryRows(qid); // count = 50
```

dbQuerySeek

Purpose

Retrieves the record at a specified position, if available, and positions the query on the retrieved record.

Format

```c
ret = dbQuerySeek(qid, idx, idx_type);
ret = dbQuerySeek(qid, idx);
```
### Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>qid</td>
<td>scalar, query number.</td>
</tr>
<tr>
<td>idx</td>
<td>scalar, the index at which to place the cursor.</td>
</tr>
<tr>
<td>idx_type</td>
<td>scalar, 1 for relative position or 0 for absolute positioning. If not specified, absolute positioning is used.</td>
</tr>
</tbody>
</table>

### Output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ret</td>
<td>scalar, 1 if successful.</td>
</tr>
</tbody>
</table>

### Remarks

The first record is at position 1. Note that the query must be in an active state before calling this function. The state of the query may be verified with the function `dbQueryIsSelect()`.

If `idx_type` is 0 (the default), the following rules apply:

If `idx` is negative, the result is positioned before the first record and 0 is returned. Otherwise, an attempt is made to move to the record at position `idx`. If the record at position `idx` could not be retrieved, the result is positioned after the last record and 0 is returned. If the record is successfully retrieved, 1 is returned.

If `idx_type` is 1, the following rules apply:

If the result is currently positioned before the first record or on the first record, and `idx` is negative, there is no change, and 0 is returned.

If the result is currently located after the last record, and `idx` is positive, there is no change, and 0 is returned. If the result is currently located somewhere in the middle,
and the relative offset $idx$ moves the result below zero, the result is positioned before the first record and 0 is returned.

Otherwise, an attempt is made to move to the record $idx$ records ahead of the current record (or $idx$ records behind the current record if $idx$ is negative).

If the record at offset $idx$ could not be retrieved, the result is positioned after the last record if $idx >= 0$, (or before the first record if $idx$ is negative), and 0 is returned. If the record is successfully retrieved, 1 is returned.

See Also

dbQuerySeekFirst, dbQuerySeekLast, dbQuerySeekNext, dbQuerySeekPrevious

dbQuerySeekFirst

Purpose

Retrieves the first record in the result, if available, and positions the query on the retrieved record.

Format

\[
ret = \text{dbQuerySeekFirst}(qid);
\]

Input

$qid$ scalar, query number.

Output

$ret$ 1 if successful. If unsuccessful the query position is set to an
invalid position and 0 is returned.

Remarks

Note that the result must be in the active state or it will do nothing and return. This can be verified by calling the `dbQueryIsSelect()` function.

Example

```cpp
qid = dbCreateQuery(db_id, "SELECT * 
                  FROM PEOPLE");

while dbQuerySeekNext(qid);
  // iterate over results
endo;

// set back to start
dbQuerySeekFirst(qid);

do while dbQuerySeekNext(qid);
  // iterate over results AGAIN
endo;
```

`dbQuerySeekLast`

Purpose

Retrieves the last record in the result, if available, and positions the query on the retrieved record.
Format

\[
ret = \text{dbQuerySeekLast}(qid);
\]

Input

| qid | scalar, query number. |

Output

| ret | scalar, returns 1 if successful. If unsuccessful the query position is set to an invalid position and 0 is returned. |

Remarks

Note that the result must be in the active state and \text{dbQueryIsSelect}() must return 1 before calling this function or it will do nothing and return 0.

Example

```c
// Given STATES is a table with all
// 50 states listed alphabetically
qid = \text{dbExecQuery}(db_id, "SELECT name
FROM STATES");

// Move to last state
ret = \text{dbQuerySeekLast}(qid);

//If 'ret' is equal to 0
if not ret;
```
print "dbQuerySeekLast failed";
else;
   // Print last state: Wyoming
   print dbQueryFetchOneSA(qid);
endif;

See also

$dbQuerySeekNext$, $dbQuerySeekPrevious$, $dbQuerySeekFirst$, $dbQuerySeek$, $dbQueryGetPosition$

$dbQuerySeekNext$

Purpose

Retrieves the next record in the result, if available, and positions the query on the retrieved record.

Format

\[ ret = \text{dbQuerySeekNext}(qid); \]

Input

$qid$  scalar, query number.

Output

$ret$  scalar, if the record could not be retrieved, the result is positioned after the last record and 0 is returned. If the record
is successfully retrieved, 1 is returned.

**Remarks**

Note that the result must be in the active state before calling this function or it will do nothing and return 0. You can verify the status of the query with `dbQueryIsSelect()`.

The following rules apply:

If the result is currently located before the first record, e.g., immediately after a query is executed, an attempt is made to retrieve the first record.

If the result is currently located after the last record, there is no change and 0 is returned.

If the result is located somewhere in the middle, an attempt is made to retrieve the next record.

**Example**

```sql
qid = dbCreateQuery(db_id, "SELECT *
                     FROM PEOPLE");

do while dbQuerySeekNext(qid);
  row = dbQueryFetchOneSA(qid);
  // Or dbQueryFetchOneM(qid) if data
  // is numeric
endo;
```

**See Also**

`dbQuerySeekFirst`, `dbQuerySeekLast`, `dbQuerySeekPrevious`, `dbQuerySeek`, `dbQueryGetPosition`
**dbQuerySeekPrevious**

**Purpose**

Retrieves the previous record in the result, if available, and positions the query on the retrieved record.

**Format**

\[ ret = \text{dbQuerySeekPrevious}(qid); \]

**Input**

- \( qid \)  
  scalar, query number.

**Output**

- \( ret \)  
  scalar, 1 if the record is successfully retrieved. If the record could not be retrieved, the result is positioned before the first record and 0 is returned.

**Remarks**

Note that the result must be in the active state before calling this function or it will do nothing and return false. The state of the query can be verified with \text{dbQueryIsSelect}().

The following rules apply:

If the result is currently located before the first record, there is no change and 0 is returned.
If the result is currently located after the last record, an attempt is made to retrieve the last record.

If the result is somewhere in the middle, an attempt is made to retrieve the previous record.

**See Also**

`dbQuerySeekFirst`, `dbQuerySeekLast`, `dbQuerySeekNext`, `dbQuerySeek`, `dbQueryGetPosition`  

**dbQuerySetForwardOnly**

**Purpose**

Sets forward only mode to forward. If forward is true, only `dbQuerySeekNext()` and `dbQuerySeek()` with positive values are allowed for navigating the results.

**Format**

```
        dbQuerySetForwardOnly(qid, forward);
```

**Input**

- `qid` : scalar, query number.
- `forward` : scalar, 1 to set forward only or 0 to allow seeking in either direction.
Remarks

Forward only mode can be (depending on the driver) more memory efficient since results do not need to be cached. It will also improve performance on some databases. For this to be true, you must call `dbQuerySetForwardOnly()` before the query is prepared or executed.

Forward only mode is set to off by default.

Setting forward only to false is a suggestion to the database engine, which has the final say on whether a result set is forward only or scrollable.

`dbQueryIsForwardOnly()` will always return the correct status of the result set.

See Also

`dbQueryIsForwardOnly`

`dbRemoveDatabase`

Purpose

Removes a database connection from the list of open database connections. Frees all related resources.

Format

```
dbRemoveDatabase(db_id);
```

Input

```
db_id          scalar, database connection index number.
```
dbRollback

Purpose

Rolls back a transaction on the database.

Format

\[
\text{ret} = \text{dbRollback}(db\_id);
\]

Input

\(db\_id\) scalar, database connection index number.

Output

\(ret\) scalar, 1 to indicate success and a 0 if the rollback fails.

Remarks

A rollback is only possible if the SQL driver supports transactions and a \text{dbTransaction}() has been started.

Note: For some databases, the rollback will fail and return 0 if there is an active query using the database for a \text{SELECT}. Make the query inactive before doing the rollback.

Call \text{dbGetLastErrorText}() to get information about errors.
**dbSetConnectOptions**

**Purpose**
Sets database-specific options.

**Format**
```
dbSetConnectOptions(db_id, db_options);
```

**Input**
- `db_id` scalar, database connection index number.
- `db_options` string, a semi-colon separated list of option names or `option=value` pairs. Available options will depend upon the database being used.
Remarks

This must be done before the connection is opened or it has no effect (or you can \texttt{dbClose()} the connection, call this function and \texttt{dbOpen()} the connection again). The format of the options string is a semicolon separated list of option names or option=value pairs. The options depend on the database client used:

\begin{verbatim}
ODBC
SQL_ATTR_ACCESS_MODE
SQL_ATTR_LOGIN_TIMEOUT
SQL_ATTR_CONNECTION_TIMEOUT
SQL_ATTR_CURRENT_CATALOG
SQL_ATTR_METADATA_ID
SQL_ATTR_PACKET_SIZE
SQL_ATTR_TRACEFILE
SQL_ATTR_TRACE
SQL_ATTR_CONNECTION_POOLING
SQL_ATTR_ODBC_VERSION

MySQL
CLIENT_COMPRESS
CLIENT_FOUND_ROWS
CLIENT_IGNORE_SPACE
CLIENT_SSL
CLIENT_ODBC
CLIENT_NO_SCHEMA
CLIENT_INTERACTIVE
UNIX_SOCKET
MYSQL_OPT_RECONNECT

PostgreSQL
connect_timeout
options
\end{verbatim}
tty
requireSSL
service

DB2
SQL_ATTR_ACCESS_MODE
SQL_ATTR_LOGIN_TIMEOUT

OCI
OCI_ATTR_PREFETCH_ROWS
OCI_ATTR_PREFETCH_MEMORY

TDS
none

SQLite
QSQLITE_BUSY_TIMEOUT
QSQLITE_OPEN_READONLY
QSQLITE_ENABLE_SHARED_CACHE

Interbase
ISC_DPB_LC_CTYPE
ISC_DPB_SQL_ROLE_NAME

Example

// MySQL connection
// use an SSL connection to the server
dbSetConnectOptions(db_id, "CLIENT_SSL=1;
CLIENT_IGNORE_SPACE=1");
if not dbOpen();
    // clears the connect option string
    dbSetConnectOptions(db_id, "");
    ...
endif;
...

// PostgreSQL connection
// enable PostgreSQL SSL connections
dbSetConnectOptions(db_id, "requiressl=1");
if not dbOpen();
    // clear options
    dbSetConnectOptions(db_id, "");
    ...
endif;
...

// ODBC connection
dbSetConnectOptions(db_id, "SQL_ATTR_ACCESS_MODE=
    SQL_MODE_READ_ONLY;
    SQL_ATTR_TRACE=
    SQL_OPT_TRACE_ON");
// set ODBC options
if not dbOpen();
    // don't try to set this option
    dbSetConnectOptions(db_id, "");
    ...
endif;
**dbSetDatabaseName**

**Purpose**

Sets the connection's database name to name. To have effect, the database name must be set before the connection is opened. Alternatively, you can `dbClose()` the connection, set the database name, and call `dbOpen()` again.

**Format**

```
dbSetDatabaseName(db_id, database_name);
```

**Input**

- **`db_id`**
  - scalar, database connection index number.
- **`database_name`**
  - string, database name to apply to specified database connection.

**Remarks**

For the OCI (Oracle) driver, the database name is the TNS Service Name.

For the ODBC driver, the name can either be a DSN, a DSN filename (in which case the file must have a .dsn extension), or a connection string.

For example, Microsoft Access users can use the following connection string to open an .mdb file directly, instead of having to create a DSN entry in the ODBC manager:

```
...  
  db_id = dboAddDatabase("ODBC");  
  dbSetDatabaseName(db_id, "DRIVER=");
```
See Also

dbGetDatabaseName

dbSetHostName

Purpose

Sets the specified database connection's host name.

Format

\[ \text{dbSetHostName}(db\_id, host\_name); \]

Input

\begin{align*}
\text{db\_id} & \quad \text{scalar, database connection index number.} \\
\text{host\_name} & \quad \text{string, the name to which the specified connection's host name should be assigned.}
\end{align*}

Remarks

For this function to have an effect, it must be called before the database connection is opened with \text{dbOpen}().
dbSetPassword

**Purpose**

Sets the database connection's password.

**Format**

```
dbSetPassword(db_id, pswd);
```

**Input**

- `db_id` scalar, database connection index number.
- `pswd` string, password for database.

**Remarks**

This function must be called before the connection is opened with `dbOpen()` to have an effect.

**See Also**

- `dbGetPassword`

---

dbSetPort

**Purpose**

Sets the specified database connection's port number.
**Format**

```c
dbSetPort(db_id, port_num);
```

**Input**

<table>
<thead>
<tr>
<th>db_id</th>
<th>scalar, database connection index number.</th>
</tr>
</thead>
<tbody>
<tr>
<td>port_num</td>
<td>scalar, port number for database connection to use.</td>
</tr>
</tbody>
</table>

**Remarks**

This function must be called before the connection is opened with `dbOpen()` to have an effect.

**See Also**

dbGetPort

**dbSetUserName**

**Purpose**

Sets the specified database connection's user name.

**Format**

```c
dbSetUserName(db_id, user_name);
```
**Input**

- `db_id` scalar, database connection index number.
- `user_name` string, user name to apply to specified database connection.

**Remarks**

This function must be called before the connection is opened with `dbOpen()` to have an effect.

**See Also**

- `dbGetUserName`

**dbTransaction**

**Purpose**

Begins a transaction on the database.

**Format**

```
ret = dbTransaction(db_id);
```

**Input**

- `db_id` scalar, database connection index number.
**Output**

\[ ret \text{ scalar, 1 to indicate success and a 0 if the transaction fails.} \]

**Example**

```plaintext
// If 'dbTransaction' succeeds
if dbTransaction(db_id);
  // All queries must succeed, or all fail.
  if not dbExecQuery(db_id,
      "INSERT INTO TEST...");
    dbRollback(db_id);
    errorlog("Query 1 failed");
  end;
endif;

  if not dbExecQuery(db_id,
      "INSERT INTO TEST...");
    dbRollback(db_id);
    errorlog("Query 2 failed");
  end;
endif;

dbCommit(db_id);
endif;
```

**Remarks**

This function can only be used with databases that support transactions.

**See Also**

`dbCommit`, `dbRollback`
**debug**

**Purpose**
- Runs a program under the source level debugger.

**Format**
- `debug filename;`

**Input**
- `filename` Literal, name of file to debug.

**Remarks**
- See Debugging, Section 1.1.

**declare**

**Purpose**
- Initializes global variables at compile time.

**Format**
- `declare [[type]] symbol [[aop clist]];`
### Input

<table>
<thead>
<tr>
<th>type</th>
<th>optional literal, specifying the type of the symbol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>matrix</td>
<td></td>
</tr>
<tr>
<td>string</td>
<td></td>
</tr>
<tr>
<td>array</td>
<td></td>
</tr>
<tr>
<td>sparse matrix</td>
<td></td>
</tr>
<tr>
<td>struct</td>
<td></td>
</tr>
<tr>
<td>structure_type</td>
<td></td>
</tr>
</tbody>
</table>

If `type` is not specified, `matrix` is assumed. Set `type` to `string` to initialize a string or string array variable.

<table>
<thead>
<tr>
<th>symbol</th>
<th>the name of the symbol being declared.</th>
</tr>
</thead>
<tbody>
<tr>
<td>aop</td>
<td>the type of assignment to be made.</td>
</tr>
<tr>
<td>=</td>
<td>if not initialized, initialize. If already initialized, reinitialize.</td>
</tr>
<tr>
<td>!=</td>
<td>if not initialized, initialize. If already initialized, reinitialize.</td>
</tr>
<tr>
<td>:=</td>
<td>if not initialized, initialize. If already initialized, redefinition error.</td>
</tr>
<tr>
<td>?=</td>
<td>if not initialized, initialize. If already initialized, leave as is.</td>
</tr>
</tbody>
</table>

If `aop` is specified, `clist` must be also.

| clist       | a list of constants to assign to `symbol`.           |

If `aop clist` is not specified, `symbol` is initialized as a
scalar 0 or a null string.

**Remarks**

The `declare` syntax is similar to the `let` statement.

`declare` generates no executable code. This is strictly for compile time initialization. The data on the right-hand side of the equal sign must be constants. No expressions or variables are allowed.

`declare` statements are intended for initialization of global variables that are used by procedures in a library system.

It is best to place `declare` statements in a separate file from procedure definitions. This will prevent redefinition errors when rerunning the same program without clearing your workspace.

The optional `aop` and `clist` arguments are allowed only for declaring matrices, strings, and string arrays. When you `declare` an N-dimensional array, sparse matrix, or structure, they will be initialized as follows:

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Initializes To</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-dimensional array</td>
<td>1-dimensional array of 1 containing 0</td>
</tr>
<tr>
<td>sparse matrix</td>
<td>empty sparse matrix</td>
</tr>
<tr>
<td>structure</td>
<td>structure containing empty and/or zeroed out members</td>
</tr>
</tbody>
</table>

Complex numbers can be entered by joining the real and imaginary parts with a sign (+ or -); there should be no spaces between the numbers and the sign. Numbers with no real part can be entered by appending an 'i' to the number.
There should be only one declaration for any symbol in a program. Multiple declarations of the same symbol should be considered a programming error. When GAUSS is looking through the library to reconcile a reference to a matrix or a string, it will quit looking as soon as a symbol with the correct name is found. If another symbol with the same name existed in another file, it would never be found. Only the first one in the search path would be available to programs.

Here are some of the possible uses of the three forms of declaration:

`!=`  Interactive programming or any situation where a global by the same name will probably be sitting in the symbol table when the file containing the declare statement is compiled. The symbol will be reset.

`=:`  Redefinition is treated as an error because you have probably just outsmarted yourself. This will keep you out of trouble because it won't allow you to zap one symbol with another value that you didn't know was getting mixed up in your program. You probably need to rename one of them.

`?=`  Interactive programming where some global defaults were set when you started and you don't want them reset for each successive run even if the file containing the declare's gets recompiled. This can get you into trouble if you are not careful.

The declare statement warning level is a compile option. Call config in the command line version of GAUSS or select Preferences from the Configure menu in the graphical user interface to edit this option. If declare warnings are on, you will be warned whenever a declare statement encounters a symbol that is already initialized. Here's what happens when you declare a symbol that is already initialized when declare warnings are turned on:

```gauss
declare !=  Reinitialize and warn.

declare :=  End program with fatal error.
```
**declare** ?= Leave as is and warn.

If **declare** warnings are off, no warnings are given for the ! = and ? = cases.

**Example**

```plaintext
declare matrix x,y,z;

x = 0  y = 0  z = 0
declare string x = "This string.";

x = "This string."

declare matrix x;

x = 0

//Initialize 'x' with the specified values and
//return a warning if 'x'already exists AND
//the 'Compile Options: declare warnings' is
//selected
declare matrix x != { 1 2 3, 4 5 6, 7 8 9 };

    1 2 3
x = 4 5 6
    7 8 9

declare matrix x[3,3] = 1 2 3  4 5 6  7 8 9;

    1 2 3
x = 4 5 6
    7 8 9

declare matrix x[3,3] = 1;
```
\begin{verbatim}
1 1 1
x = 1 1 1
1 1 1

declare matrix x[3,3];

0 0 0
x = 0 0 0
0 0 0

declare matrix x = 1 2 3 4 5 6 7 8 9;

1
2
3
x = 4
5
6
7
8
9

//Create a 2x1 character matrix
declare matrix x = alpha beta;

//To print character matrices, the '$_$' operator must
//be prepended to the variable name
print $x;
\end{verbatim}

The code snippet directly above, produces:

\begin{verbatim}
ALPHA
BETA

//Since this is declared as a matrix, the text in
//quotes will create a character vector, rather than a string array
declare matrix x = "mean" "variance";

print $x;

produces:

mean
variance

declare array a;

*a* is a 1-dimensional array of 1 containing 0.

declare sparse matrix sm;

*sm* is an empty sparse matrix.

**struct** mystruct {
  matrix m;
  string s;
  string array sa;
  array a;
  sparse matrix sm;
};

declare struct mystruct ms;

*ms* is a **mystruct** structure, with its members set as follows:

*ms.m* empty matrix

*ms.s* null string
See Also
let, external

dele

Purpose

Deletes global symbols from the symbol table.

Format

delete-flagssymbol_list;
deletesymbol_list;

Input

flags specify the type(s) of symbols to be deleted

\(p\) procedures

\(k\) keywords

\(f\) \(fn\) functions

\(m\) matrices
$s$ strings
$g$ only procedures with global references
$l$ only procedures with all local references
$n$ no pause for confirmation

$symbol$ literal, name of symbol to be deleted. If symbol ends in an asterisk, all symbols matching the leading characters will be deleted.

**Remarks**

This completely and irrevocably deletes a symbol from GAUSS's memory and workspace.

Flags must be preceded by a dash (e.g. `-pfk`). If the $n$ (no pause) flag is used, you will not be asked for confirmation for each symbol.

This command is supported only from interactive level. Since the interpreter executes a compiled pseudo-code, this command would invalidate a previously compiled code image and therefore would destroy any program it was a part of. If any symbols are deleted, all procedures, keywords and functions with global references to those symbols will be deleted as well.

**Example**

```gauuss
//Create a matrix 'x'
x = { 1, 2, 3, 4 };

//'show' returns information about active symbols
show x;
```

This should return:
At the Delete?[Yes No Previous Quit] prompt, enter y.

\[ \text{show } x; \]

\( x \) no longer exists.

**delete (dataloop)**

**Purpose**

Removes specific rows in a data loop based on a logical expression.

**Format**

\[ \text{delete } \text{logical_expression}; \]

**Remarks**

Deletes only those rows for which \textit{logical_expression} is TRUE. Any variables referenced must already exist, either as elements of the source data set, as \texttt{extern}'s, or as the result of a previous \texttt{make}, \texttt{vector}, or \texttt{code} statement.

\textbf{GAUSS} expects \textit{logical_expression} to return a row vector of 1's and 0's. The relational and other operators (e.g. \textless) are already interpreted in terms of their dot equivalents (\texttt{. <}), but it is up to the user to make sure that function calls within \textit{logical_expression} result in a vector.
Example

```
delete age < 40 or sex == 'FEMALE';
```

See Also

select (dataloop)

DeleteFile

Purpose

Deletes files.

Format

```
ret = DeleteFile(name);
```

Input

```
name : string or NxK string array, name of file or files to delete.
```

Output

```
ret : scalar or NxK matrix, 0 if successful.
```

Remarks

The return value, `ret`, is scalar if `name` is a string. If `name` is an NxK string

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array, \ ret \ will \ be \ an \ NxK \ matrix \ reflecting \ the \ success \ or \ failure \ of \ each \ separate \ file \ deletion.

\textbf{DeleteFile} \ calls \ the \ C \ library \ \texttt{unlink} \ function \ for \ each \ file. \ If \ \texttt{unlink} \ fails \ it \ sets \ the \ C \ library \ \texttt{errno} \ value. \ \textbf{DeleteFile} \ returns \ the \ value \ of \ \texttt{errno} \ if \ \texttt{unlink} \ fails, \ otherwise \ it \ returns \ zero. \ If \ you \ want \ detailed \ information \ about \ the \ reason \ for \ failure, \ consult \ the \ C \ library \ \texttt{unlink} \ documentation \ for \ your \ platform \ for \ details.

\section*{delif}

\section*{Purpose}

Deletes rows from a matrix. The rows deleted are those for which there is a 1 in the corresponding row of \( e \).

\section*{Format}

\[ y = \text{delif}(x, \ e); \]

\section*{Input}

\begin{itemize}
  \item \textit{x} \quad \text{NxK data matrix.}
  \item \textit{e} \quad \text{Nx1 logical vector (vector of 0's and 1's).}
\end{itemize}

\section*{Output}

\begin{itemize}
  \item \textit{y} \quad \text{MxK data matrix consisting of the rows of \( y \) for which there is a 0 in the corresponding row of \( e \). If no rows remain, \textit{delif} will return a scalar missing.}
\end{itemize}
Remarks

The input $e$ will usually be generated by a logical expression using dot operators. For instance:

```plaintext
//Create a vector 'e' with a 1 for each row in which the value in the second column of 'x' is less than 100, otherwise a 0
e = x[.,2] .> 100;

y = delif(x, e);
```

Or the equivalent statement:

```plaintext
y = delif(x, x[.,2] .> 100);
```

will delete all rows of $x$ whose second element is greater than 100. The remaining rows of $x$ will be assigned to $y$.

Example

```plaintext
x = { 0 10 20,
     30 40 50,
     60 70 80 };

/* logical vector */
e = (x[.,1] .gt 0) .and (x[.,3] .lt 100);

y = delif(x,e);
```

After the code above:

```plaintext
y = 0 10 20
```

All rows for which the elements in column 1 are greater than 0 and the elements in column 3 are less than 100 are deleted.
See Also

selif

delrows

Purpose

Deletes rows from a matrix. The second argument contains the indices of the rows to be deleted.

Format

\[ y = \text{delrows}(x, \ r); \]

Input

\( x \)  
N\times K data matrix.

\( r \)  
M\times 1 vector, indices of rows to delete.

Output

\( y \)  
P\times K matrix containing the remaining rows of \( x \). If no rows remain, \( y \) will be an empty matrix.

Remarks

If \( r \) is an empty matrix, the result will be unchanged. Negative values of \( r \) are counted from the end of the matrix, therefore:
\[ r = -1; \]
\[ y = \text{delrows}(x, r); \]

will delete last row of \( x \). The remaining rows of \( x \) will be assigned to \( y \).

**Example**

\[
\begin{align*}
x &= \{ \begin{array}{c}
0 \ 10 \ 20, \\
30 \ 40 \ 50, \\
32 \ 42 \ 52, \\
35 \ 45 \ 55, \\
60 \ 70 \ 80 \\
\end{array} \}; \\
\end{align*}
\]

\[
\begin{align*}
r &= \{ \begin{array}{c}
2, \\
4 \end{array} \}; \\
\end{align*}
\]

\[ y = \text{delrows}(x, r); \]

After the code above:

\[
\begin{align*}
y &= \begin{array}{c}
0 \ 10 \ 20 \\
32 \ 42 \ 52 \\
60 \ 70 \ 80 \\
\end{array} \\
\end{align*}
\]

Rows 2 and 3 are deleted.

**See Also**

`delif`
**denseToSp**

**Purpose**

Converts a dense matrix to a sparse matrix.

**Format**

\[ y = \text{denseToSp}(x, \; \text{eps}); \]

**Input**

- **x**: MxN dense matrix.
- **eps**: scalar, elements of x whose absolute values are less than or equal to eps will be treated as zero.

**Output**

- **y**: MxN sparse matrix.

**Remarks**

A dense matrix is just a normal format matrix.

Since sparse matrices are strongly typed in **GAUSS**, y must be defined as a sparse matrix before the call to **denseToSp**.

**Example**

```plaintext
//Declare 'y' as a sparse matrix
```
sparse matrix y;

x = { 0.01 0.00 0.01 1.00, 
     0.00 4.00 0.02 0.00, 
     0.00 0.01 0.00 0.00, 
     0.02 0.00 -2 0.00 };

// Create a sparse matrix 'y' from 'x' and set all elements
// less than 0.04 equal to 0
y = denseToSpRE(x, 0.04);

After the code above, y is equal to:

0.00 0.00 0.00 1.00
0.00 4.00 0.00 0.00
0.00 0.00 0.00 0.00
0.00 0.00 -2.00 0.00

See Also

spCreate, spDenseSubmat, spToDense

denseToSpRE

Purpose

Converts a dense matrix to a sparse matrix, using a relative epsilon.

Format

\[ y = \text{denseToSpRE}(x, \text{reps}); \]
**Input**

$x$  
MxN dense matrix.

$reps$  
scalar, relative epsilon. Elements of $x$ will be treated as zero if their absolute values are less than or equal to $reps$ multiplied by the mean of the absolute values of the non-zero values in $x$.

**Output**

$y$  
MxN sparse matrix.

**Remarks**

A dense matrix is just a normal format matrix.

Since sparse matrices are strongly typed in **GAUSS**, $y$ must be defined as a sparse matrix before the call to **denseToSpRE**.

**Example**

```
sparse matrix y;
x = {  -9  0  0  1,
      0  4  0  0,
      5  0  0  7,
      0  0  -2  2.2};

y = denseToSpRE(x, 0.5);
d = spToDense(y);
```

After the code above, $d$ is equal to:
You can calculate the mean of the non-zero elements of $x$ like this:

```plaintext
//Create a matrix of 1's and 0's with a 1 where the
//corresponding element in 'x' is not equal to 0
mask = x ./= 0;

//Calculate the sum of 'mask', this is the number of
//non-zeros in 'x'
nnz = sumc(sumc(mask));

//Divide the sum of the absolute value of 'x' by the number
//of non-zeros
nzmean = sumc(sumc(abs(x)))/nnz;
```

```
nnz =  7
nzmean = 4.31
```

The call to `denseToSpRE` towards the start of this example, removed all non-zeros less than $0.5 \times nzmean$, or approximately 2.16.

**See Also**

denseToSp, spCreate, spToDense

denToZero

**Purpose**

Converts every denormal to a 0 in a matrix or array.
**Format**

\[ y = \text{denToZero}(x); \]

**Input**

\[ x \] A matrix or an N-dimensional array.

**Output**

\[ y \] A matrix or an N-dimensional array with the same orders as the input. Every denormal in the input will be converted to 0 in the output.

**Example**

\[ x = \{ 1, \exp(-724.5), 3 \}; \]

//If 'x' contains any denormals set them to 0
if isden(x);
    x2 = denToZero(x);
endif;

After the first line above, \( x \) is equal to:

1.000e+000
2.902e-057
3.000e+000

At the end of the example, \( x \) is equal to:
design

Purpose

Creates a design matrix of 0's and 1's from a column vector of numbers specifying the columns in which the 1's should be placed.

Format

\[ y = \text{design}(x); \]

Input

\( x \)

\( N \times 1 \) vector.

Output

\( y \)

\( N \times K \) matrix, where \( K = \text{maxc}(x) \); each row of \( y \) will contain a single 1, and the rest 0's. The one in the \( i \)th row will be in the \text{round}(\text{round}(x[i,1])) column.

Remarks

Note that \( x \) does not have to contain integers: it will be rounded to nearest if
necessary.

**Example**

This example uses **design** to interchange the rows of a matrix.

```plaintext
// Suppress printing of digits after the decimal place
format /rd 6,0;

// Set the rng seed for repeatable random numbers
rndseed 345425235;

// Create a 4x4 matrix of random integers with a standard deviation of 10
x = round(10*rndn(4,4));
print x;
```

The code above returns:

```
  4   12  -1  -10
  5   -3  12   8
 12   -2  21  -21
-7  -13   0  -1
```

Continuing on with the example:

```plaintext
// The order of the rows we want
rowOrder = { 3, 1, 4, 2 };

// Create a permutation matrix from 'rowOrder'
p = design(rowOrder);
print p;
```

This section returns:
//Create a permuted version of 'x' with our preferred row order
x2 = p*x;
print x2;

This final section returns:

<table>
<thead>
<tr>
<th>12</th>
<th>-2</th>
<th>21</th>
<th>-21</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>12</td>
<td>-1</td>
<td>-10</td>
</tr>
<tr>
<td>-7</td>
<td>-13</td>
<td>0</td>
<td>-1</td>
</tr>
<tr>
<td>5</td>
<td>-3</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

This last print statement shows us that we have indeed changed the order of the rows. In x the row order is 1, 2, 3, 4. However, in x2, the row order is 3, 1, 4, 2 (i.e. the third row is now first, the first row is now second, etc.)

**Source**
design.src

**See Also**
cumprodc, cumsumc, recserrc

det

**Purpose**
Returns the determinant of a square matrix.
Format

\[ y = \text{det}(x); \]

Input

\( x \)  
N\( N \times N \) square matrix or \( K \)-dimensional array where the last two dimensions are \( N \times N \).

Output

\( y \)  
scalar or \([K-2]\)-dimensional array, the determinant(s) of \( x \).

Remarks

\( x \) may be any valid expression that returns a square matrix (number of rows equals number of columns) or a \( K \)-dimensional array where the last two dimensions are of equal size.

If \( x \) is a \( K \)-dimensional array, the result will be a \([K-2]\)-dimensional array containing the determinants of each 2-dimensional array described by the two trailing dimensions of \( x \). In other words, for a \( 10 \times 4 \times 4 \) array, the result will be a 1-dimensional array of 10 elements containing the determinants of each of the 10 \( 4 \times 4 \) arrays contained in \( x \).

\( \text{det} \) computes an LU decomposition.

\( \text{det1} \) can be much faster in many applications.

Example

\[
\begin{bmatrix}
3 & 2 & 1 \\
0 & 1 & -2
\end{bmatrix}
\]
The code above, produces:

```
  y = det(x);
  format /rd 3,0;
  print "The determinant of y =" y;
```

The determinant of y = 25

See Also
det

detl

Purpose

Returns the determinant of the last matrix that was passed to one of the intrinsic matrix decomposition routines.

Format

```
y = detl;
```

Remarks

Whenever one of the intrinsic matrix decomposition routines is executed, the determinant of the matrix is also computed and stored in a system variable. This function will return the value of that determinant and, because the value has been computed in a previous instruction, this will require no computation.
The following functions will set the system variable used by \texttt{det1}:

\begin{verbatim}
chol(x)
crout(x)
croutp(x)
det(x)
inv(x)
invpd(x)
solpd(y, x)  \hspace{1cm} \text{determinant of } x
\end{verbatim}

\textbf{Example}

If both the inverse and the determinant of the matrix are needed, the following two commands will return both with the minimum amount of computation:

\begin{verbatim}
xi = inv(x);
xd = det1;
\end{verbatim}

The function \texttt{det(x)} returns the determinant of a matrix using the Crout decomposition. If you only want the determinant of a positive definite matrix, the following code will be the fastest for matrices larger than 10x10:

\begin{verbatim}
//The 'call' keyword tells GAUSS to ignore the values
//returned from chol
call chol(x);
xd = det1;
\end{verbatim}
The Cholesky decomposition is computed and the result from that is discarded. The determinant saved during that instruction is retrieved using \texttt{detl}. This can execute up to 2.5 times faster than \texttt{det}(x) for large positive definite matrices.

\textbf{See Also}

\texttt{det}

\textbf{dfft}

\textbf{Purpose}

Computes a discrete Fourier transform.

\textbf{Format}

\[ y = \texttt{dfft}(x); \]

\textbf{Input}

\[ x \quad \text{Nx1 vector.} \]

\textbf{Output}

\[ y \quad \text{Nx1 vector.} \]

\textbf{Remarks}

The transform is divided by N.
This uses a second-order Goertzel algorithm. It is considerably slower than fft, but it may have some advantages in some circumstances. For one thing, N does not have to be an even power of 2.

**Source**
dfft.src

**See Also**
dfti, fft, ffti

dfft

**Purpose**
Computes inverse discrete Fourier transform.

**Format**

\[ y = \text{dfft}(x); \]

**Input**

\[ x \]
N x 1 vector.

**Output**

\[ y \]
N x 1 vector.
Remarks

The transform is divided by N.

This uses a second-order Goertzel algorithm. It is considerably slower than \texttt{ffti}, but it may have some advantages in some circumstances. For one thing, N does not have to be an even power of 2.

Source

dffti.src

See Also

\texttt{ff}, \texttt{dfli}, \texttt{ffti}

diag

Purpose

Creates a column vector from the diagonal of a matrix.

Format

$$y = \texttt{diag}(x);$$

Input

\begin{itemize}
  \item \texttt{x} \hspace{1cm} \text{NxK matrix or L-dimensional array where the last two dimensions are NxK.}
\end{itemize}
Output

\[ y \text{ min}(N,K) \times 1 \text{ vector or } L\text{-dimensional array where the last two dimensions are } \text{min}(N,K) \times 1. \]

Remarks

If \( x \) is a matrix, it need not be square. Otherwise, if \( x \) is an array, the last two dimensions need not be equal.

If \( x \) is an array, the result will be an array containing the diagonals of each 2-dimensional array described by the two trailing dimensions of \( x \). In other words, for a 10x4x4 array, the result will be a 10x4x1 array containing the diagonals of each of the 10 4x4 arrays contained in \( x \).

\texttt{diagrv} reverses the procedure and puts a vector into the diagonal of a matrix.

Example

\begin{verbatim}
    x = rndu(3,3);
y = diag(x);

    0.28330575  0.17602494  0.11521377  0.28330575
    x = 0.46050011  0.36578753  0.99670527
    y = 0.36578753
          0.58591859  0.39876576  0.94153871  0.94153871
    x = rndn(48,1);

    //Reshape the 48x1 vector into a 3x4x4 dimensional array
    x = reshape(x, 3|4|4);
    d = diag(x);

    Now x is equal to:
\end{verbatim}
Plane [1,..,]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.082720153</td>
<td>-0.49502230</td>
<td>-0.40613944</td>
<td>1.9283280</td>
</tr>
<tr>
<td>0.23583965</td>
<td>-0.24230946</td>
<td>-0.66047073</td>
<td>-0.73098141</td>
</tr>
<tr>
<td>-1.1187279</td>
<td>-0.27867822</td>
<td>-1.7846293</td>
<td>-0.44603382</td>
</tr>
<tr>
<td>0.030071777</td>
<td>-1.0387861</td>
<td>0.23768949</td>
<td>0.019151917</td>
</tr>
</tbody>
</table>

Plane [2,..,]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.7238416</td>
<td>0.17660645</td>
<td>-0.14798006</td>
<td>0.072065419</td>
</tr>
<tr>
<td>1.3685721</td>
<td>-0.11216325</td>
<td>-0.12985589</td>
<td>1.1816008</td>
</tr>
<tr>
<td>0.63154571</td>
<td>-1.4945397</td>
<td>-1.7276380</td>
<td>-0.28275797</td>
</tr>
<tr>
<td>-0.71832623</td>
<td>-1.3193506</td>
<td>-0.53934998</td>
<td>-0.78348484</td>
</tr>
</tbody>
</table>

Plane [3,..,]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.71111209</td>
<td>-0.30818842</td>
<td>-0.38982318</td>
<td>-2.7205066</td>
</tr>
<tr>
<td>-1.5455077</td>
<td>-0.27131853</td>
<td>0.98686691</td>
<td>0.10870999</td>
</tr>
<tr>
<td>0.57916876</td>
<td>1.8180884</td>
<td>0.76104693</td>
<td>1.1237605</td>
</tr>
<tr>
<td>1.0727710</td>
<td>-1.1071168</td>
<td>1.7443178</td>
<td>-1.0684433</td>
</tr>
</tbody>
</table>

and \(d\) is a 3x4x1 array containing the diagonals from \(x\) above.
Plane [3,3,3]

-0.78348484

-0.71111209
-0.27131853
0.76104693
1.0684433

See Also

diagr

diagr

Purpose

Inserts a vector into the diagonal of a matrix.

Format

\[ y = \text{diagrv}(x, v); \]

Input

\[ x \]

NxK matrix.

\[ v \]

min(N,K)x1 vector.
Output

| \( y \) | NxK matrix equal to \( x \) with its principal diagonal elements equal to those of \( v \). |

Remarks

\texttt{diag} reverses the procedure and pulls the diagonal out of a matrix.

Example

\begin{verbatim}
x = \texttt{rndu}(3,3);
v = \texttt{ones}(3,1);
y = \texttt{diagrv}(x,v);
\end{verbatim}

After the code above:

\begin{verbatim}
0.614 0.686 0.633 1.000 1.000 0.686 0.633
x = 0.802 0.185 0.707 v = 1.000 y = 0.802 1.000 0.707
0.551 0.761 0.418 1.000 0.551 0.761 1.000
\end{verbatim}

See Also

\texttt{diag}

\texttt{digamma}

Purpose

Computes the digamma function.
**Format**

\[ y = \text{digamma}(x); \]

**Input**

\( x \) \hspace{1cm} MxN matrix or N-dimensional array.

**Output**

\( y \) \hspace{1cm} MxN matrix or N-dimensional array, digamma.

**Remarks**

The digamma function is the first derivative of the log of the gamma function with respect to its argument.

**dlibrary**

**Purpose**

Dynamically links and unlinks shared libraries.

**Format**

\[
\text{dlibrary} \ lib1[[lib2]]...; \\
\text{dlibrary} -alib1[[lib2]]...; \\
\text{dlibrary} -d; \\
\text{dlibrary};
\]
## Input

lib1 lib2...  
literal, the base name of the library or the pathed name of the library.

dlibrary  takes two types of arguments, "base" names and file names. Arguments without any "/" path separators are assumed to be library base names, and are expanded by adding the suffix .so, .dll or .dylib, depending on the platform. They are searched for in the default dynamic library directory. Arguments that include "/" path separators are assumed to be file names, and are not expanded. Relatively pathed file names are assumed to be specified relative to the current working directory, not relative to the dynamic library directory.

-a  
append flag, the shared libraries listed are added to the current set of shared libraries rather than replacing them. For search purposes, the new shared libraries follow the already active ones. Without the -a flag, any previously linked libraries are dumped.

-d  
dump flag, ALL shared libraries are unlinked and the functions they contain are no longer available to your programs. If you use dllcall to call one of your functions after executing a

```
dlibrary -d
```

your program will terminate with an error.

## Remarks

If no flags are used, the shared libraries listed are linked into GAUSS and any
previously linked libraries are dumped. When you call dllcall, the shared libraries will be searched in the order listed for the specified function. The first instance of the function found will be called.

dllibrary with no arguments prints out a list of the currently linked shared libraries. The order in which they are listed is the order in which they are searched for functions.

dllibrary recognizes a default directory in which to look for dynamic libraries. You can specify this by setting the variable dlib_path in gauss.cfg. Set it to point to a single directory, not a sequence of directories. sysstate, case 24, may also be used to get and set this default.

GAUSS maintains its own shared libraries which are listed when you execute dllibrary with no arguments, and searched when you call dllcall. The default shared library or libraries are searched last. You can force them to be searched earlier by listing them explicitly in a dllibrary statement. They are always active and are not unlinked when you execute

dllibrary -d

For more information, see Foreign Language Interface, Chapter 1.

See Also

dllcall, sysstate

dlcall

Purpose

Calls functions located in dynamic libraries.
Format

```plaintext
dllcall [-r] [-v] func(arg1...argN);
```

dllcall works in conjunction with dlibrary. dlibrary is used to link shared libraries into GAUSS; dllcall is used to access the functions contained in those shared libraries. dllcall searches the shared libraries (see dlibrary for an explanation of the search order) for a function named func, and calls the first instance it finds. The default shared libraries are searched last.

Input

- **func**
  - the name of a function contained in a shared library (linked into GAUSS with dlibrary). If func is not specified or cannot be located in a shared library, dllcall will fail.
- **arg#**
  - arguments to be passed to func, optional. These must be simple variable references; they cannot be expressions.
- **-r**
  - optional flag. If -r is specified, dllcall examines the value returned by func, and fails if it is nonzero.
- **-v**
  - optional flag. Normally, dllcall passes parameters to func in a list. If -v is specified, dllcall passes them in a vector. See below for more details.

Remarks

**func** should be written to:

1. Take 0 or more pointers to doubles as arguments.
2. Take arguments either in a list or a vector.
3. Return an integer.
In C syntax, \texttt{func} should take one of the following forms:

1. \texttt{int \ func(void);} \\
2. \texttt{int \ func(double *arg1 [, arg2...argN]);} \\
3. \texttt{int \ func(double *arg[]);} \\

\texttt{dllcall} can pass a list of up to 100 arguments to \texttt{func}; if it requires more arguments than that, you MUST write it to take a vector of arguments, and you MUST specify the \texttt{-v} flag when calling it. \texttt{dllcall} can pass up to 1000 arguments in vector format. In addition, in vector format \texttt{dllcall} appends a null pointer to the vector, so you can write \texttt{func} to take a variable number of arguments and just test for the null pointer.

Arguments are passed to \texttt{func} by reference. This means you can send back more than just the return value, which is usually just a success/failure code. (It also means that you need to be careful not to overwrite the contents of matrices or strings you want to preserve.) To return data from \texttt{func}, simply set up one or more of its arguments as return matrices (basically, by making them the size of what you intend to return), and inside \texttt{func} assign the results to them before returning.

For more information, see \textbf{Foreign Language Interface}, Chapter 1.

**See Also**

\texttt{dlibrary,\ sysstate}

**do while,do until**

**Purpose**

Executes a series of statements in a loop as long as a given expression is true (or false).
Format

```
    do while expression;
    or
    do until expression;
    .
    .
    .
    statements in loop
    .
    .
    .
    endo;
```

Remarks

`expression` is any expression that returns a scalar. It is TRUE if it is nonzero and FALSE if it is zero.

In a `do while` loop, execution of the loop will continue as long as the expression is TRUE.

In a `do until` loop, execution of the loop will continue as long as the expression is FALSE.

The condition is checked at the top of the loop. If execution can continue, the statements of the loop are executed until the `endo` is encountered. Then `GAUSS` returns to the top of the loop and checks the condition again.

The `do` loop does not automatically increment a counter. See the first example below. `do` loops may be nested.
It is often possible to avoid using loops in **GAUSS** by using the appropriate matrix operator or function. It is almost always preferable to avoid loops when possible, since the corresponding matrix operations can be much faster.

**Example**

```plaintext
format /rdn 1,0;
space = " ";
comma = ",";
i = 1;
do while i <= 4;
j = 1;
do while j <= 3;
    print space i comma j;;
j = j+1;
endo;
i = i+1;
print;
endo;
```

The code above prints the following output:

```
1,1 1,2 1,3
2,1 2,2 2,3
3,1 3,2 3,3
4,1 4,2 4,3
```

In the example above, two nested loops are executed and the loop counter values are printed out. Note that the inner loop counter must be reset inside of the outer loop before entering the inner loop. An empty `print` statement is used to print a carriage return/line feed sequence after the inner loop finishes.

The following are examples of simple loops that execute a predetermined number of times. These loops will both have the result shown.

First loop:
format /rd 1,0;
i = 1;
do while i <= 10;
    print i;;
i = i+1;
endo;

produces:
1 2 3 4 5 6 7 8 9 10

Second loop:
format /rd 1,0;
i = 1;
do until i > 10;
    print i;;
i = i+1;
endo;

produces:
1 2 3 4 5 6 7 8 9 10

See Also
continue, break

dos

Purpose
Provides access to the operating system from within GAUSS.
**Format**

```
dos commd;
```

**Input**

`commd` literal or ^string, the OS command to be executed.

**Portability**

**UNIX/Linux**

Control and output go to the controlling terminal, if there is one.

This function may be used in terminal mode.

**Windows**

The `dos` function opens a new terminal.

Running programs in the background is allowed on both of the aforementioned platforms.

**Remarks**

This allows all operating system commands to be used from within GAUSS. It allows other programs to be run even though GAUSS is still resident in memory.

If no operating system command (for instance, `dir` or `copy`) or program name is specified, then a shell of the operating system will be entered which can be used just like the base level OS. The `exit` command must be given from the shell to get back into GAUSS. If a command or program name is included, the return to GAUSS is automatic after the OS command has been executed.
All matrices are retained in memory when the OS is accessed in this way. This command allows the use of word processing, communications, and other programs from within **GAUSS**.

Do not execute programs that terminate and remain resident because they will be left resident inside of **GAUSS**'s workspace. Some examples are programs that create RAM disks or print spoolers.

If the command is to be taken from a string variable, the ^ (caret) must precede the string.

The shorthand " > " can be used in place of " dos ".

**Example**

```plaintext
cmdstr = "atog myfile";
dos ^cmdstr;
```

This will run the ATOG utility, using **myfile.cmd** as the ATOG command file. For more information, see **ATOG**, Chapter 1.

```plaintext
> dir *.prg;
```

This will use the DOS **dir** command to print a directory listing of all files with a `.prg` extension on Windows. When the listing is finished, control will be returned to **GAUSS**.

```plaintext
> ls *.prg
```

This will perform the same operation on UNIX/Linux.

```plaintext
dos;
```

This will cause a second level OS shell to be entered. The OS prompt will appear and OS commands or other programs can be executed. To return to **GAUSS**, type **exit**.
See Also

exec
doswin

Purpose

Opens the DOS compatibility window with default settings. NOTE: This function is no longer supported. This documentation is provided as a reference for understanding legacy code. In many cases, you may simply comment out calls to doswin and the program will run successfully in the program input/output window.

Format

```
  doswin;
```

Portability

Windows only

Remarks

Calling doswin is equivalent to:

```
call DOSWinOpen("", error(0));
```

Source

gauss.src
DOSWinCloseall

Purpose

Closes the DOS compatibility window. NOTE: The DOS compatibility window is no longer supported. This documentation is provided as a reference for understanding legacy code.

Format

DOSWinCloseall;

Portability

Windows only

Remarks

Calling DOSWinCloseall closes the DOS window immediately, without asking for confirmation. If a program is running, its I/O reverts to the Command window.

Example

```plaintext
let attr = 50 50 7 0 7;
if not DOSWinOpen("Legacy Window", attr);
    errorlog "Failed to open DOS window, aborting";
    stop;
endif;
.
.
.
DOSWinCloseall;
```
DOSWinOpen

Purpose

Opens the DOS compatibility window and gives it the specified title and attributes. NOTE: This function is no longer supported. This documentation is provided as a reference for understanding legacy code. In many cases, you may simply comment out calls to DOSWinOpen and the program will run successfully in the program input/output window.

Format

\[ ret = \text{DOSWinOpen}(title, attr); \]

Input

<table>
<thead>
<tr>
<th>title</th>
<th>string, window title.</th>
</tr>
</thead>
<tbody>
<tr>
<td>attr</td>
<td>5x1 vector or scalar missing, window attributes.</td>
</tr>
<tr>
<td>[1]</td>
<td>window x position</td>
</tr>
<tr>
<td>[2]</td>
<td>window y position</td>
</tr>
<tr>
<td>[3]</td>
<td>text foreground color</td>
</tr>
<tr>
<td>[4]</td>
<td>text background color</td>
</tr>
<tr>
<td>[5]</td>
<td>close action bit flags</td>
</tr>
<tr>
<td></td>
<td>bit 0 (1's bit)</td>
</tr>
<tr>
<td></td>
<td>issue dialog</td>
</tr>
<tr>
<td></td>
<td>bit 1 (2's bit)</td>
</tr>
<tr>
<td></td>
<td>close window</td>
</tr>
<tr>
<td></td>
<td>bit 2 (4's bit)</td>
</tr>
<tr>
<td></td>
<td>stop program</td>
</tr>
</tbody>
</table>
**Output**

```
ret     scalar, success flag, 1 if successful, 0 if not.
```

**Portability**

Windows only

**Remarks**

If `title` is a null string (""'), the window will be titled "GAUSS-DOS".

Defaults are defined for the elements of `attr`. To use the default, set an element to a missing value. Set `attr` to a scalar missing to use all defaults. The defaults are defined as follows:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>varies</td>
<td>use x position of previous DOS window</td>
</tr>
<tr>
<td>[2]</td>
<td>varies</td>
<td>use y position of previous DOS window</td>
</tr>
<tr>
<td>[3]</td>
<td>7</td>
<td>white foreground</td>
</tr>
<tr>
<td>[4]</td>
<td>0</td>
<td>black background</td>
</tr>
<tr>
<td>[5]</td>
<td>6</td>
<td>4+2: stop program and close window without confirming</td>
</tr>
</tbody>
</table>

If the DOS window is already open, the new `title` and `attr` will be applied to it. Elements of `attr` that are missing are not reset to the default values, but are left as is.

To set the close action flags value (`attr[5]`), just sum the desired bit values. For example:

stop program (4) + close window (2) + confirm close (1) = 7

The close action flags are only relevant when a user attempts to interactively close the DOS window while a program is running. If `GAUSS` is idle, the window will be
closed immediately. Likewise, if a program calls \texttt{DOSWinCloseall}, the window is closed, but the program does not get terminated.

\textbf{Example}

\begin{verbatim}
let attr = 50 50 7 0 7;

if not DOSWinOpen("Legacy Window", attr);
    errorlog "Failed to open DOS window, aborting";
    stop;
endif;
\end{verbatim}

This example opens the DOS window at screen location (50,50), with white text on a black background. The close action flags are \(4 + 2 + 1\) (stop program + close window + issue confirm dialog) = 7. Thus, if the user attempts to close the window while a program is running, he/she will be asked for confirmation. Upon confirmation, the window will be closed and the program terminated.

\textbf{Purpose}

\texttt{dotfeq, dotfge, dotfgt, dotfle, dotflt, dotfne}

Fuzzy comparison functions. These functions use \texttt{_fcmptol} to fuzz the comparison operations to allow for roundoff error.
**Format**

\[ y = \text{dotfeq}(a, b); \]
\[ y = \text{dotfge}(a, b); \]
\[ y = \text{dotfgt}(a, b); \]
\[ y = \text{dotfle}(a, b); \]
\[ y = \text{dotflt}(a, b); \]
\[ y = \text{dotfne}(a, b); \]

**Input**

\[ a \quad \text{NxK matrix, first matrix.} \]
\[ b \quad \text{LxM matrix, second matrix, ExE compatible with } a. \]

**Global Input**

\[ _{fcmptol} \quad \text{scalar, comparison tolerance. The default value is 1.0e-15.} \]

**Output**

\[ y \quad \text{max(N,L) by max(K,M) matrix of 1's and 0's.} \]

**Remarks**

The return value is 1 if TRUE and 0 if FALSE.

The statement:

\[ y = \text{dotfeq}(a, b); \]
is equivalent to:

\[
\text{\texttt{y = a .eq b;}}
\]

The calling program can reset \_fcmptol before calling these procedures:

\[
\text{\texttt{\_fcmptol = 1e-12;}}
\]

**Example**

\[
\begin{align*}
x & = \text{pi*ones(2,2)}; \\
y & = x; \\
y[1,1] & = 2*\text{pi};
\end{align*}
\]

//Test for elements where 'x' is > 'y'
\[
t = \text{dotfge}(x,y);
\]

```
x = 3.14 3.14  y = 6.28 3.14  t = 0.00 1.00
   3.14 3.14  3.14 3.14  1.00 1.00
```

Continuing with the data above:

```
//Test for elements where 'x' is < 'y'
\]
t = \text{dotflt}(x,y);
```

```
t = 1.00 0.00  0.00 0.00
```

**Source**

fcompare.src

**Globals**

\_fcmptol
See Also

*feq-fnc*

**dotfeqmt**, **dotfgempt**, **dotgltmt**, **dotflemt**, **dotfltmt**, **dotfnemt**

**Purpose**

Fuzzy comparison functions. These functions use the `fcmptol` argument to fuzz the comparison operations to allow for roundoff error.

**Format**

\[
\begin{align*}
\text{y} &= \text{dotfeqmt}(a, b, \text{fcmptol}); \\
\text{y} &= \text{dotfgempt}(a, b, \text{fcmptol}); \\
\text{y} &= \text{dotgltmt}(a, b, \text{fcmptol}); \\
\text{y} &= \text{dotflemt}(a, b, \text{fcmptol}); \\
\text{y} &= \text{dotfltmt}(a, b, \text{fcmptol}); \\
\text{y} &= \text{dotfnemt}(a, b, \text{fcmptol});
\end{align*}
\]

**Input**

\[
\begin{align*}
\text{a} & \quad \text{NxK matrix, first matrix.} \\
\text{b} & \quad \text{LxM matrix, second matrix, ExE compatible with } a. \\
\text{fcmptol} & \quad \text{scalar, comparison tolerance.}
\end{align*}
\]
Output

\[ y \quad \text{max(N,L) by max(K,M) matrix of 1's and 0's.} \]

Remarks

The return value is 1 if TRUE and 0 if FALSE.

The statement:

\[ y = \text{dotfeqmt}(a,b,1e-13); \]

is equivalent to:

\[ y = a .eq b; \]

Example

\[
\begin{align*}
x &= \text{rndu}(2,2); \\
y &= x; \\
y[1,1] &= y[1,1] + 0.00000002; \\
t &= \text{dotfgemt}(x,y,1e-15); \\
t &= 0 \ 1 \ x-y = -2e-8 \ 0 \\
&\quad 1 \ 1 \ 0 \ 0
\end{align*}
\]

Source

fcomparemt.src

See Also

feqmt-fnemt
draw

Purpose

Graphs lines, symbols, and text using the PQG global variables. This procedure does not require actual X, Y, or Z data since its main purpose is to manually build graphs using _pline, _pmsgctl, _psym, _paxes, _parrow and other globals.

NOTE: This function is for the deprecated PQG graphics.

Library

pgraph

Format

```
draw;
```

Remarks

`draw` is especially useful when used in conjunction with transparent windows.

Example

```
library pgraph;
graphset;

begwind;
makewind(9,6.855,0,0,0); /* make full size window for plot */
makewind(3,1,3,3,0);    /* make small overlapping window */
```
setwind(1);
    x = seqa(.1,.1,100);
    y = sin(x);
    xy(x,y);            /* plot data in first window */
nextwind;
    _pbox = 15;
    _paxes = 0;
    _pnum = 0;
    _ptitlht = 1;
margin(0,0,2,0);
title("This is a text window.");
draw;             /* add a smaller text window */
endwind;             /* create graph */

Source
pdraw.src

See Also
window, makewind

drop (dataloop)

Purpose

    Specifies columns to be dropped from the output data set in a data loop.

Format

    drop variable_list;
Remarks

Commas are optional in variable_list.

Deletes the specified variables from the output data set. Any variables referenced must already exist, either as elements of the source data set, or as the result of a previous make, vector, or code statement.

If neither keep nor drop is used, the output data set will contain all variables from the source data set, as well as any defined variables. The effects of multiple keep and drop statements are cumulative.

Example

```
   drop age, pay, sex;
```

See Also

keep (dataloop)

dsCreate

Purpose

Creates an instance of a structure of type DS set to default values.

Include

ds.sdf

Format

```
s = dsCreate;
```
Output

$s$ instance of structure of type DS.

Example

```c
//Define 'DS' structure definition
#include ds.sdf;

//Declare 'myData' as instance of 'DS' structure
struct DS myData;

//Apply default settings
myData = dsCreate;
```

Source
ds.src
dstat

Purpose

Computes descriptive statistics.

Format

```c
{ vnam, mean, var, std, min, max, valid, mis } = dstat(dataset, vars);
```
# Input

**dataset**  
string, name of data set.  
If *dataset* is null or 0, *vars* will be assumed to be a matrix containing the data.

**vars**  
the variables.  
If *dataset* contains the name of a **GAUSS** data set, *vars* will be interpreted as:

- Kx1 character vector, names of variables.
- or -
  
  Kx1 numeric vector, indices of variables.

These can be any size subset of the variables in the data set and can be in any order. If a scalar 0 is passed, all columns of the data set will be used.

If *dataset* is null or 0, *vars* will be interpreted as:

N x K matrix, the data on which to compute the descriptive statistics.

# Global Input

**_altnam**  
matrix, default 0.  
This can be a Kx1 character vector of alternate variable names for the output.

**_maxbytes**  
scalar, the maximum number of bytes to be read per iteration of the read loop. Default = 1e9.
| **maxvec** | scalar, the largest number of elements allowed in any one matrix. Default = 20000. |
| **miss** | scalar, default 0. |
| 0 | there are no missing values (fastest). |
| 1 | listwise deletion, drop a row if any missings occur in it. |
| 2 | pairwise deletion. |
| **row** | scalar, the number of rows to read per iteration of the read loop. |
| 0 | if 0, (default) the number of rows will be calculated using **maxbytes** and **maxvec**. |
| **output** | scalar, controls output, default 1. |
| 1 | print output table. |
| 0 | do not print output. |

**Output**

| vnam | Kx1 character vector, the names of the variables used in the statistics. |
| mean | Kx1 vector, means. |
| var | Kx1 vector, variance. |
| std | Kx1 vector, standard deviation. |
| min | Kx1 vector, minima. |
max Kx1 vector, maxima.
valid Kx1 vector, the number of valid cases.
mis Kx1 vector, the number of missing cases.

Example

```c
//Calculate statistics on all variables in dataset: AGE, PAY, SEX and WT
vars = 0;
{ vnam, mean, var, std, min, max, valid, mis } = dstat("fr eqdata.dat", vars);

//Calculate statistics on just AGE and PAY
vars = { AGE, PAY };
{ vnam, mean, var, std, min, max, valid, mis } = dstat("fr eqdata.dat", vars);

//Calculate statistics on just AGE and PAY using numerical indices
vars = { 1, 2 };
{ vnam, mean, var, std, min, max, valid, mis } = dstat("fr eqdata.dat", vars);
```

Remarks

If pairwise deletion is used, the minima and maxima will be the true values for the valid data. The means and standard deviations will be computed using the correct number of valid observations for each variable.
**Source**
dstat.src

**dstatmt**

**Purpose**
Compute descriptive statistics.

**Format**

\[ dout = \texttt{dstatmt}(dc0, \textit{dataset}, vars); \]

**Input**

\( dc0 \) instance of a **dstatmtControl** structure containing the following members:

- **dc0.altnames** Kx1 string array of alternate variable names to be used if a matrix in memory is analyzed (i.e., \textit{dataset} is a null string or 0). Default = "".
- **dc0.maxbytes** scalar, the maximum number of bytes to be read per iteration of the read loop. Default = 1e9.
- **dc0.vartype** scalar, unused in **dstatmt**.
- **dc0.miss** scalar, default 0.

0 there are no missing values
(fastest).

1  listwise deletion, drop a row if any missings occur in it.

2  pairwise deletion.

\textit{dc0.row}  \textit{scalar}, the number of rows to read per iteration of the read loop.

If 0, (default) the number of rows will be calculated using \textit{dc0.maxbytes} and \textit{maxvec}.

\textit{dc0.output}  \textit{scalar}, controls output, default 1.

1  print output table.

0  do not print output.

\textit{dataset}  \textit{string}, name of data set.

If \textit{dataset} is null or 0, \textit{vars} will be assumed to be a matrix containing the data.

\textit{vars}  the variables.

If \textit{dataset} contains the name of a \textbf{GAUSS} data set, \textit{vars} will be interpreted as:

\begin{itemize}
  \item Kx1 \textit{string array}, names of variables.
  \item - or - \textit{Kx1 numeric vector}, indices of variables.
\end{itemize}

These can be any size subset of the variables in the data set and can be in any order. If a scalar 0 is passed, all columns of the data set
will be used.

If \textit{dataset} is null or 0, \textit{vars} will be interpreted as:

\begin{itemize}
    \item[NxK] matrix, the data on which to compute the descriptive statistics.
\end{itemize}

\section*{Output}

\textit{dout} instance of a \texttt{dstatmtOut} structure containing the following members:

\begin{itemize}
    \item \texttt{dout.vnames} Kx1 string array, the names of the variables used in the statistics.
    \item \texttt{dout.mean} Kx1 vector, means.
    \item \texttt{dout.var} Kx1 vector, variance.
    \item \texttt{dout.std} Kx1 vector, standard deviation.
    \item \texttt{dout.min} Kx1 vector, minima.
    \item \texttt{dout.max} Kx1 vector, maxima.
    \item \texttt{dout.valid} Kx1 vector, the number of valid cases.
    \item \texttt{dout.missing} Kx1 vector, the number of missing cases.
    \item \texttt{dout.errcode} scalar, error code, 0 if successful; otherwise, one of the following:
        \begin{itemize}
            \item 2 Can't open file.
            \item 7 Too many missings - no data left after packing.
        \end{itemize}
\end{itemize}
9 \textit{altnames} member of \texttt{dstatmtControl} structure wrong size.

10 \textit{vartype} member of \texttt{dstatmtControl} structure wrong size.

\section*{Remarks}

If pairwise deletion is used, the minima and maxima will be the true values for the valid data. The means and standard deviations will be computed using the correct number of valid observations for each variable.

\section*{Example}

\subsection*{Example 1: Computing statistics on a GAUSS dataset}

The \texttt{examples} directory contains a \texttt{GAUSS} dataset entitled \texttt{freqdata.dat}. This example will compute descriptive statistics on this file.

```gauss
#include dstatmt.sdf
struct dstatmtControl d0;
struct dstatmtOut dout;

d0 = dstatmtControlCreate();

//Placing a '0' in for varnames will tell dstatmt to
//compute statistics for all variables in the dataset
dout = dstatmt(d0, "freqdata.dat", 0);
```

The above example will compute statistics for all variables in the dataset. If you run this code, you will see a printout of the statistics. You will also see that this dataset contains the variables \texttt{AGE}, \texttt{PAY}, \texttt{SEX} and \texttt{WT}. If you just wanted to compute statistics for the second variable, \texttt{PAY}, change the last line above to:
dout = \texttt{dstatmt}(d0, "freqdata.dat", "PAY");

or:

\[
dout = \texttt{dstatmt}(d0, "freqdata.dat", 2);
\]

If we wanted to compute statistics for AGE and WT, you could:

\[
\text{//The '$|$' operator performs vertical concatenation of strings}
\]
\[
\text{varnames = "AGE"$|"WT";}
\]
\[
dout = \texttt{dstatmt}(d0, "freqdata.dat", \text{varnames});
\]

\textbf{Example 2: Computing statistics on a matrix}

\[
\texttt{#include dstatmt.sdf}
\]
\[
\texttt{struct dstatmtControl d0;}
\]
\[
\texttt{struct dstatmtOut dout;}
\]
\[
d0 = \texttt{dstatmtControlCreate}();
\]

\[
\text{//Create a random matrix on which to compute statistics}
\]
\[
A = \texttt{rndn}(10,3);
\]

\[
\text{//The empty string as the second input tells GAUSS to compute statistics on a matrix rather than a dataset}
\]
\[
dout = \texttt{dstatmt}(d0, "", A);
\]

You can specify custom variable names for the printout by setting \texttt{d0.altnames}. Continuing with the data from above:

\[
\texttt{d0.altnames = "Alpha"$|"Beta"$|"Gamma";}
\]
\[
dout = \texttt{dstatmt}(d0, "", A);
\]

\textbf{Source}

\texttt{dstatmt.src}
**See Also**
dstatmtControlCreate

dstatmtControlCreate

**Purpose**

Creates default **dstatmtControl** structure.

**Include**

dstatmt.sdf

**Format**

```c
c = dstatmtControlCreate();
```

**Output**

```c
instance of dstatmtControl structure with members set to default values.
```

**Example**

```c
//Declare 'dsm' as an instance of a
//'dstatmtControl' structure
struct dstatmtControl dsm;

//Apply default values to 'dsm'
dsm = dstatmtControlCreate();
```
Source
dstatmt.src

See Also
dstatmt
dtdate

Purpose

Creates a matrix in DT scalar format.

Format

\[ dt = \text{dtdate}(year, month, day, hour, minute, second); \]

Input

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>NxK matrix of years.</td>
</tr>
<tr>
<td>month</td>
<td>NxK matrix of months, 1-12.</td>
</tr>
<tr>
<td>day</td>
<td>NxK matrix of days, 1-31.</td>
</tr>
<tr>
<td>hour</td>
<td>NxK matrix of hours, 0-23.</td>
</tr>
<tr>
<td>minute</td>
<td>NxK matrix of minutes, 0-59.</td>
</tr>
<tr>
<td>second</td>
<td>NxK matrix of seconds, 0-59.</td>
</tr>
</tbody>
</table>
**Output**

\[ dt \]  
NxK matrix of DT scalar format dates.

**Remarks**

The arguments must be ExE conformable.

**Source**

time.src

**See Also**

dtday, dtime, utctodt, dttostr

**dtday**

**Purpose**

Creates a matrix in DT scalar format containing only the year, month and day. Time of day information is zeroed out.

**Format**

\[ dt = \texttt{dtday(year, month, day)}; \]

**Input**

\[ year \]  
NxK matrix of years.
### month
NxK matrix of months, 1-12.

### day
NxK matrix of days, 1-31.

### Output

| dt | NxK matrix of DT scalar format dates. |

### Remarks
This amounts to 00:00:00 or midnight on the given day. The arguments must be ExE conformance.

### Source
time.src

### See Also
dttme, dtdate, utctodt, dttostr

### dttme

### Purpose
Creates a matrix in DT scalar format containing only the hour, minute and second. The date information is zeroed out.

### Format

```
dt = dttme(hour, minute, second);
```
**Input**

- **hour**  
  NxK matrix of hours, 0-23.
- **minute**  
  NxK matrix of minutes, 0-59.
- **second**  
  NxK matrix of seconds, 0-59.

**Output**

- **dt**  
  NxK matrix of DT scalar format times.

**Remarks**

The arguments must be ExE conformable.

**Source**

time.src

**See Also**

dtday, dtdate, utctodt, dttostr

dttodtv

**Purpose**

Converts DT scalar format to DTV vector format.
Format

\[ dtv = dttodtv(dt); \]

Input

\( dt \)  
Nx1 vector, DT scalar format.

Output

\( dtv \)  
Nx8 matrix, DTV vector format.

Remarks

In DT scalar format, 15:10:55 on July 3, 2005 is 20050703151055.

Each row of \( dtv \), in DTV vector format, contains:

\[ \begin{array}{c}
N, 1 & \text{Year} \\
N, 2 & \text{Month in Year, 1-12} \\
N, 3 & \text{Day of month, 1-31} \\
N, 4 & \text{Hours since midnight, 0-23} \\
N, 5 & \text{Minutes, 0-59} \\
N, 6 & \text{Seconds, 0-59} \\
N, 7 & \text{Day of week, 0-6, 0 = Sunday} \\
N, 8 & \text{Days since Jan 1 of current year, 0-365}
\end{array} \]
**Example**

```
dt = 20100326110722;
print "dt = " dt;
```

20100326110722

```
dtv = dttodtv(dt);
print "dtv = " dtv;
```

2010 3 26 11 7 22 1 84

**Source**

time.src

**See Also**

dtvnormal, timeutc, utctodtv, dtvtodt, dttoutc, dtvtodt, strtodt, dttostr

**dttostr**

**Purpose**

Converts a matrix containing dates in DT scalar format to a string array.

**Format**

```
sa = dttostr(x, fmt);
```
**Input**

- **x**
  
  NxK matrix containing dates in DT scalar format.

- **fmt**
  
  string, or ExE conformable string array containing date/time format characters.

**Output**

- **sa**
  
  NxK string array.

**Remarks**

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number

```
20120703105031
```

represents 10:50:31 or 10:50:31 AM on July 3, 2012. `dttostr` converts a date in DT scalar format to a character string using the format string in `fmt`.

The following formats are supported:

- **YYYY**
  4 digit year

- **YR**
  Last two digits of year

- **QQ**
  Quarter of the year. This is calculated from the month number.

- **MO**
  Number of month, 01-12
DD    Day of month, 01-31
HH    Hour of day, 00-23
MI    Minute of hour, 00-59
SS    Second of minute, 00-59

A complete DT scalar format number will have 14 digits all to the left of the decimal point. However, `dttostr` will accept numbers with fewer digits. It will assume that the first four digits are the year, the next two the month and so on.

**Example**

**Example 1**

```plaintext
dt = 201202;
pdint dttostr(dt, "QQ-YYYY");
```

produces the output:

```
Q1-2012
```

**Example 2**

```plaintext
s0 = dttostr(utctodt(timeutc), "YYYY-MO-DD HH:MI:SS");
pdint ("Date and Time are: " $+ s0);
```

produces the output:

```
Date and time are: 2012-09-14 11:49:10
```

**Example 3**

```plaintext
print dttostr(utctodt(timeutc), "Today is DD-MO-YR");
```

produces the output:

```
38-438
```
Today is 14-09-12

**Example 4**

```cpp
x = { 19120317060424, 19370904010928, 19510221031129 };  
s = dttostr(x, "YYYY-MO-DD");
```

produces `s` equal to:

```
1912-03-17  
1937-09-04  
1951-02-21  
```

Using the same `x` from above:

```cpp
s = dttostr(x, "DD/MO/YYYY");
```

produces `s` equal to:

```
03/17/1912  
09/04/1937  
02/21/1951  
```

Continuing with the same `x` from above:

```cpp
string fmt = { "YYYY-QQ", "YYYY-QQ-DD", "DD/MO/YYYY" };  
s = dttostr(x, fmt);
```

produces `s` equal to:

```
1912-Q1   
1937-Q3-04  
21/02/1951  
```
See Also

strtod, dttoutc, utctodt

dttoutc

Purpose

Converts DT scalar format to UTC scalar format.

Format

\[
\text{utc} = \text{dttoutc}(dt);
\]

Input

\(dt\)  
Nx1 vector, DT scalar format.

Output

\(utc\)  
Nx1 vector, UTC scalar format.

Remarks

In DT scalar format, 10:50:31 on July 15, 2010 is 20100703105031. A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Example

\[
dt = 20010326085118;
\]
The above code produces the following output:

```
tc = 985633642;
```

**Source**

time.src

**See Also**
dtvnormal, timeutc, utcodt, dtodt, dtvtodt, dtvtoUTC, dttodt, strtodt, dttostr

dtvnormal

**Purpose**

Normalizes a date and time (DTV) vector.

**Format**

```
d = dtvnormal(t);
```

**Input**

```
t  1x8 date and time vector that has one or more elements outside the normal range.
```
Output

\[ d \]
Normalized 1x8 date and time vector.

Remarks

The date and time vector is a 1x8 vector whose elements consist of:

- **Year**: Year, four digit integer.
- **Month**: 1-12, Month in year.
- **Day**: 1-31, Day of month.
- **Hour**: 0-23, Hours since midnight.
- **Min**: 0-59, Minutes.
- **Sec**: 0-59, Seconds.
- **DoW**: 0-6, Day of week, 0 = Sunday.
- **DiY**: 0-365, Days since Jan 1 of year.

On input missing values are treated as zeros and the last two elements are ignored.

Example

```
format /rd 4,0;

dStart = { 2011 08 21 6 21 37 0 0 };
mnth = { 0 1 0 0 0 0 0 0 };
```
//Add 6 months to 'dStart' which will give a 14 for the //month
dEnd = dStart + 6*mnth;

//Normalize the date vector
dEnd2 = dtvnormal(dEnd);

After the code above:

<table>
<thead>
<tr>
<th>dEnd</th>
<th>2011</th>
<th>14</th>
<th>21</th>
<th>6</th>
<th>21</th>
<th>37</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>dEnd2</td>
<td>2012</td>
<td>2</td>
<td>21</td>
<td>6</td>
<td>21</td>
<td>37</td>
<td>2</td>
<td>51</td>
</tr>
</tbody>
</table>

See Also

date, ethsec, etstr, time, timestr, timeutc, utctodtv

dtvtodt

Purpose

Converts DT vector format to DT scalar format.

Format

\[ dt = dtvtodt(dtv); \]

Input

\[ dtv \quad \text{Nx8 matrix, DTV vector format.} \]
Output

\[ dt \]  
Ny1 vector, DT scalar format.

Remarks

In DT scalar format, 11:06:47 on March 15, 2012 is 20120315110647.

Each row of \( dtv \), in DTV vector format, contains:

\[
\begin{align*}
[N,1] & \quad \text{Year} \\
[N,2] & \quad \text{Month in Year, 1-12} \\
[N,3] & \quad \text{Day of month, 1-31} \\
[N,4] & \quad \text{Hours since midnight, 0-23} \\
[N,5] & \quad \text{Minutes, 0-59} \\
[N,6] & \quad \text{Seconds, 0-59} \\
[N,7] & \quad \text{Day of week, 0-6, 0 = Sunday} \\
[N,8] & \quad \text{Days since Jan 1 of current year, 0-365}
\end{align*}
\]

Example

```plaintext
let dtv = { 2012 9 16 11 7 22 1 84 }; 
dt = dtvtodt(dtv);
```

The code above assigns \( dt \) as follows:
Source
time.src

See Also
dtvnorm, timeutc, utctodtv, dttodtv, dttoutc, strtodt, dtstr

dttoutc

Purpose
Converts DTV vector format to UTC scalar format.

Format

utc = dttoutc(dtv);

Input
dtv
N x 8 matrix, DTV vector format.

Output
utc
N x 1 vector, UTC scalar format.
Remarks

A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Each row of \( dtv \), in DTV vector format, contains:

- \( [N,1] \) Year
- \( [N,2] \) Month in Year, 1-12
- \( [N,3] \) Day of month, 1-31
- \( [N,4] \) Hours since midnight, 0-23
- \( [N,5] \) Minutes, 0-59
- \( [N,6] \) Seconds, 0-59
- \( [N,7] \) Day of week, 0-6, 0 = Sunday
- \( [N,8] \) Days since Jan 1 of current year, 0-365

Example

\[
\begin{align*}
dtv &= \text{utctodtv}(\text{timeutc}); \\
\text{utc} &= \text{dtvtoutc}(dtv);
\end{align*}
\]

\[
\begin{align*}
dtv &= 2012 \ 7 \ 17 \ 10 \ 13 \ 48 \ 2 \ 198 \\
\text{utc} &= 1342545228
\end{align*}
\]

See Also

\texttt{dtvnormal, timeutc, utctodt, dttodtv, dttoute, dtvtodt, dtvtoute, strtordt, dtstr}
**dummy**

**Purpose**

Creates a set of dummy (0/1) variables by breaking up a variable into specified categories. The highest (rightmost) category is unbounded on the right.

**Format**

\[ y = \text{dummy}(x, \ v); \]

**Input**

- **x**: \(N \times 1\) vector of data that is to be broken up into dummy variables.
- **v**: \((K-1) \times 1\) vector specifying the K-1 breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.

**Output**

- **y**: \(N \times K\) matrix containing the K dummy variables.

**Remarks**

Missings are deleted before the dummy variables are created.
All categories are open on the left (i.e., do not contain their left boundaries) and all but the highest are closed on the right (i.e., do contain their right boundaries). The highest (rightmost) category is unbounded on the right. Thus, only K-1 breakpoints are required to specify K dummy variables.

The function `dummybr` is similar to `dummy`, but in that function the highest category is bounded on the right. The function `dummydn` is also similar to `dummy`, but in that function a specified column of dummies is dropped.

**Example**

```plaintext
//Set seed for repeatable random numbers
rndseed 135345;

//Create uniform random integers between 1 and 9
x = ceil(9*rndu(5,1));

//Set the breakpoints
v = { 1, 5, 7 };

dm = dummy(x,v);
```

The code above produces four dummies based upon the breakpoints in the vector `v`:

- $x < 1$
- $1 < x < 5$
- $5 < x < 7$
- $7 < x$

which look like:

```
0 1 0 0 2
0 0 0 1 9
dm = 0 1 0 0 x = 4
```
### Source

datatran.src

### See Also

dummybr, dummydn

### dummybr

#### Purpose

Creates a set of dummy (0/1) variables. The highest (rightmost) category is bounded on the right.

#### Format

\[ y = \text{dummybr}(x, \ v); \]

#### Input

<table>
<thead>
<tr>
<th>( x )</th>
<th>Nx1 vector of data that is to be broken up into dummy variables.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v )</td>
<td>Kx1 vector specifying the K breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.</td>
</tr>
</tbody>
</table>
Output

$y$     NxK matrix containing the K dummy variables. Each row will have a maximum of one 1.

Remarks

Missings are deleted before the dummy variables are created.

All categories are open on the left (i.e., do not contain their left boundaries) and are closed on the right (i.e., do contain their right boundaries). Thus, K breakpoints are required to specify K dummy variables.

The function `dummy` is similar to `dummybr`, but in that function the highest category is unbounded on the right.

Example

```plaintext
//Set seed for repeatable random numbers
rndseed 135345;

//Create uniform random integers between 1 and 9
x = ceil(9*rndu(5,1));

//Set the breakpoints
v = {1, 5, 7};

dm = dummybr(x,v);
```

The code above produces three dummies based upon the breakpoints in the vector $v$:
which look like:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>dm</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Source**

datatran.src

**See Also**

dummydn, dummy

dummydn

**Purpose**

Creates a set of dummy (0/1) variables by breaking up a variable into specified categories. The highest (rightmost) category is unbounded on the right, and a specified column of dummies is dropped.

**Format**

\[ y = \text{dummydn}(x, \ v, \ p); \]
**Input**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>Nx1 vector of data to be broken up into dummy variables.</td>
</tr>
<tr>
<td>$v$</td>
<td>(K-1)x1 vector specifying the K-1 breakpoints (these must be in ascending order) that determine the K categories to be used. These categories should not overlap.</td>
</tr>
<tr>
<td>$p$</td>
<td>positive integer in the range [1,K], specifying which column should be dropped in the matrix of dummy variables.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>Nx(K-1) matrix containing the K-1 dummy variables.</td>
</tr>
</tbody>
</table>

**Remarks**

This is just like the function `dummy`, except that the $p$th column of the matrix of dummies is dropped. This ensures that the columns of the matrix of dummies do not sum to 1, and so these variables will not be collinear with a vector of ones.

Missings are deleted before the dummy variables are created.

All categories are open on the left (i.e., do not contain their left boundaries) and all but the highest are closed on the right (i.e., do contain their right boundaries). The highest (rightmost) category is unbounded on the right. Thus, only K-1 breakpoints are required to specify K dummy variables.

**Example**

```plaintext
//Set seed for repeatable random numbers
rndseed 135345;
```
//Create uniform random integers between 1 and 9
x = ceil(9*rndu(5,1));

//Set the breakpoints
v = { 1, 5, 7 };

//Column to drop
p = 2;

dm = dummydn(x,v,p);

The code above produces four dummies based upon the breakpoints in the vector v:

\[
\begin{align*}
x &< 1 \\
1 &< x < 5 \\
5 &< x < 7 \\
7 &< x
\end{align*}
\]

and then remove the \( p \)th column which will result in:

\[
\begin{array}{ccccccc}
0 & 0 & 0 & 2 \\
0 & 0 & 1 & 9 \\
dm & = & 0 & 0 & 0 & x & = 4 \\
0 & 1 & 0 & 7 \\
1 & 0 & 0 & 1
\end{array}
\]

**Source**

datatran.src

**See Also**
dummy, dummybr
**Purpose**

Accesses an alternate editor.

**Format**

```
ed filename;
```

**Input**

`filename` literal, the name of the file to be edited.

**Remarks**

The default name of the editor is set in `gauss.cfg`. To change the name of the editor used from within a **GAUSS** session, enter:

```
ed = editor_name flags;
```

or

```
ed = "editor_nameflags";
```

The flags are any command line flags you may want between the name of the editor and the filename when your editor is invoked. The quoted version will prevent the flags, if any, from being forced to uppercase.
This command can be placed in the startup file, so it will be set for you automatically when you start GAUSS.

See the `edit` command to open a file in the GAUSS editor from the command line.

**edit**

**Purpose**

Edits a disk file.

**Format**

```
edit filename;
```

**Input**

*filename* literal, the name of the file to be edited.

This command loads a disk file in a GAUSS edit window. It is available only in the GAUSS graphical user interface.

**Remarks**

The edit command does not follow the `src_path` to locate files. You must specify the location in the `filename`. The default location is the current directory.

To edit the last run file, use F7 or the Action List toolbar.

**Example**

```
edit test1.e;
```
See Also

run

erfInv, erfCInv

Purpose

Computes the inverse of the Gaussian error function (erfInv) and its complement (erfCInv).

Format

\[
\begin{align*}
x &= \text{erfInv}(y); \\
x &= \text{erfCInv}(y);
\end{align*}
\]

Input

\[
y \quad \text{scalar or NxB matrix.} \quad -1 < y < 1.
\]

Output

\[
x \quad \text{scalar or NxB matrix.}
\]

Example

\[
\begin{align*}
x &= \text{seqa}(1,1,10); \\
y &= \text{erf}(x);
\end{align*}
\]
See Also

[erf, erfc, cdfN, cdfNC, cdfNi]

eig

Purpose

Computes the eigenvalues of a general matrix.
Format

\[ va = \text{eig}(x); \]

Input

\( x \)  
NxN matrix or K-dimensional array where the last two dimensions are NxN.

Output

\( va \)  
Nx1 vector or K-dimensional array where the last two dimensions are Nx1, the eigenvalues of \( x \).

Remarks

If \( x \) is an array, the result will be an array containing the eigenvalues of each 2-dimensional array described by the two trailing dimensions of \( x \). In other words, for a 10x4x4 array, the result will be a 10x4x1 array containing the eigenvalues of each of the 10 4x4 arrays contained in \( x \).

Errors

If the eigenvalues cannot all be determined, \( va[1] \) is set to an error code. Passing \( va[1] \) to the \texttt{scalerr} function will return the index of the eigenvalue that failed. The eigenvalues for indices \( \text{scalerr}(va[1])+1 \) to N should be correct.

Error handling is controlled with the low bit of the trap flag.

- \texttt{trap 0}  
set \( va[1] \) and terminate with message

- \texttt{trap 1}  
set \( va[1] \) and continue execution
Invalid inputs, such as an infinity, missing value or Nan will cause an error. If the trap is set to 1, va will be set to a scalar error code and program execution will continue. Passing this scalar error code to the scalerr function will return -1.

**Eigenvalue ordering**

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first.

**Example**

```matlab
x = [4 8 1,
     9 4 2,
     5 5 7];

va = eig(x);

14.4757
va = -4.4979
5.0222
```

To calculate eigenvalues and eigenvectors see `eigv`.

**See Also**

*eigh, eigv, eigv*

**eigh**

**Purpose**

Computes the eigenvalues of a complex hermitian or real symmetric matrix.
Format

\[ va = \text{eigh}(x); \]

Input

\( x \)

- NxN matrix or K-dimensional array where the last two dimensions are NxN.

Output

\( va \)

- Nx1 vector or K-dimensional array where the last two dimensions are Nx1, the eigenvalues of \( x \).

Remarks

If \( x \) is an array, the result will be an array containing the eigenvalues of each 2-dimensional array described by the two trailing dimensions of \( x \). In other words, for a 10x4x4 array, the result will be a 10x4x1 array containing the eigenvalues of each of the 10 4x4 arrays contained in \( x \).

Errors

If the eigenvalues cannot all be determined, \( va[1] \) is set to an error code. Passing \( va[1] \) to the \texttt{scalerr} function will return the index of the eigenvalue that failed. The eigenvalues for indices 1 to \texttt{scalerr}(\( va[1] \))-1 should be correct.

Error handling is controlled with the low bit of the trap flag.

- \texttt{trap 0} - set \( va[1] \) and terminate with message
- \texttt{trap 1} - set \( va[1] \) and continue execution
Invalid inputs, such as an infinity, missing value or Nan will cause an error. If the `trap` is set to 1, \(va\) will be set to a scalar error code and program execution will continue. Passing this scalar error code to the `scalerr` function will return -1.

**Eigenvalue ordering**

The eigenvalues are in ascending order.

The eigenvalues of a complex hermitian or real symmetric matrix are always real.

**See Also**

`eig`, `eigh`, `eigv`  

**eighv**

**Purpose**

Computes eigenvalues and eigenvectors of a complex hermitian or real symmetric matrix.

**Format**

\[
\{ va, \ ve \} = \text{eighv}(x);
\]

**Input**

\(x\)  

NxN matrix or K-dimensional array where the last two dimensions are NxN.
Output

<table>
<thead>
<tr>
<th>va</th>
<th>Nx1 vector or K-dimensional array where the last two dimensions are Nx1, the eigenvalues of x.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ve</td>
<td>NxN matrix or K-dimensional array where the last two dimensions are NxN, the eigenvectors of x.</td>
</tr>
</tbody>
</table>

Remarks

If \( x \) is an array, \( va \) will be an array containing the eigenvalues of each 2-dimensional array described by the two trailing dimensions of \( x \), and \( ve \) will be an array containing the corresponding eigenvectors. In other words, for a 10x4x4 array, \( va \) will be a 10x4x1 array containing the eigenvalues and \( ve \) a 10x4x4 array containing the eigenvectors of each of the 10 4x4 arrays contained in \( x \).

Errors

If the eigenvalues cannot all be determined, \( va[1] \) is set to an error code. Passing \( va[1] \) to the \texttt{scalerr} function will return the index of the eigenvalue that failed. The eigenvalues for indices 1 to \texttt{scalerr}(va[1])-1 should be correct. The eigenvectors are not computed.

Error handling is controlled with the low bit of the trap flag.

- \texttt{trap 0} set \( va[1] \) and terminate with message
- \texttt{trap 1} set \( va[1] \) and continue execution

Invalid inputs, such as an infinity, missing value or Nan will cause an error. If the \texttt{trap} is set to 1, \( va \) will be set to a scalar error code and program execution will continue. Passing this scalar error code to the \texttt{scalerr} function will return -1.

Eigenvalue ordering

The eigenvalues are in ascending order. The columns of \( ve \) contain the eigenvectors of \( x \) in the same order as the eigenvalues. The eigenvectors are orthonormal.
The eigenvalues of a complex hermitian or real symmetric matrix are always real.

**See Also**

eig, eigh, eigv

eigv

**Purpose**

Computes eigenvalues and eigenvectors of a general matrix.

**Format**

\[
\{ va, ve \} = \text{eigv}(x);
\]

**Input**

\( x \)

NxN matrix or K-dimensional array where the last two dimensions are NxN.

**Output**

\( va \)

Nx1 vector or K-dimensional array where the last two dimensions are Nx1, the eigenvalues of \( x \).

\( ve \)

NxN matrix or K-dimensional array where the last two dimensions are NxN, the eigenvectors of \( x \).
Remarks

If $x$ is an array, $va$ will be an array containing the eigenvalues of each 2-dimensional array described by the two trailing dimensions of $x$, and $ve$ will be an array containing the corresponding eigenvectors. In other words, for a 10x4x4 array, $va$ will be a 10x4x1 array containing the eigenvalues and $ve$ a 10x4x4 array containing the eigenvectors of each of the 10 4x4 arrays contained in $x$.

Errors

If the eigenvalues cannot all be determined, $va[1]$ is set to an error code. Passing $va[1]$ to the `scalerr` function will return the index of the eigenvalue that failed. The eigenvalues for indices `scalerr(va[1])+1` to N should be correct. The eigenvectors are not computed.

Error handling is controlled with the low bit of the trap flag.

```
  trap  0        set  va[1] and terminate with message
  trap  1        set  va[1] and continue execution
```

Invalid inputs, such as an infinity, missing value or Nan will cause an error. If the `trap` is set to 1, $va$ will be set to a scalar error code and program execution will continue. Passing this scalar error code to the `scalerr` function will return -1.

Eigenvalue ordering

The eigenvalues are unordered except that complex conjugate pairs of eigenvalues will appear consecutively with the eigenvalue having the positive imaginary part first. The columns of $ve$ contain the eigenvectors of $x$ in the same order as the eigenvalues. The eigenvectors are not normalized.

Example

```
x = [ [ 4, 8, 1, ],
      [ 9, 4, 2, ] ],
```
5 5 7

\{ y, n \} = \text{eigv}(x);

\begin{align*}
-4.4979 & & -0.6693 & & -0.6408 & & -0.4015 \\
y = 14.4757 & & n = 0.7134 & & -0.7249 & & -0.2605 \\
5.0222 & & -0.0192 & & -0.9134 & & 1.6734
\end{align*}

See Also
eig, eigh, eigv

elapsedTradingDays

Purpose

Computes number of trading days between two dates inclusively.

Format

\[ n = \text{elapsedTradingDays}(a, b); \]

Input

\begin{align*}
a & & \text{scalar, date in DT scalar format.} \\
b & & \text{scalar, date in DT scalar format.}
\end{align*}

Output

\[ n \quad \text{number of trading days between dates inclusively, that is,} \]
elapsed time includes the dates \( a \) and \( b \).

**Remarks**

A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2013. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

**Example**

```latex
//September 10, 2012
tStart = 20120910110231;

//September 14, 2012
tEnd = 20120914080722;

nDays = elapsedTradingDays(tStart, tEnd);
```

```
nDays = 4
```

**Source**

`finutils.src`

**Globals**

`_fin_holidays`

**See Also**

`getNextTradingDay`, `getPreviousTradingDay`, `getNextWeekDay`, `getPreviousWeekDay`
end

Purpose

Terminates a program.

Format

end;

Remarks

end causes GAUSS to revert to interactive mode, and closes all open files. end also closes the auxiliary output file and turns the window on. It is not necessary to put an end statement at the end of a program.

An end command can be placed above a label which begins a subroutine to make sure that a program does not enter a subroutine without a gosub.

stop also terminates a program but closes no files and leaves the window setting as it is.

Example

```gauss
output on;
screen off;
print x;
end;
```

In this example, a matrix x is printed to the auxiliary output. The output to the window is turned off to speed up the printing. The end statement is used to terminate the program, so the output file will be closed and the window turned back on.
See Also

new, stop, system

endp

Purpose

Closes a procedure or keyword definition.

Format

endp;

Remarks

endp marks the end of a procedure definition that began with a proc or keyword statement. (For details on writing and using procedures, see Procedures and Keywords, Chapter 1.)

Example

```
proc regress(y,x);
    retp(inv(x'x)*x'y);
endp;

x = { 1 3 2, 7 4 9, 1 1 6, 3 3 2 };
y = { 3, 5, 2, 7 };

b = regress(y,x);
```
After executing the above code:

\[
\begin{align*}
0.1546 \\
b &= 1.5028 \\
-0.1284
\end{align*}
\]

See Also

`proc`, `keyword`, `retp`

### endwind

**Purpose**

Ends graphic panel manipulation; displays graphs with `rerun`. Note: This function is for use with the deprecated PQG graphics.

**Library**

`pgraph`

**Format**

`endwind;`

**Remarks**

This function uses `rerun` to display the most recently created `.tkf` file.

**Source**

`pwindow.src`
See Also
begwind, window, makewind, setwind, nextwind, getwind

envget

Purpose
Searches the environment table for a defined name.

Format
\[ y = \text{envget}(s); \]

Input
\[ s \]  string, the name to be searched for.

Output
\[ y \]  string, the string that corresponds to that name in the environment table or a null string if it is not found.

Example
Example 1

//%USERPROFILE% is the user's home directory on most Windows systems
hmFld = envget("USERPROFILE");
Example 2

```pascal
proc dopen(file);
    local fname, fp;
    fname = envget("DPATH");
    // Check to see if DPATH is set or empty
    if fname $== ""
        fname = file;
    else
        // Check to see if 'fname' ends with a path separator
        if strsect(fname, strlen(fname), 1) $== "\\"
            fname = fname $+ file;
        else
            fname = fname $+ "\\" $+ file;
        endif;
    endif;
    open fp = ^fname;
    retp(fp);
endp;
```

This is an example of a procedure that will open a data file using a path stored in an environment string called DPATH. The procedure returns the file handle and is called as follows:

```pascal
fp = dopen("myfile");
```

See Also

cdir
eof

Purpose

Tests if the end of a file has been reached.

Format

\[ y = \text{eof}(fh); \]

Input

\[ fh \]
scalar, file handle.

Output

\[ y \]
scalar, 1 if end of file has been reached, else 0.

Remarks

This function is used with \texttt{readr} and the \texttt{fgets} \texttt{xxx} commands to test for the end of a file.

The \texttt{seekr} function can be used to set the pointer to a specific row position in a data set; the \texttt{fseek} function can be used to set the pointer to a specific byte offset in a file opened with \texttt{fopen}.

Example

\begin{verbatim}
open f1 = dat1;
\end{verbatim}
xx = 0;
do until eof(f1);
    xx = xx + moment(readr(f1,100),0);
endo;

In this example, the data file `dat1.dat` is opened and given the handle `f1`. Then the data are read from this data set and are used to create the moment matrix \((x'x)\) of the data. On each iteration of the loop, 100 additional rows of data are read in, and the moment matrix for this set of rows is computed and added to the matrix `xx`. When all the data have been read, `xx` will contain the entire moment matrix for the data set.

*GAUSS* will keep reading until `eof(f1)` returns the value 1, which it will when the end of the data set has been reached. On the last iteration of the loop, all remaining observations are read in if there are 100 or fewer left.

### See Also

`open`, `readr`, `seekr`

### eqSolve

#### Purpose

Solves a system of nonlinear equations.

#### Format

\[
\{ x, \ retcode \} = eqSolve(&F,start);
\]

#### Input

`start` Kx1 vector, starting values.
&F scalar, a pointer to a procedure which computes the value at \( x \) of the equations to be solved.

## Global Input

The following are set by `eqSolveSet`:

- `_eqs_JacobianProc` pointer to a procedure which computes the analytical Jacobian. By default, `eqSolve` will compute the Jacobian numerically.

- `_eqs_MaxIters` scalar, the maximum number of iterations. Default = 100.

- `_eqs_StepTol` scalar, the step tolerance. Default = \( _{macheps}^{2/3} \).

- `_eqs_TypicalF` Kx1 vector of the typical \( F(x) \) values at a point not near a root, used for scaling. This becomes important when the magnitudes of the components of \( F(x) \) are expected to be very different. By default, function values are not scaled.

- `_eqs_TypicalX` Kx1 vector of the typical magnitude of \( x \), used for scaling. This becomes important when the magnitudes of the components of \( x \) are expected to be very different. By default, variable values are not scaled.

- `_eqs_IterInfo` scalar, if nonzero, iteration information is printed. Default = 0.

The following are set by `gausset`:

- `__Tol` scalar, the tolerance of the scalar function \( f = 0.5*||F(x)||^2 \) required to terminate the algorithm. Default = 1e-5.
**__altnam**

Kx1 character vector of alternate names to be used by the printed output. By default, the names "X1, X2,X3..." or "X01,X02,X03..." (depending on how __vpad is set) will be used.

**__output**

scalar. If non-zero, final results are printed.

**__title**

string, a custom title to be printed at the top of the iterations report. By default, only a generic title will be printed.

**__vpad**

scalar. If __altnam is not set, variable names are automatically created. Two types of names can be created:

- **0**: Variable names are not padded to give them equal length. For example, \(x_1, x_2, \ldots, x_{10}, \ldots\)
- **1**: Variable names are padded with zeros to give them an equal number of characters. For example, \(x_{01}, x_{02}, \ldots, x_{10}, \ldots\) This is useful if you want the variable names to sort properly.

### Output

\[ x \]

Kx1 vector, solution.

### Remarks

The equation procedure should return a column vector containing the result for each equation. For example:

- **Equation 1**: \[ x_1^2 + x_2^2 - 2 = 0 \]
- **Equation 2**: \[ \exp(x_1 - 1) + x_2^3 - 2 = 0 \]
Example

eqSolveSet;

proc \textbf{f}(x);
    \textbf{local} f1, f2, f3;
    f3 = 3*x[1]^3 + 2*x[2]^2 - 4*x[3];
    \textbf{retp}(f1|f2|f3);
endp;

proc \textbf{fjc}(x);
    \textbf{local} fjc1, fjc2, fjc3;
    fjc1 = 9*x[1]^2 - 4*x[2] - 5;
    fjc2 = -3*x[1]^2 - 6*x[2] - 1;
    fjc3 = 9*x[1]^2 - 4*x[2] - 4;
    \textbf{retp}(fjc1|fjc2|fjc3);
endp;

start = \{-1, 12, -1\};

_eqs_JacobianProc = \&\textbf{fjc};

\{ x, tcode \} = \textbf{eqSolve}(\&\textbf{f}, \text{start});

produces:
EqSolve Version 11.0.5 7/17/2012 5:47 pm

||F(X)|| at final solution: 0.93699762

Termination Code = 1:

Norm of the scaled function value is less than __Tol;

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>START</th>
<th>ROOTS</th>
<th>F(ROOTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>-1.00000</td>
<td>0.54144351</td>
<td>4.4175402e-006</td>
</tr>
<tr>
<td>X2</td>
<td>12.00000</td>
<td>1.4085912</td>
<td>-6.6263102e-006</td>
</tr>
<tr>
<td>X3</td>
<td>-1.00000</td>
<td>1.1111111</td>
<td>4.4175402e-006</td>
</tr>
</tbody>
</table>

Source
eqsolve.src

eqSolvemt

Purpose
Solves a system of nonlinear equations.

Include
eqsolvemt.sdf
Format

\[ \text{out} = \text{eqSolvemt(}&fct, \text{par, data, c);} \]

Input

\&fct

pointer to a procedure that computes the function to be minimized. This procedure must have two input arguments, an instance of a PV structure containing the parameters, and an instance of a DS structure containing data, if any. And, one output argument, a column vector containing the result of each equation.

par

an instance of a PV structure. The par instance is passed to the user-provided procedure pointed to by \&fct. par is constructed using the pvPack functions.

data

an array of instances of a DS structure. This array is passed to the user-provided procedure pointed to by \&fct to be used in the objective function. eqSolvemt does not look at this structure. Each instance contains the following members which can be set in whatever way that is convenient for computing the objective function:

\- data1[i].dataMatrix
  NxK matrix, data matrix.

\- data1[i].dataArray
  NxKxL... array, data array.

\- data1[i].vnames
  string array, variable names (optional).

\- data1[i].dsname
  string, data name (optional).

\- data1[i].type
  scalar, type of data (optional).
an instance of an `eqSolventControl` structure. Normally an instance is initialized by calling `eqSolventControlCreate` and members of this instance can be set to other values by the user. For an instance named `c`, the members are:

- `c.jacobianProc` pointer to a procedure which computes the analytical Jacobian. By default, `eqSolvent` will compute the Jacobian numerically.
- `c.maxIters` scalar, the maximum number of iterations. Default = 100.
- `c.stepTolerance` scalar, the step tolerance. Default = `macheps^{2/3}`.
- `c.typicalF` Kx1 vector of the typical \( \mathbf{fct}(x) \) values at a point not near a root, used for scaling. This becomes important when the magnitudes of the components of \( \mathbf{fct}(x) \) are expected to be very different. By default, function values are not scaled.
- `c.typicalX` Kx1 vector of the typical magnitude of \( x \), used for scaling. This becomes important when the magnitudes of the components of \( x \) are expected to be very different. By default, variable values are not scaled.
- `c.printIters` scalar, if nonzero, iteration information is printed. Default = 0.
- `c.tolerance` scalar, the tolerance of the scalar function \( f \)
\[ 0.5 \| fct(X) \|^2 \]

required to terminate the algorithm. That is, the condition that \(|f(x)| \leq c.tolerance \) must be met before that algorithm can terminate successfully. Default = 1e-5.

\texttt{c.altname} Kx1 character vector of alternate names to be used by the printed output. By default, the names "X1,X2,X3..." will be used.

\texttt{c.title} string, printed as a title in output.

\texttt{c.output} scalar. If non-zero, final results are printed.

\textbf{Output}

\texttt{out} an instance of an eqSolvemtOut structure. For an instance named \texttt{out}, the members are:

\texttt{out.par} an instance of a PV structure containing the parameter estimates.

\texttt{out.fct} scalar, function evaluated at \( x \)

\texttt{out.retcode} scalar, return code:

-1 Jacobian is singular.

1 Norm of the scaled function value is less than \( c.tolerance \cdot x \) given is an approximate root of \( fct(x) \) (unless \( c.tolerance \) is too large).
2 The scaled distance between the last two steps is less than the step-tolerance (c.stepTolerance). \( x \) may be an approximate root of \( \text{fct}(x) \), but it is also possible that the algorithm is making very slow progress and is not near a root, or the step-tolerance is too large.

3 The last global step failed to decrease \( \text{norm2}(\text{fct}(x)) \) sufficiently; either \( x \) is close to a root of \( \text{fct}(x) \) and no more accuracy is possible, or an incorrectly coded analytic Jacobian is being used, or the secant approximation to the Jacobian is inaccurate, or the step-tolerance is too large.

4 Iteration limit exceeded.

5 Five consecutive steps of maximum step length have been taken; either \( \text{norm2}(\text{fct}(x)) \) asymptotes from above to a finite value in some direction or the maximum step length is too small.

6 \( x \) seems to be an approximate local minimizer of \( \text{norm2}(\text{fct}(x)) \) that is not a root of \( \text{fct}(x) \). To find a root of \( \text{fct}(x) \), restart \text{eqSolve}t \) from a different region.
Remarks

The equation procedure should return a column vector containing the result for each equation.

If there is no data, you can pass an empty DS structure in the second argument:

call eqSolvemt(&fct,par,dsCreate(),c);

Example

Equation 1: \( x_1^2 + x_2^2 - 2 = 0 \)
Equation 2: \( \exp(x_1-1) + x_2^3 - 2 = 0 \)

```c
#include eqSolvemt.sdf
struct eqSolvemtControl c;
c = eqSolvemtControlCreate;

c.printIters = 1;

struct PV par;
par = pvPack(pvCreate,1,"x1");
par = pvPack(par,1,"x2");

struct eqSolvemtOut out1;
out1 = eqSolvemt(&fct,par,dsCreate(),c);

proc fct(struct PV p, struct DS d);
    local x1, x2, z;
    x1 = pvUnpack(p,"x1");
    x2 = pvUnpack(p,"x2");
    z = x1^2 + x2^2 - 2 | exp(x1-1) + x2^3 - 2;
    retp(z);
endp;
```
**Source**
eqsolvemt.src

**See Also**
eqSolventControlCreate, eqSolventOutCreate

**eqSolventControlCreate**

**Purpose**

Creates default eqSolventControl structure.

**Include**
eqsolvemt.sdf

**Format**

\[ c = \text{eqSolventControlCreate}(); \]

**Output**

\[ c \]

instance of eqSolventControl structure with members set to default values.

**Example**

Since structures are strongly typed in GAUSS, each structure must be declared before it can be used.
//declare c as an
//eqSolvemtControl structure
struct eqSolvemtControl c;

//initialize structure c
c = eqSolvemtControlCreate();

The members of an eqSolvemtControl structure and default values are described in the manual entry for eqSolvemt.

If you intend to just use the default values for the eqSolvemtControl structure, you can simply pass in the function eqSolvemtControlCreate as the final argument to eqSolvemt:

//set up data, function pointer, etc.

out = eqSolvemt(&fct, par, data, eqSolvemtControlCreate());

**Source**
eqsolvemt.src

**See Also**
eqSolvent

eqSolvemtOutCreate

**Purpose**

Creates default eqSolvemtOut structure.
Include

include eqsolvemt.sdf

Format

\[ c = \text{eqSolvemtOutCreate}(); \]

Output

\( c \)

instance of \text{eqSolvemtOut} structure with members set to default values.

Example

Since structures are strongly typed in \texttt{GAUSS}, each structure must be declared before it can be used.

```gauss
//declare structure
struct eqSolvemtOut c;

//Initialize structure
\text{c = eqSolvemtOutCreate}();
```

The members of an \texttt{eqSolvemtOut} structure and default values are described in the manual entry for \texttt{eqSolvemt}.

Source

eqsolvemt.src

See Also

\texttt{eqSolvemt}
**eqSolveSet**

**Purpose**

Sets global input used by `eqSolve` to default values.

**Format**

```markdown
eqSolveset;
```

**Global Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>__eqs_TypicalX</code></td>
<td>Set to 0.</td>
</tr>
<tr>
<td><code>__eqs_TypicalF</code></td>
<td>Set to 0.</td>
</tr>
<tr>
<td><code>__eqs_IterInfo</code></td>
<td>Set to 0.</td>
</tr>
<tr>
<td><code>__eqs_JacobianProc</code></td>
<td>Set to 0.</td>
</tr>
<tr>
<td><code>__eqs_MaxIters</code></td>
<td>Set to 100.</td>
</tr>
<tr>
<td><code>__eqs_StepTol</code></td>
<td>Set to <code>macheps^{2/3}</code></td>
</tr>
</tbody>
</table>

**erf, erfc**

**Purpose**

Computes the Gaussian error function (`erf`) and its complement (`erfc`).

38-486
**Format**

\[ y = \text{erf}(x); \]
\[ y = \text{erfc}(x); \]

**Input**

\( x \)  
N\text{x}K matrix.

**Output**

\( y \)  
N\text{x}K matrix.

**Remarks**

The \texttt{erf} and \texttt{erfc} functions are closely related to the Normal distribution:

\[
\begin{align*}
\text{if } x > 0 & \quad \text{cdfn}(x) = 0.5 \times (1 + \text{erf}(x / \sqrt{2})); \\
\text{if } x \leq 0 & \quad \text{cdfn}(x) = 0.5 \times \text{erfc}(-x / \sqrt{2});
\end{align*}
\]

**Example**

```plaintext
//Print 3 digits after the decimal point
format /rd 5,3;

x = { .5 .4 .3,
     .6 .8 .3 };
y = \texttt{erf}(x);
```
yc = \texttt{erfc}(x);

// The '~' operator performs horizontal concatenation
// and causes this print statement to format 'x',
// 'y' and 'yc' as if they were one 2x9 matrix rather
// than 3 2x3 matrices
// This does not change the variable values, only
// their appearance for this print statement
\texttt{print x~y~yc;}

produces the following output:

\[
\begin{array}{cccccccccc}
0.500 & 0.400 & 0.300 & 0.520 & 0.428 & 0.329 & 0.480 & 0.572 & 0.671 \\
0.600 & 0.800 & 0.300 & 0.604 & 0.742 & 0.329 & 0.396 & 0.258 & 0.671 \\
\end{array}
\]

\textbf{See Also}

cdfN, cdfNc

\textbf{Technical Notes}

\texttt{erf} and \texttt{erfc} are computed by summing the appropriate series and continued fractions. They are accurate to about 12 or more digits.

\textbf{erfcplx, erfccplx}

\textbf{Purpose}

Computes the Gaussian error function (\texttt{erfcplx}) and its complement (\texttt{erfccplx}) for complex inputs.
**Format**

\[
f = \text{erfcplx}(z); \\
f = \text{erfccplx}(z);
\]

**Input**

| \( z \) | NxK complex matrix; \( z \) must be > 0. |

**Output**

| \( f \) | NxK complex matrix. |

**Technical Notes**

Accuracy is better than 12 significant digits.

**References**

1. Abramowitz & Stegun, section 7.1, equations 7.1.9, 7.1.23, and 7.1.29
2. Main author Paul Godfrey
3. Small changes by Peter J. Acklam

**error**

**Purpose**

Allows the user to generate a user-defined error code which can be tested quickly with the `scalerr` function.
**Format**

\[ y = \text{error}(x); \]

**Input**

\( x \)  
Scalar, in the range 0-65535.

**Output**

\( y \)  
Scalar error code which can be interpreted as an integer with the `scalerr` function.

**Remarks**

The user may assign any number in the range 0-65535 to denote particular error conditions. This number may be tested for as an error code by `scalerr`.

The `scalerr` function will return the value of the error code and so is the reverse of `error`. These user-generated error codes work in the same way as the intrinsic `GAUSS` error codes which are generated automatically when `trap 1` is on and certain `GAUSS` functions detect a numerical error such as a singular matrix.

\[ \text{error}(0); \]

is equal to the missing value code.

**Example**

```plaintext
proc syminv(x);
    local oldtrap,y;
```
if not x == x';
    retp(error(99));
endif;
oldtrap = trapchk(0xffff);
trap 1;
y = invpd(x);
if scalerr(y);
    y = inv(x);
endif;
trap oldtrap,0xffff;
retp(y);
endp;

The procedure `syminv` returns error code 99 if the matrix is not symmetric. If `invpd` fails, it returns error code 20. If `inv` fails, it returns error code 50. The original trap state is restored before the procedure returns.

**See Also**

`scalerr`, `trap`, `trapchk`

**errorlog**

**Purpose**

Prints an error message to the window and error log file.

**Format**

`errorlog str;`
Input

str string, the error message to print.

Remarks

This command enables you to do your own error handling in your GAUSS programs. To print an error message to the window and error log file along with file name and line number information, use errorlogat.

See Also

errorlogat

errorlogat

Purpose

Prints an error message to the window and error log file, along with the file name and line number at which the error occurred.

Format

errorlogat str;

Input

str string, the error message to print.
**Remarks**

This command enables you to do your own error handling in your **Gauss** programs. To print an error message to the window and error log file without file name and line number information, use `errorlog`.

**See Also**

`errorlog`

**etdays**

**Purpose**

Computes the difference between two times, as generated by the `date` command, in days.

**Format**

$$days = etdays(tstart, tend);$$

**Input**

| `tstart` | 3x1 or 4x1 vector, starting date, in the order: yr, mo, day. (Only the first 3 elements are used.) |
| `tend`   | 3x1 or 4x1 vector, ending date, in the order: yr, mo, day. (Only the first 3 elements are used.) MUST be later than `tstart`. |
Output

_days_ scalar, elapsed time measured in days.

Remarks

This will work correctly across leap years and centuries. The assumptions are a Gregorian calendar with leap years on the years evenly divisible by 4 and not evenly divisible by 100, unless divisible by 400.

Example

```
let date1 = 2008 1 2;
let date2 = 2009 9 14;
d = _etdays_(date1,date2);
```

After the code above, _d_ is equal to:

621

Source

time.src

See Also

dayinyr
ethsec

**Purpose**

Computes the difference between two times, as generated by the `date` command, in hundredths of a second.

**Format**

\[ hs = \text{ethsec}(tstart, \ tend); \]

**Input**

- **tstart** 4x1 vector, starting date, in the order: yr, mo, day, hundredths of a second.
- **tend** 4x1 vector, ending date, in the order: yr, mo, day, hundredths of a second. MUST be later date than \( tstart \).

**Output**

- **hs** scalar, elapsed time measured in hundredths of a second.

**Remarks**

This will work correctly across leap years and centuries. The assumptions are a Gregorian calendar with leap years on the years evenly divisible by 4 and not evenly divisible by 100, unless divisible by 400.
Example

```plaintext
let date1 = 2008 1 2 0;
let date2 = 2009 9 14 0;
t = ethsec(date1, date2);
```

After the code above, \( t \) is equal to:

5365440000

Source
time.src

See Also
dayinyr

etstr

Purpose

Formats an elapsed time measured in hundredths of a second to a string.

Format

```plaintext
str = etstr(tothsecs);
```

Input

<table>
<thead>
<tr>
<th>tothsecs</th>
<th>scalar, an elapsed time measured in hundredths of a second, as given, for instance, by the <code>ethsec</code> function.</th>
</tr>
</thead>
</table>

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Output

\( \text{str} \) string containing the elapsed time in the form:

\[
\begin{array}{cccc}
\# \text{ days} & \# \text{ hours} & \# \text{ minutes} & \# , \# \# \text{ seconds}
\end{array}
\]

Example

```c
d1 = { 2012, 1, 2, 0 };
d2 = { 2012, 1, 14, 815642 };
t = \text{ethsec}(d1,d2);
str = \text{etstr}(t);

\text{print} \ "t = " \ t;
\text{print} \ "str = " \ str;
```

Output:

```
t = 104495642.000
str = 12 days 2 hours 15 minutes 56.42 seconds
```

Source

time.src

See Also

\text{ethsec}
EuropeanBinomCall

Purpose

Prices European call options using binomial method.

Format

\[ c = \text{EuropeanBinomCall}(S_0, K, r, d, t, \sigma, N); \]

Input

- \( S_0 \): scalar, current price.
- \( K \): Mx1 vector, strike prices.
- \( r \): scalar, risk free rate.
- \( d \): continuous dividend yield.
- \( t \): scalar, elapsed time to exercise in annualized days of trading.
- \( \sigma \): scalar, volatility.
- \( N \): number of time segments.

Output

- \( c \): Mx1 vector, call premiums.
Remarks

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", Journal of Financial Economics, 7:229:264) as described in Options, Futures, and other Derivatives by John C. Hull is the basis of this procedure.

Example

```plaintext
S0 = 718.46;
K = { 720, 725, 730 };
r = .0498;
sigma = .2493;
t0 = dtday(2001, 1, 30);
t1 = dtday(2001, 2, 16);
tau = elapsedTradingDays(t0,t1) / annualTradingDays(2012);
c = EuropeanBinomCall(S0,K,r,0,tau,sigma,60);
print c;
```

produces:

```
17.1325
14.8599
12.6383
```

Source

finprocs.src
**EuropeanBinomCall_Greeks**

**Purpose**

Computes Delta, Gamma, Theta, Vega, and Rho for European call options using binomial method.

**Format**

\[
\{ d, g, t, v, rh \} = \text{EuropeanBinomCall_Greeks}(S0, K, r, \text{div}, \text{tau}, \sigma, N);
\]

**Input**

- \( S0 \) : scalar, current price.
- \( K \) : Mx1 vector, strike prices.
- \( r \) : scalar, risk free rate.
- \( \text{div} \) : continuous dividend yield.
- \( \text{tau} \) : scalar, elapsed time to exercise in annualized days of trading.
- \( \sigma \) : scalar, volatility.
- \( N \) : number of time segments.

**Global Input**

- \( \_\text{fin}_\theta\text{etaType} \) : scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
- \( \_\text{fin}_\epsilon\text{psilon} \) : scalar, finite difference stepsize. Default = 1e-8.
Output

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( d )</td>
<td>Mx1 vector, delta.</td>
</tr>
<tr>
<td>( g )</td>
<td>Mx1 vector, gamma.</td>
</tr>
<tr>
<td>( t )</td>
<td>Mx1 vector, theta.</td>
</tr>
<tr>
<td>( v )</td>
<td>Mx1 vector, vega.</td>
</tr>
<tr>
<td>( rh )</td>
<td>Mx1 vector, rho.</td>
</tr>
</tbody>
</table>

Remarks

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", *Journal of Financial Economics*, 7:229:264) as described in *Options, Futures, and other Derivatives* by John C. Hull is the basis of this procedure.

Example

```plaintext
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
div = 0;
print EuropeanBinomcall_Greeks(S0,K,r,0,tau,sigma,30);
```

produces:

```
0.670
0.000
0.000
-38.426
```
Source
finprocs.src

See Also
EuropeanBinomCall_ImpVol, EuropeanBinomCall, EuropeanBinomPut_Greeks, EuropeanBSCall_Greeks

EuropeanBinomCall_ImpVol

Purpose
Computes implied volatilities for European call options using binomial method.

Format

\[
\sigma = \text{EuropeanBinomCall\_ImpVol}(c, S_0, K, r, \text{div}, \tau, N);
\]

Input

- \( c \) : Mx1 vector, call premiums.
- \( S_0 \) : scalar, current price.
- \( K \) : Mx1 vector, strike prices.
$r$ scalar, risk free rate.

div continuous dividend yield.

tau scalar, elapsed time to exercise in annualized days of trading.

$N$ number of time segments.

**Output**

$\sigma$ Mx1 vector, volatility.

**Remarks**

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", *Journal of Financial Economics*, 7:229:264) as described in *Options, Futures, and other Derivatives* by John C. Hull is the basis of this procedure.

**Example**

```plaintext
  c = { 13.70, 11.90, 9.10 }; 
  S0 = 718.46; 
  K = { 720, 725, 730 }; 
  r = .0368; 
  div = 0; 
  t0 = dtday(2012, 1, 30); 
  t1 = dtday(2012, 2, 16); 
  tau = elapsedTradingDays(t0,t1) / 
         annualTradingDays(2012); 
  sigma = EuropeanBinomCall_ImpVol(c,S0,K,r,0,tau,30); 
  print sigma;
```

produces:
EuropeanBinomPut

**Purpose**

Prices European put options using binomial method.

**Format**

\[ c = \text{EuropeanBinomPut}(S0, K, r, div, tau, sigma, N); \]

**Input**

- **S0** scalar, current price.
- **K** Mx1 vector, strike prices.
- **r** scalar, risk free rate.
- **div** continuous dividend yield.
- **tau** scalar, elapsed time to exercise in annualized days of trading.
- **sigma** scalar, volatility.
- **N** number of time segments.
Output

| c       | Mx1 vector, put premiums. |

Remarks

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", *Journal of Financial Economics*, 7:229:264) as described in *Options, Futures, and other Derivatives* by John C. Hull is the basis of this procedure.

Example

```plaintext
S0 = 718.46;
K = { 720, 725, 730 };
r = .0398;
sigma = .2493;
t0 = dtday(2012, 1, 30);
t1 = dtday(2012, 2, 16);
tau = elapsedTradingDays(t0,t1) /
      annualTradingDays(2012);
c = EuropeanBinomPut(S0,K,r,0,tau,sigma,60);print c;
```

produces:

```
16.872213
19.606098
22.390831
```

Source

finprocs.src
EuropeanBinomPut_Greeks

Purpose

Computes Delta, Gamma, Theta, Vega, and Rho for European put options using binomial method.

Format

\{ d, g, t, v, rh \} = EuropeanBinomPut_Greeks(S0, K, r, div, tau, sigma, N);

Input

- \( S0 \) scalar, current price.
- \( K \) Mx1 vector, strike prices.
- \( r \) scalar, risk free rate.
- \( div \) continuous dividend yield.
- \( tau \) scalar, elapsed time to exercise in annualized days of trading.
- \( sigma \) scalar, volatility.
- \( N \) number of time segments.

Global Input

- \_fin_thetaType scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
_fin_\_epsilon  scalar, finite difference stepsize. Default = 1e-8.

**Output**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d)</td>
<td>Mx1 vector, delta.</td>
</tr>
<tr>
<td>(g)</td>
<td>Mx1 vector, gamma.</td>
</tr>
<tr>
<td>(t)</td>
<td>Mx1 vector, theta.</td>
</tr>
<tr>
<td>(v)</td>
<td>Mx1 vector, vega.</td>
</tr>
<tr>
<td>(rh)</td>
<td>Mx1 vector, rho.</td>
</tr>
</tbody>
</table>

**Remarks**

The binomial method of Cox, Ross, and Rubinstein ("Option pricing: a simplified approach", *Journal of Financial Economics*, 7:229:264) as described in *Options, Futures, and other Derivatives* by John C. Hull is the basis of this procedure.

**Example**

```plaintext
S0 = 305;
K = 300;
r = .08;
div = 0;
sigma = .25;
tau = .33;
print EuropeanBinomPut_Greeks(S0,K,r,0,tau,sigma,60);
```

produces:
Source
finprocs.src

See Also
EuropeanBinomPut_ImpVol, EuropeanBinomPut, EuropeanBinomCall_Greeks, EuropeanBSPut_Greeks

EuropeanBinomPut_ImpVol

Purpose
Computes implied volatilities for European put options using binomial method.

Format
\[ \sigma = \text{EuropeanBinomPut}_\text{ImpVol}(c, S_0, K, r, \text{div}, \tau, N); \]

Input
- \(c\) Mx1 vector, put premiums.
- \(S_0\) scalar, current price.
\( K \)  
Mx1 vector, strike prices.

\( r \)  
scalar, risk free rate.

\( \text{div} \)  
continuous dividend yield.

\( \text{tau} \)  
scalar, elapsed time to exercise in annualized days of trading.

\( N \)  
number of time segments.

\textbf{Output}

\( \text{sigma} \)  
Mx1 vector, volatility.

\textbf{Remarks}


\textbf{Example}

```plaintext
p = \{ 14.60, 17.10, 20.10 \};
S0 = 718.46;
K = \{ 720, 725, 730 \};
r = .0398;
\text{div} = 0;
t0 = \text{dtday}(2012, 1, 30);
t1 = \text{dtday}(2012, 2, 16);
\text{tau} = \text{elapsedTradingDays}(t0,t1) / \text{annualTradingDays}(2012);
sigma = \text{EuropeanBinomPut_ImpVol}(p,S0,K,r,0,\text{tau},30);
\text{print} \ \text{sigma};
```
produces:

| 0.21609253 |
| 0.21139494 |
| 0.21407512 |

**Source**

finprocs.src

**EuropeanBS_Call**

**Purpose**

Prices European call options using Black, Scholes and Merton method.

**Format**

\[ c = \text{EuropeanBS_Call}(S_0, K, r, \text{div}, \tau, \sigma); \]

**Input**

- \( S_0 \) scalar, current price.
- \( K \) Mx1 vector, strike prices.
- \( r \) scalar, risk free rate.
- \( \text{div} \) continuous dividend yield.
- \( \tau \) scalar, elapsed time to exercise in annualized days of trading.
- \( \sigma \) scalar, volatility.
Output

$c$  Mx1 vector, call premiums.

Example

```
S0 = 718.46;
K = {720, 725, 730};
r = .0498;
sigma = .2493;
t0 = dtday(2012, 1, 30);
t1 = dtday(2012, 2, 16);
tau = elapsedTradingDays(t0, t1) / annualTradingDays(2012);
c = EuropeanBS(0, K, r, 0, tau, sigma);
print c;
```

produces:

```
17.1351
14.7955
12.6860
```

Source

finprocs.src
# EuropeanBSCall_Greeks

## Purpose

Computes Delta, Gamma, Theta, Vega, and Rho for European call options using Black, Scholes, and Merton method.

## Format

\[
\{ d, g, t, v, rh \} = \text{EuropeanBSCall}_\text{Greeks}(S0, K, r, \text{div}, \tau, \sigma);
\]

## Input

- **S0**: scalar, current price.
- **K**: Mx1 vector, strike prices.
- **r**: scalar, risk free rate.
- **div**: continuous dividend yield.
- **tau**: scalar, elapsed time to exercise in annualized days of trading.
- **sigma**: scalar, volatility.

## Global Input

- **_fin_thetaType**: scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.
- **_fin_epsilon**: scalar, finite difference stepsize. Default = 1e-8.
Output

\[
\begin{align*}
  d & \quad \text{Mx1 vector, delta.} \\
  g & \quad \text{Mx1 vector, gamma.} \\
  t & \quad \text{Mx1 vector, theta.} \\
  v & \quad \text{Mx1 vector, vega.} \\
  \rho & \quad \text{Mx1 vector, rho.}
\end{align*}
\]

Example

\begin{verbatim}
S0 = 305;
K = 300;
r = .08;
sigma = .25;
tau = .33;
print EuropeanBS_Call_Greeks(S0,K,r,0,tau,sigma);
\end{verbatim}

produce:

\[
\begin{align*}
  0.6446 \\
  0.0085 \\
  -38.5054 \\
  65.2563 \\
  56.8720
\end{align*}
\]

Source

finprocs.src
See Also

EuropeanBSCall_ImpVol, EuropeanBSCall, EuropeanBSPut_Greeks, EuropeanBinomCall_Greeks

EuropeanBSCall_ImpVol

Purpose

Computes implied volatilities for European call options using Black, Scholes, and Merton method.

Format

\[ \sigma = \text{EuropeanBSCall}_\text{ImpVol}(c, S_0, K, r, \text{div}, \tau) \]

Input

- **c**: Mx1 vector, call premiums.
- **S0**: scalar, current price.
- **K**: Mx1 vector, strike prices.
- **r**: scalar, risk free rate.
- **div**: continuous dividend yield.
- **tau**: scalar, elapsed time to exercise in annualized days of trading.
Output

\( \text{sigma} \) Mx1 vector, volatility.

Example

\[
\begin{align*}
c & = \{ 13.70, 11.90, 9.10 \}; \\
S_0 & = 718.46; \\
K & = \{ 720, 725, 730 \}; \\
r & = .0498; \\
t_0 & = \text{dtday}(2012, 1, 30); \\
t_1 & = \text{dtday}(2012, 2, 16); \\
\tau & = \text{elapsedTradingDays}(t_0, t_1) / \text{annualTradingDays}(2012); \\
\text{sigma} & = \text{EuropeanBSCall_ImpVol}(c, S_0, K, r, 0, \tau); \\
\text{print} & \text{ sigma;}
\end{align*}
\]

produces:

0.1986
0.2064
0.1951

Source

finprocs.src

EuropeanBSPut

Purpose

Prices European put options using Black, Scholes, and Merton method.
Format

\[ c = \text{EuropeanBSPut}(S_0, K, r, \text{div}, \tau, \sigma); \]

Input

- **S0**: scalar, current price.
- **K**: Mx1 vector, strike prices.
- **r**: scalar, risk free rate.
- **div**: continuous dividend yield.
- **\tau**: scalar, elapsed time to exercise in annualized days of trading.
- **\sigma**: scalar, volatility.

Output

- **c**: Mx1 vector, put premiums.

Example

```matlab
S0 = 718.46;
K = [720, 725, 730];
r = .0498;
sigma = .2493;
t0 = dtday(2012, 1, 30);
t1 = dtday(2012, 2, 16);
\tau = \text{elapsedTradingDays}(t0, t1) / \sigma;
```
annualTradingDays(2012);
c = EuropeanBSPut(S0,K,r,0,tau,sigma);
print c;

produces:

16.6700
19.3164
22.1930

Source
finprocs.src

EuropeanBSPut_Greeks

Purpose
Computes Delta, Gamma, Theta, Vega, and Rho for European put options using Black, Scholes, and Merton method.

Format

\{ d, g, t, v, rh \} = EuropeanBSPut_Greeks(S0, K, r, div, tau, sigma);

Input

S0  scalar, current price.
K   Mx1 vector, strike prices.
Scalar, risk free rate.

Continuous dividend yield.

Scalar, elapsed time to exercise in annualized days of trading.

Scalar, volatility.

**Global Input**

_fin_thetaType scalar, if 1, one day look ahead, else, infinitesimal. Default = 0.

_fin_epsilon scalar, finite difference stepsize. Default = 1e-8.

**Output**

\(d\) Mx1 vector, delta.

\(g\) Mx1 vector, gamma.

\(t\) Mx1 vector, theta.

\(v\) Mx1 vector, vega.

\(rh\) Mx1 vector, rho.

**Example**

\[
S0 = 305; \\
K = 300;
\]
r = .08;
sigma = .25;
tau = .33;

print EuropeanBSPut_Greeks(S0, K, r, 0, tau, sigma);

produces:

-0.3554
0.0085
-15.1307
65.2563
-39.54861

Source

finprocs.src

See Also

EuropeanBSPut_ImpVol, EuropeanBSPut, EuropeanBSCall_Greeks, EuropeanBinomPut_Greeks

EuropeanBSPut_ImpVol

Purpose

Computes implied volatilities for European put options using Black, Scholes, and Merton method.

Format

\[ \sigma = \text{EuropeanBSPut\_ImpVol}(c, S0, K, r, \text{div}, \tau); \]
**Input**

- $c$: Mx1 vector, put premiums
- $S_0$: scalar, current price.
- $K$: Mx1 vector, strike prices.
- $r$: scalar, risk free rate.
- $div$: continuous dividend yield.
- $\tau$: scalar, elapsed time to exercise in annualized days of trading.

**Output**

- $\sigma$: Mx1 vector, volatility.

**Example**

```plaintext
p = { 14.60, 17.10, 20.10 };  # put premiums
S0 = 718.46;
K = { 720, 725, 730 };  # strike prices
r = .0498;
t0 = dtday(2012, 1, 30);
t1 = dtday(2012, 2, 16);
tau = elapsedTradingDays(t0, t1) / annualTradingDays(2012);
sigma = EuropeanBSPut_ImpVol(p, S0, K, r, 0, tau);
print sigma;  # output: 38-520
```
0.2188
0.2165
0.2177

Source
finprocs.src

exctsmpl

Purpose
Computes a random subsample of a data set.

Format
\[ n = \text{exctsmpl}(\text{infile}, \text{outfile}, \text{percent}); \]

Input
\begin{align*}
\text{ infile } & \quad \text{string, the name of the original data set.} \\
\text{ outfile } & \quad \text{string, the name of the data set to be created.} \\
\text{ percent } & \quad \text{scalar, the percentage random sample to take. This must be in the range 0-100.} \\
\end{align*}

Output
\[ n \quad \text{scalar, number of rows in output data set.} \]
Error returns are controlled by the low bit of the trap flag:

- **trap 0**: terminate with error message
- **trap 1**: return scalar negative integer
  - -1: can't open input file
  - -2: can't open output file
  - -3: disk full

**Remarks**

Random sampling is done with replacement. Thus, an observation may be in the resulting sample more than once. If `percent` is 100, the resulting sample will not be identical to the original sample, though it will be the same size.

**Example**

```gauss
n = exctsmpl("freqdata.dat","rout",30);
```

`freqdata.dat` is an example data set provided with **GAUSS**. Switching to the `examples` subdirectory of your **GAUSS** installation directory will make it possible to do the above example as shown. Otherwise you will need to substitute another data set name for "freqdata.dat".

**Source**

`exctsmpl.src`
exec

**Purpose**

Executes an executable program and returns the exit code to GAUSS.

**Format**

\[ y = \text{exec}(\text{program, comline}); \]

**Input**

- **program** string, the name of the program, including the extension, to be executed.
- **comline** string, the arguments to be placed on the command line of the program being executed.

**Output**

- **y** scalar, the exit code returned by `program`.

If `exec` can't execute `program`, the error returns will be negative:

- `-1` file not found
- `-2` the file is not an executable file
- `-3` not enough memory
- `-4` command line too long
Example

```plaintext
y = exec("atog","comdl.cmd");

//If 'y' is nonzero
if y;
    errorlog"atog failed";
    end;
endif;
```

In this example the ATOG ASCII conversion utility is executed under the `exec` function. The name of the command file to be used, `comdl.cmd`, is passed to ATOG on its command line. The exit code `y` returned by `exec` is tested to see if ATOG was successful; if not, the program will be terminated after printing an error message. See ATOG, Section 1.

execbg

**Purpose**

Executes an executable program in the background and returns the process id to GAUSS.

**Format**

```plaintext
pid = execbg(program, comline);
```

**Input**

- `program` string, the name of the program, including the extension, to be executed.
**comline**

string, the arguments to be placed on the command line of the program being executed.

**Output**

**pid**

scalar, the process id of the executable returned by program.

If `execbg` cannot execute program, the error returns will be negative:

-1  file not found

-2  the file is not an executable file

-3  not enough memory

-4  command line too long

**Example**

```
y = execbg("atog.exe","comdl.cmd");
if (y < 0);
    errorlog"atog failed";
end;
endif;
```

In this example, the ATOG ASCII conversion utility is executed under the `execbg` function. The name of the command file to be used, `comdl.cmd`, is passed to ATOG on its command line. The returned value, `y`, is tested to see whether ATOG was successful. If not successful the program terminates after printing an error message. See ATOG, Chapter 1.
exp

Purpose

Calculates the exponential function.

Format

\[ y = \exp(x); \]

Input

\[ x \]  
NxK matrix or N-dimensional array.

Output

\[ y \]  
NxK matrix or N-dimensional array containing \( e \), the base of natural logs, raised to the powers given by the elements of \( x \).

Example

\[
\begin{align*}
x &= \text{eye}(3); \\
y &= \exp(x);
\end{align*}
\]

\[
\begin{bmatrix}
1.000000 & 0.000000 & 0.000000 \\
0.000000 & 1.000000 & 0.000000 \\
0.000000 & 0.000000 & 1.000000
\end{bmatrix}
\]
This example creates a 3x3 identity matrix and computes the exponential function for each one of its elements. Note that \( \exp(1) \) returns \( e \), the base of natural logs.

**See Also**

ln

**extern (dataloop)**

**Purpose**

Allows access to matrices or strings in memory from inside a data loop.

**Format**

```
extern variable_list;
```

**Remarks**

Commas in `variable_list` are optional.

`extern` tells the translator not to generate local code for the listed variables, and not to assume that they are elements of the input data set.

`extern` statements should be placed before any reference to the symbols listed. The specified names should not exist in the input data set, or be used in a `make` statement.
**Example**

This example shows how to assign the contents of an external vector to a new variable in the data set, by iteratively assigning a range of elements to the variable. The reserved variable $x_x$ contains the data read from the input data set on each iteration. The external vector must have at least as many rows as the data set.

```plaintext
base = 1;  /* used to index a range of */
    /* elements from exvec */
dataloop olddata newdata;
extern base, exvec;
make ndvar = exvec[seqa(base,1, rows(x_x))];
# base = base + rows(x_x);  /* execute command */
    /* literally */
enda;
```

**external**

**Purpose**

Lets the compiler know about symbols that are referenced above or in a separate file from their definitions.
Format

```
external proc dog, cat;
external keyword dog;
external fn dog;
external matrix x, y, z;
external string mstr, cstr;
external array a, b;
external sparse matrix sma, smb;
external struct structure_type sta, stb;
```

Remarks

See Procedures and Keywords, Chapter 1.

You may have several procedures in different files that reference the same global variable. By placing an `external` statement at the top of each file, you can let the compiler know what the type of the symbol is. If the symbol is listed and strongly typed in an active library, no `external` statement is needed.

If a matrix, string, N-dimensional array, sparse matrix, or structure appears in an `external` statement, it needs to appear once in a `declare` statement. If no declaration is found, an **Undefined symbol** error message will result.

Example

Let us suppose that you created a set of procedures defined in different files, which all set a global matrix `_errcode` to some scalar error code if errors were encountered.

You could use the following code to call one of the procedures in the set and check whether it succeeded:
external  matrix  _errcode;

x  =  rdn(10,5);
y  =  myproc1(x);
if  _errcode;
   print  "myproc1 failed";
   end;
endif;

Without  the  external  statement,  the  compiler  would  assume  that  _errcode
was  a  procedure  and  incorrectly  compile  this  program.  The  file  containing  the
myproc1  procedure  must  also  contain  an  external  statement  that  defines  _
errcode  as  a  matrix,  but  this  would  not  be  encountered  by  the  compiler  until  the
if  statement  containing  the  reference  to _errcode  in  the  main  program  file  had
already  been  incorrectly  compiled.

See Also

declare

eye

Purpose

Creates  an  identity  matrix.

Format

y  =  eye(n);
**Input**

\( n \)  
scalar, size of identity matrix to be created.

**Output**

\( y \)  
\( n \times n \) identity matrix.

**Remarks**

If \( n \) is not an integer, it will be truncated to an integer.  
The matrix created will contain 1's down the diagonal and 0's everywhere else.

**Example**

```matlab
x = eye(3);
```

The code above assigns \( x \) to be equal to:

```
1.0000 0.0000 0.0000  
0.0000 1.0000 0.0000  
0.0000 0.0000 1.0000
```

**See Also**

zeros, ones
fcheckerr

Purpose

Gets the error status of a file.

Format

\[ \text{err} = \text{fcheckerr}(f); \]

Input

\( f \) scalar, file handle of a file opened with fopen.

Output

\( \text{err} \) scalar, error status.

Remarks

If there has been a read or write error on a file, fcheckerr returns 1, otherwise 0.
If you pass `fcheckerr` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

**fclearerr**

**Purpose**

Gets the error status of a file, then clears it.

**Format**

```
err = fclearerr(f);
```

**Input**

- `f` scalar, file handle of a file opened with `fopen`.

**Output**

- `err` scalar, error status.

**Remarks**

Each file has an error flag that gets set when there is an I/O error on the file. Typically, once this flag is set, you can no longer do I/O on the file, even if the error is a recoverable one. `fclearerr` clears the file's error flag, so you can attempt to continue using it.

If there has been a read or write error on a file, `fclearerr` returns 1, otherwise 0.
If you pass `fclearerr` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

The flag accessed by `fclearerr` is not the same as that accessed by `fstrerror`.

### feq, fge, fgt, fle, flt, fne

#### Purpose

Fuzzy comparison functions. These functions use `fcmptol` to fuzz the comparison operations to allow for roundoff error.

#### Format

```plaintext
y = feq(a, b);
y = fge(a, b);
y = fgt(a, b);
y = fle(a, b);
y = flt(a, b);
y = fne(a, b);
```

#### Input

- **a**: NxK matrix, first matrix.
- **b**: LxM matrix, second matrix, ExE compatible with a.

#### Global Input

- **fcmptol**: scalar, comparison tolerance. The default value is 1.0e-15.
Output

$y$ scalar, 1 (TRUE) or 0 (FALSE).

Remarks

The return value is TRUE if every comparison is TRUE.

The statement:

$$y = \texttt{feq}(a,b);$$

is equivalent to:

$$y = a \texttt{ eq } b;$$

For the sake of efficiency, these functions are not written to handle missing values. If $a$ and $b$ contain missing values, use \texttt{missrv} to convert the missing values to something appropriate before calling a fuzzy comparison function.

The calling program can reset _fcmptol before calling these procedures:

$$\_\texttt{fcmptol} = 1e-12;$$

Example

$$\_\texttt{fcmptol} = 1e-12;$$

$$x = \texttt{rndu}(2,2);$$

$$y = x + 0.5*(\_\texttt{fcmptol});$$

$$\texttt{if fge}(x,y);$$
print "each element of x is greater than";
print "or equal to each element of y";
else;
print "at least one element of x is less";
print "its corresponding element in y";
endif;

Source
fcompare.src

See Also
dotfeg-dotfne

feqmt, fgemt, fgtmt, flemt, fltmt, fnemt

Purpose
Fuzzy comparison functions. These functions use the fcmtol argument to fuzz the comparison operations to allow for roundoff error.

Format

```
y = feqmt(a, b, fcmtol);
y = fgemt(a, b, fcmtol);
y = fgtmt(a, b, fcmtol);
y = flemt(a, b, fcmtol);
y = fltmt(a, b, fcmtol);
y = fnemt(a, b, fcmtol);
```
Input

\[ a \]  
N\times K matrix, first matrix.

\[ b \]  
L\times M matrix, second matrix, ExE compatible with \( a \).

\[ fcmp tol \]  
scalar, comparison tolerance.

Output

\[ y \]  
scalar, 1 (TRUE) or 0 (FALSE).

Remarks

The return value is TRUE if every comparison is TRUE.

The statement:

\[
y = \text{feqmt}(a, b, 1e-15);
\]

is equivalent to:

\[
y = a \text{ eq } b;
\]

For the sake of efficiency, these functions are not written to handle missing values. If \( a \) and \( b \) contain missing values, use \texttt{missrv} to convert the missing values to something appropriate before calling a fuzzy comparison function.

Example

\[
tol = 1e-12;
\]
x = rndu(2,2);

y = x + 0.5*(tol);

if ffgemt(x,y,tol);
   print "each element of x is greater than";
   print "or equal to each element of y";
else;
   print "at least one element of x is less";
   print "its corresponding element in y";
endif;

Source
fcomparemt.src

See Also
dotfegmt-dotfnemt

fflush

Purpose
Flushes a file's output buffer.

Format
ret = fflush(f);
Input

\( f \)
scalar, file handle of a file opened with `fopen`.

Output

\( ret \)
scalar, 0 if successful, -1 if not.

Remarks

If `fflush` fails, you can call `fstrerror` to find out why.

If you pass `fflush` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

fft

Purpose

Computes a 1- or 2-D Fast Fourier transform.

Format

\[ y = \text{fft}(x); \]

Input

\( x \)
N\times K matrix.
Output

\[ y \]

LxM matrix, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.

Remarks

This computes the FFT of \( x \), scaled by \( 1/N \).
This uses a Temperton Fast Fourier algorithm.
If N or K is not a power of 2, \( x \) will be padded out with zeros before computing the transform.

See Also

ffti, rfft, rffti

ffti

Purpose

Computes an inverse 1- or 2-D Fast Fourier transform.

Format

\[ y = \text{ffti}(x); \]

Input

\( x \)

NxK matrix.
Output

\[ y \]
LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

Remarks

Computes the inverse FFT of \( x \), scaled by \( 1/N \).
This uses a Temperton prime factor Fast Fourier algorithm.

See Also

fft, rfft, rfft4

fftm

Purpose

Computes a multi-dimensional FFT.

Format

\[ y = \text{fftm}(x, \ dim); \]

Input

\[ x \]
Mx1 vector, data.
\[ \text{dim} \]
Kx1 vector, size of each dimension.
Output

\[ y \] Lx1 vector, FFT of \( x \).

Remarks

The multi-dimensional data are laid out in a recursive or hierarchical fashion in the vector \( x \). That is to say, the elements of any given dimension are stored in sequence left to right within the vector, with each element containing a sequence of elements of the next smaller dimension. In abstract terms, a 4-dimensional 2x2x2x2 hypercubic \( x \) would consist of two cubes in sequence, each cube containing two matrices in sequence, each matrix containing two rows in sequence, and each row containing two columns in sequence. Visually, \( x \) would look something like this:

\[
X_{\text{hyper}} = X_{\text{cube1}}\mid X_{\text{cube2}} \\
X_{\text{cube1}} = X_{\text{mat1}}\mid X_{\text{mat2}} \\
X_{\text{mat1}} = X_{\text{row1}}\mid X_{\text{row2}}
\]

Or, in an extended GAUSS notation, \( x \) would be:

\[
X_{\text{hyper}} = x[1,\ldots,\ldots] \mid x[2,\ldots,\ldots]; \\
X_{\text{cube1}} = x[1,1,\ldots] \mid x[1,2,\ldots]; \\
X_{\text{mat1}} = x[1,1,1,\ldots] \mid x[1,1,2,\ldots]; \\
X_{\text{row1}} = x[1,1,1,1] \mid x[1,1,1,2];
\]

To be explicit, \( x \) would be laid out like this:

\[
\begin{align*}
&x[1,1,1,1] \ x[1,1,1,2] \ x[1,1,2,1] \ x[1,1,2,2] \\
&x[1,2,1,1] \ x[1,2,1,2] \ x[1,2,2,1] \ x[1,2,2,2] \\
&x[2,1,1,1] \ x[2,1,1,2] \ x[2,1,2,1] \ x[2,1,2,2] \\
&x[2,2,1,1] \ x[2,2,1,2] \ x[2,2,2,1] \ x[2,2,2,2]
\end{align*}
\]

If you look at the last diagram for the layout of \( x \), you'll notice that each line actually constitutes the elements of an ordinary matrix in normal row-major order. This is easy
to achieve with `vecr`. Further, each pair of lines or "matrices" constitutes one of the desired cubes, again with all the elements in the correct order. And finally, the two cubes combine to form the hypercube. So, the process of construction is simply a sequence of concatenations of column vectors, with a `vecr` step if necessary to get started.

Here's an example, this time working with a 2x3x2x3 hypercube.

```plaintext
let dim = 2 3 2 3;
let x1[2,3] = 1 2 3 4 5 6;
let x2[2,3] = 6 5 4 3 2 1;
let x3[2,3] = 1 2 3 5 7 11;
xcl = `vecr`(x1)|`vecr`(x2)|`vecr`(x3); /* cube 1 */
let x1 = 1 1 2 3 5 8;
let x2 = 1 2 6 24 120 720;
let x3 = 13 17 19 23 29 31;
xc2 = x1|x2|x3; /* cube 2 */

xh = xcl|xc2; /* hypercube */
xhfft = `fftm`(xh,dim);

let dimi = 2 4 2 4;
xhfft = `fftmi`(xhfft,dimi);
```

We left out the `vecr` step for the 2nd cube. It's not really necessary when you're constructing the matrices with `let` statements.

`dim` contains the dimensions of `x`, beginning with the highest dimension. The last element of `dim` is the number of columns, the next to the last element of `dim` is the number of rows, and so on. Thus

```plaintext
dim = { 2, 3, 3 };
```

indicates that the data in `x` is a 2x3x3 three-dimensional array, i.e., two 3x3 matrices of data. Suppose that `x1` is the first 3x3 matrix and `x2` the second 3x3 matrix, then:
\[ x = \text{vecr}(x_1) | \text{vecr}(x_2) \]

The size of \( \text{dim} \) tells you how many dimensions \( x \) has.

The arrays have to be padded in each dimension to the nearest power of two. Thus the output array can be larger than the input array. In the 2x3x2x3 hypercube example, \( x \) would be padded from 2x3x2x3 out to 2x4x2x4. The input vector would contain 36 elements, while the output vector would contain 64 elements. You may have noticed that we used a \( \text{dimi} \) with padded values at the end of the example to check our answer.

**Source**

fftm.src

**See Also**

fftmi, fft, ffti, fftn

**fftmi**

**Purpose**

Computes a multi-dimensional inverse FFT.

**Format**

\[ y = \text{fftmi}(x, \ dim); \]

**Input**

\( x \) Mx1 vector, data.
**dim**  
Kx1 vector, size of each dimension.

**Output**

\[ y \]  
Lx1 vector, inverse FFT of \( x \).

**Remarks**

The multi-dimensional data are laid out in a recursive or hierarchical fashion in the vector \( x \). That is to say, the elements of any given dimension are stored in sequence left to right within the vector, with each element containing a sequence of elements of the next smaller dimension. In abstract terms, a 4-dimensional 2x2x2x2 hypercubic \( x \) would consist of two cubes in sequence, each cube containing two matrices in sequence, each matrix containing two rows in sequence, and each row containing two columns in sequence. Visually, \( x \) would look something like this:

\[
X_{\text{hyper}} = X_{\text{cube1}} | X_{\text{cube2}} \\
X_{\text{cube1}} = X_{\text{mat1}} | X_{\text{mat2}} \\
X_{\text{mat1}} = X_{\text{row1}} | X_{\text{row2}}
\]

Or, in an extended **GAUSS** notation, \( x \) would be:

```plaintext
Xhyper = x[1,.,.,.] | x[2,.,.,.];  
Xcube1 = x[1,1,.,.] | x[1,2,.,.];  
Xmat1 = x[1,1,1,.] | x[1,1,2,..];  
Xrow1 = x[1,1,1,1] | x[1,1,1,2];
```

To be explicit, \( x \) would be laid out like this:

\[
x[1,1,1,1] \ x[1,1,1,2] \ x[1,1,2,1] \ x[1,1,2,2]  
x[1,2,1,1] \ x[1,2,1,2] \ x[1,2,2,1] \ x[1,2,2,2]
\]
If you look at the last diagram for the layout of $x$, you'll notice that each line actually constitutes the elements of an ordinary matrix in normal row-major order. This is easy to achieve with \texttt{vecr}. Further, each pair of lines or "matrices" constitutes one of the desired cubes, again with all the elements in the correct order. And finally, the two cubes combine to form the hypercube. So, the process of construction is simply a sequence of concatenations of column vectors, with a \texttt{vecr} step if necessary to get started.

Here's an example, this time working with a $2\times3\times2\times3$ hypercube.

```plaintext
let dim = 2 3 2 3;

let x1[2,3] = 1 2 3 4 5 6;
let x2[2,3] = 6 5 4 3 2 1;
let x3[2,3] = 1 2 3 5 7 11;
xcl = vecr(x1)|vecr(x2)|vecr(x3); /* cube 1 */
let x1 = 1 1 2 3 5 8;
let x2 = 1 2 6 24 120 720;
let x3 = 13 17 19 23 29 31;
xc2 = x1|x2|x3; /* cube 2 */
xh = xcl|xc2; /* hypercube */
xhffti = fftmi(xh,dim);
```

We left out the \texttt{vecr} step for the 2nd cube. It's not really necessary when you're constructing the matrices with \texttt{let} statements.

dim contains the dimensions of $x$, beginning with the highest dimension. The last element of \texttt{dim} is the number of columns, the next to the last element of \texttt{dim} is the number of rows, and so on. Thus

```plaintext
dim = { 2, 3, 3 };
```
indicates that the data in \( x \) is a 2x3x3 three-dimensional array, i.e., two 3x3 matrices of data. Suppose that \( x_1 \) is the first 3x3 matrix and \( x_2 \) the second 3x3 matrix, then

\[
x = \text{vecr}(x_1) | \text{vecr}(x_2)
\]

The size of \( \text{dim} \) tells you how many dimensions \( x \) has.

The arrays have to be padded in each dimension to the nearest power of two. Thus the output array can be larger than the input array. In the 2x3x2x3 hypercube example, \( x \) would be padded from 2x3x2x3 out to 2x4x2x4. The input vector would contain 36 elements, while the output vector would contain 64 elements.

**Source**

fftm.src

**See Also**

fft, ffti, fftn

**fftn**

**Purpose**

Computes a complex 1- or 2-D FFT.

**Format**

\[
y = \text{fftn}(x);
\]

**Input**

\[
x \quad \text{NxK matrix.}
\]
Output

\[ y \quad \text{LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.} \]

Remarks

\texttt{fftn} uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. \texttt{GAUSS} implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, \texttt{fftn} can handle any matrix whose dimensions can be expressed as

\[ 2^p \times 3^q \times 5^r \times 7^s \]

where \( p, q \) and \( r \) are nonnegative integers and \( s \) is equal to 0 or 1.

If a dimension of \( x \) does not meet this requirement, it will be padded with zeros to the next allowable size before the FFT is computed.

\texttt{fftn} pads matrices to the next allowable dimensions; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20% faster than a 32768x1 vector, because 33600 is a highly composite number, \( 2^6 \times 3^2 \times 5^2 \times 7 \), whereas 32768 is a simple power of 2, \( 2^{15} \). For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to \texttt{fftn}. The \texttt{Run-Time Library} includes a routine, \texttt{optn}, for determining optimum dimensions.

The \texttt{Run-Time Library} also includes the \texttt{nextn} routine, for determining allowable dimensions for a matrix. (You can use this to see the dimensions to which \texttt{fftn} would pad a matrix.)

\texttt{fftn} scales the computed FFT by \( 1/(L\times M) \).
See Also
fft, ffti, fftm, fftmi, rfft, rftti, rfftip, rfftn, rfftnp, rfttp

fgets

Purpose
Reads a line of text from a file.

Format

\[ str = \text{fgets}(f, \text{maxsize}); \]

Input
\n\n\begin{tabular}{|l|l|}
\hline
\textbf{f} & scalar, file handle of a file opened with \texttt{fopen}. \\
\hline
\textbf{maxsize} & scalar, maximum size of string to read in, including the terminating null byte. \\
\hline
\end{tabular}

Output
\n\n\begin{tabular}{|l|l|}
\hline
\textbf{str} & string. \\
\hline
\end{tabular}

Remarks
\texttt{fgets} reads text from a file into a string. It reads up to a newline, the end of the file, or \textit{maxsize}-1 characters. The result is placed in \texttt{str}, which is then terminated with a null byte. The newline, if present, is retained.
If the file is already at end-of-file when you call \texttt{fgets}, your program will terminate with an error. Use \texttt{eof} in conjunction with \texttt{fgets} to avoid this.

If the file was opened for update (see \texttt{fopen}) and you are switching from writing to reading, don't forget to call \texttt{fseek} or \texttt{fflush} first, to flush the file's buffer.

If you pass \texttt{fgets} the handle of a file opened with \texttt{open} (i.e., a data set or matrix file), your program will terminate with a fatal error.

\textbf{See Also}

\texttt{fgetst}, \texttt{fgetsa}, \texttt{fopen}

\textbf{fgetsa}

\textbf{Purpose}

Reads lines of text from a file into a string array.

\textbf{Format}

\begin{equation}
 sa = \texttt{fgetsa}(f, \ numl);
\end{equation}

\textbf{Input}

\begin{itemize}
  \item \texttt{f} \hspace{1cm} scalar, file handle of a file opened with \texttt{fopen}.
  \item \texttt{numl} \hspace{1cm} scalar, number of lines to read.
\end{itemize}

\textbf{Output}

\begin{itemize}
  \item \texttt{sa} \hspace{1cm} Nx1 string array, \texttt{N} \leq \texttt{numl}.
\end{itemize}
Remarks

`fgetsa` reads up to `numl` lines of text. If `fgetsa` reaches the end of the file before reading `numl` lines, `sa` will be shortened. Lines are read in the same manner as `fgets`, except that no limit is placed on the size of a line. Thus, `fgetsa` always returns complete lines of text. Newlines are retained. If `numl` is 1, `fgetsa` returns a string. (This is one way to read a line from a file without placing a limit on the length of the line.)

If the file is already at end-of-file when you call `fgetsa`, your program will terminate with an error. Use `eof` in conjunction with `fgetsa` to avoid this. If the file was opened for update (see `fopen`) and you are switching from writing to reading, don't forget to call `fseek` or `fflush` first, to flush the file's buffer.

If you pass `fgetsa` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

See Also

`fgetsat`, `fgets`, `fopen`

fgetsat

Purpose

Reads lines of text from a file into a string array.

Format

```latex
sa = fgetsat(f, numl);
```
**Input**

$f$  
scalar, file handle of a file opened with `fopen`.  

`numl`  
scalar, number of lines to read.

**Output**

`sa`  
Nx1 string array, $N \leq numl$.

**Remarks**

`fgetsat` operates identically to `fgetsa`, except that newlines are not retained as text is read into `sa`.

In general, you don't want to use `fgetsat` on files opened in binary mode (see `fopen`). `fgetsat` drops the newlines, but it does NOT drop the carriage returns that precede them on some platforms. Printing out such a string array can produce unexpected results.

**See Also**

`fgetsa`, `fgets`, `fopen`

**fgets**

**Purpose**

Reads a line of text from a file.
Format

\[ str = \texttt{fgetst}(f, \text{maxsize}); \]

Input

\begin{itemize}
  \item \textit{f} \hspace{1cm} scalar, file handle of a file opened with \texttt{fopen}.
  \item \textit{maxsize} \hspace{1cm} scalar, maximum size of string to read in, including the null terminating byte.
\end{itemize}

Output

\begin{itemize}
  \item \textit{str} \hspace{1cm} string.
\end{itemize}

Remarks

\texttt{fgetst} operates identically to \texttt{fgets}, except that the newline is not retained in the string.

In general, you don't want to use \texttt{fgetst} on files opened in binary mode (see \texttt{fopen}). \texttt{fgetst} drops the newline, but it does NOT drop the preceding carriage return used on some platforms. Printing out such a string can produce unexpected results.

See Also

\texttt{fgets, fgetsv, fopen}
fileinfo

Purpose

Returns names and information for files that match a specification.

Format

\[
\{ fnames, finfo \} = \text{fileinfo}(fspec);
\]

Input

\textit{fspec} \quad \text{string, file specification. Can include path. Wildcards are allowed in \textit{fspec}.}

Output

\textit{fnames} \quad \text{Nx1 string array of all file names that match, null string if none are found.}

\textit{finfo} \quad \text{Nx13 matrix, information about matching files.}

**UNIX/Linux**

\[
\begin{array}{c}
[N, 1] & \text{filesystem ID} \\
[N, 2] & \text{inode number} \\
[N, 3] & \text{mode bit mask} \\
[N, 4] & \text{number of links} \\
[N, 5] & \text{user ID}
\end{array}
\]
<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>group ID</td>
</tr>
<tr>
<td>7</td>
<td>device ID (char/block special files only)</td>
</tr>
<tr>
<td>8</td>
<td>size in bytes</td>
</tr>
<tr>
<td>9</td>
<td>last access time</td>
</tr>
<tr>
<td>10</td>
<td>last data modification time</td>
</tr>
<tr>
<td>11</td>
<td>last file status change time</td>
</tr>
<tr>
<td>12</td>
<td>preferred I/O block size</td>
</tr>
<tr>
<td>13</td>
<td>number of 512-byte blocks allocated</td>
</tr>
</tbody>
</table>

**Windows**

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>drive number (A = 0, B = 1, etc.)</td>
</tr>
<tr>
<td>2</td>
<td>n/a, 0</td>
</tr>
<tr>
<td>3</td>
<td>mode bit mask</td>
</tr>
<tr>
<td>4</td>
<td>number of links, always 1</td>
</tr>
<tr>
<td>5</td>
<td>n/a, 0</td>
</tr>
<tr>
<td>6</td>
<td>n/a, 0</td>
</tr>
<tr>
<td>7</td>
<td>n/a, 0</td>
</tr>
<tr>
<td>8</td>
<td>size in bytes</td>
</tr>
<tr>
<td>9</td>
<td>last access time</td>
</tr>
<tr>
<td>10</td>
<td>last data modification time</td>
</tr>
<tr>
<td>11</td>
<td>creation time</td>
</tr>
</tbody>
</table>
Remarks

\( fnames \) will contain file names only; any path information that was passed is dropped.

The time stamp fields \( f_{info}[N,9:11] \) are expressed as the number of seconds since midnight, Jan. 1, 1970, Coordinated Universal Time (UTC).

See Also

\( \text{filesa} \)

filesa

Purpose

Returns a string array of file names.

Format

\[
y = \text{filesa}(n);
\]

Input

\[
n \quad \text{string, file specification to search for. Can include path. Wildcards are allowed in } n.
\]
Output

\( y \)  
Nx1 string array of all file names that match, or null string if none are found.

Remarks

\( y \) will contain file names only; any path information that was passed is dropped.

Example

\[
y = \text{filesa}("ch*");
\]

In this example all files listed in the current directory that begin with "ch" will be returned.

\[
\text{proc } \text{exist}(\text{filename});
\quad \text{retp}(\text{not } \text{filesa}(\text{filename}) \&\& \"\");
\quad \text{endp};
\]

This procedure will return 1 if the file exists or 0 if not.

See Also

\text{fileinfo}, \text{shell}

floor

Purpose

Round down toward \(-\infty\).
Format

\[ y = \text{floor}(x); \]

Input

\[ x \quad \text{NxK matrix or N-dimensional array}. \]

Output

\[ y \quad \text{NxK matrix or N-dimensional array containing the elements of } x \text{ rounded down}. \]

Remarks

This rounds every element in \( x \) down to the nearest integer.

Example

```plaintext
//Set the seed for repeatable random numbers
rndseed 9072345;

//Create random normal numbers with a standard
//deviation of 100
x = 100*rndn(2,2);

//Round the numbers down
f = \text{floor}(x);

//Format so numbers will print in decimal form rather than
```
//scientific notation) and will show 2 digits after the
//decimal point
format /rd 8,2;

print "********************";
print "After running this code:";
print "********************\n";
print "x = " x;
print "";
print "and, f = " f;

produces:

 ********************
After running this code:
 ********************

  x =
      0.11  314.05
    -80.87 103.73

     and, f =
        0.00  314.00
    -81.00 103.00

Notice in the code above, how the \n at the end of the statement printing the line of
asterisks, inserts a newline.

**See Also**

ceil, round, trunc
**fmod**

**Purpose**

Computes the floating-point remainder of \( x/y \).

**Format**

\[
    r = \text{fmod}(x, y);
\]

**Input**

- \( x \) : NxK matrix.
- \( y \) : LxM matrix, ExE conformable with \( x \).

**Output**

\( r \) : max(N,L) by max(K,M) matrix.

**Remarks**

Returns the floating-point remainder \( r \) of \( x/y \) such that \( x = iy + r \), where \( i \) is an integer, \( r \) has the same sign as \( x \) and \(| r | < | y |\).

Compare this with \( \% \), the modulo division operator. (See **Operators**, Chapter 1.)

**Example**

This example extracts all of the years which are evenly divisible by four, from a vector with all of the years between 1900 and 2000.
//Create a vector with all years from 1900 to 2000
//i.e. 1900, 1901, 1902...2000
yrs = seqa(1900, 1, 101);

//Create an empty matrix into which we can put our output
y4 = { };  

//Loop through each element in yrs
for i(1, rows(yrs), 1);
   //If the 'i'th element of 'yrs' is evenly divisible by
   //4, vertically concatenate it on to the bottom of 'y4'
   if not fmod(yrs[i], 4);
      y4 = y4|yrs[i];
   endif;
endfor;

//No digits after the decimal place
format /rd 8,0;

//Split 'y4' into two columns, each with half of the data
//and print the columns next to each other
print y4[1:13]~y4[14:26];

produces:

| 1900 | 1952 |
| 1904 | 1956 |
| 1908 | 1960 |
| 1912 | 1964 |
| 1916 | 1968 |
| 1920 | 1972 |
| 1924 | 1976 |
| 1928 | 1980 |
| 1932 | 1984 |
| 1936 | 1988 |
**fn**

**Purpose**

Allows user to create one-line functions.

**Format**

\[
\text{fn\ fn}\_\text{name}(\text{args})=\ \text{code\_for\_function};
\]

**Remarks**

Functions can be called in the same way as other procedures.

**Example**

\[
\text{fn \ area}(r) = \pi*r*r;
\]

\[
a = \text{area}(4);
\]

After the code above:

\[
a = 50.625
\]
**fonts**

**Purpose**

Loads fonts to be used in the graph. Note: this function is for the deprecated PQG graphics.

**Library**

pgraph

**Format**

\[ \text{fonts}(\text{str}); \]

**Input**

- **str**: string or character vector containing the names of fonts to be used in the plot. The following fonts are available:
  - Simplex: standard sans serif font.
  - Simgrma: Simplex greek, math.
  - Microb: bold and boxy.
  - Complex: standard font with serif.

**Remarks**

The first font specified will be used for the axes numbers.

If \text{str} is a null string, or \text{fonts} is not called, Simplex is loaded by default.
For more information on how to select fonts within a text string, see *Publication Quality Graphics*, Chapter 1.

**Source**

pgraph.src

**See Also**

title, xlabel, ylabel, zlabel

**fopen**

**Purpose**

Opens a file.

**Format**

\[
f = \text{fopen}(\text{filename}, \text{omode});
\]

**Input**

<table>
<thead>
<tr>
<th>filename</th>
<th>string, name of file to open.</th>
</tr>
</thead>
<tbody>
<tr>
<td>omode</td>
<td>string, file I/O mode. (See Remarks, below.)</td>
</tr>
</tbody>
</table>

**Output**

| f        | scalar, file handle. |
**Portability**

**UNIX**

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

**Remarks**

filename can contain a path specification.

omode is a sequence of characters that specify the mode in which to open the file. The first character must be one of:

- **r** Open an existing file for reading. If the file does not exist, fopen fails.
- **w** Open or create a file for writing. If the file already exists, its current contents will be destroyed.
- **a** Open or create a file for appending. All output is appended to the end of the file.

To this can be appended a + and/or a b. The + indicates the file is to opened for reading and writing, or update, as follows:

- **r+** Open an existing file for update. You can read from or write to any location in the file. If the file does not exist, fopen fails.
- **w+** Open or create a file for update. You can read from or write to any location in the file. If the file already exists, its current contents will be destroyed.
- **a+** Open or create a file for update. You can read from any location in the file, but all output will be appended to the end of the file.
Finally, the \textit{b} indicates whether the file is to be opened in text or binary mode. If the file is opened in binary mode, the contents of the file are read verbatim; likewise, anything output to the file is written verbatim. In text mode (the default), carriage return-linefeed sequences are converted on input to linefeeds, or newlines. Likewise on output, newlines are converted to carriage return-linefeeds. Also in text mode, if a CTRL+Z (char 26) is encountered during a read, it is interpreted as an end-of-file character, and reading ceases. In binary mode, CTRL+Z is read in uninterpreted.

The order of \texttt{+} and \texttt{b} is not significant; \texttt{rb+} and \texttt{r+b} mean the same thing.

You can both read from and write to a file opened for update. However, before switching from one to the other, you must make an \texttt{fseek} or \texttt{fflush} call, to flush the file's buffer.

If \texttt{fopen} fails, it returns a 0.

Use \texttt{close} and \texttt{closeall} to close files opened with \texttt{fopen}.

\textbf{See Also}

\texttt{fseek}, \texttt{close}, \texttt{closeall}

\textbf{for}

\textbf{Purpose}

\begin{verbatim}
   Begins a \texttt{for} loop.
\end{verbatim}
**Format**

```
for i(start, stop, step);
  ...
  ...
  ...
endfor;
```

**Input**

- **i**: literal, the name of the counter variable.
- **start**: scalar expression, the initial value of the counter.
- **stop**: scalar expression, the final value of the counter.
- **step**: scalar expression, the increment value.

**Remarks**

The counter is strictly local to the loop. The expressions, `start`, `stop` and `step` are evaluated only once when the loop initializes and are stored local to the loop.

The `for` loop is optimized for speed and much faster than a `do` loop.

The commands `break` and `continue` are supported. The `continue` command steps the counter and jumps to the top of the loop. The `break` command terminates the current loop.

The loop terminates when the value of `i` exceeds `stop`. If `break` is used to terminate the loop and you want the final value of the counter, you need to assign it to a variable before the `break` statement (see the third example, following).
Example

Example 1

```matlab
x = zeros(10, 5);
for i (1, rows(x), 1);
    for j (1, cols(x), 1);
        x[i,j] = i*j;
        endfor;
    endfor;
endfor;
```

Example 2

```matlab
x = rndn(3,3);
y = rndn(3,3);

for i (1, rows(x), 1);
    for j (1, cols(x), 1);
        if x[i,j] >= y[i,j];
            continue;
        endif;
        temp = x[i,j];
        x[i,j] = y[i,j];
        y[i,j] = temp;
    endfor;
endfor;
```

Example 3

```matlab
li = 0;
x = rndn(100,1);
y = rndn(100,1);

for i (1, rows(x), 1);
    if x[i] /= y[i];
```
li = i;
break;
endif;
endfor;

if li;
    print "Compare failed on row " li;
endif;

format

**Purpose**

Controls the format of matrices and numbers printed out with `print` statements.

**Format**

```
format [/typ] [[/fmted]] [[/mf]] [[/jnt]] [[f,p]]
```

**Input**

- **/typ**  
  literal, symbol type flag(s). Indicate which symbol types you are setting the output format for.
  - /mat,
  - /sa,
  - /str

Formatting parameters are maintained separately for matrices and arrays (/mat), sstring arrays (/sa), and strings (/str). You can specify more than one /typ flag; the format will be set for all types indicated. If no /typ flag is listed, *format* assumes /mat.
<table>
<thead>
<tr>
<th>Format Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>/fmted</code></td>
<td>literal, enable formatting flag. Enabling/disabling formatting determines how the contents of a variable are dumped to the screen. When formatting is disabled, the contents are displayed in a &quot;raw&quot; format. When formatting is enabled, the contents are handled similarly to string arrays. This shouldn't be surprising since a string is essentially a 1x1 string array.</td>
</tr>
<tr>
<td><code>/mf</code></td>
<td>literal, matrix row format flag. Indicates how carriage return/line feed pairs are handled when printing matrices.</td>
</tr>
</tbody>
</table>

### Matrix Row Format Flags

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>/m0</code></td>
<td>No delimiters before or after rows when printing out matrices.</td>
</tr>
<tr>
<td><code>/m1 or mb1</code></td>
<td>Print 1 carriage return/line feed pair before each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td><code>/m2 or mb2</code></td>
<td>Print 2 carriage return/line feed pairs before each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td><code>/m3 or mb3</code></td>
<td>Print &quot;Row 1&quot;, &quot;Row 2&quot;... before each row of a matrix with more than one row.</td>
</tr>
<tr>
<td><code>/ma1</code></td>
<td>Print 1 carriage return/line feed pair after each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td><code>/ma2</code></td>
<td>Print 2 carriage return/line feed pairs after each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td><code>/a1</code></td>
<td>Print 1 carriage return/line feed pair after each row of a matrix.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>/a2</td>
<td>print 2 carriage return/line feed pairs after each row of a matrix.</td>
</tr>
<tr>
<td>/b1</td>
<td>print 1 carriage return/line feed pair before each row of a matrix.</td>
</tr>
<tr>
<td>/b2</td>
<td>print 2 carriage return/line feed pairs before each row of a matrix.</td>
</tr>
<tr>
<td>/b3</td>
<td>print &quot;Row 1&quot;, &quot;Row 2&quot;... before each row of a matrix.</td>
</tr>
<tr>
<td>/jnt</td>
<td>literal, matrix element format flag - controls justification, notation and trailing character.</td>
</tr>
</tbody>
</table>

**Right-Justified**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/rd</td>
<td>Signed decimal number in the form <code>####.####</code>, where <code>&gt;####</code> is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed.</td>
</tr>
<tr>
<td>/re</td>
<td>Signed number in the form <code>#.###E±###</code>, where <code>#</code> is one decimal digit, <code>##</code> is one or more decimal digits depending on the precision, and <code>###</code> is three decimal digits. If precision is 0, the form will be <code>[-]###E±###</code> with no decimal point printed.</td>
</tr>
</tbody>
</table>
| /ro     | This will give a format like `/rd` or `/re` depending on which is most compact for the
number being printed. A format like /re will be used only if the exponent value is less than \(-4\) or greater than the precision. If a /re format is used, a decimal point will always appear. The precision signifies the number of significant digits displayed.

/re This will give a format like /rd or /re depending on which is most compact for the number being printed. A format like /re will be used only if the exponent value is less than \(-4\) or greater than the precision. If a /re format is used, trailing zeros will be suppressed and a decimal point will appear only if one or more digits follow it. The precision signifies the number of significant digits displayed.

Left-Justified

/ld Signed decimal number in the form \([-]\) \\
####.####, where #### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed. If the number is positive, a space character will replace the leading minus sign.

/le Signed number in the form \([-]\)\.##E±####, where \# is one decimal digit, ## is one or more decimal digits depending on the precision, and
### is three decimal digits. If precision is 0, the form will be \([-]#E\pm###\) with no decimal point printed. If the number is positive, a space character will replace the leading minus sign.

/lo

This will give a format like /ld or /le depending on which is most compact for the number being printed. A format like /le will be used only if the exponent value is less than -4 or greater than the precision. If a /le format is used, a decimal point will always appear. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.

/lz

This will give a format like /ld or /le depending on which is most compact for the number being printed. A format like /le will be used only if the exponent value is less than -4 or greater than the precision. If a /le format is used, trailing zeros will be supressed and a decimal point will appear only if one or more digits follow it. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.

**Trailing Character**

The following characters can be added to the /jnt parameters above to control the trailing character if any:

```plaintext
format /rdn 1,3;
```
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>s</code></td>
<td>The number will be followed immediately by a space character. This is the default.</td>
</tr>
<tr>
<td><code>c</code></td>
<td>The number will be followed immediately by a comma.</td>
</tr>
<tr>
<td><code>t</code></td>
<td>The number will be followed immediately by a tab character.</td>
</tr>
<tr>
<td><code>n</code></td>
<td>No trailing character.</td>
</tr>
<tr>
<td><code>f</code></td>
<td>Scalar expression, controls the field width.</td>
</tr>
<tr>
<td><code>p</code></td>
<td>Scalar expression, controls the precision.</td>
</tr>
</tbody>
</table>

**Remarks**

If character elements are to be printed, the precision should be at least 8 or the elements will be truncated. This does not affect the string data type.

For numeric values in matrices, \( p \) sets the number of significant digits to be printed. For string arrays, strings, and character elements in matrices, \( p \) sets the number of characters to be printed. If a string is shorter than the specified precision, the entire string is printed. For string arrays and strings, \( p = -1 \) means print the entire string, regardless of its length. \( p = -1 \) is illegal for matrices; setting \( p >= 8 \) means the same thing for character elements.

The `/xxx` slash parameters are optional. Field and precision are optional also, but if one is included, then both must be included.

Slash parameters, if present, must precede the field and precision parameters.

A `format` statement stays in effect until it is overridden by a new `format` statement. The slash parameters may be used in a `print` statement to override the current default.
\[ f \text{ and } p \] may be any legal expressions that return scalars. Nonintegers will be truncated to integers.

The total width of field will be overridden if the number is too big to fit into the space allotted. For instance, `format /rds 1,0` can be used to print integers with a single space between them, regardless of the magnitudes of the integers.

Complex numbers are printed with the sign of the imaginary half separating them and an "i" appended to the imaginary half. Also, the field parameter refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print. The character printed after the imaginary part can be changed (for example, to a "j") with the `sysstate` function, case 9.

The default when GAUSS is first started is:

```
format /mbl /ros 16,8;
```

**Example**

This code:

```gauss
x = rndn(3,3);

format /ml /rd 16,8;
print x;
```

produces:

```
  2.25240104  0.53724423  -0.67744907
-0.16183998  1.57152099  1.33836836
  0.00666162 -1.24948147 -0.77987532
```

This code:

```gauss
format /ml /rz 1,10;
print x;
```

produces:
This code:
```
format /m3 /rdn 16,4;
print x;
```
produces:
```
print x;
Row 1
  2.2524  0.5372  -0.6774
Row 2
-0.1618  1.5715  1.3384
Row 3
  0.0067 -1.2495  -0.7799
```

This code:
```
format /m1 /ldn 16,4;
print x;
```
produces:
```
  2.2524  0.5372  -0.6774
-0.1618  1.5715  1.3384
  0.0067 -1.2495  -0.7799
```

This code:
```
format /m1 /res 12,4;
print x;
```
produces:
See Also

formatcv, formatnv, print, output

formatcv

Purpose

Sets the character data format used by printfmt.

Format

\[
oldfmt = \text{formatcv}(newfmt);\]

Input

\[
newfmt \quad 1\times3 \text{ vector, the new format specification.}\]

Output

\[
oldfmt \quad 1\times3 \text{ vector, the old format specification.}\]

Remarks

See printfm for details on the format vector.
Example

This example saves the old format, sets the format desired for printing \( x \), prints \( x \), then restores the old format. This code:

\[
x = \{ \text{A 1, B 2, C 3} \};
\text{oldfmt} = \text{formatcv}(".*s" \sim 3 \sim 3);
call \text{printfmt}(x,0\sim 1);
call \text{formatcv(oldfmt)};
\]

produces:

\[
\begin{array}{l}
\text{A 1} \\
\text{B 2} \\
\text{C 3}
\end{array}
\]

Source

gauss.src

Globals

\_fmtcv

See Also

formatnv, printfm, printfmt

formatnv

Purpose

Sets the numeric data format used by printfmt.
**Format**

```plaintext
oldfmt = formatv(newfmt);
```

**Input**

```plaintext
newfmt  1x3 vector, the new format specification.
```

**Output**

```plaintext
oldfmt  1x3 vector, the old format specification.
```

**Remarks**

See `printfm` for details on the format vector.

**Example**

This example saves the old format, sets the format desired for printing `x`, prints `x`, then restores the old format. This code:

```plaintext
x = { A 1, B 2, C 3 };  
oldfmt = formatv("*.*lf" ~ 8 ~ 4);  
call printfm(x,0~1);  
call formatv(oldfmt);
```

produces:

```
A 1.0000  
B 2.0000  
C 3.0000  
```
**Source**

`gauss.src`

**Globals**

`__fmtnv`

**See Also**

`formatcv, printfm, printfmt`

**fputs**

**Purpose**

Writes strings to a file.

**Format**

```latex
numl = \texttt{fputs}(f, \ sa);
```

**Input**

- `f` scalar, file handle of a file opened with `fopen`.
- `sa` string or string array.

**Output**

- `numl` scalar, the number of lines written to the file.
Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

`fputs` writes the contents of each string in `sa`, minus the null terminating byte, to the file specified. If the file was opened in text mode (see `fopen`), any newlines present in the strings are converted to carriage return-linefeed sequences on output. If `numl` is not equal to the number of elements in `sa`, there may have been an I/O error while writing the file. You can use `fcheckerr` or `fclearerr` to check this. If there was an error, you can call `fstrerror` to find out what it was. If the file was opened for update (see `fopen`) and you are switching from reading to writing, don't forget to call `fseek` or `fflush` first, to flush the file's buffer. If you pass `fputs` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

See Also

`fputst`, `fopen`

fputst

Purpose

Writes strings to a file.

Format

\[ numl = \texttt{fputst}(f, sa); \]
**Input**

- $f$: scalar, file handle of a file opened with `fopen`.
- $sa$: string or string array.

**Output**

- $numl$: scalar, the number of lines written to the file.

**Portability**

**UNIX**

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

**Remarks**

`fputst` works identically to `fputs`, except that a newline is appended to each string that is written to the file. If the file was opened in text mode (see `fopen`), these newlines are also converted to carriage return-linefeed sequences on output.

**See Also**

- `fputs`, `fopen`

**fseek**

**Purpose**

Positions the file pointer in a file.
Format

\[ \text{ret} = \text{fseek}(f, \text{offs}, \text{base}); \]

Input

- \( f \): scalar, file handle of a file opened with \texttt{fopen}.
- \( \text{offs} \): scalar, offset (in bytes).
- \( \text{base} \): scalar, base position.
  - 0: beginning of file.
  - 1: current position of file pointer.
  - 2: end of file.

Output

- \( \text{ret} \): scalar, 0 if successful, 1 if not.

Portability

UNIX

Carriage return-linefeed conversion for files opened in text mode is unnecessary, because in UNIX a newline is simply a linefeed.

Remarks

\texttt{fseek} moves the file pointer \( \text{offs} \) bytes from the specified \( \text{base} \) position. \( \text{offs} \) can be positive or negative. The call may fail if the file buffer needs to be flushed.
If `fseek` fails, you can call `fstrerror` to find out why.

For files opened for update (see `fopen`), the next operation can be a read or a write. `fseek` is not reliable when used on files opened in text mode (see `fopen`). This has to do with the conversion of carriage return-linefeed sequences to newlines. In particular, an `fseek` that follows one of the `fget`xxx or `fput`xxx commands may not produce the expected result. For example:

```c
p = ftell(f);
s = fgetsa(f, 7);
call fseek(f, p, 0);
```

is not reliable. We have found that the best results are obtained by `fseek`'ing to the beginning of the file and then `fseek`'ing to the desired location, as in

```c
p = ftell(f);
s = fgetsa(f, 7);
call fseek(f, 0, 0);
call fseek(f, p, 0);
```

If you pass `fseek` the handle of a file opened with `open` (i.e., a data set or matrix file), your program will terminate with a fatal error.

**See Also**

`fopen`

`fstrerror`

**Purpose**

Returns an error message explaining the cause of the most recent file I/O error.
**Format**

\[ s = fstrerror; \]

**Output**

\[ s \]

string, error message.

**Remarks**

Any time an I/O error occurs on a file opened with `fopen`, an internal error flag is updated. (This flag, unlike those accessed by `fcheckerr` and `fclearerr`, is not specific to a given file; rather, it is system-wide.) `fstrerror` returns an error message based on the value of this flag, clearing it in the process. If no error has occurred, a null string is returned.

Since `fstrerror` clears the error flag, if you call it twice in a row, it will always return a null string the second time.

The Windows system command called by `ftell` does not set the internal error flag accessed by `fstrerror`. Therefore, calling `fstrerror` after `ftell` on Windows will not produce any error information.

**See Also**

`fopen`, `ftell`

**ftell**

**Purpose**

Gets the position of the file pointer in a file.
**Format**

\[ pos = \texttt{ftell}(f); \]

**Input**

\[ f \quad \text{scalar, file handle of a file opened with \texttt{fopen}.} \]

**Output**

\[ pos \quad \text{scalar, current position of the file pointer in a file.} \]

**Remarks**

\texttt{ftell} returns the position of the file pointer in terms of bytes from the beginning of the file. The call may fail if the file buffer needs to be flushed (see \texttt{fflush}).

If an error occurs, \texttt{ftell} returns -1. You can call \texttt{fstrerror} to find out what the error was.

If you pass \texttt{ftell} the handle of a file opened with \texttt{open} (i.e., a data set or matrix file), your program will terminate with a fatal error.

**See Also**

\texttt{fopen, fseek}
**ftocv**

**Purpose**

Converts a matrix containing floating point numbers into a matrix containing the decimal character representation of each element.

**Format**

\[ y = \text{ftocv}(x, \text{field}, \text{prec}); \]

**Input**

- \( x \) \( \text{NxK matrix containing numeric data to be converted.} \)
- \( \text{field} \) \( \text{scalar, minimum field width.} \)
- \( \text{prec} \) \( \text{scalar, the numbers created will have } \text{prec} \text{ places after the decimal point.} \)

**Output**

- \( y \) \( \text{NxK matrix containing the decimal character equivalent of the corresponding elements in } x \text{ in the format defined by } \text{field and prec.} \)

**Remarks**

If a number is narrower than \( \text{field} \), it will be padded on the left with zeros.

If \( \text{prec} = 0 \), the decimal point will be suppressed.
Example

```plaintext
y = seqa(6,1,5);
x = 0 $+ "beta" $+ ftocv(y,2,0);
print $x;
```

results in the following output:

```
beta06
beta07
beta08
beta09
beta10
```

Notice that the ( 0 $+ ) above was necessary to force the type of the result to matrix because the string constant "beta" would be of type string. The left operand in an expression containing a $+ operator controls the type of the result.

See Also

fts

fts

Purpose

Converts a scalar into a string containing the decimal character representation of that number.

Format

```
y = ftos(x, fmat, field, prec);
```
## Input

- **x**  
  scalar, the number to be converted.

- **fmat**  
  string, the format string to control the conversion.

- **field**  
  scalar or 2x1 vector, the minimum field width. If *field* is 2x1, it specifies separate field widths for the real and imaginary parts of *x*.

- **prec**  
  scalar or 2x1 vector, the number of places following the decimal point. If *prec* is 2x1, it specifies separate precisions for the real and imaginary parts of *x*.

## Output

- **y**  
  string containing the decimal character equivalent of *x* in the format specified.

## Remarks

The format string corresponds to the **format/jnt** (justification, notation, trailing character)slash parameter as follows:

- **/rdn**  
  "%*.*lf"

- **/ren**  
  "%*.*lE"

- **/ron**  
  "%#*.*lG"

- **/rzn**  
  "%*.lG"
If \( x \) is complex, you can specify separate formats for the real and imaginary parts by putting two format specifications in the format string. You can also specify separate fields and precisions. You can position the sign of the imaginary part by placing a "+" between the two format specifications. If you use two formats, no "i" is appended to the imaginary part. This is so you can use an alternate format if you prefer, for example, prefacing the imaginary part with a "j".

The format string can be a maximum of 80 characters.

If you want special characters to be printed after \( x \), include them as the last characters of the format string. For example:

"%*.*lf,", right-justified decimal followed by a comma.
"%-*.*s " left-justified string followed by a space.
"%*.*lf" right-justified decimal followed by nothing.

You can embed the format specification in the middle of other text:

"Time: %*.*lf seconds."

If you want the beginning of the field padded with zeros, then put a "0" before the first "*" in the format string:

"%0*.*lf" right-justified decimal.

If \( prec = 0 \), the decimal point will be suppressed.
Example

You can create custom formats for complex numbers with `ftos`. For example,

```plaintext
let c = 24.56124+6.3224e-2j;
field = 1;
prec = 3|5;
fmt = "%lf + j%le is a complex number.";
c = ftos(c,fmt,field,prec);
```

results in

```plaintext
cc = "24.561 + j6.32240e-02 is a complex number."
```

Some other things you can do with `ftos`:

```plaintext
let x = 929.857435324123;
let y = 5.46;
let z = 5;

field = 1;
prec = 0;
fmt = "%.*lf";
zz = ftos(z,fmt,field,prec);

field = 1;
prec = 10;
fmt = "%.*le";
xx = ftos(x,fmt,field,prec);

field = 7;
prec = 2;
fmt = "%.*lf seconds";
s1 = ftos(x,fmt,field,prec);
```
s2 = `ftos(y,fmat,field,prec);`

```
field = 1;
prec = 2;
fmat = "The maximum resistance is %*.1f ohms.";
om = `ftos(x,fmat,field,prec);`
```

The results:

```
zz = "5"
xx = "9.2985743532E+002"
s1 = "929.86 seconds"
s2 = "5.46 seconds"
om = "The maximum resistance is 929.86 ohms."
```

**See Also**

`ftocv`, `stof`, `format`

**ftos**

**Purpose**

Converts a matrix to a string array using a C language format specification.

**Format**

```
sa = `ftosC(x, fmt);`
```
**Input**

- **x**  
  NxK matrix, real or complex.

- **fmt**  
  Kx1, 1xK or 1x1 string array containing format information.

**Output**

- **sa**  
  NxK string array.

**Remarks**

If **fmt** has K elements, each column of **sa** can be formatted separately. If **x** is complex, there must be two format specifications in each element of **fmt**.

**Example**

```plaintext
declare string fmtr = { "%6.3lf",
                       "%11.8lf" };

declare string fmtc = { "(%6.3lf, %6.3lf)",
                       "(%11.8lf, %11.8lf)" };

xr = rndn(4, 2);
xc = sqrt(xr')';

sar = ftostrC(xr, fmtr);
sac = ftostrC(xc, fmtc);

print sar;
print sac;
```
produces:

-0.166 1.05565441
-1.590 -0.79283296
0.130 -1.84886957
0.789 0.86089687

( 0.000, -0.407) ( 1.02745044, 0.00000000)
( 0.000, -1.261) ( 0.00000000, -0.89041168)
( 0.361, 0.000) ( 0.00000000, -1.35973143)
( 0.888, 0.000) ( 0.92784529, 0.00000000)

See Also

strtof, strtocplx
gamma

Purpose

Returns the value of the gamma function.

Format

\[ y = \text{gamma}(x); \]

Input

\( x \)  
NxK matrix or N-dimensional array.

Output

\( y \)  
NxK matrix or N-dimensional array.

Remarks

For each element of \( x \) this function returns the integral

\[ \int_{0}^{\infty} t^{(x-1)} e^{-t} dt \]
All elements of $x$ must be positive and less than or equal to 169. Values of $x$ greater than 169 will cause an overflow.

The natural log of $\text{gamma}$ is often what is required and it can be computed without the overflow problems of $\text{gamma}$ using $\text{lnfact}$.

**Example**

```matlab
y = gamma(2.5);
```

After the code above:

```matlab
y = 1.329340
```

**See Also**

`cdfchic`, `cdfbeta`, `cdfch`, `cdfnc`, `cdftc`, `erf`, `erfc`, `lnfact`

**gammacplx**

**Purpose**

Computes the Gamma function for complex inputs.

**Format**

```
f = gammacplx(z);
```

**Input**

$z$ \hspace{1cm} NxK matrix; $z$ may be complex.
**Output**

$f$  
NxK matrix; $f$ may be complex.

**Technical Notes**

Accuracy is 15 significant digits along the real axis and 13 significant digits elsewhere. This routine uses the Lanczos series approximation for the complex Gamma function.

**References**

5. W. Press, "Numerical Recipes."
9. Original code by Paul Godfrey

**gammairi**

**Purpose**

Computes the inverse incomplete gamma function.
Format

\[ x = \text{gammaii}(a, p); \]

Input

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>MxN matrix, exponents.</td>
</tr>
<tr>
<td>(p)</td>
<td>KxL matrix, ExE conformable with (a), incomplete gamma values.</td>
</tr>
</tbody>
</table>

Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>max(M,K) by max(N,L) matrix, abscissae.</td>
</tr>
</tbody>
</table>

Source

cdfchii.src

Globals

_ginvinc, _macheps

gausset

Purpose

Resets the global control variables declared in gauss.dec.
**Format**

```
 gausset;
```

**Source**

gauss.src

**Globals**

```
__altnam, __con, __ff, __fmtcv, __fmtnv, __header, __miss, __output, __row, __rowfac, __sort, __title, __tol, __vpad, __vtype, __weight
```

**gdaAppend**

**Purpose**

Appends data to a variable in a GAUSS Data Archive.

**Format**

```
ret = gdaAppend(filename, x, varname);
```

**Input**

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>string, name of data file.</td>
</tr>
<tr>
<td>x</td>
<td>matrix, array, string or string array, data to append.</td>
</tr>
<tr>
<td>varname</td>
<td>string, variable name.</td>
</tr>
</tbody>
</table>
Output

scalar, return code, 0 if successful, otherwise one of the following error codes:

1 Null file name.
2 File open error.
3 File write error.
4 File read error.
5 Invalid data file type.
8 Variable not found.
10 File contains no variables.
14 File too large to be read on current platform.
17 Type mismatch.
18 Argument wrong size.
19 Data must be real.
20 Data must be complex.

Remarks

This command appends the data contained in \texttt{x} to the variable \texttt{varname} in \texttt{filename}. Both \texttt{x} and the variable referenced by \texttt{varname} must be the same data type, and they must both contain the same number of columns.
Because `gdaAppend` increases the size of the variable, it moves the variable to just after the last variable in the data file to make room for the added data, leaving empty bytes in the variable's old location. It also moves the variable descriptor table, so it is not overwritten by the variable data. This does not change the index of the variable because variable indices are determined NOT by the order of the variable data in a GDA, but by the order of the variable descriptors. Call `gdaPack` to pack the data in a GDA, so it contains no empty bytes.

**Example**

```markdown
x = rndn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda",x,"x1");

y = rndn(25,50);
ret = gdaAppend("myfile.gda",y,"x1");
```

This example adds 25*50=1250 elements to `x1`, making it a 125x50 matrix.

**See Also**

`gdaWriteSome`, `gdaUpdate`, `gdaWrite`

**gdaCreate**

**Purpose**

Creates a GAUSS Data Archive.

**Format**

```markdown
ret = gdaCreate(filename, overwrite);
```
## Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>filename</code></td>
<td>string, name of data file to create.</td>
</tr>
<tr>
<td><code>overwrite</code></td>
<td>scalar, one of the following:</td>
</tr>
<tr>
<td>0</td>
<td>error out if file already exists.</td>
</tr>
<tr>
<td>1</td>
<td>overwrite file if it already exists.</td>
</tr>
</tbody>
</table>

## Output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ret</code></td>
<td>scalar, return code, 0 if successful, otherwise one of the following error codes:</td>
</tr>
<tr>
<td>1</td>
<td>Null file name.</td>
</tr>
<tr>
<td>3</td>
<td>File write error.</td>
</tr>
<tr>
<td>6</td>
<td>File already exists.</td>
</tr>
<tr>
<td>7</td>
<td>Cannot create file.</td>
</tr>
</tbody>
</table>

## Remarks

This command creates a **GAUSS** Data Archive containing only a header. To add data to the GDA, call **gdaWrite**.

It is recommended that you include a `.gda` extension in `filename`. However, **gdaCreate** will not force an extension.

## Example

```gauss
ret = gdaCreate("myfile.gda",1);
```
See Also

gdaWrite

gdaDStat

Purpose

Computes descriptive statistics on multiple Nx1 variables in a GAUSS Data Archive.

Format

\[
dout = \text{gdaDStat}(dc0, \text{filename}, \text{vars});
\]

Input

* dc0

  an instance of a \texttt{dstatmtControl} structure with the following members:

  * dc0.altnames
    Kx1 string array of alternate variable names for the output. Default = "".

  * dc0.maxbytes
    scalar, the maximum number of bytes to be read per iteration of the read loop. Default = 1e9.

  * dc0.maxvec
    scalar, the largest number of elements allowed in any one matrix. Default = 20000.

  * dc0.miss
    scalar, one of the following:
    
    * 0 There are no missing values
(fastest).

1 Listwise deletion, drop a row if any missings occur in it.

2 Pairwise deletion.

Default = 0.

\( dc0\text{.output} \)

scalar, one of the following:

0 Do not print output table.

1 Print output table.

Default = 1.

\( dc0\text{.row} \)

scalar, the number of rows of \( \textit{var} \) to be read per iteration of the read loop.

If 0, (default) the number of rows will be calculated using \( dc0\text{.maxbytes} \) and \( dc0\text{.maxvec} \).

\( \text{filename} \)

string, name of data file.

\( \text{vars} \)

Kx1 string array, names of variables

- or -

Kx1 vector, indices of variables.

**Output**

\( dout \)

an instance of a \texttt{dstatmtOut} structure with the following members:
<table>
<thead>
<tr>
<th>dout.vnames</th>
<th>Kx1 string array, the names of the variables used in the statistics.</th>
</tr>
</thead>
<tbody>
<tr>
<td>dout.mean</td>
<td>Kx1 vector, means.</td>
</tr>
<tr>
<td>dout.var</td>
<td>Kx1 vector, variance.</td>
</tr>
<tr>
<td>dout.std</td>
<td>Kx1 vector, standard deviation.</td>
</tr>
<tr>
<td>dout.min</td>
<td>Kx1 vector, minima.</td>
</tr>
<tr>
<td>dout.max</td>
<td>Kx1 vector, maxima.</td>
</tr>
<tr>
<td>dout.valid</td>
<td>Kx1 vector, the number of valid cases.</td>
</tr>
<tr>
<td>dout.missing</td>
<td>Kx1 vector, the number of missing cases.</td>
</tr>
<tr>
<td>dout.errcode</td>
<td>scalar, error code, 0 if successful, or one of the following:</td>
</tr>
<tr>
<td></td>
<td>1                     No GDA indicated.</td>
</tr>
<tr>
<td></td>
<td>4                     Not implemented for complex data.</td>
</tr>
<tr>
<td></td>
<td>5                     Variable must be type matrix.</td>
</tr>
<tr>
<td></td>
<td>6                     Too many variables specified.</td>
</tr>
<tr>
<td></td>
<td>7                     Too many missings - no data left after packing.</td>
</tr>
<tr>
<td></td>
<td>8                     Name variable wrong size.</td>
</tr>
<tr>
<td></td>
<td>9                     $altnames$ member of $dstatmtControl$ structure wrong size.</td>
</tr>
<tr>
<td></td>
<td>11                    Data read error.</td>
</tr>
</tbody>
</table>
Remarks

The variables referenced by \textit{vars} must all be N x 1.

The names of the variables in the GDA will be used for the output by default. To use alternate names, set the \textit{altnames} member of the \texttt{dstatmtControl} structure.

If pairwise deletion is used, the minima and maxima will be the true values for the valid data. The means and standard deviations will be computed using the correct number of valid observations for each variable.

Example

\begin{verbatim}
//Execute structure definition
#include ds.sdf

struct dstatmtControl dc0;
struct dstatmtOut dout;

//Set structure to default values
dc0 = dstatmtControlCreate;

vars = { 1,4,5,8 };
dout = gdaDStat(dc0,"myfile.gda",vars);
\end{verbatim}

This example computes descriptive statistics on the first, fourth, fifth and eighth variables in \textit{myfile.gda}.

Source

\texttt{gdadstat.src}

See Also

\texttt{gdaDStatMat, dstatmtControlCreate}
**gdaDStatMat**

**Purpose**

Computes descriptive statistics on a selection of columns from a matrix located in a GAUSS Data Archive.

**Format**

\[
\text{dout} = \text{gdaDStatMat}(\text{dc0}, \text{filename}, \text{gmat}, \text{colind}, \text{vnamevar});
\]

**Input**

\[
\text{dc0} \quad \text{an instance of a dstatmtControl structure with the following members:}
\]

- \[
\text{dc0.altnames} \quad \text{Kx1 string array of alternate variable names for the output. Default = "". If set, it must have the same number of rows as \text{colind}.}
\]

- \[
\text{dc0.maxbytes} \quad \text{scalar, the maximum number of bytes to be read per iteration of the read loop. Default = 1e9.}
\]

- \[
\text{dc0.maxvec} \quad \text{scalar, the largest number of elements allowed in any one matrix. Default = 20000.}
\]

- \[
\text{dc0.miss} \quad \text{scalar, one of the following:}
\]

\[
\begin{align*}
0 & \quad \text{There are no missing values (fastest).} \\
1 & \quad \text{Listwise deletion, drop a row if any}
\end{align*}
\]
missings occur in it.

2  Pairwise deletion.

Default = 0.

*dc0.output* scalar, one of the following:

0  Do not print output table.

1  Print output table.

Default = 1.

*dc0.row* scalar, the number of rows of *var* to be read per iteration of the read loop.

If 0, (default) the number of rows will be calculated using *dc0.maxbytes* and *dc0.maxvec*.

*filename* string, name of data file.

*gmat* string, name of matrix

- or -

scalar, index of matrix.

*colind* Kx1 vector, indices of columns in variable to use.

*vnamevar* string, name of the string containing the variable names in the matrix

- or -

scalar, index of the string containing the variable names in the matrix.
**Output**

An instance of a `dstatmtOut` structure with the following members:

- `dout.vnames`: Kx1 string array, the names of the variables used in the statistics.
- `dout.mean`: Kx1 vector, means.
- `dout.var`: Kx1 vector, variance.
- `dout.std`: Kx1 vector, standard deviation.
- `dout.min`: Kx1 vector, minima.
- `dout.max`: Kx1 vector, maxima.
- `dout.valid`: Kx1 vector, the number of valid cases.
- `dout.missing`: Kx1 vector, the number of missing cases.
- `dout.errcode`: scalar, error code, 0 if successful, otherwise one of the following:
  
  1. No GDA indicated.
  2. Variable must be Nx1.
  3. Not implemented for complex data.
  4. Variable must be type matrix.
  5. Too many missings, no data left after packing.
  6. `altnames` member of `dstatmtControl` structure wrong
Remarks

Set colind to a scalar 0 to use all of the columns in var.

vnamevar must either reference an Mx1 string array variable containing variable names, where M is the number of columns in the data set variable, or be set to a scalar 0. If vnamevar references an Mx1 string array variable, then only the elements indicated by colind will be used. Otherwise, if vnamevar is set to a scalar 0, then the variable names for the output will be generated automatically ("X1,X2,...,XK") unless the alternate variable names are set explicitly in the altnames member of the dstatmtControl structure.

If pairwise deletion is used, the minima and maxima will be the true values for the valid data. The means and standard deviations will be computed using the correct number of valid observations for each variable.

Example

In order to create a real, working example that you can use, you must first create a sample GAUSS Data Archive with the code below.

```gauss
//Create an example GAUSS Data Archive
ret = gdaCreate("myfile.gda",1);

//Add a variable 'A' which is a 10x5 random normal matrix
ret = gdaWrite("myfile.gda",rndn(10,5),"A");

//Add a variable 'COLS' which is a 5x1 string array
string vnames = { "X1", "X2", "X3", "X4", "X5" };```

size.

11 Data read error.
This code above will create a **GAUSS Data Archive** containing two variables, the **GAUSS** matrix $A$ containing the data and $COLS$ which contains the names for the columns of the matrix $A$ which are the model variables ($X_1, X_2,...$).

The code below computes the statistics on each of the columns of the matrix $A$.

```gauss
#include dstatmt.sdf
struct dstatmtControl dc0;
struct dstatmtout dout;

dc0 = dstatmtControlCreate;
colind = { 1, 2, 3, 4, 5 };
dout = gdaDStatMat(dc0, "myfile.gda", "A", colind, "COLS");
```

The final input to `gdaDStatMat` above tells the function the names to use for the columns of $A$. In this example, you can reference the $COLS$ variable by name as you see in the example below. Alternatively, you can access this variable by index. Since $COLS$ is the second variable in the **GAUSS Data Archive** created at the start of this example, the following is equivalent to the last line above:

```gauss
dout = gdaDStatMat(dc0, "myfile.gda", "A", colind, 2 );
```

If you wanted to calculate the statistics on just the first, third and fifth columns of $A$:

```gauss
colind = { 1, 3, 5 };
dout = gdaDStatMat(dc0, "myfile.gda", "A", colind, "COLS");
```

Notice in these lines above that $COLS$ still contains all of the variable names i.e. $X_1, X_2, X_3, X_4$ and $X_5$. $COLS$ should always contain the full list of all variables in the matrix $A$. 

ret = `gdaWrite("myfile.gda", vnames, "COLS");`
Source

gdadstat.src

See Also

gdaDStat, dstmtControlCreate

gdaGetIndex

Purpose

Gets the index of a variable in a GAUSS Data Archive.

Format

\[ \text{ind} = \text{gdaGetIndex}(\text{filename}, \text{varname}); \]

Input

<table>
<thead>
<tr>
<th>filename</th>
<th>string, name of data file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>string, name of variable in the GDA.</td>
</tr>
</tbody>
</table>

Output

| \text{ind} | scalar, index of variable in the GDA. |

Remarks

If `gdaGetIndex` fails, it will return a scalar error code. Call `scalerr` to get the
value of the error code. The error code may be any of the following:

1   Null file name.
2   File open error.
4   File read error.
5   Invalid file type.
8   Variable not found.
10  File contains no variables.
14  File too large to be read on current platform.

**Example**

```plaintext
ind = gdaGetIndex("myfile.gda","observed");
```

**See Also**

`gdaGetName`, `gdaReadByIndex`

**gdaGetName**

**Purpose**

Gets the name of a variable in a **GAUSS** Data Archive.
**Format**

```
varname = gdaGetName(filename, varind);
```

**Input**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>filename</code></td>
<td>string, name of data file.</td>
</tr>
<tr>
<td><code>varind</code></td>
<td>scalar, index of variable in the GDA.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>varname</code></td>
<td>string, name of variable in the GDA.</td>
</tr>
</tbody>
</table>

**Remarks**

If `gdaGetName` fails, it will return a scalar error code. Call `scalerr` to get the value of the error code. The error code may be any of the following:

1. Null file name.
2. File open error.
4. File read error.
5. Invalid file type.
8. Variable not found.

**Example**

```
varname = gdaGetName("myfile.gda", 5);
```
See Also

gdaGetIndex, gdaRead, gdaGetNames

**gdaGetNames**

**Purpose**

Gets the names of all the variables in a GAUSS Data Archive.

**Format**

```
varnames = gdaGetNames(filename);
```

**Input**

```
filename              string, name of data file.
```

**Output**

```
varnames              Nx1 string array, names of all the variables in the GDA.
```

**Remarks**

If *gdaGetNames* fails, it will return a scalar error code. Call *scalerr* to get the value of the error code. The error code may be any of the following:

1. Null file name.
2. File open error.
4 File read error.
5 Invalid file type.
10 File contains no variables.
13 Result too large for current platform.
14 File too large to be read on current platform.

Example

```gauss
gdaGetNames("myfile.gda");
```

See Also

gdaGetTypes, gdaGetName

gdaGetOrders

Purpose

Gets the orders of a variable in a GAUSS Data Archive.

Format

```gauss
ord = gdaGetOrders(filename, varname);
```

Input

- `filename` string, name of data file.
varname  string, name of variable in the GDA.

Output

ord  Mx1 vector, orders of the variable in the GDA.

Remarks

If the specified variable is a matrix or string array, then ord will be a 2x1 vector containing the rows and columns of the variable respectively. If the variable is a string, then ord will be a scalar containing the length of the string. If the variable is an N-dimensional array, then ord will be an Nx1 vector containing the sizes of each dimension.

If gdaGetOrders fails, it will return a scalar error code. Call scalerr to get the value of the error code. The error code may be any of the following:

1  Null file name.
2  File open error.
4  File read error.
5  Invalid file type.
8  Variable not found.
10  File contains no variables.
14  File too large to be read on current platform.

Example

ord = gdaGetOrders("myfile.gda","x5");
See Also
gdaGetName, gdaGetIndex

gdaGetType

Purpose
Gets the type of a variable in a GAUSS Data Archive.

Format

\[
\text{vartype} = \text{gdaGetType} (\text{filename}, \text{varname});
\]

Input

- \text{filename} : string, name of data file.
- \text{varname} : string, name of variable in the GDA.

Output

- \text{vartype} : scalar, type of the variable in the GDA.

Remarks
\text{vartype} may contain any of the following:

- 6 : Matrix
If `gdaGetType` fails, it will return a scalar error code. Call `scalerr` to get the value of the error code. The error code may be any of the following:

- `1`: Null file name.
- `2`: File open error.
- `4`: File read error.
- `5`: Invalid file type.
- `8`: Variable not found.
- `10`: File contains no variables.
- `14`: File too large to be read on current platform.

**Example**

```plaintext
vartype = gdaGetType("myfile.gda","x1");
```

**See Also**

`gdaGetTypes`
**gdaGetTypes**

**Purpose**

Gets the types of all the variables in a **GAUSS** Data Archive.

**Format**

```
vartypes = gdaGetTypes(filename);
```

**Input**

- `filename` string, name of data file.

**Output**

- `vartypes` Nx1 vector, types of all the variables in the GDA.

**Remarks**

- `vartypes` may contain any of the following:
  - 6  Matrix
  - 13 String
  - 15 String array
  - 21 Array
If `gdaGetTypes` fails, it will return a scalar error code. Call `scalerr` to get the value of the error code. Valid error codes for this command include:

1. Null file name.
2. File open error.
4. File read error.
5. Invalid file type.
10. File contains no variables.
14. File too large to be read on current platform.

**Example**

```gauss
vartypes = gdaGetTypes("myfile.gda");
```

**See Also**

`gdaGetNames`, `gdaRead`

**gdaGetVarInfo**

**Purpose**

Gets information about all of the variables in a GAUSS Data Archive and returns it in an array of `gdavartable` structures.

**Include**

`gdafns.sdf`
Format

\[ vtab = \text{gdaGetVarInfo}(\text{filename}); \]

Input

- **filename**: string, name of data file.

Output

- **vtab**: Nx1 array of **gdavartable** structures, where N is the number of variables in **filename**, containing the following members:
  - **vtab[i].name**: string, name of variable.
  - **vtab[i].type**: scalar, type of variable.
  - **vtab[i].orders**: Mx1 vector or scalar, orders of the variable.

Remarks

The size of **vtab.orders** is dependent on the type of the variable as follows:

<table>
<thead>
<tr>
<th>Variable Type</th>
<th><strong>vtab.orders</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>array</td>
<td>Mx1 vector, where M is the number of dimensions in the array, containing the sizes of each dimension, from the</td>
</tr>
</tbody>
</table>
slowest-moving dimension to the fastest-moving dimension.
matrix 2x1 vector containing the rows and columns of the matrix, respectively.
string scalar containing the length of string, excluding the null terminating byte.
string array 2x1 vector containing the rows and columns of the string array, respectively.

\[ vtab.type \] may contain any of the following:

- 6 matrix
- 13 string
- 15 string array
- 21 array

**Example**

```cpp
//Execute structure definition
#include gdafns.sdf
struct gdavartable vtab;

vtab = gdaGetVarInfo("myfile.gda");
```

**Source**

gdafns.src
See Also

gdaReportVarInfo, gdaGetNames, gdaGetTypes, gdaGetOrders

gdaIsCplx

Purpose

Checks to see if a variable in a GAUSS Data Archive is complex.

Format

\[ y = \text{gdaIsCplx}(\text{filename}, \text{varname}); \]

Input

<table>
<thead>
<tr>
<th>filename</th>
<th>string, name of data file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>string, name of variable in the GDA.</td>
</tr>
</tbody>
</table>

Output

| y | scalar, 1 if variable is complex; 0 if real. |

Remarks

If \text{gdaIsCplx} fails, it will return a scalar error code. Call \text{scalerr} to get the value of the error code. Valid error codes for this command include:

1 Null file name.
File open error.

File read error.

Invalid file type.

Variable not found.

File contains no variables.

File too large to be read on current platform.

Example

```c
    cplx = gdaIsCplx("myfile.gda","x1");
```

**gdaLoad**

**Purpose**

Loads variables in a GDA into the workspace.

**Format**

```c
    ret = gdaLoad(filename, create, modify, rename, ftypes, errh, report);
```

**Input**

- `filename` string, name of data file.
create

scalar, create flag:

0  do not create any new variables in the workspace.

1  create new variables in the workspace.

modify

scalar, modify flag:

0  do not modify any variables in the workspace.

1  if the name of a variable in the data file matches the name of a variable already in the workspace, modify that variable.

rename

scalar, rename flag:

0  do not rename a variable retrieved from the data file when copying it into the workspace.

1  rename variables retrieved from the data file when copying them into the workspace if there are name conflicts with existing variables, which may not be modified.

ftypes

scalar, type force flag:

0  do not force a type change on any variables in the workspace when modifying.

1  force a type change on a variable in the workspace when modifying it with the data in a variable of the same name in the data file. Note that if ftypes is set to 1, gdaLoad will follow regular type change rules. The types of sparse matrix and structure variables will NOT be changed.
**errh** scalar, controls the error handling of *gdaLoad*:

0  skip operations that cannot be performed, without setting an error return.
1  return an error code if operations are skipped.
2  terminate program if operations are skipped.

**report** scalar, controls reporting:

0  no reporting.
1  report only name changes and operations that could not be performed.
2  report type changes, name changes, and operations that could not be performed.
3  report everything.

**Output**

**ret** scalar, return code, 0 if successful, otherwise one of the following error codes:

4  File read error.
5  Invalid file type.
10  File contains no variables.
14  File too large to be read on current platform.
24  Variables skipped.
26  Cannot add structure definition.
Remarks

For each variable in `filename`, `gdaLoad` will first compare the name of the variable against the names of the variables already resident in the GAUSS workspace to see if there is a match. If there is not a match, and `create` is set to 1, it will create a new variable. Otherwise if `create` is set to 0, it will skip that variable.

If the variable name does match that of a variable already resident in the GAUSS workspace, and `modify` is set to 1, it will attempt to modify that variable. If the types of the two variables are different, and `ftype` is set to 1, it will force the type change if possible and modify the existing variable.

If it cannot modify the variable or `modify` is set to 0, it will check to see if `rename` is set to 1, and if so, attempt to rename the variable, appending an `_num` to the variable name, beginning with `num = 1` and counting upward until it finds a name with which there are no conflicts. If the variable cannot be modified and `rename` is set to 0, then the variable will be skipped.

The `rename` argument also controls the handling of structure definitions. If a structure variable is encountered in the GDA file, and no variable of the same name exists in the workspace (or the variable is renamed), `gdaLoad` will attempt to find a structure definition in the workspace that matches the one in the GDA. Note that in order for structure definitions to match, the structure definition names must be the same as well as the number, order, names, and types of their members.

If no matching structure definition is found, the definition in the file will be loaded into the workspace. If there is already a non-matching structure definition with the same name in the workspace and `rename` is set to 1, then `gdaLoad` will attempt to rename the structure definition, using the same method as it does for variable names.

If a structure variable is encountered in the GDA file, a structure variable of the same name already exists in the workspace, and `modify` is set to 1, then `gdaLoad` will
modify the existing variable, providing that the structure definitions of the two variables match.

**Example**

```plaintext
ret = gdaLoad("myfile.gda",1,1,1,1,1,3);
```

This example loads the variables in `myfile.gda` into the workspace, creating a new variable if a variable of the same name does not already exist, modifying an existing variable if a variable of the same name does already exist and the modification does not result in an impossible type change, and renaming the variable if none of the above is possible. The example returns an error code if any variables in `myfile.gda` are skipped and reports all activity.

**See Also**

`gdaSave`

`gdaPack`

**Purpose**

Packs the data in a GAUSS Data Archive, removing all empty bytes and truncating the file.

**Format**

```plaintext
ret = gdaPack(filename);
```
**Input**

| filename | string, name of data file. |

**Output**

<table>
<thead>
<tr>
<th>ret</th>
<th>scalar, return code, 0 if successful, otherwise one of the following error codes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Null file name.</td>
</tr>
<tr>
<td>2</td>
<td>File open error.</td>
</tr>
<tr>
<td>3</td>
<td>File write error.</td>
</tr>
<tr>
<td>4</td>
<td>File read error.</td>
</tr>
<tr>
<td>5</td>
<td>Invalid data file type.</td>
</tr>
<tr>
<td>10</td>
<td>File contains no variables.</td>
</tr>
<tr>
<td>12</td>
<td>File truncate error.</td>
</tr>
<tr>
<td>14</td>
<td>File too large to be read on current platform.</td>
</tr>
</tbody>
</table>

**Remarks**

You may want to call `gdaPack` after several calls to `gdaUpdate` to remove all of the empty bytes from a GDA.

**Example**

```c
ret = gdaPack("myfile.gda");
```
See Also

gdaUpdate, gdaWrite

gdaRead

Purpose

Gets a variable from a GAUSS Data Archive.

Format

\[ y = \text{gdaRead}(\text{filename}, \text{varname}); \]

Input

| filename   | string, name of data file. |
| varname    | string, name of variable in the GDA. |

Output

| y          | matrix, array, string or string array, variable data. |

Remarks

If \text{gdaRead} fails, it will return a scalar error code. Call \text{scalerr} to get the value of the error code. The error code may be any of the following:

1 Null file name.
Example

```gauss
y = gdaRead("myfile.gda","x1");
```

See Also

gdaReadByIndex, gdaGetName

gdaReadByIndex

Purpose

Gets a variable from a GAUSS Data Archive given a variable index.

Format

```gauss
y = gdaReadByIndex(filename, varind);
```
**Input**

- **filename** string, name of data file.
- **varind** scalar, index of variable in the GDA.

**Output**

- **y** matrix, array, string or string array, variable data.

**Remarks**

If `gdaReadByIndex` fails, it will return a scalar error code. Call `scalerr` to get the value of the error code. The error code may be any of the following:

1. Null file name.
2. File open error.
3. File read error.
4. Invalid file type.
5. Variable not found.
6. File contains no variables.

**Example**

```plaintext
y = gdaReadByIndex("myfile.gda",3);
```

**See Also**

`gdaRead`, `gdaGetIndex`
gdaReadSome

Purpose

Reads part of a variable from a GAUSS Data Archive.

Format

\[ y = \text{gdaReadSome}(\text{filename}, \text{varname}, \text{index}, \text{orders}); \]

Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>string, name of data file.</td>
</tr>
<tr>
<td>varname</td>
<td>string, name of variable in the GDA.</td>
</tr>
<tr>
<td>index</td>
<td>scalar or Nx1 vector, index into variable where read is to begin.</td>
</tr>
<tr>
<td>orders</td>
<td>scalar or Kx1 vector, orders of object to output.</td>
</tr>
</tbody>
</table>

Output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>matrix, array, string or string array, variable data.</td>
</tr>
</tbody>
</table>

Remarks

This command reads part of the variable varname in filename, beginning at the position indicated by index. The orders argument determines the size and shape of the object outputted by gdaReadSome. The number of elements read equals the product of all of the elements in orders.
If `index` is a scalar, it will be interpreted as the `index`th element of the variable. Thus if `varname` references a 10x5 matrix, an `index` of 42 would indicate the 42nd element, which is equivalent to the [8,2] element of the matrix (remember that GAUSS matrices are stored in row major order). If `index` is an Nx1 vector, then N must equal the number of dimensions in the variable referenced by `varname`.

If `orders` is a Kx1 vector, then `y` will be a K-dimensional object. If `orders` is a scalar r, then `y` will be an rx1 column vector. To specify a 1xr row vector, set `output = {1, r}`.

If the variable referenced by `varname` is numeric (a matrix or array) and `orders` is a scalar or 2x1 vector, then `y` will of type matrix. If the variable is numeric and `orders` is an Nx1 vector where N>2, then `y` will be of type array.

If `varname` references a string, then both `index` and `orders` must be scalars, and `index` must contain an index into the string in characters.

If `gdaReadSome` fails, it will return a scalar error code. Call `scalerr` to get the value of the error code. The error code may be any of the following:

1 Null file name.
2 File open error.
4 File read error.
5 Invalid file type.
8 Variable not found.
10 File contains no variables.
13 Result too large for current platform.
14 File too large to be read on current platform.
15 Argument out of range.
18 Argument wrong size.
Example

```plaintext
x = rndn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda", x,"x1");

index = { 35,20 };
orders = { 25,5 };
y = gdaReadSome("myfile.gda", "x1", index, orders);
```

This example reads 25*5=125 elements from x1, beginning with the [35,20] element. The 125 elements are returned as a 25x5 matrix, y.

See Also

gdaWriteSome, gdaRead

gdaReadSparse

Purpose

Gets a sparse matrix from a GAUSS Data Archive.

Format

```
sm = gdaReadSparse(filename, varname);
```

Input

- `filename` string, name of data file.
- `varname` string, name of sparse matrix variable in the GDA.
Output

\[ sm \quad \text{sparse matrix.} \]

Remarks

If \texttt{gdaReadSparse} fails, it will return a sparse scalar error code. Call \texttt{scalerr} to get the value of the error code. The error code may be any of the following:

1. Null file name.
2. File open error.
4. File read error.
5. Invalid file type.
8. Variable not found.
10. File contains no variables.
14. File too large to be read on current platform.

Example

```c
sparse matrix sml;
sml = gdaReadSparse("myfile.gda","sm");
```

See Also

\texttt{gdaRead}, \texttt{gdaReadStruct}, \texttt{gdaWrite}
**gdaReadStruct**

**Purpose**

Gets a structure from a GAUSS Data Archive.

**Format**

```plaintext
{ instance, retcode } = gdaReadStruct(filename, varname, structure_type);
```

**Input**

- `filename`: string, name of data file.
- `varname`: string, name of structure instance in the GDA.
- `structure_type`: string, structure type.

**Output**

- `instance`: instance of the structure.
- `retcode`: scalar, 0 if successful, otherwise, any of the following error codes:
  - 1: Null file name.
  - 2: File open error.
  - 4: File read error.
  - 5: Invalid file type.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Variable not found.</td>
</tr>
<tr>
<td>10</td>
<td>File contains no variables.</td>
</tr>
<tr>
<td>14</td>
<td>File too large to be read on current platform.</td>
</tr>
</tbody>
</table>

**Remarks**

*instance* can be an array of structures.

**Example**

```plaintext
struct mystruct {
    matrix x;
    array a;
};

struct mystruct msw;
msw.x = rndn(500,25);
msw.a = areshape(rndn(5000,100),10|500|100);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda",msw,"ms");
struct mystruct msr;
{ msr, ret } = gdaReadStruct("myfile.gda","ms","mystruct");
```

**See Also**

[gdaread](.), [gdaReadSparse](.), [gdaWrite](.)
**gdaReportVarInfo**

**Purpose**

Gets information about all of the variables in a GAUSS Data Archive and returns it in a string array formatted for printing.

**Format**

```gauss
vinfo = gdaReportVarInfo(filename);
```

**Input**

*filename*  
string, name of data file.

**Output**

*vinfo*  
N×1 string array containing variable information.

**Remarks**

If you just want to print the information to the window, call `gdaReportVarInfo` without assigning the output to a symbol name:

```gauss
gdaReportVarInfo(filename);
```

**Example**

```gauss
x1 = rndn(100,50);
```
x2 = rdn(75,5);
a = areshape(rdn(10000,1),10|100|10);
fname = "myfile.gda";
ret = gdaCreate(fname,1);
ret = gdaWrite(fname,x1,"x1");
ret = gdaWrite(fname,x2,"x2");
ret = gdaWrite(fname,a,"a1");
gdaReportVarInfo(fname);

produces:

<table>
<thead>
<tr>
<th>Index</th>
<th>Name</th>
<th>Type</th>
<th>cOrders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x1</td>
<td>matrix</td>
<td>100x50</td>
</tr>
<tr>
<td>2</td>
<td>x2</td>
<td>matrix</td>
<td>75x5</td>
</tr>
<tr>
<td>3</td>
<td>a1</td>
<td>array</td>
<td>10x100x10</td>
</tr>
</tbody>
</table>

**Source**
gdafns.src

**See Also**
gdaGetVarInfo, gdaGetNames, gdaGetTypes, gdaGetOrders

gdaSave

**Purpose**

Writes variables in a workspace to a GDA.
### Format

```latex
\text{ret} = \text{gdaSave}(\text{filename, varnames, exclude, overwrite, report});
```

### Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>string, name of data file.</td>
</tr>
<tr>
<td>varnames</td>
<td>string or NxK string array, names of variables in the workspace to include or exclude.</td>
</tr>
<tr>
<td>exclude</td>
<td>scalar, include/exclude flag:</td>
</tr>
<tr>
<td></td>
<td>0 \quad \text{include all variables contained in } \text{varnames}.</td>
</tr>
<tr>
<td></td>
<td>1 \quad \text{exclude all variables contained in } \text{varnames}.</td>
</tr>
<tr>
<td>overwrite</td>
<td>scalar, controls the overwriting of the file and variables in the file:</td>
</tr>
<tr>
<td></td>
<td>0 \quad \text{if file exists, return with an error code.}</td>
</tr>
<tr>
<td></td>
<td>1 \quad \text{if file exists, overwrite completely.}</td>
</tr>
<tr>
<td></td>
<td>2 \quad \text{if file exists, append to file, appending to variable names if necessary to avoid name conflicts.}</td>
</tr>
<tr>
<td></td>
<td>3 \quad \text{if file exists, update file. When a name conflict occurs, update the existing variable in the file with the new variable.}</td>
</tr>
<tr>
<td>report</td>
<td>scalar, controls reporting:</td>
</tr>
<tr>
<td></td>
<td>0 \quad \text{no reporting.}</td>
</tr>
</tbody>
</table>
1 report only name changes (note that name changes occur only when overwrite is set to 2).

3 report everything.

**Output**

`ret` scalar, return code, 0 if successful, otherwise one of the following error codes:

1 Null file name.

3 File write error.

4 File read error.

5 Invalid file type.

6 File exists and overwrite set to 0.

7 Cannot create file.

14 File too large to be read on current platform.

16 Cannot write to GDA - version outdated.

17 Type mismatch.

**Remarks**

Only initialized variables are written to the GDA with `gdaSave`. 
If `varnames` is a null string and `exclude` is set to 0, it will be interpreted as indicating all of the variables in the workspace.

You may add an asterisk (*) to the end of a variable name in `varnames` to indicate that all variables beginning with the specified text are to be selected. For example, setting `varnames` to the string "_ *" and setting `exclude` to 1 indicates that all variables EXCEPT those starting with an underscore should be written to the GDA.

The names of the variables in the workspace are the names that are given to the variables when they are written to the GDA, with the exception of names that are changed to avoid conflicts.

If you set `overwrite` to 2, and variable name conflicts are encountered, `gdaSave` will append an underscore and a number to the name of the variable it is adding. It will first try changing the name to `name_1`. If there is a conflict with that name, it will change it to `name_2`, and so on until it finds a name that does not conflict with any of the variables already in the GDA.

**Example**

```plaintext
run -r myfile.gau;
ret = gdaSave("myfile.gda","x*",0,2,3);
```

This example runs a GAUSS program called `myfile.gau` and then writes all initialized variables in the workspace beginning with 'x' to the file `myfile.gda`. If `myfile.gda` already exists, this example appends to it, changing the names of the variables that it writes to the file if necessary to avoid name conflicts. All writing and variable name changing is reported.

**See Also**

`gdaLoad`
**gdaUpdate**

**Purpose**

Updates a variable in a GAUSS Data Archive.

**Format**

\[ ret = \text{gdaUpdate}(\text{filename}, x, \text{varname}); \]

**Input**

- `filename` : string, name of data file.
- `x` : matrix, array, string or string array, data.
- `varname` : string, variable name.

**Output**

- `ret` : scalar, return code, 0 if successful, otherwise one of the following error codes:
  - 1 : Null file name.
  - 2 : File open error.
  - 3 : File write error.
  - 4 : File read error.
  - 5 : Invalid data file type.
**Remarks**

This command updates the variable `varname` in `filename` with the data contained in `x`.

If `x` is larger than the specified variable in the file, then `gdaUpdate` writes the new variable data after the last variable in the data file, moving the variable descriptor table to make room for the data and leaving empty bytes in the place of the old variable. This does not change the index of the variable because variable indices are determined NOT by the order of the variable data in a GDA, but by the order of the variable descriptors.

If `x` is the same size or smaller than the specified variable in the file, then `gdaUpdate` writes the data in `x` over the specified variable. If `x` is smaller, then `gdaUpdate` leaves empty bytes between the end of the updated variable and the beginning of the next variable in the data file.

This command updates variables quickly by not moving data in the file unnecessarily. However, calling `gdaUpdate` several times for one file may result in a file with a large number of empty bytes. To pack the data in a GDA, so it contains no empty bytes, call `gdaPack`. Or to update a variable without leaving empty bytes in the file, call `gdaUpdateAndPack`.

**Example**

```matlab
x = randn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda",x,"x1");
```
y = rdn(75, 5);
ret = gdaUpdate("myfile.gda", y, "x1");

See Also

gdaUpdateAndPack, gdaPack, gdaWrite

gdaUpdateAndPack

Purpose

Updates a variable in a GAUSS Data Archive, leaving no empty bytes if the updated variable is smaller or larger than the variable it is replacing.

Format

\[
\text{ret} = \text{gdaUpdateAndPack}(\text{filename, } x, \text{ varname});
\]

Input

- **filename**: string, name of data file.
- **x**: matrix, array, string or string array, data.
- **varname**: string, variable name.

Output

- **ret**: scalar, return code, 0 if successful, otherwise one of the following error codes:
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Null file name.</td>
</tr>
<tr>
<td>2</td>
<td>File open error.</td>
</tr>
<tr>
<td>3</td>
<td>File write error.</td>
</tr>
<tr>
<td>4</td>
<td>File read error.</td>
</tr>
<tr>
<td>5</td>
<td>Invalid data file type.</td>
</tr>
<tr>
<td>8</td>
<td>Variable not found.</td>
</tr>
<tr>
<td>10</td>
<td>File contains no variables.</td>
</tr>
<tr>
<td>12</td>
<td>File truncate error.</td>
</tr>
<tr>
<td>14</td>
<td>File too large to be read on current platform.</td>
</tr>
</tbody>
</table>

**Remarks**

This command updates the variable `varname` in `filename` with the data contained in `x`. **gdaUpdateAndPack** always writes the data in `x` over the specified variable in the file. If `x` is larger than the specified variable, then it first moves all subsequent data in the file to make room for the new data. If `x` is smaller, then **gdaUpdateAndPack** writes the data, packs all of the subsequent data, leaving no empty bytes after the updated variable, and truncates the file.

This command uses disk space efficiently; however, it may be slow for large files (especially if the variable to be updated is one of the first variables in the file). If speed is a concern, you may want to use **gdaUpdate** instead.

**Example**

```plaintext
x = rndn(100, 50);
ret = gdaCreate("myfile.gda", 1);
```
See Also
gdaUpdate, gdaWrite

gdaVars

Purpose

Gets the number of variables in a GAUSS Data Archive.

Format

\[ nvars = \text{gdaVars}(\text{filename}); \]

Input

filename \hspace{1cm} \text{string, name of data file.}

Output

nvars \hspace{1cm} \text{scalar, the number of variables in \text{filename}.}

Example

\[ \text{nvars} = \text{gdaVars("myfile.gda")}; \]
Source

gdafns.src

See Also

gdaReportVarInfo, gdaGetNames

gdaWrite

Purpose

Writes a variable to a GAUSS Data Archive.

Format

\[ ret = \text{gdaWrite}(\text{filename}, x, \text{varname}); \]

Input

<table>
<thead>
<tr>
<th>filename</th>
<th>string, name of data file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>matrix, array, string or string array, data to write to the GDA.</td>
</tr>
<tr>
<td>varname</td>
<td>string, variable name.</td>
</tr>
</tbody>
</table>

Output

<table>
<thead>
<tr>
<th>ret</th>
<th>scalar, return code, 0 if successful, otherwise one of the following error codes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Null file name.</td>
</tr>
</tbody>
</table>
2 File open error.
3 File write error.
4 File read error.
5 Invalid data file type.
9 Variable name too long.
11 Variable name must be unique.
14 File too large to be read on current platform.

Remarks

`gdaWrite` adds the data in `x` to the end of the variable data in `filename`, and gives the variable the name contained in `varname`.

Example

```matlab
x = rndn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda",x,"x1");
```

See Also

`gdaWrite32`, `gdaCreate`
gdaWrite32

**Purpose**

Writes a variable to a GAUSS Data Archive using 32-bit system file write commands.

**Format**

```markdown
ret = gdaWrite32(filename, x, varname);
```

**Input**

- `filename`: string, name of data file.
- `x`: matrix, array, string or string array, data to write to the GDA.
- `varname`: string, variable name.

**Output**

- `ret`: scalar, return code, 0 if successful, otherwise one of the following error codes:
  - 1: Null file name.
  - 2: File open error.
  - 3: File write error.
  - 4: File read error.
  - 5: Invalid data file type.
9  Variable name too long.
11  Variable name must be unique.
14  File too large to be read on current platform.
25  Not supported for use with a file created on a machine with a different byte order.

Remarks

gdaWrite32 adds the data in x to the end of the variable data in filename, and gives the variable the name contained in varname.

This command is a speed optimization command for Windows. On all other platforms, this function is identical to gdaWrite. gdaWrite uses system file write commands that support 64-bit file sizes. These commands are slower on Windows XP than the 32-bit file write commands that were used for binary writes in GAUSS 6.0 and earlier. gdaWrite32 uses the 32-bit Windows system write commands, which will be faster on Windows XP. Note, however, that gdaWrite32 does not support 64-bit file sizes.

This command does not support writing to a GDA that was created on a platform with a different byte order than the current machine. gdaWrite supports full cross-platform writing to GDA's.

Example

```gauss
x = rndn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite32("myfile.gda",x,"x1");
```

See Also

gdaWrite, gdaCreate
gdaWriteSome

Purpose
Overwrites part of a variable in a GAUSS Data Archive.

Format
\[ \text{ret} = \text{gdaWriteSome}(\text{filename, } x, \text{ varname, index}); \]

Input
- **filename**: string, name of data file.
- **x**: matrix, array, string or string array, data.
- **varname**: string, variable name.
- **index**: scalar or Nx1 vector, index into variable where new data is to be written.

Output
- **ret**: scalar, return code, 0 if successful, otherwise one of the following error codes:
  - 1: Null file name.
  - 2: File open error.
  - 3: File write error.
  - 4: File read error.
5  Invalid data file type.
8  Variable not found.
10 File contains no variables.
14 File too large to be read on current platform.
15 Argument out of range.
17 Type mismatch.
18 Argument wrong size.
19 Data must be real.
20 Data must be complex.

Remarks

This command overwrites part of the variable \textit{varname} in \textit{filename} with the data contained in \textit{x}. The new data is written to \textit{varname} beginning at the position indicated by \textit{index}.

If \textit{index} is a scalar, it will be interpreted as the \textit{index}th element of the variable. Thus if \textit{varname} references a 10x5 matrix, an \textit{index} of 42 would indicate the 42nd element, which is equivalent to the [8,2] element of the matrix (remember that \texttt{GAUSS} matrices are stored in row major order). If \textit{index} is an Nx1 vector, then N must equal the number of dimensions in the variable referenced by \textit{varname}.

If \textit{varname} references a string, then \textit{index} must be a scalar containing an index into the string in characters.

\texttt{gdaWriteSome} may not be used to extend the size of a variable in a GDA. If there are more elements (or characters for strings) in \textit{x} than there are from the indexed
position of the specified variable to the end of that variable, then \texttt{gdaWriteSome} will fail. Call \texttt{gdaAppend} to append data to an existing variable.

The shape of \( x \) need not match the shape of the variable referenced by \texttt{varname}. If \texttt{varnum} references an \( NxK \) matrix, then \( x \) may be any \( LxM \) matrix (or \( P \)-dimensional array) that satisfies the size limitations described above. If \( x \) contains \( R \) elements, then the elements in \( x \) will simply replace the indexed element of the specified variable and the subsequent \( R-1 \) elements (as they are laid out in memory).

If \texttt{varname} references a string array, then the size of the overall variable will change if the sum of the length of the string array elements in \( x \) is different than the sum of the length of the elements that they are replacing.

In this case, if the variable increases in size, then the variable data will be rewritten after the last variable in the data file, moving the variable descriptor table to make room for the data and leaving empty bytes in its old location. This does not change the index of the variable because variable indices are determined NOT by the order of the variable data in a GDA, but by the order of the variable descriptors. If the variable decreases in size, then \texttt{gdaWriteSome} leaves empty bytes between the end of the variable and the beginning of the next variable in the data file. Call \texttt{gdaPack} to pack the data in a GDA, so it contains no empty bytes.

\textbf{Example}

\begin{verbatim}
x = rndn(100,50);
ret = gdaCreate("myfile.gda",1);
ret = gdaWrite("myfile.gda",x,"x1");

y = rndn(75,5);
index = { 52, 4 };
ret = gdaWriteSome("myfile.gda",y,"x1",index);
\end{verbatim}

This example replaces \( 75*5=375 \) elements in \( x1 \), beginning with the \([52,4]\) element, with the elements in \( y \).
See Also
gdaReadSome, gdaUpdate, gdaWrite

getarray

Purpose

Gets a contiguous subarray from an N-dimensional array.

Format

\[ y = \text{getarray}(a, \ loc); \]

Input

\[
\begin{array}{ll}
  a & \text{N-dimensional array.} \\
  loc & \text{Mx1 vector of indices into the array to locate the subarray of interest, where} \ 1 \leq M \leq N.
\end{array}
\]

Output

\[
\begin{array}{ll}
  y & \text{[N-M]-dimensional subarray or scalar.}
\end{array}
\]

Remarks

If N-M>0, \text{getarray} will return an array of [N-M] dimensions, otherwise, if N-M=0, it will return a scalar.
**Example**

```plaintext
a = seqa(1,1,720);
a = areshape(a,2|3|4|5|6);
loc = { 2,1 };
y = getarray(a,loc);
```

`y` will be a 4x5x6 array of sequential values, beginning at `[1,1,1]` with 361, and ending at `[4,5,6]` with 480.

**See Also**

- `getmatrix`
- `getdims`

**getdims**

**Purpose**

Gets the number of dimensions in an array.

**Format**

```plaintext
y = getdims(a);
```

**Input**

- `a` N-dimensional array.

**Output**

- `y` scalar, the number of dimensions in the array.
Example

```matlab
a = arrayinit(3|4|5|6|7|2,0);
dims = getdims(a);
```

The code above, assigns `dims` to be equal to 6.

See Also

`getorders`

**getf**

**Purpose**

Loads an ASCII or binary file into a string.

**Format**

```matlab
y = getf(filename, mode);
```

**Input**

- `filename` : string, any valid file name.
- `mode` : scalar 1 or 0 which determines if the file is to be loaded in ASCII mode (0) or binary mode (1).

**Output**

- `y` : string containing the file.
Remarks

If the file is loaded in ASCII mode, it will be tested to see if it contains any end of file characters. These are ^Z (ASCII 26). The file will be truncated before the first ^Z, and there will be no ^Z's in the string. This is the correct way to load most text files because the ^Z's can cause problems when trying to print the string to a printer.

If the file is loaded in binary mode, it will be loaded just like it is with no changes.

Example

Suppose you have a file which writes the results of its calculations to a file in a report format. For this example, we will use the code snippet below:

```plaintext
x1 = rdn(100,5);
y1 = rdu(100,1);

output file = regression_results.txt reset;
call ols("", y1, x1);
output off;

x2 = rdn(100,5);
y2 = rdu(100,1);

output file = ols_results.txt reset;
call ols("", y2, x2);
output off;
```

Running the code above will create a file named "regression_results.txt" and a file named "ols_results.txt" in your current working directory. You can retrieve the output from either of these files with the `getf` command.

```plaintext
str = getf("regression_results.txt",1);
print str;
```
You can take this further and create a procedure that will load a list of output files for you. It can then print the output from each file as you are ready to read it.

```
declare string array fileList = { "regression_results.txt", "ols_results.txt" };

showOutput(fileList);

proc (0) = showOutput(fileList);
  local k;
  for i(1, rows(fileList), 1);
    print "Press any key to view the next file:"
    //wait for user input and assign the first key stroke
    //to 'k'
    k = keyw;
    print getf(fileList[i], 1);
  endfor;
endp;
```

See Also

`load`, `save`, `let`, `con`

getmatrix

**Purpose**

Gets a contiguous matrix from an N-dimensional array.

**Format**

```
y = getmatrix(a, loc);
```
**Input**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>N-dimensional array.</td>
</tr>
<tr>
<td>$loc$</td>
<td>Mx1 vector of indices into the array to locate the matrix of interest, where M equals N, N-1 or N-2.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>KxL or 1xL matrix or scalar, where L is the size of the fastest moving dimension of the array and K is the size of the second fastest moving dimension.</td>
</tr>
</tbody>
</table>

**Remarks**

Inputting an Nx1 locator vector will return a scalar, an (N-1)x1 locator vector will return a 1xL matrix, and an (N-2)x1 locator vector will return a KxL matrix.

**Example**

```plaintext
//Create the sequence 1, 2, 3...20
a = seqa(1, 1, 20);

//Reshape the column vector 'a' into a 3x3x2 dimensional array
a = areshape(a, 3|3|2);

//Extract the second 3x2 array
mat = getmatrix(a, 2);
```

After code above $a$ is equal to:
<table>
<thead>
<tr>
<th>Plane [1,..]</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000000</td>
<td>2.0000000</td>
<td></td>
</tr>
<tr>
<td>3.0000000</td>
<td>4.0000000</td>
<td></td>
</tr>
<tr>
<td>5.0000000</td>
<td>6.0000000</td>
<td></td>
</tr>
<tr>
<td>Plane [2,..]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0000000</td>
<td>8.0000000</td>
<td></td>
</tr>
<tr>
<td>9.0000000</td>
<td>10.000000</td>
<td></td>
</tr>
<tr>
<td>11.000000</td>
<td>12.000000</td>
<td></td>
</tr>
<tr>
<td>Plane [3,..]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.000000</td>
<td>14.000000</td>
<td></td>
</tr>
<tr>
<td>15.000000</td>
<td>16.000000</td>
<td></td>
</tr>
<tr>
<td>17.000000</td>
<td>18.000000</td>
<td></td>
</tr>
</tbody>
</table>

and \( \text{mat} \) is equal to:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0000000</td>
<td>8.0000000</td>
</tr>
<tr>
<td>9.0000000</td>
<td>10.000000</td>
</tr>
<tr>
<td>11.000000</td>
<td>12.000000</td>
</tr>
</tbody>
</table>

**See Also**

getarray, getmatrix4D

**getmatrix4D**

**Purpose**

Gets a contiguous matrix from a 4-dimensional array.
Format

\[ y = \text{getmatrix4D}(a, \ i1, \ i2); \]

Input

- \( a \) : 4-dimensional array.
- \( i1 \) : scalar, index into the slowest moving dimension of the array.
- \( i2 \) : scalar, index into the second slowest moving dimension of the array.

Output

- \( y \) : \( K \times L \) matrix, where \( L \) is the size of the fastest moving dimension of the array and \( K \) is the size of the second fastest moving dimension.

Remarks

\text{getmatrix4D} \ \text{returns the contiguous matrix that begins at the } [i1,i2,1,1] \ \text{position in array} \ a \ \text{and ends at the } [i1, i2, K,L] \ \text{position.}

A call to \text{getmatrix4D} \ \text{is faster than using the more general } \text{getmatrix} \ \text{function to get a matrix from a 4-dimensional array, especially when } i1 \ \text{and } i2 \ \text{are the counters from nested for loops.}

Example

//Create a column vector 1, 2, 3...120


```plaintext
a = seqa(1,1,120);

// Reshape the column vector into a 2x3x4x5 dimensional array
a = areshape(a,2|3|4|5);

// Extract a submatrix
y = getmatrix4D(a,2,3);
```

After the code above:

```
101 102 103 104 105
y = 106 107 108 109 110
     111 112 113 114 115
     116 117 118 119 120
```

**See Also**

getmatrix, getscalar4D, getarray

**getline**

**Purpose**

Returns a column vector containing the names of the variables in a GAUSS data set.

**Format**

```
y = getline(dset);
```
**Input**

*dset*  
string specifying the name of the data set from which the function will obtain the variable names.

**Output**

*y*  
Nx1 vector containing the names of all of the variables in the specified data set.

**Remarks**

The output, *y*, will have as many rows as there are variables in the data set.

**Example**

```plaintext
y = getname("olsdat");
format 8,8;
print $y;
```

produces:

```
TIME
DIST
TEMP
FRICT
```

The above example assumes that the data set *olsdat* contains the variables: *TIME, DIST, TEMP, FRICT*.

Note that the extension is not included in the filename passed to the *getname* function.
See Also

getnamef, indev

getnamef

Purpose

Returns a string array containing the names of the variables in a GAUSS data set.

Format

\[ y = \text{getnamef}(f); \]

Input

\( f \)
scalar, file handle of an open data set

Output

\( y \)
N\times1 string array containing the names of all of the variables in the specified data set.

Remarks

The output, \( y \), will have as many rows as there are variables in the data set.
Example

```plaintext
//Open the dataset
open f = olsdat for read;

//Create a string array with the variable names from the //dataset
y = getnamef(f);

//Check which variables are character and which are numeric
t = vartypef(f);

print y;
```

produces:

time
dist
temp
frict

The above example assumes that the data set `olsdat` contains the variables: `TIME, DIST, TEMP, FRICT`.

Note the use of `vartypef` to determine the types of these variables.

See Also

glename, indcv, vartypef

getNextTradingDay

Purpose

Returns the next trading day.
**Format**

\[ n = \text{getNextTradingDay}(a); \]

**Input**

- \( a \) scalar, date in DT scalar format.

**Output**

- \( n \) scalar, next trading day in DT scalar format.

**Remarks**

A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2006. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

**Source**

`finutils.src`

**Globals**

`_fin_holidays`

**See Also**

`getPreviousTradingDay`, `annualTradingDays`
**getNextWeekDay**

**Purpose**

Returns the next day that is not on a weekend.

**Format**

\[ n = \text{getNextWeekDay}(a); \]

**Input**

\( a \)

scalar, date in DT scalar format.

**Output**

\( n \)

scalar, next week day in DT scalar format.

**Source**

finutils.src

**See Also**

getNextPreviousWeekDay
**getnr**

**Purpose**

Computes number of rows to read per iteration for a program that reads data from a disk file in a loop.

**Format**

\[ nr = \text{getnr}(nsets, \ ncols); \]

**Input**

- **nsets** scalar, estimate of the maximum number of duplicate copies of the data matrix read by *readr* to be kept in memory during each iteration of the loop.
- **ncols** scalar, columns in the data file.

**Output**

- **nr** scalar, number of rows *readr* should read per iteration of the read loop.

**Remarks**

If \_\_\_\_\_row is greater than 0, \_\_\_\_\_\_nr will be set to \_\_\_\_\_\_row.

If an insufficient memory error is encountered, change \_\_\_\_\_\_rowfac to a number less than 1.0 (e.g., 0.75). The number of rows read will be reduced in size by this factor.
**Source**

`gauss.src`

**Globals**

`__row, __rowfac, __maxvec`

**getnrmt**

**Purpose**

Computes number of rows to read per iteration for a program that reads data from a disk file in a loop.

**Format**

\[ nr = \text{getnr}(nsets, ncols, row, rowfac, maxv); \]

**Input**

- `nsets` scalar, estimate of the maximum number of duplicate copies of the data matrix read by `readr` to be kept in memory during each iteration of the loop.
- `ncols` scalar, columns in the data file.
- `row` scalar, if row is greater than 0, \( nr \) will be set to \( row \).
- `rowfac` scalar, \( nr \) will be reduced in size by this factor. If insufficient memory error is encountered, change this to a number less than one (e.g., 0.9).
**maxv**  
Scalar, the largest number of elements allowed in any one matrix.

**Output**

**nr**  
Scalar, number of rows `readr` should read per iteration of the read loop.

**Source**

gaussmt.src

**getorders**

**Purpose**

Gets the vector of orders corresponding to an array.

**Format**

\[
y = \text{getorders}(a);
\]

**Input**

\(a\)  
N-dimensional array.

**Output**

\(y\)  
Nx1 vector of orders, the sizes of the dimensions of the
array.

Example

```c
//Allocate a 7x6x5x4x3 dimensional array
a = arrayalloc(7|6|5|4|3,0);
orders = getorders(a);
```

After the code above:

```
7
6
orders = 5
4
3
```

See Also

getdims

gxpath

Purpose

Returns an expanded filename including the drive and path.

Format

```c
fname = getpath(pfname);
```
**Input**

`pfname` string, partial filename with only partial or missing path information.

**Output**

`fname` string, filename with full drive and path.

**Remarks**

This function handles relative path references.

**Example**

```plaintext
y = getpath("temp.e");
print y;
```

produces:

```plaintext
C:\gauss\temp.e
```

assuming that `C:\gauss` is the current directory.

**Source**

`getpath.src`
getPreviousTradingDay

**Purpose**

Returns the previous trading day.

**Format**

\[ n = \text{getPreviousTradingDay}(a); \]

**Input**

\( a \)  
scalar, date in DT scalar format.

**Output**

\( n \)  
scalar, previous trading day in DT scalar format.

**Remarks**

A trading day is a weekday that is not a holiday as defined by the New York Stock Exchange from 1888 through 2006. Holidays are defined in `holidays.asc`. You may edit that file to modify or add holidays.

**Source**

`finutils.src`

**Globals**

`_fin_holidays`
See Also
getNextTradingDay

getPreviousWeekDay

Purpose

Returns the previous day that is not on a weekend.

Format

\[ n = \text{getPreviousWeekDay}(a); \]

Input

\[ a \]

scalar, date in DT scalar format.

Output

\[ n \]

scalar, previous week day in DT scalar format.

Source

finutils.src

See Also

getNextWeekDay
**getRow**

**Purpose**

Returns a specified row from a matrix.

**Format**

\[ y = \text{getRow}(a, \ row); \]

**Input**

- **a**: N×K matrix
- **row**: The row of the matrix to extract.

**Output**

- **y**: A 1×K row vector.

**Remarks**

getRow is designed to give an alternative access to rows in a matrix than indexing the matrix by brackets.

**Example**

First create a matrix, \( a \):

\[ a = \text{rndn}(10,10); \]
Now you can assign a variable $y$ to be equal the third row of $a$ with either of the following statements.

\[
y = \text{getRow}(a, 3);
\]

or

\[
y = a[3, :];
\]

While both statements will produce the same result, the first may make for code that is easier to read and interpret.

**See Also**

*CR-getTrRow*

**getscalar3D**

**Purpose**

Gets a scalar from a 3-dimensional array.

**Format**

\[
y = \text{getscalar3D}(a, i1, i2, i3);
\]

**Input**

- $a$: 3-dimensional array.
- $i1$: scalar, index into the slowest moving dimension of the array.
- $i2$: scalar, index into the second slowest moving dimension of
the array.

\[ i3 \]

scalar, index into the fastest moving dimension of the array.

Output

\[ y \]

scalar, the element of the array indicated by the indices.

Remarks

getscalar3D returns the scalar that is located in the \([i1, i2, i3]\) position of array \(a\).

A call to getscalar3D is faster than using the more general getmatrix function to get a scalar from a 3-dimensional array.

Example

```
//Create a column vector 1, 2, 3,...24
a = seqa(1,1,24);

//Reshape the column vector into a 2x3x4 dimensional array
a = areshape(a,2|3|4);

y = getscalar3D(a,1,3,2);
```

A 2x3x4 dimensional array can be thought of as two 3x4 dimensional matrices. The call to getScalar3D above, returns the \([3,2]\) element of the first of these matrices. The value of which is:

\[ y = 10 \]
See Also
getmatrix, getscalar4D, getarray

getscalar4D

Purpose
Gets a scalar from a 4-dimensional array.

Format

\[ y = \text{getscalar4D}(a, \ i1, \ i2, \ i3, \ i4); \]

Input

\( a \) 4-dimensional array.
\( i1 \) scalar, index into the slowest moving dimension of the array.
\( i2 \) scalar, index into the second slowest moving dimension of the array.
\( i3 \) scalar, index into the second fastest moving dimension of the array.
\( i4 \) scalar, index into the fastest moving dimension of the array.

Output

\( y \) scalar, the element of the array indicated by the indices.
Remarks

getscalar4D returns the scalar that is located in the \([i1, \ i2, \ i3, \ i4]\) position of array \(a\).

A call to getscalar4D is faster than using the more general getmatrix function to get a scalar from a 4-dimensional array.

Example

\begin{verbatim}
a = seqa(1,1,120);
a = areshape(a,2|3|4|5);
y = getscalar4D(a,1,3,2,5);
\end{verbatim}

The code above assigns \(y\) equal to 50.

See Also

getmatrix, getscalar3D, getarray

getTrRow

Purpose

Transposes a matrix and then returns a single row from it.

Format

\begin{verbatim}
y = getTrRow(a, \ row);
\end{verbatim}
**Input**

- **a**: NxK matrix
- **row**: The row of the matrix to extract.

**Output**

- **y**: A 1xK row vector.

**Remarks**

`getRow` is designed to give an alternative access to rows in a matrix than indexing the matrix by brackets.

**Example**

```matlab
a = randn(10,10);
y = getTrRow(a,3);
```

**See Also**

- `getRow`
- `getwind`

**Purpose**

Retrieve the current graphic panel number. Note: This function is for use with the deprecated PQG graphics.
**Library**
pgraph

**Format**

\[ n = \text{getwind}; \]

**Output**

\[ n \]
scalar, graphic panel number of current graphic panel.

**Remarks**

The current graphic panel is the graphic panel in which the next graph will be drawn.

**Source**
pwindow.src

**See Also**
endwind, begwind, window, setwind, nextwind

gosub

**Purpose**

Causes a branch to a subroutine. Note: This is an advanced function that gives extra flexibility for sophisticated users in some circumstances. In most cases, it is preferable to create a procedure (proc).
Format

```plaintext
gosub label;
.
.
.
label:
.
.
.
return;
```

Remarks

For multi-line recursive user-defined functions, see Procedures and Keywords, Chapter 1.

When a `gosub` statement is encountered, the program will branch to the label and begin executing from there. When a `return` statement is encountered, the program will resume executing at the statement following the `gosub` statement. Labels are 1-32 characters long and are followed by a colon. The characters can be A-Z or 0-9, but they must begin with an alphabetic character. Uppercase or lowercase is allowed.

It is possible to pass parameters to subroutines and receive parameters from them when they return. See the second example, following.

The only legal way to enter a subroutine is with a `gosub` statement.

If your subroutines are at the end of your program, you should have an `end` statement before the first one to prevent the program from running into a subroutine without using a `gosub`. This will result in a Return without gosub error message.

The variables used in subroutines are not local to the subroutine and can be accessed from other places in your program. (See Procedures and Keywords, Chapter 1.)
Example

In the program below the name *mysub* is a label. When the *gosub* statement is executed, the program will jump to the label *mysub* and continue executing from there. When the *return* statement is executed, the program will resume executing at the statement following the *gosub*.

```plaintext
x = rdn(3,3);  
z = 0;           
gosub mysub;   
print z;       
end;           
/* -------- Subroutines Follow -------- */

mysub:          
z = inv(x);     
return;
```

Parameters can be passed to subroutines in the following way (line numbers are added for clarity):

```plaintext
1. gosub mysub(x,y);   
2. pop j; /* b will be in j */  
3. pop k; /* a will be in k */  
4. t = j*k;          
5. print t;          
6. end;              
7.  
8. /* -------- Subroutines Follow -------- */  
9.  
10. mysub:           
11. pop b; /* y will be in b */  
12. pop a; /* x will be in a */  
13.```
14. \( a = \text{inv}(b) \cdot b + a; \)
15. \( b = a' \cdot b; \)
16. return \((a, b);\)

In the above example, when the `gosub` statement is executed, the following sequence of events results (line numbers are included for clarity):

1. \( x \) and \( y \) are pushed on the stack and the program branches to the label \( \text{mysub} \) in line 10.

11. the second argument that was pushed, \( y \), is \text{pop}'ped into \( b \).

12. the first argument that was pushed, \( x \), is \text{pop}'ped into \( a \).

14. \( \text{inv}(b) \cdot b + a \) is assigned to \( a \).

15. \( a' \cdot b \) is assigned to \( b \).

16. \( a \) and \( b \) are pushed on the stack and the program branches to the statement following the `gosub`, which is line 2.

2. the second argument that was pushed, \( b \), is \text{pop}'ped into \( j \).

3. the first argument that was pushed, \( a \), is \text{pop}'ped into \( k \).

4. \( j \cdot k \) is assigned to \( t \).

5. \( t \) is printed.

6. the program is terminated with the \text{end} statement.

Matrices are pushed on a last-in/first-out stack in the `gosub()` and `return()` statements. They must be \text{pop}'ped off in the reverse order. No intervening statements are allowed between the label and the `pop` or the `gosub` and the `pop`. Only one matrix may be \text{pop}'ped per `pop` statement.
See Also

goto, proc, pop, return

goto

Purpose

Causes a branch to a label.

Format

```
gotolabel;
  .
  .
  .
label:
```

Remarks

Label names can be any legal GAUSS names up to 32 alphanumeric characters, beginning with an alphabetic character or an underscore, not a reserved word.

Labels are always followed immediately by a colon.

Labels do not have to be declared before they are used. GAUSS knows they are labels by the fact that they are followed immediately by a colon.

When GAUSS encounters a goto statement, it jumps to the specified label and continues execution of the program from there.

Parameters can be passed in a goto statement the same way as they can with a gosub.
Example

```plaintext
x = seqa(.1,.1,5);
n = { 1 2 3 };
goto fip;
print x;
end;

fip:
print n;
```

produces:

```
1.0000000 2.0000000 3.0000000
```

See Also

gosub, if

gradMT

Purpose

Computes numerical gradient.

Include

optim.sdf

Format

```plaintext
g = gradMT(&fct, par1, datal);
```
**Input**

- **&fct** scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar.
- **par1** an instance of structure of type PV containing parameter vector at which gradient is to be evaluated.
- **data1** structure of type DS containing any data needed by \( fct \).

**Output**

- **g** NxK Jacobian or 1xK gradient.

**Remarks**

**par1** must be created using the `pvPack` procedures.

**Example**

```cpp
#include optim.sdf

struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1, 0.1|0.2, "P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1, 1, 15);

proc fct(struct PV p0, struct DS d0);
    local p, y;
    p = pvUnpack(p0, "P");
```
\begin{verbatim}
y = p[1] * exp(-p[2] * d0.dataMatrix);
    retp(y);
endp;

g = gradMT(&fct,p1,d0);
\end{verbatim}

**Source**

gradmt.src

**gradMTm**

**Purpose**

Computes numerical gradient with mask.

**Include**

optim.sdf

**Format**

\[ g = \text{gradMTm}(&fct,par1,datal, mask); \]

**Input**

- **&fct**
  - scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar.

- **par1**
  - an instance of structure of type PV containing parameter vector at which gradient is to be evaluated.
data1  structure of type DS containing any data needed by fct.

mask  Kx1 matrix, elements in g corresponding to elements of mask set to zero are not computed, otherwise they are computed.

Output

g  NxK Jacobian or 1xK gradient.

Remarks

par1 must be created using the pvPack procedures.

Example

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1, 0.1|0.2,"P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc fct(struct PV p0, struct DS d0);
  local p,y;
  p = pvUnpack(p0, "P");
  y = p[1] * exp(-p[2] * d0.dataMatrix);
  retp(y);
endp;
```
```
mask = { 0, 1 };
g = gradMTm(&fct,p1,d0,mask);
```

**Source**

gradmt.src

**gradMTT**

**Purpose**

Computes numerical gradient using available threads.

**Include**

optim.sdf

**Format**

```
g = gradMTT(&fct,parl,data1);
```

**Input**

- **fct**
  scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar.

- **parl**
  structure of type PV containing parameter vector at which gradient is to be evaluated

- **data1**
  structure of type DS containing any data needed by fct
Output

\( g \)  
NxK Jacobian or 1xK gradient

Remarks

`par1` must be created using the `pvPack` procedures

Example

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1, 0.1|0.2, "P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc fct(struct PV p0, struct DS d0);
    local p,y;
    p = pvUnpack(p0, "P");
    y = p[1] * exp(-p[2] * d0.dataMatrix);
    retp(y);
endp;

g = gradMT(&fct,p1,d0);
```

Source

gradmtt.src
gradMTTm

**Purpose**

Computes numerical gradient with mask using threads.

**Include**

sqpsolvent.sdf

**Format**

\[ g = \text{gradMTTm}(&fct, \text{par1}, \text{data1}, \text{mask}); \]

**Input**

- **&fct**  
  scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar

- **par1**  
  structure of type PV containing parameter vector at which gradient is to be evaluated

- **data1**  
  structure of type DS containing any data needed by \( fct \)

- **mask**  
  Kx1 matrix, elements in \( g \) corresponding to elements of mask set to zero are not computed otherwise are computed.

**Output**

- **g**  
  NxK Jacobian or 1xK gradient
Remarks

par1 must be created using the pvPack procedures

Example

```c
#include sqpsolvemt.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2,"P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc fct(struct PV p0, struct DS d0);
    local p,y;
    p = pvUnpack(p0,"P");
    y = p[1] * exp(-p[2] * d0.dataMatrix);
    retp(y);
endp;

mask = { 0, 1 };
g = gradMTTm(&fct,p1,d0,mask);
```

Source

gradmtt.src
**gradp, gradcplx**

**Purpose**
Computes the gradient vector or matrix (Jacobian) of a vector-valued function that has been defined in a procedure. Single-sided (forward difference) gradients are computed. *gradcplx* allows for complex arguments.

**Format**

\[
g = \text{gradp}(&f, x0); \\
g = \text{gradcplx}(&f, x0);
\]

**Input**

- **&f**
a pointer to a vector-valued function \( f : K \times 1 \rightarrow N \times 1 \) defined as a procedure. It is acceptable for \( f(x) \) to have been defined in terms of global arguments in addition to \( x \), and thus \( f \) can return an \( N \times 1 \) vector:

  ```
  proc f(x);
  retp( exp(x.*b));
  endp;
  ```

- **x0**
  Kx1 vector of points at which to compute gradient.

**Output**

- **g**
  NxK matrix containing the gradients of \( f \) with respect to the variable \( x \) at \( x0 \).
Remarks

`gradp` will return a row for every row that is returned by `f`. For instance, if `f` returns a scalar result, then `gradp` will return a 1xK row vector. This allows the same function to be used regardless of N, where N is the number of rows in the result returned by `f`. Thus, for instance, `gradp` can be used to compute the Jacobian matrix of a set of equations.

Example

```plaintext
proc myfunc(x);
   retp(x .* 2 .* exp(x .* x ./ 3));
endp;

x0 = 2.5|3.0|3.5;
y = gradp(&myfunc,x0);
```

After the code above, `y` is equal to:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>82.989017</td>
<td>0.00000000</td>
<td>0.00000000</td>
</tr>
<tr>
<td>0.00000000</td>
<td>281.19753</td>
<td>0.00000000</td>
</tr>
<tr>
<td>0.00000000</td>
<td>0.00000000</td>
<td>1087.9541</td>
</tr>
</tbody>
</table>

It is a 3x3 matrix because we are passing it 3 arguments and `myfunc` returns 3 results when we do that; the off-diagonals are zeros because the cross-derivatives of 3 arguments are 0.

Source

`gradp.src`

See Also

`hessp`, `hesscplx`
graphprt

**Purpose**

Controls automatic printer hardcopy and conversion file output. Note: This function is for use with the deprecated PQG graphics. Use the `plotSave` function instead.

**Library**

pgraph

**Format**

`graphprt(str);`

**Input**

`str` string, control string.

**Portability**

UNIX

Not supported.

**Remarks**

`graphprt` is used to create hardcopy output automatically without user intervention. The input string `str` can have any of the following items, separated by spaces. If `str` is a null string, the interactive mode is entered. This is the default.
-p
print graph.

-po=c
set print orientation:
1 landscape.
 p portrait.

-c=n
convert to another file format:
1 Encapsulated PostScript file.
3 HPGL Plotter file.
5 BMP (Windows Bitmap).
8 WMF (Windows Enhanced Metafile).

-cf=name
set converted output file name.

-i
minimize (iconize) the graphics window.

-q
close window after processing.

-w=n
display graph, wait n seconds, then continue.

If you are not using graphic panels, you can call `graphprt` anytime before the call to the graphics routine. If you are using graphic panels, call `graphprt` just before the `endwind` statement.

The print option default values are obtained from the viewer application. Any parameters passed through `graphprt` will override the default values. See `Publication Quality Graphics`, Chapter 1.

**Example**

Automatic print using a single graphics call:
Automatic print using multiple graphic panels. Note `graphprt` is called once just before the `endwind` call:

```plaintext
library pgraph;
graphset;
load x,y;

graphprt("-p"); /* tell "xy" to print */
xy(x,y); /* create graph and print */
```

The next example shows how to build a string to be used with `graphprt`:

```plaintext
library pgraph;
graphset;
load x,y;

cvtnam = "mycvt.eps"; /* name of output file */
/* concatenate options into one string */

```
The above string `cmdstr` will read as follows:

```
"-c=1 -cf=mycvt.eps -q"
```

### Source

pgraph.src

### graphset

#### Purpose
Reset graphics global variables to default values. Note: This function is for use with the deprecated PQG graphics.

#### Library
pgraph

#### Format

```
graphset;
```

#### Remarks
This procedure is used to reset the defaults between graphs.
**graphset** may be called between each graphic panel to be displayed.

To change the default values of the global control variables, make the appropriate changes in the file *pgraph.dec* and to the procedure *graphset*.

**Source**

*pgraph.src*
hasimag

Purpose

Tests whether the imaginary part of a complex matrix is negligible.

Format

\[ y = \text{hasimag}(x); \]

Input

\( x \)  
N\times K matrix.

Output

\( y \)  
scalar, 1 if the imaginary part of \( x \) has any nonzero elements, 0 if it consists entirely of 0's.

Remarks

The function \texttt{iscplx} tests whether \( x \) is a complex matrix or not, but it does not test the contents of the imaginary part of \( x \). \texttt{hasimag} tests the contents of the imaginary part of \( x \) to see if it is zero.
hasimag actually tests the imaginary part of \( x \) against a tolerance to determine if it is negligible. The tolerance used is the imaginary tolerance set with the `sysstate` command, case 21.

Some functions are not defined for complex matrices. `iscplx` can be used to determine whether a matrix has no imaginary part and so can pass through those functions. `hasimag` can be used to determine whether a complex matrix has a negligible imaginary part and could thus be converted to a real matrix to pass through those functions.

`iscplx` is useful as a preliminary check because for large matrices it is much faster than `hasimag`.

**Example**

```plaintext
x = { 1 2 3i,
     4-i 5 6i,
     7 8i 9 };

if hasimag(x);
   //code path for complex case
else;
   //code path for real case
endif;
```

**See Also**

`iscplx`
header

Purpose

Prints a header for a report.

Format

header(prcnm, dataset, ver);

Input

prcnm  string, name of procedure that calls header.

dataset  string, name of data set.

ver  2x1 numeric vector, the first element is the major version number of the program, the second element is the revision number. Normally this argument will be the version/revision global (_??_ver) associated with the module within which header is called. This argument will be ignored if set to 0.

Global Input

__header  string, containing one or more of the following letters:

  t       title is to be printed

  l       lines are to bracket the title
Purpose
Prints a header for a report.

Format
`headermt(prcnnm, dataset, ver, header, title);`

Input
- `prcnnm` string, name of procedure that calls `header`.
- `dataset` string, name of data set.
- `ver` 2x1 numeric vector, the first element is the major version number of the program, the second element is the revision number. Normally this argument will be the version/revision...
global \(_{\text{?\_ver}}\) associated with the module within which header is called. This argument will be ignored if set to 0.

header

string, containing one or more of the following letters:

- \(t\) title is to be printed
- \(l\) lines are to bracket the title
- \(d\) a date and time is to be printed
- \(v\) version number of program is to be printed
- \(f\) file name being analyzed is to be printed

title

string, title for header.

Source

gaussmt.src

hess

Purpose

Computes the Hessenberg form of a square matrix.

Format

\[
\{ \ h, \ z \} = \text{hess}(x);
\]
**Input**

\[ x \]  
KxK matrix.

**Output**

\[ h \]  
KxK matrix, Hessenberg form.

\[ z \]  
KxK matrix, transformation matrix.

**Remarks**

**hess** computes the Hessenberg form of a square matrix. The Hessenberg form is an intermediate step in computing eigenvalues. It also is useful for solving certain matrix equations that occur in control theory (see Van Loan, Charles F. "Using the Hessenberg Decomposition in Control Theory". *Algorithms and Theory in Filtering and Control*. Sorenson, D.C. and R.J. Wets, eds., Mathematical Programming Study No. 18, North Holland, Amsterdam, 1982, 102-111).

\[ z \] is an orthogonal matrix that transforms \( x \) into \( h \) and vice versa. Thus:

\[
    h = z' \times x \times z
\]

and since \( z \) is orthogonal,

\[
    x = z \times h \times z'
\]

\( x \) is reduced to upper Hessenberg form using orthogonal similarity transformations. This preserves the Frobenious norm of the matrix and the condition numbers of the eigenvalues.

**hess** uses the ORTRAN and ORTHES functions from EISPACK.
Example

```plaintext
let x[3,3] = 1 2 3
    4 5 6
    7 8 9;

{ h, z } = hess(x);
```

See Also

schur

hessMT

Purpose

Computes numerical Hessian.

Include

optim.sdf

Format

```plaintext
h = hessMT(&fct, par1, data1);
```

Input

- `&fct`: scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar.
par1  an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.

data1  structure of type DS containing any data needed by fct.

Output

h  KxK matrix, Hessian.

Remarks

par1 must be created using the pvPack procedures.

Example

```c
#include optim.sdf
struct PV p1;
struct DS d0;

p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2, "P");
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc fct(struct PV p0, struct DS d0);
    local p,y;

    p = pvUnpack(p0, "P");
y = p[1] * exp( -p[2] * d0.dataMatrix);
    retp(y);
endp;
```
\[ h = \text{hessMT}(&fct,p1,d0); \]

**Source**

`hessmt.src`

**hessMTg**

**Purpose**

Computes numerical Hessian using gradient procedure.

**Include**

`optim.sdf`

**Format**

\[ h = \text{hessMTg}(&gfct,par1,data1); \]

**Input**

- `&gfct` scalar, pointer to procedure computing either 1xK gradient or NxK Jacobian.
- `par1` an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.
- `data1` structure of type DS containing any data needed by `gfct`. 
Output

$h$ KxK matrix, Hessian.

Remarks

`par1` must be created using the `pvPack` procedures.

Example

```c
#include optim.sdf
struct PV p1;
struct DS d0;
p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2, "P");
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc gfct(&fct, struct PV p0, struct DS d0);
  local p,y,g1,g2;

  p = pvUnpack(p0, "P");
g1 = exp(-p[2] * d0.dataMatrix);
y = p[1] * exp( -p[2] * d0.dataMatrix);
g2 = -p[1] * d0.dataMatrix .* g1;
  retp(g1~g2);
endp;

h = hessMTg(&gfct,p1,d0);
```

Source

hessmt.src
**hessMTgw**

**Purpose**
Computes numerical Hessian using gradient procedure with weights.

**Include**
optim.sdf

**Format**

\[ h = \text{hessMTgw}(&gfct, \text{par1}, \text{data1}, \text{wgts}); \]

**Input**
- **&gfct**: scalar, pointer to procedure computing either NxK Jacobian.
- **par1**: an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.
- **data1**: structure of type DS containing any data needed by &gfct.
- **wgts**: Nx1 vector.

**Output**
- **h**: KxK matrix, Hessian.
Remarks

par1 must be created using the pvPack procedures.

Example

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2, "P");
struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);
wgts = zeros(5,1) | ones(10,1);

proc gfct(&fct, struct PV p0, struct DS d0);
    local p,y,g1,g2;
    p = pvUnpack(p0, "P");
g1 = exp(-p[2] * d0.dataMatrix);
y = p[1] * exp(-p[2] * d0.dataMatrix);
g2 = -p[1] * d0.dataMatrix .* g1;
    retp(g1~g2);
endp;

h = hessMTgw(&gfct,p1,d0,wgts);
```

Source

hessmt.src
**hessMTm**

**Purpose**
Computes numerical Hessian with mask.

**Include**
optim.sdf

**Format**

\[ h = \text{hessMTm}(\&fct, \ par1, \ data1, \ mask); \]

**Input**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;fct</td>
<td>scalar, pointer to procedure returning either Nx1 vector or scalar.</td>
</tr>
<tr>
<td>\par1</td>
<td>an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.</td>
</tr>
<tr>
<td>data1</td>
<td>structure of type DS containing any data needed by \ fct.</td>
</tr>
<tr>
<td>mask</td>
<td>KxK matrix, elements in \ h corresponding to elements of mask set to zero are not computed, otherwise are computed.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\ h</td>
<td>KxK matrix, Hessian.</td>
</tr>
</tbody>
</table>
Remarks

_par1_ must be created using the _pvPack_ procedures. Only lower left part of mask looked at.

Example

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2, "P");
struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

mask = { 1 1,
       1 0 };

proc fct(struct PV p0, struct DS d0);
    local p,y;

    p = pvUnpack(p0, "P");
y = p[1] * exp(-p[2] * d0.dataMatrix);
    retp(y);
endp;

h = hessMTm(&fct,p1,d0,mask);
```

Source

hessmt.src
**hessMTmw**

**Purpose**

Computes numerical Hessian with mask and weights.

**Include**

optim.sdf

**Format**

\[ h = \text{hessMTmw}(\&fct, \text{parl}, \text{data1}, \text{mask}, \text{wgts}); \]

**Input**

- **&fct**
  scalar, pointer to procedure returning Nx1 vector.
- **parl**
  an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.
- **data1**
  structure of type DS containing any data needed by \( fct \).
- **mask**
  KxK matrix, elements in \( h \) corresponding to elements of mask set to zero are not computed, otherwise are computed.
- **wgts**
  Nx1 vector, weights.

**Output**

- **h**
  KxK matrix, Hessian.
Remarks

\( fct \) must evaluate to an \( Nx1 \) vector conformable to the weight vector. \( \text{par1} \) must be created using the \texttt{pvPack} procedures.

Example

```c
#include optim.sdf

struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1, 0.1|0.2, "P");
struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);
wgts = zeros(5,1) | ones(10,1);

mask = {
    1 1,
    1 0
};

proc fct(&fct, struct PV p0, struct DS d0, wgts);
    local p,y;

    p = pvUnpack(p0, "P");
    y = p[1] * exp(-p[2] * d0.dataMatrix);
    retp(y);
endp;

h = hessMTmw(&fct, p1, d0, mask, wgt);
```

Source

hessmt.src
**hessMTT**

**Purpose**

Computes numerical Hessian using available threads.

**Format**

```plaintext
h = hessMTT(&fct,par1,data1);
```

**Include**

optim.sdf

**Input**

- `fct` scalar, pointer to procedure returning either Nx1 vector or 1x1 scalar.
- `par1` structure of type PV containing parameter vector at which Hessian is to be evaluated
- `data1` structure of type DS containing any data needed by `fct`

**Output**

- `h` KxK matrix, Hessian

**Remarks**

`par1` must be created using the `pvPack` procedures
Example

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;

p1 = pvPack(p1, 0.1|0.2, "P");
struct DS d0;
d0 = dsCreate;

d0.dataMatrix = seqa(1,1,15);

proc fct(struct PV p0, struct DS d0);
    local p, y;
    p = pvUnpack(p0, "P");
    y = p[1] * exp( -p[2] * d0.dataMatrix);
    retp(y);
endp;

h = hessMTT(&fct, p1, d0);
```

Source

hessmtt.src

hessMTTg

Purpose

Computes numerical Hessian using gradient procedure with available threads.
Include
optim.sdf

Format

\[
\begin{align*}
    h &= \text{hessMTTg}(\&gfct, \ par1, \ data1); \\
\end{align*}
\]

Input

- \&gfct: scalar, pointer to procedure computing either 1xK gradient or NxK Jacobian
- par1: structure of type PV containing parameter vector at which Hessian is to be evaluated
- data1: structure of type DS containing any data needed by \( fct \)

Output

- \( h \): KxK matrix, Hessian

Remarks

\( par1 \) must be created using the \texttt{pvPack} procedures.

Example

\[
\begin{align*}
    \#include \ optim.sdf \\
\end{align*}
\]
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1,0.1|0.2, "P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);

proc gfct(&fct, struct PV p0, struct DS d0, wgt);
    local p,y,g1,g2;
    p = pvUnpack(p0, "P");
    g1 = exp(-p[2] * d0.dataMatrix);
    y = p[1] * exp(-p[2] * d0.dataMatrix);
    g2 = -p[1] * d0.dataMatrix .* g1;
    retp(g1~g2);
endp;

h = hessMTTg(&gfct,p1,d0);

Source
hessmtt.src

hessMTTgw

Purpose
Computes numerical Hessian using gradient procedure with weights and using available threads.

Include
optim.sdf
**Format**

\[ h = \text{hessMTTgw}(\&gfct, \ par1, \ data1, \ wgts); \]

**Input**

- **gfct**: scalar, pointer to procedure computing either 1xK gradient or NxK Jacobian
- **par1**: structure of type PV containing parameter vector at which Hessian is to be evaluated
- **data1**: structure of type DS containing any data needed by fct
- **wgts**: Nx1 vector, weights

**Output**

- **h**: KxK matrix, Hessian

**Remarks**

*par1* must be created using the *pvPack* procedures.

**Example**

```c
#include optim.sdf

struct PV p1;
p1 = pvCreate;
```
pl = pvPack(p1,0.1|0.2, "P");

struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);
wgts = zeros(5,1) | ones(10,1);

proc gfct(&fct, struct PV p0, struct DS d0);
    local p,y,g1,g2;
    p = pvUnpack(p0, "P");
    g1 = exp(-p[2] * d0.dataMatrix);
    y = p[1] * exp( -p[2] * d0.dataMatrix);
    g2 = -p[1] * d0.dataMatrix .* g1;
    retp(g1~g2);
endp;

h = hessMTTg(&gfct,p1,d0,wgts);

Source
hessmtt.src

hessMTTm

Purpose
Computes numerical Hessian with mask using available threads.

Include
optim.sdf
Format

\[ h = \text{hessMTTm}(\&fct, \text{par1}, \text{data1}, \text{mask}) \];

Input

- **fct**: scalar, pointer to procedure returning either \(N\times1\) vector or \(1\times1\) scalar.
- **par1**: structure of type PV containing parameter vector at which Hessian is to be evaluated.
- **data1**: structure of type DS containing any data needed by \(fct\).
- **mask**: \(K\times K\) matrix, elements in \(h\) corresponding to elements of mask set to zero are not computed otherwise are computed.

Output

- **h**: \(K\times K\) matrix, Hessian

Remarks

- **par1** must be created using the **pvPack** procedures. Only lower left part of mask looked at.

Example

```c
#include optim.sdf
struct PV p1;
```
p1 = pvCreate;
p1 = pvPack(p1, [0.1, 0.2], "P");
struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1, 1, 15);

mask = { 1 1
          1 0 };

proc fct(struct PV p0, struct DS d0);
    local p, y;
    p = pvUnpack(p0, "P");
    y = p[1] * exp(-p[2] * d0.dataMatrix);
    ret p(y);
endp;

h = hessMTTm(&fct, p1, d0, mask);

Source

hessmtt.src

hessMTw

Purpose

Computes numerical Hessian with weights.

Include

optim.sdf

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**Format**

\[
h = \text{hessMTw}(&fct, \ par1, \ data1, \ wgts);\]

**Input**

- **&fct**: scalar, pointer to procedure returning Nx1 vector.
- **par1**: an instance of structure of type PV containing parameter vector at which Hessian is to be evaluated.
- **data1**: structure of type DS containing any data needed by \( fct \).
- **wgts**: Nx1 vector, weights.

**Output**

- **h**: KxK matrix, Hessian.

**Remarks**

\( fct \) must evaluate to an Nx1 vector conformable to the weight vector. \( par1 \) must be created using the \texttt{pvPack} procedures.

**Example**

```c
#include optim.sdf
struct PV p1;
p1 = pvCreate;
p1 = pvPack(p1, 0.1|0.2, "P");
```
struct DS d0;
d0 = dsCreate;
d0.dataMatrix = seqa(1,1,15);
wgt = zeros(5,1) | ones(10,1);

proc fct(&fct, struct PV p0, struct DS d0, wgt);
    local p,y;
    p = pvUnpack(p0, "P");
    y = p[1] * exp( -p[2] * d0.dataMatrix);
    retp(y);
endp;

h = hessMTw(&fct,p1,d0,wgt);

Source

hessmt.src

hessp, hesscplx

Purpose

Computes the matrix of second partial derivatives (Hessian matrix) of a function defined as a procedure. hesscplx allows for complex arguments.

Format

\[ h = \text{hessp}(\&f, x0); \]
**Input**

- **&f**
  
  pointer to a single-valued function \( f(x) \), defined as a procedure, taking a single Kx1 vector argument \( f: Kx1 \to 1x1 \); \( f(x) \) may be defined in terms of global arguments in addition to \( x \).

- **x0**

  Kx1 vector specifying the point at which the Hessian of \( f(x) \) is to be computed.

**Output**

- **h**

  KxK matrix of second derivatives of \( f \) with respect to \( x \) at \( x0 \); this matrix will be symmetric.

**Remarks**

This procedure requires \( K*(K+1)/2 \) function evaluations. Thus if \( K \) is large, it may take a long time to compute the Hessian matrix.

No more than 3-4 digit accuracy should be expected from this function, though it is possible for greater accuracy to be achieved with some functions.

It is important that the function be properly scaled, in order to obtain greatest possible accuracy. Specifically, scale it so that the first derivatives are approximately the same size. If these derivatives differ by more than a factor of 100 or so, the results can be meaningless.

**Example**

\[
\begin{align*}
x & = \{ 1, 2, 3 \};
\end{align*}
\]
proc  g(b);
    retp( exp(x'b));
endp;

b0 = { 3, 2, 1 };

h = hessp(&g,b0);

The resulting matrix of second partial derivatives of \( g(b) \) evaluated at \( b=b0 \) is:

\[
\begin{pmatrix}
22026.865 & 44053.686 & 66080.596 \\
44053.686 & 88107.753 & 132161.059 \\
66080.596 & 132161.059 & 198240.695
\end{pmatrix}
\]

**Source**

hessp.src

**See Also**

gradp, gradcplx

**hist**

**Purpose**

Computes and graphs a frequency histogram for a vector. The actual frequencies are plotted for each category. Note: this function is for use with the deprecated PQG graphics. **plotHist** instead.

**Library**

pgraph
Format

\[ \{b, m, freq\} = \text{hist}(x, v); \]

Input

- \( x \) : Mx1 vector of data.
- \( v \) : Nx1 vector, the breakpoints to be used to compute the frequencies
  - or -
  scalar, the number of categories.

Output

- \( b \) : Px1 vector, the breakpoints used for each category.
- \( m \) : Px1 vector, the midpoints of each category.
- \( freq \) : Px1 vector of computed frequency counts.

Remarks

If a vector of breakpoints is specified, a final breakpoint equal to the maximum value of \( x \) will be added if the maximum breakpoint value is smaller.

If a number of categories is specified, the data will be divided into \( v \) evenly spaced categories.
Each time an element falls into one of the categories specified in $b$, the corresponding element of $freq$ will be incremented by one. The categories are interpreted as follows:

\[
\begin{align*}
& \quad \vdots \\
freq[P] &= b[P-1] < x < b[P]
\end{align*}
\]

**Example**

```plaintext
library pgraph;
\texttt{x = \textbf{rndn}(5000,1);}
\{ b,m,f \} = \textbf{hist}(x,20);
```

**Source**

phist.src

**See Also**

histp, histf, bar

**histf**

**Purpose**

Graphs a histogram given a vector of frequency counts. Note: This function is for use with the deprecated PQG graphics. Use `plotSetHistF` instead.
**Library**  
pgraph

**Format**

\[
\text{histf}(f, c);
\]

**Input**

- \( f \): Nx1 vector, frequencies to be graphed.
- \( c \): Nx1 vector, numeric labels for categories. If this is a scalar 0, a sequence from 1 to \( \text{rows}(f) \) will be created.

**Remarks**

The axes are not automatically labeled. Use \texttt{xlabel} for the category axis and \texttt{ylabel} for the frequency axis.

**Source**

phist.src

**See Also**

\texttt{hist, bar, xlabel, ylabel}
**histp**

**Purpose**
Computes and graphs a percent frequency histogram of a vector. The percentages in each category are plotted.

**Library**
pgraph

**Format**

\[
\{ b, m, \text{freq} \} = \text{histp}(x, v);
\]

**Input**

- **x**: Mx1 vector of data.
- **v**: Nx1 vector, the breakpoints to be used to compute the frequencies
  
  - or -

  scalar, the number of categories.

**Output**

- **b**: Px1 vector, the breakpoints used for each category.
- **m**: Px1 vector, the midpoints of each category.
- **freq**: Px1 vector of computed frequency counts. This is the vector...
of counts, not percentages.

**Remarks**

If a vector of breakpoints is specified, a final breakpoint equal to the maximum value of \( x \) will be added if the maximum breakpoint value is smaller.

If a number of categories is specified, the data will be divided into \( v \) evenly spaced categories.

Each time an element falls into one of the categories specified in \( b \), the corresponding element of \( freq \) will be incremented by one. The categories are interpreted as follows:

\[
\begin{align*}
. & . \\
. & . \\
freq[P] &= b[P-1] < x < b[P]
\end{align*}
\]

**Source**

phist.src

**See Also**

hist, histf, bar
hsec

Purpose

Returns the number of hundredths of a second since midnight.

Format

\[ y = \text{hsec}; \]

Output

\[ y \quad \text{scalar, hundredths of a second since midnight.} \]

Remarks

The number of hundredths of a second since midnight can also be accessed as the [4,1] element of the vector returned by the date function.

Example

```gauss
x = \text{rndu}(1000,1000);
tStart = \text{hsec};

y = x*x;
tTotal = \text{hsec-tEnd};
```

In this example, hsec is used to time a 1000x1000 multiplication in GAUSS. A 1000x1000 matrix, \( x \), is created, and the current time, in hundredths of a second since midnight, is stored in the variable \( tStart \). Then the multiplication is carried out.
Finally, $t_{Start}$ is subtracted from $h_{sec}$ to give the time difference which is assigned to $t_{Total}$.

**See Also**

date, time, timestr, ethsec, etstr
if, else, elseif

**Purpose**

Controls program flow with conditional branching.

**Format**

if scalar_expression;
   list of statements;
elseif scalar_expression;
   list of statements;
elseif scalar_expression;
   list of statements;
else;
   list of statements;
endif;

**Remarks**

*scalar_expression* is any expression that returns a scalar. It is TRUE if it is not zero, and FALSE if it is zero.

A *list of statements* is any set of GAUSS statements.
GAUSS will test the expression after the *if* statement. If it is TRUE (nonzero), then the first list of statements is executed. If it is FALSE (zero), then GAUSS will move to the expression after the first *elseif* statement, if there is one, and test it. It will keep testing expressions and will execute the first list of statements that corresponds to a TRUE expression. If no expression is TRUE, then the list of statements following the *else* statement is executed. After the appropriate list of statements is executed, the program will go to the statement following the *endif* and continue on.

*if* statements can be nested.

One *endif* is required per *if* statement. If an *else* statement is used, there may be only one per *if* statement. There may be as many *elseif*’s as are required. There need not be any *elseif*’s or any *else* statement within an *if* statement.

Note the semicolon after the *else* statement.

**Example**

```plaintext
if x < 0;
    y = -1;
elseif x > 0;
    y = 1;
else;
    y = 0;
endif;
```

**See Also**

*do*
**imag**

**Purpose**

Returns the imaginary part of x.

**Format**

\[ zi = \text{imag}(x); \]

**Input**

\( x \)  
N×K matrix or N-dimensional array.

**Output**

\( zi \)  
N×K matrix or N-dimensional array, the imaginary part of x.

**Remarks**

If \( x \) is real, \( zi \) will be an N×K matrix or N-dimensional array of zeros.

**Example**

\[
\begin{align*}
  x = \{ & 4i & 9 & 3, \\
          & 2 & 5-6i & 7i \}; \\
  y = \text{imag}(x);
\end{align*}
\]

\[
\begin{bmatrix}
  y = & 4 & 0 & 0 \\
       & 0 & -6 & 7
\end{bmatrix}
\]
# See Also

*complex, real*

---

## #include

### Purpose

Inserts code from another file into a GAUSS program.

### Format

```
#include filename
#include "filename"
```

### Remarks

*filename* can be any legitimate file name.

This command makes it possible to write a section of general-purpose code, and insert it into other programs.

The code from the #include'd file is inserted literally as if it were merged into that place in the program with a text editor.

If a path is specified for the file, then no additional searching will be attempted if the file is not found.

If a path is not specified, the current directory will be searched first, then each directory listed in src_path. src_path is defined in gauss.cfg.

```
#include /gauss/myprog.prc
```

No additional search will be made if the file is not found.
#include myprog.prc

The directories listed in src_path will be searched for myprog.prc if the file is not found in the current directory.

Compile time errors will return the line number and the name of the file in which they occur. For execution time errors, if a program is compiled with #lineson, the line number and name of the file where the error occurred will be printed. For files that have been #include'd this reflects the actual line number within the #include'd file. See #lineson for a more complete discussion of the use of and the validity of line numbers when debugging.

Example

```
#include "/gauss/inc/cond.inc"
```

The command will cause the code in the program cond.inc to be merged into the current program at the point at which this statement appears.

See Also

run, lineson

indcv

Purpose

Checks one character vector against another and returns the indices of the elements of the first vector in the second vector.
Format

\[ z = \text{indcv}(\text{what}, \text{where}); \]

Input

<table>
<thead>
<tr>
<th>what</th>
<th>Nx1 character vector which contains the elements to be found in vector where.</th>
</tr>
</thead>
<tbody>
<tr>
<td>where</td>
<td>Mx1 character vector to be searched for matches to the elements of what.</td>
</tr>
</tbody>
</table>

Output

| z       | Nx1 vector of integers containing the indices of the corresponding element of what in where. |

Remarks

If no matches are found for any of the elements in what, then the corresponding elements in the returned vector are set to the GAUSS missing value code.

Both arguments will be forced to uppercase before the comparison.

If there are duplicate elements in where, the index of the first match will be returned.

Example

```plaintext
let newVars = YEARS BONUS GENDER;
let what = AGE PAY SEX;
let where = AGE SEX JOB DATE PAY;
```
//Return the indices in 'where' of the items in 'what'

z = indcv(what, where);

//Replace AGE, PAY, SEX with YEARS, BONUS, GENDER

where[z] = newVars;

After the code above:

<table>
<thead>
<tr>
<th>YEARS</th>
<th>GENDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>where = JOB z = 5</td>
<td></td>
</tr>
<tr>
<td>DATE</td>
<td>2</td>
</tr>
<tr>
<td>BONUS</td>
<td></td>
</tr>
</tbody>
</table>

**See Also**

indnv, indsav

**indexcat**

**Purpose**

Returns the indices of the elements of a vector which fall into a specified category

**Format**

\[ y = \text{indexcat}(x, \text{range}); \]
**Input**

\( x \)  
N\( x \)x1 vector.

\( range \)  
scalar or 2x1 vector.

If scalar, the function returns the indices of all elements of \( x \) equal to \( range \).

If 2x1, then the function returns the indices of all elements of \( x \) that fall into the range:

\[
range[1] < x \leq range[2]
\]

If \( range \) is scalar, it can contain a single missing to specify the missing value as the category.

**Output**

\( y \)  
L\( x \)x1 vector, containing the indices of the elements of \( x \) which fall into the category defined by \( range \). It will contain error code 13 if there are no elements in this category.

**Remarks**

Use a loop to pull out indices of multiple categories.

**Example**

**Example 1**
Locate and extract the values that fall in a specified range:
Example 2

Return the indices of the elements of a vector that match a specific value:

```plaintext
x = [ 1.0, 4.0, 3.3, 4.2, 6.0, 5.7, 8.1, 5.5 ];
range = [ 4, 6 ];
indx = indexcat(x, range);

in_bounds = x[indx]
```

<table>
<thead>
<tr>
<th>Index</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.20</td>
</tr>
<tr>
<td>5</td>
<td>6.00</td>
</tr>
<tr>
<td>6</td>
<td>5.70</td>
</tr>
<tr>
<td>8</td>
<td>5.50</td>
</tr>
</tbody>
</table>

Example 3

If no matching values are found, `indexcat` will return a scalar error code. Error codes are a special type of missing value that can contain an integer error code. The return from `indexcat` can be checked with `isinfnanmiss` like this:

```plaintext
x = [ 1, 2, 3, 9, 10 ];
range = [ 5, 7 ];
indx = indexcat(x, range);

//Check to see if 'indexcat' found any matches
if isinfnanmiss(indx);
   print "no matching values found";
endif;
```
The integer value inside of an error code can be retrieved with the `scalerr` command. As stated earlier, if `indexcat` cannot find a match, it will return an error code that contains the value 13.

### indices

#### Purpose
 Processes a set of variable names or indices and returns a vector of variable names and a vector of indices.

#### Format

```
\{ \text{name}, \text{indx} \} = \text{indices}(\text{dataset}, \text{vars});
```

#### Input

<table>
<thead>
<tr>
<th>dataset</th>
<th>string, the name of the data set.</th>
</tr>
</thead>
<tbody>
<tr>
<td>vars</td>
<td>Nx1 vector, a character vector of names or a numeric vector of column indices. If scalar 0, all variables in the data set will be selected.</td>
</tr>
</tbody>
</table>

#### Output

| name | Nx1 character vector, the names associated with `vars`. |
|indx | Nx1 numeric vector, the column indices |
associated with \( \text{vars} \).

**Remarks**

If an error occurs, \( \text{indices} \) will either return a scalar error code or terminate the program with an error message, depending on the \( \text{trap} \) state. If the low order bit of the trap flag is 0, \( \text{indices} \) will terminate with an error message. If the low order bit of the trap flag is 1, \( \text{indices} \) will return an error code. The value of the trap flag can be tested with \text{trapchk}; the return from \( \text{indices} \) can be tested with \text{scalerr}.

You only need to check one argument; they will both be the same. The following error codes are possible:

1. Can't open dataset.
2. Index of variable out of range, or undefined data set variables.

**Source**

\text{indices.src}

**indices2**

**Purpose**

Processes two sets of variable names or indices from a single file. The first is a single variable and the second is a set of variables. The first must not occur in the second set and all must be in the file.
Format

\{name1, indx1, name2, indx2\} = indices2(dataset, var1, var2);

Input

dataset

string, the name of the data set.

var1

string or scalar, variable name or index.

This can be either the name of the variable, or the column index of the variable.

If null or 0, the last variable in the data set will be used.

var2

Nx1 vector, a character vector of names or a numeric vector of column indices.

If scalar 0, all variables in the data set except the one associated with var1 will be selected.

Output

name1

scalar character matrix containing the name of the variable associated with var1.

indx1

scalar, the column index of var1.

name2

Nx1 character vector, the names associated with var2.

indx2

Nx1 numeric vector, the column indices of var2.
Remarks

If an error occurs, `indices2` will either return a scalar error code or terminate the program with an error message, depending on the `trap` state. If the low order bit of the trap flag is 0, `indices2` will terminate with an error message. If the low order bit of the trap flag is 1, `indices2` will return an error code. The value of the trap flag can be tested with `trapchk`; the return from `indices2` can be tested with `scalerr`. You only need to check one argument; they will all be the same. The following error codes are possible:

1. Can't open dataset.
2. Index of variable out of range, or undefined data set variables.
3. First variable must be a single name or index.
4. First variable contained in second set.

Source

`indices2.src`

`indicesf`

Purpose

Processes a set of variable names or indices and returns a vector of variable names and a vector of indices.

Format

```
{ name, indx } = indicesf(fp, namein, indxin);
```
**Input**

\[ fp \]
 scalar, file handle of an open data set.

\[ namein \]
 Nx1 string array, names of selected columns in the data set. If set to a null string, columns are selected using \[ indxin \]

\[ indxin \]
 Nx1 vector, indices of selected columns in the data set. If set to 0, columns are selected using \[ namein \].

**Output**

\[ name \]
 Nx1 string array, the names of the selected columns.

\[ indx \]
 Nx1 vector, the indices of the selected columns.

**Remarks**

If \[ namein \] is a null string and \[ indxin \] is 0, all columns of the data set will be selected.

If an error occurs, \[ indx \] will be set to a scalar error code. The following error codes are possible:

1 Can't open data file

2 Variable not found

3 Indices outside of range of columns
Source
indices.src

See Also
indicesfn, indices

indicesfn

Purpose
Processes a set of variable names or indices and returns a vector of variable names and a vector of indices.

Format
\[
\{ \text{name}, \text{indx} \} = \text{indicesfn}(\text{dataset}, \text{namein}, \text{indxin});
\]

Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dataset</td>
<td>string, name of the data set.</td>
</tr>
<tr>
<td>namein</td>
<td>Nx1 string array, names of selected columns in the data set. If set to a null string, columns are selected using indxin</td>
</tr>
<tr>
<td>indxin</td>
<td>Nx1 vector, indices of selected columns in the data set. If set to 0, columns are selected using namein.</td>
</tr>
</tbody>
</table>
Output

name  Nx1 string array, the names of the selected columns.
indx  Nx1 vector, the indices of the selected columns.

Remarks

If namein is a null string and indxin is 0, all columns of the data set will be selected.

If an error occurs, indx will be set to a scalar error code. The following error codes are possible:

1  Can't open data file
2  Variable not found
3  Indices outside of range of columns

Source

indices.src

See Also

indicesf, indices
**indnv**

**Purpose**

Checks one numeric vector against another and returns the indices of the elements of the first vector in the second vector.

**Format**

\[ z = \text{indnv}(\text{what, where}); \]

**Input**

- **what**: Nx1 numeric vector which contains the values to be found in vector *where*.
- **where**: Mx1 numeric vector to be searched for matches to the values in *what*.

**Output**

- **z**: Nx1 vector of integers, the indices of the corresponding elements of *what* in *where*.

**Remarks**

If no matches are found for any of the elements in *what*, then those elements in the returned vector are set to the **GAUSS** missing value code.

If there are duplicate elements in *where*, the index of the first match will be returned.
### Example

```plaintext
what = { 8, 7, 3 };  
where = { 2, 7, 8, 4, 3 };  
z = indnv(what,where);  
```

```
3  
z = 2  
5  
```

### indsav

#### Purpose

Checks one string array against another and returns the indices of the first string array in the second string array.

#### Format

```plaintext
indx = indsav(what, where);  
```

#### Input

<table>
<thead>
<tr>
<th>what</th>
<th>Nx1 string array which contains the values to be found in vector where.</th>
</tr>
</thead>
<tbody>
<tr>
<td>where</td>
<td>Mx1 string array to be searched for the corresponding elements of what.</td>
</tr>
</tbody>
</table>
Output

\[ index \quad \text{Nx1 vector of indices, the values of } \text{what in where.} \]

Remarks

If no matches are found, those elements in the returned vector are set to the \textsc{Gauss} missing value code.

If there are duplicate elements in \text{where}, the index of the first match will be returned.

\textbf{intgrat2}

\textbf{Purpose}

Integrates the following double integral, using user-defined functions \( f \), \( g_1 \) and \( g_2 \) and scalars \( a \) and \( b \):

\[
\int_a^b \int_{g_2(x)}^{g_1(x)} f(x, y) \, dy \, dx
\]

\textbf{Format}

\[ y = \text{intgrat2}(&f, xl, g1); \]

\textbf{Input}

\[ &f \quad \text{scalar, pointer to the procedure containing the function to be integrated.} \]
** xl **

2x1 or 2xN matrix, the limits of \( x \). These must be scalar limits.

** gl **

2x1 or 2xN matrix of function pointers, the limits of \( y \).

For \( xl \) and \( gl \), the first row is the upper limit and the second row is the lower limit. N integrations are computed.

### Global Input

** _intord **

Scalar, the order of the integration. The larger \( _\text{intord} \), the more precise the final result will be. \( _\text{intord} \) may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.

Default = 12.

** _intrec **

Scalar. This variable is used to keep track of the level of recursion of \texttt{intgrat2} and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set \( _\text{intrec} \) explicitly to 0 before any call to \texttt{intgrat2}.

### Output

** \( y \)**

N\( x \)1 vector of the estimated integral(s) of \( f(x, y) \), evaluated between the limits given by \( xl \) and \( gl \).

### Remarks

The user-defined functions specified by \( f \) and \( gl \) must either
1. Return a scalar constant
   - or -
2. Return a vector of function values. \texttt{intgrat2} will pass to user-defined functions a vector or matrix for \textit{x} and \textit{y} and expect a vector or matrix to be returned. Use \texttt{.*} and \texttt{./} instead of \texttt{*} and \texttt{/}.

\textbf{Example}

\begin{verbatim}
proc f(x,y);
   retp(cos(x) + 1).*(sin(y) + 1));
endp;

proc g1(x);
   retp(sqrt(1-x^2));
endp;

proc g2(x);
   retp(0);
endp;

xl = 1|-1;
g0 = &g1||g2;
_intord = 40;
_intrec = 0;
y = intgrat2(&f,xl,g0);
\end{verbatim}

This will integrate the function

\[ f(x,y) = (\cos(x)+1)(\sin(y)+1) \]

over the upper half of the unit circle. Note the use of the \texttt{.*} operator instead of just \texttt{*} in the definition of \( f(x,y) \). This allows \( f \) to return a vector or matrix of function values.
Source
intgrat.src

Globals
_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec

See Also
intgrat3, intquad1, intquad2, intquad3, intsimp

intgrat3

Purpose
Integrates the following triple integral, using user-defined functions and scalars for bounds:

\[ \int_{a}^{b} \int_{g_{2}(x)}^{h_{2}(x,y)} \int_{g_{1}(x)}^{h_{1}(x,y)} f(x, y, z) dzdydx \]

Format

\[ y = \text{intgrat3}(&f, x1, g1, h1); \]

Input

&f scalar, pointer to the procedure containing the function to be integrated. f is a function of (x, y, z).
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_l$</td>
<td>2x1 or 2xN matrix, the limits of $x$. These must be scalar limits.</td>
</tr>
<tr>
<td>$g_l$</td>
<td>2x1 or 2xN matrix of function pointers. These procedures are functions of $x$.</td>
</tr>
<tr>
<td>$h_l$</td>
<td>2x1 or 2xN matrix of function pointers. These procedures are functions of $x$ and $y$.</td>
</tr>
</tbody>
</table>

For $x_l$, $g_l$, and $h_l$, the first row is the upper limit and the second row is the lower limit. N integrations are computed.

**Global Input**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_intord</td>
<td>scalar, the order of the integration. The larger _intord, the more precise the final result will be. _intord may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.</td>
</tr>
</tbody>
</table>

Default = 12.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_intrec</td>
<td>scalar. This variable is used to keep track of the level of recursion of intgrat3 and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set _intrec explicitly to 0 before any call to intgrat3.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>Nx1 vector of the estimated integral(s) of $f(x,y,z)$ evaluated between the limits given by $x_l$, $g_l$ and $h_l$.</td>
</tr>
</tbody>
</table>
Remarks

User-defined functions $f$, and those used in $gl$ and $hl$ must either:

1. Return a scalar constant
   - or -

2. Return a vector of function values. intgrat3 will pass to user-defined functions a vector or matrix for $x$ and $y$ and expect a vector or matrix to be returned. Use .* and ./ operators instead of just * and /.

Example

```plaintext
proc f(x,y,z);
  retp(2);
endp;

proc gl(x);
  retp(sqrt(25-x^2));
endp;

proc g2(x);
  retp(-g1(x));
endp;

proc h1(x,y);
  retp(sqrt(25 - x^2 - y^2));
endp;

proc h2(x,y);
  retp(-h1(x,y));
endp;

xl = 5|-5;
```
g0 = &g1|&g2;
h0 = &h1|&h2;

_intrec = 0;
_intord = 40;

y = intgrat3(&f,x1,g0,h0);

This will integrate the function f(x,y,z) over the sphere of radius 5. The result will be approximately twice the volume of a sphere of radius 5.

Source
intgrat.src

Globals
_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8, _intrec

See Also
intgrat2, intquad1, intquad2, intquad3, intsmp

inthp1

Purpose

Integrates a user-defined function over an infinite interval.

Include

inthp.sdf
**Format**

\[ y = \text{inthp1}(\&f, \ pds, \ ctl); \]

**Input**

<table>
<thead>
<tr>
<th>&amp;f</th>
<th>scalar, pointer to the procedure containing the function to be integrated.</th>
</tr>
</thead>
<tbody>
<tr>
<td>\pds</td>
<td>scalar, pointer to instance of a <strong>DS</strong> structure. The members of the <strong>DS</strong> are:</td>
</tr>
<tr>
<td>\pds-&gt;dataMatrix</td>
<td>NxK matrix.</td>
</tr>
<tr>
<td>\pds-&gt;dataArray</td>
<td>NxKxL... array.</td>
</tr>
<tr>
<td>\pds-&gt;vnames</td>
<td>string array.</td>
</tr>
<tr>
<td>\pds-&gt;dsname</td>
<td>string.</td>
</tr>
<tr>
<td>\pds-&gt;type</td>
<td>scalar.</td>
</tr>
<tr>
<td><strong>ctl</strong></td>
<td>instance of an <strong>inthpControl</strong> structure with members</td>
</tr>
<tr>
<td>\ctl.maxEvaluations</td>
<td>scalar, maximum number of function evaluations, default = 1e5;</td>
</tr>
<tr>
<td>\ctl.p</td>
<td>scalar, termination parameter</td>
</tr>
<tr>
<td>0</td>
<td>heuristic termination, default.</td>
</tr>
<tr>
<td>1</td>
<td>deterministic</td>
</tr>
</tbody>
</table>

The contents, if any, are set by the user and are passed by **inthp1** to the user-provided function without modification.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ctl.d</code></td>
<td>scalar termination parameter</td>
</tr>
<tr>
<td></td>
<td>1 if heuristic termination</td>
</tr>
<tr>
<td></td>
<td>$0 &lt; ctl.d &lt; \pi/2$ if deterministic termination</td>
</tr>
<tr>
<td><code>ctl.eps</code></td>
<td>scalar, relative error bound. Default = 1e-6.</td>
</tr>
</tbody>
</table>

A default `ctl` can be generated by calling `inthpControlCreate`.

**Output**

| `y`         | scalar, the estimated integral of $f(x)$ evaluated over the interval $(-\infty, +\infty)$. |

**Remarks**

The user-provided function must have the following format

```c
f(struct DS *pds, x)
```

where
The pointer to the instance of the data structure, `pds`, is passed untouched to the user-provided procedure computing the function to be integrated. Any information needed by that function can be put into that data structure.

**Example**

```c
#include inthp.sdf

proc fct(struct DS *pds, x);
local var;
    var = pds->dataMatrix;
retp( exp( -(x*x) / (2*var) ));
endp;

struct DS d0;
struct DS *pds;
variance = 3;
pds = &d0;
d0.dataMatrix = variance;

struct inthpControl c0;
c0 = inthpControlCreate;

r = inthpl(&fct,pds,c0);

format /ld 16,10;
print r;
```


```c
print sqrt(2*pi*variance);
```

results in the following output:

```
4.3416075273
4.3416075273
```

### References


### Source

inhp.src

### See Also

inhpControlCreate, inhp2, inhp3, inhp4

### inthp2

#### Purpose

Integrates a user-defined function over the \([a, +\infty)\) interval.

#### Include

inhp.sdf

#### Format

```c
y = inthp2(&f, pd, ctl, a);
```
**Input**

&\texttt{f} \\
**scalar**, pointer to the procedure containing the function to be integrated.

\texttt{pds} \\
**scalar**, pointer to instance of a \texttt{DS} structure. The members of the \texttt{DS} are:

\begin{itemize}
  \item \texttt{pds->dataMatrix} \texttt{NxK matrix}.
  \item \texttt{pds->dataArray} \texttt{NxKxL... array}.
  \item \texttt{pds->vnames} \texttt{string array}.
  \item \texttt{pds->dsname} \texttt{string}.
  \item \texttt{pds->type} \texttt{scalar}.
\end{itemize}

The contents, if any, are set by the user and are passed by \texttt{inthp1} to the user-provided function without modification.

\texttt{ctl} \\
instance of an \texttt{inthpControl} structure with members

\begin{itemize}
  \item \texttt{ctl.maxEvaluations} \texttt{scalar}, maximum number of function evaluations, default = 1e5;
  \item \texttt{ctl.p} \texttt{scalar}, termination parameter
\end{itemize}

\begin{itemize}
  \item 0 \texttt{heuristic termination, default}.
  \item 1 \texttt{deterministic termination with infinity norm}.
  \item 2,... \texttt{deterministic termination with p-}
\end{itemize}
\( ctl.d \) scalar termination parameter

1 if heuristic termination

0 < \( ctl.d < \pi/2 \) if deterministic termination

\( ctl.e \) scalar, relative error bound. Default = 1e-6.

A default \( ctl \) can be generated by calling \texttt{inthpControlCreate}.

\( a \) 1xN vector, lower limits of integration.

**Output**

\( y \) \( \text{Nx1 vector, the estimated integrals of } \mathbf{f}(x) \text{ evaluated over the interval } [a, +\infty). \)

**Remarks**

The user-provided function must have the following format

\[
f(\text{struct DS *pds, x})
\]

where

\( pds \) scalar, pointer to an instance of a \texttt{DS} structure.

\( x \) scalar, value at which integral will be evaluated.
If \(ctl.d\) can be specified (see Sikorski and Stenger, 1984), deterministic termination can be specified and accuracy guaranteed. If not, the heuristic method can be used and the value of \(ctl.d\) is disregarded.

The pointer to the instance of the data structure, \(pds\), is passed untouched to the user-provided procedure computing the function to be integrated. Any information needed by that function can be put into that data structure.

**Example**

```c
#include inthp.sdf

proc normal(struct DS *pd0, x);
    local var;
    var = pd0->dataMatrix;
    retp( (1/sqrt(2*pi*var))*exp( -(x*x) / (2*var) ) );
endp;

struct DS d0;
struct DS *pd0;

pd0 = &d0;

struct inthpControl c0;
c0 = inthpControlCreate;

lim = 2;

c0.d = pi/4;
c0.p = 2;

var = 1;
d0.dataMatrix = var;
```
\[
\begin{align*}
  r &= \text{inthp2}(&\text{normal}, \text{pd}0, \text{c}0, \text{lim}); \\
  \text{format } /\text{l}d 16,10; \\
  \text{print } r; \\
  \text{print } \text{cdfnc}(2);
\end{align*}
\]

produces the following output:

\[
\begin{align*}
  0.0227501281 \\
  0.0227501319
\end{align*}
\]

References


Source

inthp.src

See Also

\text{inthpControlCreate}, \text{inthp1}, \text{inthp3}, \text{inthp4}

inthp3

Purpose

Integrates a user-defined function over the \([a, +\infty)\) interval that is oscillatory.

Include

inthp.sdf
## Format

\[ y = \text{inthp3}(\&f, \ pds, \ ctl, \ a); \]

## Input

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;f</td>
<td>scalar, pointer to the procedure containing the function to be integrated.</td>
</tr>
<tr>
<td>pds</td>
<td>scalar, pointer to instance of a DS structure. The members of the DS are:</td>
</tr>
<tr>
<td></td>
<td>( pds-&gt;dataMatrix ): N(x)K matrix.</td>
</tr>
<tr>
<td></td>
<td>( pds-&gt;dataArray ): N(x)KxL... array.</td>
</tr>
<tr>
<td></td>
<td>( pds-&gt;vnames ): string array.</td>
</tr>
<tr>
<td></td>
<td>( pds-&gt;dsname ): string.</td>
</tr>
<tr>
<td></td>
<td>( pds-&gt;type ): scalar.</td>
</tr>
</tbody>
</table>

The contents, if any, are set by the user and are passed by \texttt{inthp1} to the user-provided function without modification.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctl</td>
<td>instance of an \texttt{inthpControl} structure with members</td>
</tr>
<tr>
<td></td>
<td>( ctl.maxEvaluations ): scalar, maximum number of function evaluations, default = 1e5;</td>
</tr>
<tr>
<td></td>
<td>( ctl.p ): scalar, termination parameter</td>
</tr>
<tr>
<td></td>
<td>0: heuristic termination, default.</td>
</tr>
<tr>
<td></td>
<td>1: deterministic termination with</td>
</tr>
</tbody>
</table>
infinity norm.
2,... deterministic termination with p-th norm.

$ctl.d$ scalar termination parameter

1 if heuristic termination

$0 < ctl.d < \pi/2$ if deterministic termination

$ctl.eps$ scalar, relative error bound. Default = 1e-6.

A default $ctl$ can be generated by calling `inthpControlCreate`.

$a$ 1xN vector, lower limits of integration.

**Output**

$y$ Nx1 vector, the estimated integrals of $f(x)$ evaluated over the interval $[a, +\infty)$.

**Remarks**

This procedure is designed especially for oscillatory functions.

The user-provided function must have the following format
\[ f(\text{struct DS } *\text{pds}, \ x) \]

where

\textit{pds} \quad \text{scalar, pointer to an instance of a DS structure.}

\textit{x} \quad \text{scalar, value at which integral will be evaluated.}

If \textit{ctl.d} can be specified (see Sikorski and Stenger, 1984), deterministic termination can be specified and accuracy guaranteed. If not, the heuristic method can be used and the value of \textit{ctl.d} is disregarded.

The pointer to the instance of the data structure, \textit{pds}, is passed untouched to the user-provided procedure computing the function to be integrated. Any information needed by that function can be put into that data structure.

**Example**

```c
#include inthp.sdf

proc fct(struct DS *pd0, x);
   local m, a;
   m = pd0->dataMatrix[1];
   a = pd0->dataMatrix[2];
   retp( exp(-a*x)*cos(m*x));
endp;

struct DS d0;
struct DS *pd0;

struct inthpControl c0;
c0 = inthpControlCreate;
```
c0.p = 2;
c0.d = pi/3;

m = 2;
a = 1;
pd0 = &d0;
d0.dataMatrix = m | a;

lim = 0;

r = intph3(&fct,pd0,c0,lim);

format /ld 16,10;
print r;
print a/(a*a + m*m);

produces the following output:

0.2000000000
0.2000000000

References


Source

inthp.src

See Also

inthpControlCreate, inthp1, inthp2, inthp4
**inthp4**

**Purpose**

Integrates a user-defined function over the \([a, b]\) interval.

**Include**

inthp.sdf

**Format**

\[ y = \text{inthp4}(&f, pds, ctl, c); \]

**Input**

- **&f**
  scalar, pointer to the procedure containing the function to be integrated.

- **pds**
  scalar, pointer to instance of a DS structure. The members of the DS are:

  - **pds->dataMatrix**
    NxK matrix.
  - **pds->dataArray**
    NxKxL... array.
  - **pds->vnames**
    string array.
  - **pds->dsname**
    string.
  - **pds->type**
    scalar.

  The contents, if any, are set by the user and are passed by inthp1 to the user-provided function without modification.
**ctl**

instance of an **inthpControl** structure with members

- **ctl.maxEvaluations**
  scalar, maximum number of function evaluations, default = 1e5;

- **ctl.p**
  scalar, termination parameter
  
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>heuristic termination, default.</td>
</tr>
<tr>
<td>1</td>
<td>deterministic termination with infinity norm.</td>
</tr>
<tr>
<td>2,...</td>
<td>deterministic termination with p-th norm.</td>
</tr>
</tbody>
</table>

- **ctl.d**
  scalar termination parameter
  
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>if heuristic termination</td>
</tr>
<tr>
<td>0 &lt; ctl.d &lt; π/2</td>
<td>if deterministic termination</td>
</tr>
</tbody>
</table>

- **ctl.eps**
  scalar, relative error bound. Default = 1e-6.

A default **ctl** can be generated by calling **inthpControlCreate**.

**c**

2×N vector, upper and lower limits of integration, the first row contains upper limits and the second row the lower.

### Output

**y**

N×1 vector, the estimated integrals of \( f(x) \) evaluated over the interval \([a, b]\).
Remarks

The user-provided function must have the following format

\[ f(\text{struct DS } \ast pds, x) \]

where

- \( pds \) is scalar, pointer to an instance of a DS structure.
- \( x \) is scalar, value at which integral will be evaluated.

If \( ctl.d \) can be specified (see Sikorski and Stenger, 1984), deterministic termination can be specified and accuracy guaranteed. If not, the heuristic method can be used and the value of \( ctl.d \) is disregarded.

The pointer to the instance of the data structure, \( pds \), is passed untouched to the user-provided procedure computing the function to be integrated. Any information needed by that function can be put into that data structure.

Example

```c
#include inthp.sdf

proc fct(struct DS *pd0, x);
    local a, b, c;
    a = pd0->dataMatrix[1];
    b = pd0->dataMatrix[2];
    c = pd0->dataMatrix[3];
    retp( 1/sqrt(a*x*x + b*x + c));
endp;

struct DS d0;
struct DS *pd0;
```
```c
struct inthpControl c0;
c0 = inthpControlCreate;

c0.p = 2;
c0.d = pi/2;

a = -1;
b = -2;
c = 3;
pd0 = &d0;
d0.dataMatrix = a|b|c;

lim = 1 | -1;

r = inthp4(&fct,pd0,c0,lim);

format /ld 16,10;
print r;
print pi/2;
```

produces the following output:

```
1.5707962283
1.5707963268
```

**References**


**Source**

inthp.src
See Also

inthpControlCreate, inthp1, inthp2, inthp3

inthpControlCreate

Purpose

Creates default inthpControl structure.

Include

inthp.sdf

Format

\[ c = \text{inthpControlCreate}(); \]

Output

\[ c \]
instance of inthpControl structure with members set to default values.

Source

inthp.src

See Also

inthp1, inthp2, inthp3, inthp4
intquad1

Purpose

Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.

Format

\[ y = \text{intquad1}(\&f, \ xl); \]

Input

\&f  
scalar, pointer to the procedure containing the function to be integrated. This must be a function of \( x \).

\( xl \)  
2xN matrix, the limits of \( x \).

The first row is the upper limit and the second row is the lower limit. N integrations are computed.

Global Input

\_intord  
scalar, the order of the integration. The larger \_intord, the more precise the final result will be. \_intord may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.

Default = 12.
Output

\[ y \quad \text{Nx1 vector of the estimated integral(s) of } f(x) \text{ evaluated between the limits given by } x_l. \]

Remarks

The user-defined function \( f \) must return a vector of function values. \texttt{intquadl} will pass to the user-defined function a vector or matrix for \( x \) and expect a vector or matrix to be returned. Use the \( .* \) and \( ./ \) instead of \( * \) and \( / \).

Example

```plaintext
proc f(x);
    retp (x.*sin(x));
endp;

xl = 1|0;
y = intquad1(&f,xl);
```

This will integrate the function \( f(x) = x*sin(x) \) between 0 and 1. Note the use of the \( .* \) instead of \( * \).

Source

integral.src

Globals

_intord, _intq12, _intq16, _intq2, _intq20, _intq24, _intq3, _intq32, _intq4, _intq40, _intq6, _intq8
See Also
intsimp, intquad2, intquad3, intgrat2, intgrat3

intquad2

Purpose
Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.

Format

\[ y = \text{intquad2}(&f, \ x_l, \ y_l); \]

Input

- \( &f \): scalar, pointer to the procedure containing the function to be integrated.
- \( x_l \): 2x1 or 2xN matrix, the limits of \( x \).
- \( y_l \): 2x1 or 2xN matrix, the limits of \( y \).

For \( x_l \) and \( y_l \), the first row is the upper limit and the second row is the lower limit. \( N \) integrations are computed.

Global Input

- \( \_\text{intord} \): scalar, the order of the integration. The larger \( \_\text{intord} \), the more precise the final result will be. \( \_\text{intord} \) may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.
Default = 12.

\_intrec

scalar. This variable is used to keep track of the level of recursion of intquad2 and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set \_intrec explicitly to 0 before any calls to intquad2.

Output

\(y\)

N\(x1\) vector of the estimated integral(s) of \(f(x,y)\) evaluated between the limits given by \(xl\) and \(yl\).

Remarks

The user-defined function \(f\) must return a vector of function values. intquad2 will pass to user-defined functions a vector or matrix for \(x\) and \(y\) and expect a vector or matrix to be returned. Use \(.*\) and \(./\) instead of \(*\) and \(/\).

intquad2 will expand scalars to the appropriate size. This means that functions can be defined to return a scalar constant. If users write their functions incorrectly (using \(*\) instead of \(.*\), for example), intquad2 may not compute the expected integral, but the integral of a constant function.

To integrate over a region which is bounded by functions, rather than just scalars, use intgrat2 or intgrat3.

Example

```
proc f(x,y);
  retp(x.*sin(x+y));
endp;
```
This will integrate the function:

\[ f(x) = x \cdot \sin(x+y) \]

between \( x = 0 \) and \( 1 \), and between \( y = 0 \) and \( 1 \).

**Source**

integral.src

**Globals**

\_intord, \_intq12, \_intq16, \_intq2, \_intq20, \_intq24, \_intq3, \_intq32, \_intq4, \_intq40, \_intq6, \_intq8, \_intrec

**See Also**

intquad1, intquad3, intsmp, intgrat2, intgrat3

**intquad3**

**Purpose**

Integrates a specified function using Gauss-Legendre quadrature. A suite of upper and lower bounds may be calculated in one procedure call.
Format

\[ y = \text{intquad3}(&f, \ xl, \ yl, \ zl); \]

**Input**

- \( &f \) scalar, pointer to the procedure containing the function to be integrated. \( f \) is a function of \((x, y, z)\).
- \( xl \) 2x1 or 2xN matrix, the limits of \( x \).
- \( yl \) 2x1 or 2xN matrix, the limits of \( y \).
- \( zl \) 2x1 or 2xN matrix, the limits of \( z \).

For \( xl, yl, \) and \( zl \), the first row is the upper limit and the second row is the lower limit. \( N \) integrations are computed.

**Global Input**

- \( _\text{intord} \) scalar, the order of the integration. The larger \( _\text{intord} \), the more precise the final result will be. \( _\text{intord} \) may be set to 2, 3, 4, 6, 8, 12, 16, 20, 24, 32, 40.
  
  Default = 12.

- \( _\text{intrec} \) scalar. This variable is used to keep track of the level of recursion of \text{intquad3} and may start out with a different value if your program terminated inside of the integration function on a previous run. Always set \( _\text{intrec} \) explicitly to 0 before any calls to \text{intquad3}. 
Output

\[
Y \quad \text{Nx1 vector of the estimated integral(s) of } f(x,y,z) \text{ evaluated between the limits given by } x_l, y_l, \text{ and } z_l.
\]

Remarks

The user-defined function \( f \) must return a vector of function values. \texttt{intquad3} will pass to the user-defined function a vector or matrix for \( x, y \text{ and } z \) and expect a vector or matrix to be returned. Use \( .* \text{ and } ./ \) instead of \( * \text{ and } / \).

\texttt{intquad3} will expand scalars to the appropriate size. This means that functions can be defined to return a scalar constant. If users write their functions incorrectly (using \( * \) instead of \( .* \), for example), \texttt{intquad3} may not compute the expected integral, but the integral of a constant function.

To integrate over a region which is bounded by functions, rather than just scalars, use \texttt{intgrat2} or \texttt{intgrat3}.

Example

```plaintext
proc f(x,y,z);
  retp(x.*y.*z);
endp;

xl = 1|0;
yl = 1|0;
zl = { 1 2 3, 0 0 0 };
_intrec = 0;

y = intquad3(&f,xl,yl,zl);
```

38-787
This will integrate the function \( f(x) = x^*y*z \) over 3 sets of limits, since \( z_1 \) is defined to be a 2x3 matrix.

**Source**

integral.src

**Globals**

\_intord, \_intq12, \_intq16, \_intq2, \_intq20, \_intq24, \_intq3, \_intq32, \_intq4, \_intq40, \_intq6, \_intq8, \_intrec

**See Also**

intquad1, intquad2, intsimp, intgrat2, intgrat3

**intrleav**

**Purpose**

Interleaves the rows of two files that have been sorted on a common variable to produce a single file sorted on that variable.

**Format**

\[ \texttt{intrleav(infile1, infile2, outfile, keyvar, keytyp);} \]

**Input**

- **infile1**  
  string, name of input file 1.

- **infile2**  
  string, name of input file 2.
###(outfile)

String, name of output file.

###(keyvar)

String, name of key variable; this is the column the files are sorted on.

###(keytyp)

Scalar, data type of key variable.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Numeric key, ascending order</td>
</tr>
<tr>
<td>2</td>
<td>Character key, ascending order</td>
</tr>
<tr>
<td>-1</td>
<td>Numeric key, descending order</td>
</tr>
<tr>
<td>-2</td>
<td>Character key, descending order</td>
</tr>
</tbody>
</table>

###Remarks

The two files MUST have exactly the same variables, that is, the same number of columns AND the same variable names. They must both already be sorted on the key column. This procedure will combine them into one large file, sorted by the key variable.

If the inputs are null ("" or 0), the procedure will ask for them.

###Source

sortd.src

###See Also

intrleavsa
**intrleavsa**

**Purpose**

Interleaves the rows of two string arrays that have been sorted on a common column.

**Format**

\[ y = \text{intrleavsa}(sa1, sa2, ikey); \]

**Input**

- **sal**  
  N\times K string array 1.

- **sa2**  
  M\times K string array 2.

- **ikey**  
  Scalar integer, index of the key column the string arrays are sorted on.

**Output**

- **y**  
  L\times K interleaved (combined) string array.

**Remarks**

The two string arrays MUST have exactly the same number of columns AND have been already sorted on a key column.

This procedure will combine them into one large string array, sorted by the key column.
**Source**
sortd.src

**See Also**
intrleav

**intrsect**

**Purpose**
Returns the intersection of two vectors, with duplicates removed.

**Format**

\[ y = \text{intrsect}(v1, v2, \text{flag}); \]

**Input**

| v1        | Nx1 vector. |
| v2        | Mx1 vector. |
| flag      | scalar, if 1, \( v1 \) and \( v2 \) are numeric; if 0, character. |

**Output**

| y          | Lx1 vector containing all unique values that are in both \( v1 \) and \( v2 \), sorted in ascending order. |
Remarks

Place smaller vector first for fastest operation.

If there are a lot of duplicates within a vector, it is faster to remove them with the function \texttt{unique} before calling \texttt{intrsect}.

Source

\texttt{intrsect.src}

Example

\begin{verbatim}
v1 = { 3, 9, 5, 2, 10, 15 };v2 = { 4, 9, 8, 5, 12, 3, 1 };y = \texttt{intrsect(v1,v2,1)};
\end{verbatim}

Assigns the values that are contained in both input vectors to \textit{y}:

\begin{verbatim}
3
y = 5
9
\end{verbatim}

See Also

\texttt{intrsects}\texttt{a}

\texttt{intrsects}\texttt{a}

Purpose

Returns the intersection of two string vectors, with duplicates removed.
**Format**

\[ y = \text{intrsectsa}(sv1, sv2); \]

**Input**

<table>
<thead>
<tr>
<th>sv1</th>
<th>Nx1 or 1xN string vector.</th>
</tr>
</thead>
<tbody>
<tr>
<td>sv2</td>
<td>Mx1 or 1xM string vector.</td>
</tr>
</tbody>
</table>

**Output**

| sy        | Lx1 vector containing all unique strings that are in both sv1 and sv2, sorted in ascending order. |

**Remarks**

Place smaller vector first for fastest operation.

If there are a lot of duplicates it is faster to remove them with unique before calling intrsectsa.

**Example**

```plaintext
string sv1 = { "age", "weight", "bmi" };
string sv2 = { "hdl", "ldl", "age", "bmi", "smoking" };

sy = intrsectsa(sv1,sv2);
print "Both studies reported the following variables:";
print sy;
```
The code above, returns:

Both studies reported the following variables:

age       bmi

Source
intrsect.src

See Also
intrsect

intsimp

Purpose

Integrates a specified function using Simpson's method with end correction. A single integral is computed in one function call.

Format

\[ y = \text{intsimp}(&f, \ x_l, \ tol); \]

Input

\&f pointer to the procedure containing the function to be integrated.

xl 2x1 vector, the limits of \( x \).

The first element is the upper limit and the second element is the lower limit.
**tol**

The tolerance to be used in testing for convergence.

**Output**

| y | The estimated integral of $f(x)$ between $x_1[1]$ and $x_1[2]$. |

**Example**

```plaintext
proc f(x);
    retp(sin(x));
endp;

let xl = { 1, 0 };

y = intsimp(&f,xl,1e-8);
print y;
```

The code above, returns the following:

0.45969769

This will integrate the function between 0 and 1.

**Source**

intsimp.src

**See Also**

intquad1, intquad2, intquad3, intgrat2, intgrat3
inv, invpd

Purpose

inv returns the inverse of an invertible matrix. invpd returns the inverse of a symmetric, positive definite matrix.

Format

\[
y = \text{inv}(x);
\]
\[
y = \text{invpd}(x);
\]

Input

\(x\) \hspace{1cm} \text{NxN matrix or K-dimensional array where the last two dimensions are NxN.}

Output

\(y\) \hspace{1cm} \text{NxN matrix or K-dimensional array where the last two dimensions are NxN, containing the inverse of } x.

Remarks

\(x\) can be any legitimate expression that returns a matrix or array that is legal for the function.

If \(x\) is an array, the result will be an array containing the inverses of each 2-dimensional array described by the two trailing dimensions of \(x\). In other words, for a
10x4x4 array, the result will be an array of the same size containing the inverses of each of the 10 4x4 arrays contained in \( x \).

For \( \text{inv} \), if \( x \) is a matrix, it must be square and invertible. Otherwise, if \( x \) is an array, the 2-dimensional arrays described by the last two dimensions of \( x \) must be square and invertible.

For \( \text{invpd} \), if \( x \) is a matrix, it must be symmetric and positive definite. Otherwise, if \( x \) is an array, the 2-dimensional arrays described by the last two dimensions of \( x \) must be symmetric and positive definite.

If the input matrix is not invertible by these functions, they will either terminate the program with an error message or return an error code which can be tested for with the \( \text{scalerr} \) function. This depends on the \( \text{trap} \) state as follows:

If \( \text{trap} \) is set to 1, they will return a scalar errorcode:

\[
\begin{array}{cc}
\text{inv} & \text{invpd} \\
50 & 20
\end{array}
\]

If \( \text{trap} \) is set to 0, they will terminate with an error message:

\[
\begin{array}{cc}
\text{inv} & \text{invpd} \\
"Matrix singular" & "Matrix not positive definite"
\end{array}
\]

If the input to \( \text{invpd} \) is not symmetric, it is possible that the function will (erroneously) appear to operate successfully.

Positive definite matrices can be inverted by \( \text{inv} \). However, for symmetric, positive definite matrices (such as moment matrices), \( \text{invpd} \) is about twice as fast as \( \text{inv} \).

**Example**

\[
n = 4000;
\]
x1 = \texttt{rndn}(n,1);
x = \texttt{ones}(n,1)\sim x1;
btrue = \{ 1, 0.5 \};
y = x \times btrue + \texttt{rndn}(n,1);
bols = \texttt{invpd}(x'x) \times x'y;

After the code above, \textit{bols} will be equal to:

1.00237215
0.48249445

This example simulates some data and computes the \textit{ols} coefficient estimator using the \texttt{invpd} function. First, the number of observations is specified. Second, a vector \textit{x1} of standard Normal random variables is generated and is concatenated with a vector of \texttt{ones} (to create a constant term). The true coefficients are specified, and the dependent variable \textit{y} is created. Then the \textit{ols} coefficient estimates are computed.

When computing least-squares problems with poorly conditioned matrices, the slash operator "/" and the function \texttt{olsqr} will provide greater accuracy.

\textbf{\texttt{invswp}}

**Purpose**

Computes a generalized sweep inverse.

**Format**

\[ y = \texttt{invswp}(x); \]
**Input**

\( x \)  

NxN matrix.

**Output**

\( y \)  

NxN matrix, the generalized inverse of \( x \).

**Remarks**

This will invert any general matrix. That is, even matrices which will not invert using \( \text{inv} \) because they are singular will invert using \( \text{invswp} \).

\( x \) and \( y \) will satisfy the two conditions:

1. \( xyx = x \)
2. \( yxy = y \)

\( \text{invswp} \) returns a row and column with zeros when the pivot fails. This is good for quadratic forms since it essentially removes rows with redundant information, i.e., the statistics generated will be "correct" but with reduced degrees of freedom.

The tolerance used to determine if a pivot element is zero is taken from the \( \text{crout} \) singularity tolerance. The corresponding row and column are zeroed out. See \textit{Singularity Tolerance}, Chapter 1.

**iscplx**

**Purpose**

Returns whether a matrix or N-dimensional array is complex or real.
**Format**

\[ y = \text{iscplx}(x); \]

**Input**

\( x \) : NxK matrix or N-dimensional array.

**Output**

\( y \) : scalar, 1 if \( x \) is complex, 0 if it is real.

**Example**

```matlab
x = { 1, 2i, 3 }; 
if iscplx(x); 
    //code path for complex case 
else; 
    //code path for real case 
endif;
```

**See Also**

hasimag, iscplxf

**iscplxf**

**Purpose**

Returns whether a data set is complex or real.
**Format**

\[ y = \text{iscplxf}(fh); \]

**Input**

\( fh \) scalar, file handle of an open file.

**Output**

\( y \) scalar, 1 if the data set is complex, 0 if it is real.

**See Also**

`hasimag`, `iscplx`

---

**isden**

**Purpose**

Returns whether a scalar, matrix or N-dimensional array contains denormals.

**Format**

\[ y = \text{isden}(x); \]

**Input**

\( x \) NxK matrix or N-dimensional array.
Output

$y$ scalar, 1 if $x$ contains a denormal, 0 if it does not.

Example

Sometimes denormals can unnecessarily slow down calculations and it is best to flush them to zero. This example tests whether the vector $x$ contains any denormals and then sets any values between 0 and $1e^{-25}$ to be equal to 0.

```c
tol = 1e-25;

//Create a vector that contains a denormal
x = { 1, exp(-724.5), 3 };

if isden(x);
    //Get the index of all elements between 0 and tol
    idx = indexcat(x, 0|tol);
    //Set all elements between 0 and tol equal to 0
    x[idx] = 0;
endif;
```

Before the if block in the code above, the second element of $x$ is equal to approximately $3e-57$. After the if block this element is set equal to 0, the other elements of $x$ are unchanged.

See Also

denToZero
isinfnanmiss

**Purpose**

Returns true if the argument contains an infinity, NaN, or missing value.

**Format**

\[ y = \text{isinfnanmiss}(x); \]

**Input**

\( x \)  
NxK matrix.

**Output**

\( y \)  
scalar, 1 if \( x \) contains any infinities, NaNs, or missing values, else 0.

**See Also**

scalisinfnanmiss, ismiss, scalmiss

ismiss

**Purpose**

Returns a 1 if its matrix argument contains any missing values, otherwise returns a 0.
Format

\[ y = \text{ismiss}(x); \]

Input

\[ x \quad \text{NxK matrix.} \]

Output

\[ y \quad \text{scalar, 1 if } x \text{ contains any missing values, otherwise 0.} \]

Remarks

An element of \( x \) is considered to be a missing if and only if it contains a missing value in the real part. Thus, if \( x = 1 + .i \), \( \text{ismiss}(x) \) will return a 0.

Example

```plaintext
x = { 1, 2, 3, 4 };  

//Set the second element of 'x' to be a missing value
x[2] = \text{miss}(0,0);  

print "before 'if' block, x = " x;  

//If there are any missing values in 'x'
if ismiss(x);  
    //Remove all rows with missing values from 'x'
    x = \text{packr}(x);  
endif;
```
print "after 'if' block, x = " x;

before 'if' block, x =
  1.0000000
  .
  3.0000000
  4.0000000
after 'if' block, x =
  1.0000000
  3.0000000
  4.0000000

To reset all missing values to a specified value, replace the call to packr above with a call to missrv.

See Also

scalmiss, miss, missrv

itos

Purpose

Converts a scalar or matrix to the string representation of an integer.

Format

str = itos(x);
**Input**

\[ x \]  
scalar or NxK matrix.

**Output**

\[ y \]  
string or string array containing the string representation of the elements of \( x \).

**Example**

**Example 1**

\[
x = 4;
str = \text{itos}(x);
print "x = " x;
print "str = " str;
\]

\[
x =
1.000000
\]

\[
str =
1
\]

**Example 2**

\[
\text{for} \ i(1, 4, 1);
\quad \text{print "iteration " + itos(i)};
\text{endfor};
\]

**See Also**

ftos, stof
**keep (dataloop)**

**Purpose**

Specifies columns (variables) to be saved to the output data set in a data loop.

**Format**

```plaintext
keep variable_list;
```

**Remarks**

Commas are optional in `variable_list`.

Retains only the specified variables in the output data set. Any variables referenced must already exist, either as elements of the source data set, or as the result of a previous `make`, `vector`, or `code` statement.

If neither `keep` nor `drop` is used, the output data set will contain all variables from the source data set, as well as any newly defined variables. The effects of multiple `keep` and `drop` statements are cumulative.

**Example**

```plaintext
keep age, pay, sex;
```

**See Also**

`drop (dataloop)`
**key**

**Purpose**

Returns the ASCII value of the next key available in the keyboard buffer.

**Format**

\[ y = \text{key}; \]

**Output**

| \( y \) | scalar, ASCII value of next available key in keyboard buffer. |

**Remarks**

If you are working in terminal mode, key does not "see" any keystrokes until ENTER is pressed. The value returned will be zero if no key is available in the buffer or it will equal the ASCII value of the key if one is available. The key is taken from the buffer at this time and the next call to key will return the next key.

**Example**

```plaintext
format /rds 1,0;
k = 0;
do until kk == 113;
k = key;
if kk == 0;
    continue;
elseif kk == vals(" ");
    print "space \"" kk;
```


elseif kk >= vals("0") and kk <= vals("9")
    print "digit \" kk chrs(kk);
else;
    print "\" kk;
endif;
end;

This is an example of a loop that processes keyboard input. This loop will continue until the q key (ASCII 113) is pressed.

See Also
vals, chrs, upper, lower, con, cons

keyav

Purpose
Check if keystroke is available.

Format

```
x = keyav;
```

Output

```
x            scalar, value of key or 0 if no key is available.
```

See Also
keyw, key
keyw

Purpose

Waits for and gets a key.

Format

$k = \text{keyw};$

Output

$k$

scalar, ASCII value of the key pressed.

Remarks

If you are working in terminal mode, GAUSS will not see any input until you press the ENTER key. keyw gets the next key from the keyboard buffer. If the keyboard buffer is empty, keyw waits for a keystroke. For normal keys, keyw returns the ASCII value of the key.

See Also

key

keyword

Purpose

Begins the definition of a keyword procedure. Keywords are user-defined functions with local or global variables.
**Format**

```
keyword name(str);
```

**Input**

<table>
<thead>
<tr>
<th>name</th>
<th>literal, name of the keyword. This name will be a global symbol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>string, a name to be used inside the keyword to refer to the argument that is passed to the keyword when the keyword is called. This will always be local to the keyword, and cannot be accessed from outside the keyword or from other keywords or procedures.</td>
</tr>
</tbody>
</table>

**Remarks**

A keyword definition begins with the `keyword` statement and ends with the `endp` statement. See [Procedures and Keywords](#), Chapter 1.

Keywords always have 1 string argument and 0 returns. **GAUSS** will take everything past `name`, excluding leading spaces, and pass it as a string argument to the keyword. Inside the keyword, the argument is a local string. The user is responsible to manipulate or parse the string.

An example of a keyword definition is:

```gauss
keyword add(str);
    local tok,sum;
    sum = 0;
    do until str $== "";
        { tok, str } = token(str);
        sum = sum + stof(tok);
```
endo;
print "Sum is: " sum;
endp;

To use this keyword, type:
add 1 2 3 4 5;

This keyword will respond by printing:
Sum is: 15

See Also
proc, local, endp
**lag (dataloop)**

**Purpose**

Lags variables a specified number of periods.

**Format**

```
lag nv1 = var1:p1 [[nv2 = var2:p2...]];  
```

**Input**

- **var** name of the variable to lag.
- **p** scalar constant, number of periods to lag.

**Output**

- **nv** name of the new lagged variable.

**Remarks**

You can specify any number of variables to lag. Each variable can be lagged a different number of periods. Both positive and negative lags are allowed.
Lagging is executed before any other transformations. If the new variable name is different from that of the variable to lag, the new variable is first created and appended to a temporary data set. This temporary data set becomes the input data set for the dataloop, and is then automatically deleted.

**lag1**

**Purpose**

Lags a matrix by one time period for time series analysis.

**Format**

\[ y = \text{lag1}(x); \]

**Input**

\[ x \]

Nx1 column vector or NxK matrix.

**Output**

\[ y \]

NxK matrix, \( x \) lagged 1 period.

**Remarks**

*lag1* lags \( x \) by one time period, so the first observations of \( y \) are missing. *lag1* assumes that each column of the input is a different time series and that each row is an observation. Therefore if a 1xK row vector is passed to *lag1*, it will return a 1xK of missing values.
Example

```r
y = c(1.2,
     3.4,
     2.5,
     4.1,
     2.8);
y_lag = lag1(y);
print(y_lag);
```

will return:

```
1.2000000
3.4000000
2.5000000
4.1000000
```

Source

lag.src

See Also

lagn, ismiss, packr

lagn

Purpose

Lags a matrix a specified number of time periods for time series analysis.
Format

\[ y = \text{lagn}(x, \ t); \]

Input

\( x \quad \text{NxK matrix.} \)
\( t \quad \text{scalar or Px1 vector, number of time periods.} \)

Output

\( y \quad \text{NxK matrix, x lagged \ t periods.} \)

Example

```
nlags = 2;
x = [ 1.4,  2.7,  3.1,  2.9,  3.2,  2.5,  2.8 ];
x_lag2 = \text{lagn}(x, nlags);
```

will assign \( x\_\text{lag2} \) to equal:

```
. 
. 
1.4  
2.7  
3.1  
2.9  
3.2  
```

Creating multiple lags
If the number of time periods to lag is a Px1 column vector, then the output matrix will be an NxP matrix where each column contains one of the lags. For example, changing the $nlags$ variable from the example above to be a 3x1 column vector like this:

```plaintext
nlags = { 1, 2, 3 };  
x = { 1.4, 2.7, 3.1, 2.9, 3.2, 2.5, 2.8 };  
lag_mat = lagn(x, nlags);
```

will assign $lag_mat$ to equal:

```
   .   .   .   
   1.4 .   .   
   2.7 1.4 .   
   3.1 2.7 1.4  
   2.9 3.1 2.7  
   3.2 2.9 3.1  
   2.5 3.2 2.9  
```

**Remarks**

If $t$ is positive, $lagn$ lags $x$ back $t$ time periods, so the first $t$ observations of $y$ are missing. If $t$ is negative, $lagn$ lags $x$ forward $t$ time periods, so the last $t$ observations of $y$ are missing.

**Source**

lag.src

**See Also**

lag1
**lapeighb**

**Purpose**

Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by bounds.

**Format**

\[ ve = \text{lapeighb}(x, vl, vu, abstol); \]

**Input**

- \( x \): NxN matrix, real symmetric or complex Hermitian.
- \( vl \): scalar, lower bound of the interval to be searched for eigenvalues.
- \( vu \): scalar, upper bound of the interval to be searched for eigenvalues; \( vu \) must be greater than \( vl \).
- \( abstol \): scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval \([a, b]\) of width less than or equal to:

\[ abstol + EPS*\max(|a|, |b|) \]

where \( EPS \) is machine precision. If \( abstol \) is less than or equal to zero, then \( EPS*\|T\| \) will be used in its place, where \( T \) is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.
Output

\( ve \quad \) Mx1 vector, eigenvalues, where \( M \) is the number of eigenvalues on the half open interval \([v_l, v_u]\). If no eigenvalues are found then \( ve \) is a scalar missing value.

Remarks

\texttt{lapeighb} computes eigenvalues only which are found on the half open interval \([v_l, v_u]\). To find eigenvalues within a specified range of indices see \texttt{lapeighi}. For eigenvectors see \texttt{lapeighvi}, or \texttt{lapeighvb}. \texttt{lapeighb} is based on the LAPACK drivers DSYEVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

Example

\begin{verbatim}
x = [ 5 2 1,
    2 6 2,
    1 2 9 ];

vl = 5;
vu = 10;
ve = \texttt{lapeighb}(x,vl,vu,1e-15);
print ve;
\end{verbatim}

The code above returns:

\begin{verbatim}
6.0000
\end{verbatim}

See Also

\texttt{lapeighvi}, \texttt{lapeighvb}
lapeighi

Purpose

Computes eigenvalues only of a real symmetric or complex Hermitian matrix selected by index.

Format

\[ ve = \text{lapeighi}(x, il, iu, abstol); \]

Input

- **x**: NxN matrix, real symmetric or complex Hermitian.
- **il**: scalar, index of the smallest desired eigenvalue ranking them from smallest to largest.
- **iu**: scalar, index of the largest desired eigenvalue, \( iu \) must be greater than \( il \).
- **abstol**: scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval \([a, b]\) of width less than or equal to \( abstol + EPS*\max(|a|, |b|) \), where \( EPS \) is machine precision. If \( abstol \) is less than or equal to zero, then \( EPS*\|T\| \) will be used in its place, where \( T \) is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.
**Output**

<table>
<thead>
<tr>
<th>ve</th>
<th>(iu-il+1)x1 vector, eigenvalues.</th>
</tr>
</thead>
</table>

**Remarks**

`lapeighi` computes \( iu-il+1 \) eigenvalues only given a range of indices, i.e., the \( i \)th to \( j \)th eigenvalues, ranking them from smallest to largest. To find eigenvalues within a specified range see `lapeighxb`. For eigenvectors see `lapeighvi`, or `lapeighvb`. `lapeighi` is based on the LAPACK drivers DSYEVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

**Example**

```plaintext
x = { 5 2 1, 2 6 2, 1 2 9 };

il = 2; iu = 3;
ve = lapeighi(x,il,iu,0);
print ve;
```

The code above calculates the second and third eigenvalues and returns:

| 6.0000 |
| 10.6056 |

To calculate the first, second and third eigenvalues, reusing the same \( x \) from above:

```plaintext
ve = lapeighi(x,1,3,0);
print ve;
```
The output from this code is:

```
3.3944
6.0000
10.6056
```

See Also

lapeighb, lapeighvi, lapeighvb

## lapeighvb

### Purpose

Computes eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix selected by bounds.

### Format

```
{ ve, va } = lapeighvb(x, vl, vu, abstol);
```

### Input

- **x**: NxN matrix, real symmetric or complex Hermitian.
- **vl**: scalar, lower bound of the interval to be searched for eigenvalues.
- **vu**: scalar, upper bound of the interval to be searched for eigenvalues; **vu** must be greater than **vl**.
- **abstol**: scalar, the absolute error tolerance for the eigenvalues. An
approximate eigenvalue is accepted as converged when it is determined to lie in an interval \([a, b]\) of width less than or equal to \(abstol + \text{EPS} \cdot \max(|a|, |b|)\), where \(\text{EPS}\) is machine precision. If \(abstol\) is less than or equal to zero, then \(\text{EPS} \cdot \|T\|\) will be used in its place, where \(T\) is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

**Output**

- **\(ve\)**: Mx1 vector, eigenvalues, where \(M\) is the number of eigenvalues on the half open interval \([vl, vu]\). If no eigenvalues are found then \(s\) is a scalar missing value.
- **\(va\)**: NxM matrix, eigenvectors.

**Remarks**

`lapeighvb` computes eigenvalues and eigenvectors which are found on the half open interval \([vl, vu]\). `lapeighvb` is based on the LAPACK drivers DSYEVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

**Example**

```plaintext
x = [ 5 2 1,
     2 6 2,
     1 2 9 ];

vl = 5;
vu = 10;
```
\{ \text{ve}, \text{va} \} = \text{lapeighvb}(x,\text{vl},\text{vu},0);

\text{print} \ "\text{Eigenvalues}" \ \text{ve};
\text{print} \ "\text{Eigenvectors} =" \ \text{va};

\text{Eigenvalues} = \ 6.0000
\text{Eigenvectors} =
-0.5774
-0.5774
0.5774

\text{If you increase the value of } \text{vu} \text{ to 12.}

\{ \text{ve}, \text{va} \} = \text{lapeighvb}(x,5,12,0);

\text{print} \ "\text{Eigenvalues}" \ \text{ve};
\text{print} \ "\text{Eigenvectors} =" \ \text{va};

\text{Eigenvalues}
  6.0000
  10.6056
\text{Eigenvectors} =
-0.5774 \ 0.3197
-0.5774 \ 0.4908
0.5774 \ 0.8105

\text{laeighvi}

\text{Purpose}

Computes selected eigenvalues and eigenvectors of a real symmetric or complex Hermitian matrix.
Format

\{ ve, va \} = \textbf{lapeighvi}(x, il, iu, abstol);

Input

- **x**
  - NxN matrix, real symmetric or complex Hermitian.

- **il**
  - scalar, index of the smallest desired eigenvalue ranking them from smallest to largest.

- **iu**
  - scalar, index of the largest desired eigenvalue, \( iu \) must be greater than \( il \).

- **abstol**
  - scalar, the absolute error tolerance for the eigenvalues. An approximate eigenvalue is accepted as converged when it is determined to lie in an interval \([a, b]\) of width less than or equal to \( abstol + \text{EPS} \times \max(|a|, |b|) \), where \( \text{EPS} \) is machine precision. If \( abstol \) is less than or equal to zero, then \( \text{EPS} \times \|T\| \) will be used in its place, where \( T \) is the tridiagonal matrix obtained by reducing the input matrix to tridiagonal form.

Output

- **ve**
  - \((iu - il + 1)\times 1\) vector, eigenvalues.

- **va**
  - \(N \times (iu - il + 1)\) matrix, eigenvectors.

Remarks

\textbf{lapeighvi} computes \( iu-il+1 \) eigenvalues and eigenvectors given a range of 38-825
indices, i.e., the $i$th to $j$th eigenvalues, ranking them from smallest to largest. To find eigenvalues and eigenvectors within a specified range see `lapeighvb`. `lapeighvi` is based on the LAPACK drivers DSYEVX and ZHEEVX. Further documentation of these functions may be found in the LAPACK User's Guide.

**Example**

```plaintext
x = { 5 2 1,
     2 6 2,
     1 2 9 };

il = 2;
iu = 3;
{ ve,va } = lapeighvi(x,il,iu,0);
print "ve = " ve;
print "va = " va;

ve =
 6.0000
10.6056

va =
-0.5774  0.3197
-0.5774  0.4908
 0.5774  0.8105
```

**See Also**

`lapeighvb`, `lapeighb`
**lapgeig**

**Purpose**

Computes generalized eigenvalues for a pair of real or complex general matrices.

**Format**

\[
\{ \text{val}, \text{va2} \} = \text{lapgeig}(A, B);
\]

**Input**

- **A**  
  NxN matrix, real or complex general matrix.
- **B**  
  NxN matrix, real or complex general matrix.

**Output**

- **val**  
  Nx1 vector, numerator of eigenvalues.
- **va2**  
  Nx1 vector, denominator of eigenvalues.

**Remarks**

*val* and *va2* are the vectors of the numerators and denominators respectively of the eigenvalues of the solution of the generalized symmetric eigenproblem of the form \(Aw = eBw\) where \(A\) and \(B\) are real or complex general matrices and \(w = \text{val}./\text{va2}\). The generalized eigenvalues are not computed directly because some elements of \(\text{va2}\) may be zero, i.e., the eigenvalues may be infinite. This procedure calls the LAPACK routines DGGEV and ZGGEV.
See Also
lapgeig, lapgeigh

lapgeigh

Purpose
Computes generalized eigenvalues for a pair of real symmetric or Hermitian matrices.

Format
\[ \text{ve} = \text{lapgeigh}(A, B); \]

Input
\( A \)  
NxN matrix, real or complex symmetric or Hermitian matrix.

\( B \)  
NxN matrix, real or complex positive definite symmetric or Hermitian matrix.

Output
\( \text{ve} \)  
Nx1 vector, eigenvalues.

Remarks
\( \text{ve} \) is the vector of eigenvalues of the solution of the generalized symmetric eigenproblem of the form \( Ax = \lambda Bx \).
**Example**

```plaintext
A = { 3 4 5,
     2 5 2,
     3 2 4 };

B = { 4 2 2,
     2 6 1,
     2 1 8 };

ve = lapgeigh(A,B);
print ve;
```

The code above returns:

```
0.1219
0.6787
0.9494
```

This procedure calls the LAPACK routines DSYGV and ZHEGV.

**See Also**

lapgeig, lapgeighv

**lapgeighv**

**Purpose**

Computes generalized eigenvalues and eigenvectors for a pair of real symmetric or Hermitian matrices.
Format

\{ ve, va \} = \texttt{lapgeighv}(A, B);

Input

\begin{align*}
A & \quad \text{NxN matrix, real or complex symmetric or Hermitian matrix.} \\
B & \quad \text{NxN matrix, real or complex positive definite symmetric or Hermitian matrix.}
\end{align*}

Output

\begin{align*}
ve & \quad \text{Nx1 vector, eigenvalues.} \\
va & \quad \text{NxN matrix, eigenvectors.}
\end{align*}

Remarks

ve and va are the eigenvalues and eigenvectors of the solution of the generalized symmetric eigenproblem of the form \( Ax = \lambda B \). Equivalently, va diagonalizes \( U^{-1} A U^{-1} \) in the following way

\[ \text{va}^* U^{-1} A^* Y^{-1} \text{va}' = \text{ve} \]

where \( B = U^* U \). This procedure calls the LAPACK routines DSYGV and ZHEGV.

Example

\[ A = \begin{bmatrix} 3 & 4 & 5 \\ 2 & 5 & 2 \\ 3 & 2 & 4 \end{bmatrix} ; \]
B = { 4 2 2,
      2 6 1,
      2 1 8 };

{ ve, va } = lapgeighv(A,B);

print ve;
-0.0425
0.5082
0.8694

print va;
0.3575 -0.0996 0.9286
-0.2594 0.9446 0.2012
-0.8972 -0.3128 0.3118

See Also
lapgeig, lapgeigh

lapgeigv

Purpose
Computes generalized eigenvalues, left eigenvectors, and right eigenvectors for a pair of real or complex general matrices.

Format

{ va1, va2, lve, rve } = lapgeigv(A, B);
**Input**

- **A**: NxN matrix, real or complex general matrix.
- **B**: NxN matrix, real or complex general matrix.

**Output**

- **val**: Nx1 vector, numerator of eigenvalues.
- **va2**: Nx1 vector, denominator of eigenvalues.
- **lve**: NxN left eigenvectors.
- **rve**: NxN right eigenvectors.

**Remarks**

*val* and *va2* are the vectors of the numerators and denominators respectively of the eigenvalues of the solution of the generalized symmetric eigenproblem of the form

\[ Aw = \lambda Bw \]

where **A** and **B** are real or complex general matrices and \( w = \frac{val}{va2} \). The generalized eigenvalues are not computed directly because some elements of *va2* may be zero, i.e., the eigenvalues may be infinite.

The left and right eigenvectors diagonalize \( U^{-1} A U^{-1} \) where \( B = U^* U \), that is,

\[ lve^* U^{-1} A U lve' = w \]

and

\[ rve' U^{-1} A U^{-1} rve = w \]

This procedure calls the LAPACK routines DGGEV and ZGGEV.
See Also

lapgeig, lapgeigh

lapgsvdct

Purpose

Compute the generalized singular value decomposition of a pair of real or complex general matrices.

Format

{ C, S, R, U, V, Q } = lapgsvdct( A, B );

Input

A  MxN matrix.
B  PxN matrix.

Output

C  Lx1 vector, singular values for A.
S  Lx1 vector, singular values for B.
R  (K+L)x(K+L) upper triangular matrix.
U  MxM matrix, orthogonal transformation matrix.
V  PxP matrix, orthogonal transformation matrix.
Remarks

(1) The generalized singular value decomposition of $A$ and $B$ is

$$U' * A * Q = D_1 * Z$$

$$V' * B * Q = D_2 * Z$$

where $U$, $V$, and $Q$ are orthogonal matrices (see `lapgsvdcst` and `lapgsvdst`). Letting $K + L$ = the rank of $A|B$ then $R$ is a $(K+L)\times(K+L)$ upper triangular matrix, $D1$ and $D2$ are $M\times(K+L)$ and $P\times(K+L)$ matrices with entries on the diagonal, $Z = [0 \ R]$, and if $M-K-L \geq 0$

$$D1 = \begin{bmatrix} K & L \\ K & [I \ 0] \\ L & [0 \ C] \\ M-K-L & [0 \ 0] \end{bmatrix}$$

$$D2 = \begin{bmatrix} K \\ P \ [0 \ S] \\ P-L \ [0 \ 0] \end{bmatrix}$$

$$\begin{bmatrix} N-K-L & K & L \\ 0 & R11 & R12 \end{bmatrix} = \begin{bmatrix} K & 0 & R11 & R12 \\ L & 0 & 0 & R22 \end{bmatrix}$$

or if $M-K-L < 0$

$$D1 = \begin{bmatrix} K & M-K & K+L-M \\ K & [I \ 0 \ 0] \\ M-K & [0 \ 0 \ 0] \end{bmatrix}$$
(2) Form the matrix

\[
X = Q \begin{bmatrix} I & 0 \\ 0 & R^{-1} \end{bmatrix}
\]

then

\[
A = U^{-1}E_1X
\]
\[
B = V^{-1}E_2X^{-1}
\]

where

\[
E_1 = \begin{bmatrix} 0 & D_1 \\ 0 & D_2 \end{bmatrix}
\]

(3) The generalized singular value decomposition of \(A\) and \(B\) implicitly produces the singular value decomposition of \(AB^{-1}\):

\[
AB^{-1} = UD_1D_2^{-1}V'
\]

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

**See Also**

lapgsvds, lapsvdst
**lapgsvds**

**Purpose**
Compute the generalized singular value decomposition of a pair of real or complex general matrices.

**Format**

\[
\{ C, S, R \} = \text{lapgsvds}(A, B);
\]

**Input**

- \( A \) : MxN real or complex matrix.
- \( B \) : PxN real or complex matrix.

**Output**

- \( C \) : Lx1 vector, singular values for \( A \).
- \( S \) : Lx1 vector, singular values for \( B \).
- \( R \) : \((K+L)x(K+L)\) upper triangular matrix.

**Remarks**

(1) The generalized singular value decomposition of \( A \) and \( B \) is

\[
U'AQ = D_1Z
\]

\[
V'BQ = D_2Z
\]
where $U$, $V$, and $Q$ are orthogonal matrices (see `lapgsvdcsf` and `lapgsvdtsf`). Letting $K+L = \text{the rank of } A|B$ then $R$ is a $(K+L) \times (K+L)$ upper triangular matrix, $D_1$ and $D_2$ are $M \times (K+L)$ and $P \times (K+L)$ matrices with entries on the diagonal, $Z = [0R]$, and if $M-K-L \geq 0$

\[
D_1 = \begin{bmatrix}
K & L \\
K & \begin{bmatrix} I & 0 \\ 0 & C \end{bmatrix} \\
M-K-L & [0 \ 0]
\end{bmatrix}
\]

\[
D_2 = \begin{bmatrix}
K & L \\
P & \begin{bmatrix} 0 & S \\ 0 & 0 \end{bmatrix} \\
P-L & [0 \ 0]
\end{bmatrix}
\]

\[
[0 \ R] = \begin{bmatrix}
K & 0 & R_{11} & R_{12} \\
0 & 0 & R_{22} & R_{23} \\
0 & 0 & R_{33}
\end{bmatrix}
\]

or if $M-K-L < 0$

\[
D_1 = \begin{bmatrix}
K & M-K & K+L-M \\
K & \begin{bmatrix} I & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \\
M-K & [0 \ 0 \ 0]
\end{bmatrix}
\]

\[
[0 \ R] = \begin{bmatrix}
K & 0 & R_{11} & R_{12} & R_{13} \\
M-K & 0 & 0 & R_{22} & R_{23} \\
K+L-M & 0 & 0 & 0 & R_{33}
\end{bmatrix}
\]

(2) Form the matrix

\[
X = Q \begin{bmatrix} I & 0 \\ 0 & R^{-1} \end{bmatrix}
\]

then
where

\[
E_1 = \begin{bmatrix} 0 & D_1 \end{bmatrix} \\
E_2 = \begin{bmatrix} 0 & D_2 \end{bmatrix}
\]

(3) The generalized singular value decomposition of \(A\) and \(B\) implicitly produces the singular value decomposition of \(AB^{-1}\):

\[
AB^{-1} = UD_1D_2^{-1}V'
\]

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

**See Also**

lapgsvdcst, lapgsvdst

**lapgsvdst**

**Purpose**

Compute the generalized singular value decomposition of a pair of real or complex general matrices.

**Format**

\[
\{ D1, D2, Z, U, V, Q \} = \text{lapgsvdst}(A, B);
\]
**Input**

- **A** \( \text{MxN matrix.} \)
- **B** \( \text{PxN matrix.} \)

**Output**

- **D1** \( \text{Mx(K+L) matrix, with singular values for } A \text{ on diagonal.} \)
- **D2** \( \text{Px(K+L) matrix, with singular values for } B \text{ on diagonal.} \)
- **Z** \( \text{(K+L)xN matrix, partitioned matrix composed of a zero matrix and upper triangular matrix.} \)
- **U** \( \text{MxM matrix, orthogonal transformation matrix.} \)
- **V** \( \text{PxP matrix, orthogonal transformation matrix.} \)
- **Q** \( \text{NxN matrix, orthogonal transformation matrix.} \)

**Remarks**

(1) The generalized singular value decomposition of \( A \text{ and } B \) is

\[
U'AQ = D_1Z
\]

\[
V'BQ = D_2Z
\]

where \( U, V, \text{ and } Q \) are orthogonal matrices (see \texttt{lapgsvdct} and \texttt{lapgsvdst}). Letting \( K+L = \text{the rank of } AB \text{ then } R \) is a \( (K+L)x(K+L) \) upper triangular matrix, \( D_1 \) and \( D_2 \) are \( Mx(K+L) \) and \( Px(K+L) \) matrices with entries on the diagonal, \( Z = [0R] \), and if \( M-K-L \geq 0 \)
\[ D_1 = \begin{bmatrix} K & L \\ K & [ I & 0 ] \\ L & [ 0 & C ] \\ M-K-L & [ 0 & 0 ] \end{bmatrix} \]

\[ D_2 = \begin{bmatrix} K & L \\ K & [ 0 & S ] \\ P & [ 0 & 0 ] \end{bmatrix} \]

\[ N-K-L \quad K \quad L \\
[ 0 \quad R ] = \begin{bmatrix} K & [ 0 & R_{11} & R_{12} ] \\ L & [ 0 & 0 & R_{22} ] \end{bmatrix} \]

or if \( M-K-L < 0 \)

\[ D_1 = \begin{bmatrix} K & M-K & K+L-M \\ K & [ I & 0 & 0 ] \\ M-K & [ 0 & 0 & 0 ] \end{bmatrix} \]

\[ N-K-L \quad K \quad M-K \quad K+L-M \\
[ 0 \quad R ] = \begin{bmatrix} N-K-L & K & M-K & K+L-M \\ K & [ 0 & R_{11} & R_{12} & R_{13} ] \\ M-K & [ 0 & 0 & R_{22} & R_{23} ] \\ K+L-M & [ 0 & 0 & 0 & R_{33} ] \end{bmatrix} \]

(2) Form the matrix

\[ X = Q \begin{bmatrix} I & 0 \\ 0 & R^{-1} \end{bmatrix} \]

then

\[ A = U^{-1}E_1X \]
\[ B = V^{-1}E_2X^{-1} \]

where
The generalized singular value decomposition of $A$ and $B$ implicitly produces the singular value decomposition of $AB^{-1}$:

$$AB^{-1} = UD_1D_2^{-1}V'$$

This procedure calls the LAPACK routines DGGSVD and ZGGSVD.

**See Also**

lapgsvds, lapgsvdest

**lapgschur**

**Purpose**

Compute the generalized Schur form of a pair of real or complex general matrices.

**Format**

$$\{ sa, \ sb, \ Q, \ z \} = \text{lapgschur}(A, \ B);$$

**Input**

$A$  
NxN matrix, real or complex general matrix.

$B$  
NxN matrix, real or complex general matrix.
Output

\[ sa \quad \text{NxN matrix, Schur form of } A. \]

\[ sb \quad \text{NxN matrix, Schur form of } B. \]

\[ q \quad \text{NxN matrix, left Schur vectors.} \]

\[ z \quad \text{NxN matrix, right Schur vectors.} \]

Remarks

The pair of matrices \( A \) and \( B \) are in generalized real Schur form when \( B \) is upper triangular with non-negative diagonal, and \( A \) is block upper triangular with 1x1 and 2x2 blocks. The 1x1 blocks correspond to real generalized eigenvalues and the 2x2 blocks to pairs of complex conjugate eigenvalues. The real generalized eigenvalues can be computed by dividing the diagonal element of \( sa \) by the corresponding diagonal element of \( sb \). The complex generalized eigenvalues are computed by first constructing two complex conjugate numbers from 2x2 block where the real parts are on the diagonal of the block and the imaginary part on the off-diagonal. The eigenvalues are then computed by dividing the two complex conjugate values by their corresponding diagonal elements of \( sb \). The generalized Schur vectors \( q \) and \( z \) are orthogonal matrices that reduce \( A \) and \( B \) to Schur form:

\[ sa = q'Az \]

\[ sb = q'Bz \]

This procedure calls the LAPACK routines DGGES and ZGGES.

Source

lapschur.src
lapsvdcusv

**Purpose**

Computes the singular value decomposition of a real or complex rectangular matrix, returns compact $U$ and $v$.

**Format**

\[
\{ u, s, v \} = \text{lapsvdcusv}(x);
\]

**Input**

$x$ MxN matrix, real or complex rectangular matrix.

**Output**

$u$ Mxmin(M,N) matrix, left singular vectors.
$s$ min(M,N)xN matrix, singular values.
$v$ NxN matrix, right singular values.

**Remarks**

`lapsvdcusv` computes the singular value decomposition of a real or complex rectangular matrix. The SVD is

\[
x = u s v'
\]
where $v$ is the matrix of right singular vectors. \texttt{lapsvdusv} is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

\section*{Example}

\begin{verbatim}
x = { 2.143 4.345 6.124, 1.244 5.124 3.412, 0.235 5.657 8.214 };

{ u,s,v } = lapsvdusv(x);

print u;

-0.55531277 0.049048431 0.83019394
-0.43090168 0.83684123 -0.33766923
-0.71130266 -0.54524400 -0.44357356

print s;

13.895868 0.0000000 0.0000000
0.0000000 2.1893939 0.0000000
0.0000000 0.0000000 1.4344261

print v;

-0.13624432 -0.62209955 -0.77099263
 0.46497296  0.64704876 -0.60425826
 0.87477862  -0.44081748  0.20110275
\end{verbatim}
See Also

lapsvds, lapsvdusv

lapsvds

Purpose

Computes the singular values of a real or complex rectangular matrix

Format

\[ s = \text{lapsvds}(x); \]

Input

\[ x \]
MxN matrix, real or complex rectangular matrix.

Output

\[ s \]
min(M,N)x1 vector, singular values.

Remarks

\texttt{lapsvds} computes the singular values of a real or complex rectangular matrix. The SVD is

\[ x = u s v' \]
where \( v \) is the matrix of right singular vectors. For the computation of the singular vectors, see \texttt{lapsvdcusv} and \texttt{lapsvdusv}.

\texttt{lapsvds} is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

**Example**

```matlab
x = [ 2.143 4.345 6.124, 1.244 5.124 3.412, 0.235 5.657 8.214 ];

va = \texttt{lapsvds}(x);
print va';
```

\[
13.895868 \quad 2.1893939 \quad 1.4344261
\]

```matlab
xi = [ 4+1 3+1 2+2, 1+2 5+3 2+2, 1+1 2+1 6+2 ];

ve = \texttt{lapsvds}(xi);
print ve';
```

\[
10.352877 \quad 4.0190557 \quad 2.3801546
\]

Note the transpose operator (') at the end of the print statements. This causes the output of these column vectors to be printed as a row vector.

**See Also**

\texttt{lapsvdcusv}, \texttt{lapsvdusv}
**lapsvdusv**

**Purpose**
Computes the singular value decomposition a real or complex rectangular matrix.

**Format**

\[
\{ u, s, v \} = \text{lapsvdusv}(x);
\]

**Input**

\( x \) MxN matrix, real or complex rectangular matrix.

**Output**

\( u \) MxM matrix, left singular vectors.
\( s \) MxN matrix, singular values.
\( v \) NxN matrix, right singular values.

**Remarks**

*lapsvdusv* computes the singular value decomposition of a real or complex rectangular matrix. The SVD is

\[
x = u s v'
\]
where \( v \) is the matrix of right singular vectors. \texttt{lapsv dusv} is based on the LAPACK drivers DGESVD and ZGESVD. Further documentation of these functions may be found in the LAPACK User's Guide.

**Example**

```matlab
x = [ 2.143 4.345 6.124,
     1.244 5.124 3.412,
     0.235 5.657 8.214 ];

{ u,s,v } = lapsv dusv(x);

print u;

-0.5553  0.0490  0.8302
-0.4309  0.8368 -0.3377
-0.7113 -0.5452 -0.4436

print s;

13.8959  0.0000  0.0000
 0.0000  2.1894  0.0000
 0.0000  0.0000  1.4344

print v;

-0.1362  0.4650  0.8748
 0.6221  0.6470 -0.4408
-0.7710 -0.6043  0.2011
```

**See Also**

\texttt{lapsvds}, \texttt{lapsvdcusv}
**let**

**Purpose**

Creates a matrix from a list of numeric or character values. The result is always of type matrix, string, or string array.

**Format**

```
let x = constant_list;
```

**Remarks**

Expressions and variable names are not allowed in the `let` command, expressions such as this:

```
let x[2,1] = 3*a b
```

are illegal. To define matrices by combining matrices and expressions, use an expression containing the concatenation operators: ~ and |.

Numbers can be entered in scientific notation. The syntax is `dE±n`, where `d` is a number and `n` is an integer (denoting the power of 10):

```
let x = 1e+10 1.1e-4 4.019e+2;
```

Complex numbers can be entered by joining the real and imaginary parts with a sign (+ or -); there should be no spaces between the numbers and the sign. Numbers with no real part can be entered by appending an "i" to the number:

```
let x = 1.2+23 8.56i 3-2.1i -4.2e+6i 1.2e-4-4.5e+3i;
```

If curly braces are used, the `let` is optional.
let x = { 1 2 3, 4 5 6, 7 8 9 };

x = { 1 2 3, 4 5 6, 7 8 9 };

If indices are given, a matrix of that size will be created:

let x[2,2] = 1 2 3 4;

x = 1 2
   3 4

If indices are not given, a column vector will be created:

let x = 1 2 3 4;

1
x = 2
   3
   4

You can create matrices with no elements, i.e., "empty matrices". Just use a set of empty curly braces:

x = {};

Empty matrices are chiefly used as the starting point for building up a matrix, for example in a do loop. See Matrices, Section 1.0.1, for more information on empty matrices.

Character elements are allowed in a let statement:

let x = age pay sex;
Lowercase elements can be created if quotation marks are used. Note that each element must be quoted.

```
let x = "age""pay""sex";
```

### Example

```
let x;
```

assigns `x` to be:

```
x = 0
```

```
let x = { 1 2 3, 4 5 6, 7 8 9 };
```

assigns `x` to be:

```
   1 2 3
x = 3 4 5
   6 7 8
```

```
let x[3,3] = 1 2 3 4 5 6 7 8 9;
```

assigns `x` to be:
1 2 3
x = 3 4 5
6 7 8

let x[3,3] = 1;

assigns x to be:

1 1 1
x = 1 1 1
1 1 1

let x[3,3];

assigns x to be:

0 0 0
x = 0 0 0
0 0 0

let x = dog cat;

assigns x to be:

x = DOG
   CAT

let x = "dog""cat";

assigns x to be:

x = dog
cat

let string x = { "Median Income", "Country" };
assigns $x$ to be:

$$x = \text{Median Income}$$

Country

See Also

con, cons, declare, load

lib

Purpose

Builds and updates library files.

Format

\[
\text{lib} \ \text{library file;}
\]

\[
\text{lib} \ \text{library} \ -\text{flag};
\]

\[
\text{lib} \ \text{library file} \ -\text{flag1} \ -\text{flag2};
\]

Input

<table>
<thead>
<tr>
<th>library</th>
<th>literal, name of library.</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>optional literal, name of source file to be updated or added.</td>
</tr>
<tr>
<td>flags</td>
<td>optional literal preceded by '−', controls operation of library update. To control handling of path information on source filenames:</td>
</tr>
<tr>
<td>-addpath</td>
<td>add paths to entries without paths and</td>
</tr>
</tbody>
</table>
expand relative paths.

-gausspath reset all paths using a normal file search.
-leavepath (default) leave all path information untouched.
-nopath drop all path information.

To specify a library update or a complete library build:

-update (default) update the symbol information for the specified file only.
-build update the symbol information for every library entry by compiling the actual source file.

-delete delete a file from the library.
-list list files in a library.

To control the symbol type information placed in the library file:

-strong (default) use strongly typed symbol entries.
-weak save no type information. This should only be used to build a library compatible with a previous version of GAUSS.

To control location of temporary files for a complete library build:

-temp (default) use the directory pointed to by the tmp_path configuration variable. If tmp_path is not defined, lib will look for a
Example

Let us suppose that you have a file named `myprocs.gss` located in your GAUSS src directory. Let us further suppose that you would like to create a new library named `mylibrary`. You could accomplish that task like this:

```
lib mylibrary myprocs.gss;
```

Now that this library has been created, you could add other files in the same manner. To add a file named `mystats.gss` would look like this:

```
lib mylibrary mystats.gss;
```

This second command will add the file `mystats.gss` to the `mylibrary` which was created in the first step above. It will not overwrite or replace the library.

You may print the list of files contained in the library by using the `-list` flag. Entering the command:

```
lib mylibrary -list;
```

at the GAUSS command line will produce the output similar to:

```
Listing library: mylibrary.lcg
  myprocs.gss
  mystats.gss
```
If you add procedures to one of the files in your library, you will need to update the library to reflect these new changes. Continuing with the example from above, if you added some new procedures to the file mystats.gss, you could update the mylibrary library with the following command:

```
lib mylibrary mystats.gss -update;
```

Note that, as in the command above, the `-update` flag must be used with a file. To update, or rebuild the references for all files in the library, use the `-build` flag.

```
lib mylibrary -build;
```

**Remarks**

The library management functionality offered by the `lib` command can also be accomplished interactively with windows and buttons, using the Library Tool in the user interface. See The Library Tool, Chapter 1, for more information on using the Library Tool.

The flags can be shortened to one or two letters, as long as they remain unique—for example, `-b` to `-build` a library, `-li` to list files in a library.

If the filenames include a full path, the compilation process is faster because no unnecessary directory searching is needed during the autoloading process. The default path handling adds a path to each file listed in the library and also expands any relative paths so the system will work from any drive or subdirectory.

When a path is added to a filename containing no path information, the file is searched for on the current directory and then on each subdirectory listed in `src_path`. The first path encountered that contains the file is added to the filename in the library entry.
See Also

library

library

Purpose

Sets up the list of active libraries.

Format

```
library lib1 [,lib2,lib3,lib4...];
library;
```

Example

Example 1

If no arguments are given, the list of current libraries will be printed out. For example:

```
library;
```

will produce output similar to:

```
Library path: C:\gauss13\gaussplot\lib
C:\gauss13\lib

Libraries: C:\gauss13\lib\user.lcg
C:\gauss13\lib\gauss.lcg
```

Example 2

Load multiple libraries by passing a comma-separated list of library names.
library pgraph, cmlmt;

After executing the code above, entering the `library` command without any arguments will produce output similar to this:

```
Library path: C:\gauss13\gaussplot\lib
             C:\gauss13\lib

Libraries:  C:\gauss13\lib\user.lcg
            C:\gauss13\lib\pgraph.lcg
            C:\gauss13\lib\cmlmt.lcg
            C:\gauss13\lib\gauss.lcg
```

The output from the `library` command above is printed in the order in which GAUSS will search. For this particular example, GAUSS will first search the `user` library, then the `pgraph` library, followed by the `cmlmt` library and finally the `gauss` library.

**Example 3**

Loading a library or list of libraries with the `library` command will also close any open libraries other than `user` and `gauss` which are always loaded.

Continuing with the last example in which the `user`, `pgraph`, `cmlmt` and `gauss` libraries were open, executing the command:

```
library pgraph, tsmt;
```

would open `tsmt`, while closing `pgraph` and `cmlmt`.

**Remarks**

For more information about the library system, see Libraries, Chapter 1.

The required extension for library files is `.lcg`.

**Library searching**
If a list of library names is given, they will be the new set of active libraries. The two default libraries are `user.lcg` and `gauss.lcg`. Unless otherwise specified, `user.lcg` will be searched first and `gauss.lcg` will be searched last. Any other user-specified libraries will be searched after `user.lcg` in the order they were entered in the `library` statement.

If the statement:

```
y = myProc(x);
```

is encountered in a program, `myProc` will be searched for in the active libraries. If it is found, it will be compiled. If it cannot be found in a library, the deletion state determines how it is handled:

```
autodelete on
autodelete off
```

If `myProc` calls `myRegress` and `myRegress` calls `myUtil` and they are all in separate files, they will all be found by the autoloader.

The source browser and the help facility will search for `myProc` in exactly the same sequence as the autoloader.

**Library file contents**

Library files are simple ASCII files that you can create with a text editor. Here is an example:

```
/*
** This is a GAUSS library file.
*/

eig.src
```
The lines not indented are the file names. The lines that are indented are the symbols defined in that file. As you can see, a GAUSS library is a dictionary of files and the global symbols they contain.

Any line beginning with /*, **, or */ is considered a comment. Currently, // comments are not supported in library files. Blank lines are okay.

To make the autoloading process more efficient, you can put the full pathname for each file in the library:

```
/gauss/src/eig.src
  eig  : proc
  eigsym : proc
  _eigerr : matrix

/gauss/src/svd.src
  cond  : proc
  pinv  : proc
  rank  : proc
  svd   : proc
  _svdtol : matrix
```

Here's a debugging hint. If your program is acting strange and you suspect it is autoloading the wrong copy of a procedure, use the Library Tool on the Source Page, or the CTRL+F1 hotkey to locate the suspected function. It will use the same search path that the autoloader uses.
See Also
declare, external, lib, proc

#lineson, #linesoff

Purpose

The #lineson command causes GAUSS to embed line number and file name records in a program for the purpose of reporting the location where an error occurs. The #linesoff command causes GAUSS to stop embedding line and file records in a program.

Format

#lineson
#linesoff

Remarks

In the "lines on" mode, GAUSS keeps track of line numbers and file names and reports the location of an error when an execution time error occurs. In the "lines off" mode, GAUSS does not keep track of lines and files at execution time. During the compile phase, line numbers and file names will always be given when errors occur in a program stored in a disk file.

It is easier to debug a program when the locations of errors are reported, but this slows down execution. In programs with several scalar operations, the time spent tracking line numbers and file names is most significant.
These commands have no effect on interactive programs (that is, those typed in the window and run from the command line), since there are no line numbers in such programs.

Line number tracking can be turned on and off through the user interface, but the #lineson and #linesoff commands will override that.

The line numbers and file names given at run-time will reflect the last record encountered in the code. If you have a mixture of procedures that were compiled without line and file records and procedures that were compiled with line and file records, use the trace command to locate exactly where the error occurs.

The Currently active call error message will always be correct. If it states that it was executing procedure xyz at line number nnn in file ABC and xyz has no line nnn or is not in file ABC, you know that it just did not encounter any line or file records in xyz before it crashed.

When using #include'd files, the line number and file name will be correct for the file the error was in within the limits stated above.

See Also

trace

linsolve

Purpose

Solves $Ax = b$ using the inverse function.

Format

\[
x = \text{linsolve}(b, A);
\]
### Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$</td>
<td>NxK matrix.</td>
</tr>
<tr>
<td>$A$</td>
<td>NxN matrix.</td>
</tr>
</tbody>
</table>

### Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>NxK matrix, the linear solution of $b/A$ for each column in $b$.</td>
</tr>
</tbody>
</table>

### Remarks

`linsolve` solves for $x$ by computing $\text{inv}(A)*b$. If $A$ is square and $b$ contains more than 1 column, it is much faster to use `linsolve` than the $/$ operator. However, while faster, there is some sacrifice in accuracy.

A test shows `linsolve` to be accurate to within approximately 1.2e-11, while the slash operator $'/'$ is accurate to within approximately 4e-13. However, the accuracy sacrifice can be much greater for poorly conditioned matrices.

### Example

```matlab
b = [2, 3, 4];
A = [10 2 3, 6 14 2, 1 1 9];
x = linsolve(b, A);
print x
```

```
0.04586330
0.13399281
0.42446043
```
See Also
qrsol, qrtsol, solpd, cholsol

listwise (dataloop)

Purpose

Controls listwise deletion of missing values.

Format

listwise [[read]] [[write]];

Remarks

If read is specified, the deletion of all rows containing missing values happens immediately after reading the input file and before any transformations. If write is specified, the deletion of missing values happens after any transformations and just before writing to the output file. If no listwise statement is present, rows with missing values are not deleted.

The default is read.

In

Purpose

Computes the natural log of all elements of x.
**Format**

\[
y = \ln(x);
\]

**Input**

\[
x \quad \text{NxK matrix or N-dimensional array.}
\]

**Output**

\[
y \quad \text{NxK matrix or N-dimensional array containing the natural log values of the elements of } x.
\]

**Remarks**

\textit{ln} is defined for \(x \neq 0\).

If \(x\) is negative, complex results are returned.

You can turn the generation of complex numbers for negative inputs on or off in the \texttt{GAUSS} configuration file, and with the \texttt{sysstate} function, case 8. If you turn it off, \texttt{ln} will generate an error for negative inputs.

If \(x\) is already complex, the complex number state doesn't matter; \texttt{ln} will compute a complex result.

\(x\) can be any expression that returns a matrix.

**Example**

\[
y = \ln(16);
\]
38-866

\[
y = 2.7725887
\]

**See Also**

\(\log\)

**Incdfbvn**

**Purpose**

Computes natural log of bivariate Normal cumulative distribution function.

**Format**

\[
y = \text{lncdfbvn}(x1, \ x2, r);
\]

**Input**

- \(x1\) \(\) NxK matrix, abscissae.
- \(x2\) \(\) LxM matrix, abscissae.
- \(r\) \(\) PxQ matrix, correlations.

**Output**

\[
y \quad \text{max(N,L,P) x max(K,M,Q) matrix:}
\]

\[
\ln \Pr(X < x1, X < x2 | r)
\]
Remarks

$x_1$, $x_2$, and $r$ must be ExE conformable.

Source

lncdfn.src

See Also

cdfbvn, lncdfmvn

Incdfbvn2

Purpose

Returns natural log of standardized bivariate Normal cumulative distribution function of a bounded rectangle.

Format

$$y = \text{lncdfbvn2}(h, \ dh, \ k, \ dk, \ r);$$

Input

$h$  \hspace{1cm} Nx1 vector, upper limits of integration for variable 1.
$dh$  \hspace{1cm} Nx1 vector, increments for variable 1.
$k$   \hspace{1cm} Nx1 vector, upper limits of integration for variable 2.
$dk$  \hspace{1cm} Nx1 vector, increments for variable 2.
\( r \)  
\( r \) is an \( N \times 1 \) vector, correlation coefficients between the two variables.

**Output**

\( y \)  
\( y \) is an \( N \times 1 \) vector, the log of the integral from \( h, k \) to \( h + dh, k + dk \) of the standardized bivariate Normal distribution.

**Remarks**

Scalar input arguments are okay; they will be expanded to \( N \times 1 \) vectors.

`lncdfbvn2` will abort if the computed integral is negative.

`lncdfbvn2` computes an error estimate for each set of inputs—the real integral is \( \exp(y) \pm \text{err} \). The size of the error depends on the input arguments. If `trap 2` is set, a warning message is displayed when \( \text{err} \geq \exp(y) / 100 \).

For an estimate of the actual error, see `cdfBvn2e`.

**Example**

Example 1

```matlab
lncdfbvn2(1,1,1,1,0.5);
```
produces:

\[-3.2180110258198771e+000\]
Example 3

```matlab
trap 2,2;
lncdfbvn2(1,-1e-45,1,1e-45,0.5);
```

produces:

```
WARNING: Dubious accuracy from lncdfbvn2:
0.000e+000 +/- 2.8e-060
-INF
```

See Also

cdfbvn2, cdfbvn2e

**Incdfmvn**

**Purpose**

Computes natural log of multivariate Normal cumulative distribution function.

**Format**

```matlab
y = lncdfmvn(x, r);
```
**Input**

- **x**: KxL matrix, abscissae.
- **r**: KxK matrix, correlation matrix.

**Output**

- **y**: Lx1 vector,

\[
\ln Pr(X < x | r)
\]

**Remarks**

You can pass more than one set of abscissae at a time; each column of \( x \) is treated separately.

**Source**

lncdfn.src

**See Also**

cdfmvn, lncdfbvn

**Incdfn**

**Purpose**

Computes natural log of Normal cumulative distribution function.
**Format**

\[ y = \text{lncdfn}(x); \]

**Input**

\( x \)  
N\( x \)K matrix or N-dimensional array, abscissae.

**Output**

\( y \)  
N\( x \)K matrix or N-dimensional array,

\[ \ln \Pr(X < x) \]

**Source**

lncdfn.src

**Incdfn2**

**Purpose**

Computes natural log of interval of Normal cumulative distribution function.

**Format**

\[ y = \text{lncdfn2}(x, r); \]
**Input**

- $x$: MxN matrix, abscissae.
- $r$: KxL matrix, ExE conformable with $x$, intervals.

**Output**

- $y$: max(M,K)xmax(N,L) matrix, the log of the integral from $x$ to $x+dx$ of the Normal distribution, i.e.,

\[
\ln \Pr(x < X < x+dx)
\]

**Remarks**

The relative error is:

- $|x| < 1$ and $dx < 1$ ±1e-14
- $1 < |x| < 37$ and $|dx| < 1/|x|$ ±1e-13
- $\min(x,x+dx) > -37$ and $y > -690$ ±1e-11 or better

A relative error of ±1e-14 implies that the answer is accurate to better than ±1 in the 14th digit after the decimal point.

**Example**

```plaintext
print lncdfN2(-10,29);
-7.6198530241605269e-24
```
print lncdfN2(0,1);
-1.0748623268620716e+00

print lncdfN2(5,1);
-1.506846096529453e+01

Source
lncdfn.src

See Also
cdfn2

Incdfnc

Purpose
Computes natural log of complement of Normal cumulative distribution function.

Format
\[ y = \text{lncdfnc}(x); \]

Input
\[ x \quad \text{NxK matrix, abscissae.} \]
**Output**

| $y$ | NxK matrix, \[ \text{ln} \ (1 - \Pr(X < x)) \] |

**Source**

lncdfn.src

**Infact**

**Purpose**

Computes the natural log of the factorial function and can be used to compute log gamma.

**Format**

\[ y = \text{lnfact}(x); \]

**Input**

| $x$ | NxK matrix or N-dimensional array, all elements must be positive. |

**Output**

| $y$ | NxK matrix containing the natural log of the factorial of each of the elements in $x$. |
Remarks

For integer $x$, this is (approximately) $\ln(x!)$. However, the computation is done using a formula, and the function is defined for noninteger $x$.

In most formulae in which the factorial operator appears, it is possible to avoid computing the factorial directly, and to use $\text{lifact}$ instead. The advantage of this is that $\text{lifact}$ does not have the overflow problems that the factorial (!) operator has.

For $x > 1$, this function has at least 6 digit accuracy, for $x > 4$ it has at least 9 digit accuracy, and for $x > 10$ it has at least 12 digit accuracy. For $0 < x < 1$, accuracy is not known completely but is probably at least 6 digits.

Sometimes log gamma is required instead of log factorial. These functions are related by:

$$\text{lngamma}(x) = \text{lifact}(x-1);$$

Example

```plaintext
let x = 100 500 1000;
y = lifact(x);
```

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>363.73938</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2611.3305</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5912.1282</td>
<td></td>
</tr>
</tbody>
</table>

Source

lifact.src

See Also

gamma
Technical Notes

For $x > 1$, Stirling's formula is used.

For $0 < x \leq 1$, $\ln(\text{gamma}(x+1))$ is used.

Ingammacplx

Purpose

Returns the natural log of the Gamma function.

Format

$f = \text{lngammacplx}(z);$  

Input

$z$  

NxK matrix; $z$ may be complex.

Output

$f$  

NxK matrix.

Remarks

Note that $\text{lngammacplx}(z)$ may yield a result with a different imaginary part than $\ln(\text{gamma}(z))$. This is because $\text{lngammacplx}(z)$ returns the value of the logarithm of $\text{gamma}(z)$ on the corresponding branch of the complex plane, while a call
to \( \ln(z) \) always returns a function value with an imaginary part within \([-\pi, \pi]\). Hence the imaginary part of the result can differ by a multiple of \(2\pi\). However, \( \exp(\ln\text{gammacplx}(z)) = \text{gammacplx}(z) \). This routine uses a Lanczos series approximation for the complex \( \ln(\gamma) \) function.

**References**

5. W. Press, "Numerical Recipes."
8. Original code by Paul Godfrey

**lnpdfmvn**

**Purpose**

Computes multivariate Normal log-probabilities.

**Format**

\[
z = \text{lnpdfmvn}(x, \ s);
\]
**Input**

- $x$  
  NxK matrix, data.
- $s$  
  KxK matrix, covariance matrix.

**Output**

- $z$  
  Nx1 vector, log-probabilities.

**Remarks**

This computes the multivariate Normal log-probability for each row of $x$.

**Source**

lnpdfn.src

**lnpdfmvt**

**Purpose**

Computes multivariate Student's t log-probabilities.

**Format**

$$z = \text{lnpdfmvt}(x, \ s, \ nu);$$
**Input**

- $x$  
  NxK matrix, data.
- $s$  
  KxK matrix, covariance matrix.
- $nu$  
  scalar, degrees of freedom.

**Output**

- $z$  
  Nx1 vector, log-probabilities.

**Source**

`lnpdfn.src`

**See Also**

`lnpdf`  
`lnpdfn`  

**Inpdfn**

**Purpose**

Computes standard Normal log-probabilities.

**Format**

$$z = \text{lnpdfn}(x);$$
**Input**

\[ x \]

NxK matrix or N-dimensional array, data.

**Output**

\[ z \]

NxK matrix or N-dimensional array, log-probabilities.

**Remarks**

This computes the log of the scalar Normal density function for each element of \( x \). \( z \) could be computed by the following **GAUSS** code:

\[
z = -\ln(\sqrt{2\pi}) - x .* x / 2;
\]

For multivariate log-probabilities, see **lnpdfmvn**.

**Example**

\[
x = \{-2, -1, 0, 1, 2\};
\]
\[
z = \text{lnpdfn}(x);
\]

\[
-2.9189385
-1.4189385
-0.9189385
-1.4189385
-2.9189385
\]
Inpdft

Purpose

Computes Student's t log-probabilities.

Format

\[ z = \text{lnpdft}(x, \ nu); \]

Input

\begin{itemize}
  \item \textbf{x} \quad \text{NxK matrix, data.}
  \item \textbf{nu} \quad \text{scalar, degrees of freedom.}
\end{itemize}

Output

\begin{itemize}
  \item \textbf{z} \quad \text{NxK matrix, log-probabilities.}
\end{itemize}

Remarks

This does not compute the log of the joint Student's t pdf. Instead, the scalar Normal density function is computed element-by-element.

For multivariate probabilities with covariance matrix see \texttt{lnpdfmvt}.

See Also

lnpdfmvt
load, loadf, loadk, loadm, loadp, loads

**Purpose**

Loads from a disk file.

**Format**

```plaintext
load [[path=path]]x, y[ ]=filename, z=filename;
```

**Remarks**

All the `loadxx` commands use the same syntax—they only differ in the types of symbols you use them for:

- `load, loadm`  matrix
- `loads`  string
- `loadf`  function (fn)
- `loadk`  keyword (keyword)
- `loadp`  procedure (proc)

If no filename is given, as with `x` above, then the symbol name the file is to be loaded into is used as the filename, and the proper extension is added.

If more than one item is to be loaded in a single statement, the names should be separated by commas.

The filename can be either a literal or a string. If the filename is in a string variable, then the `^` (caret) operator must precede the name of the string, as in:
filestr = "mydata/char";
loadm x = ^filestr;

If no extension is supplied, the proper extension for each type of file will be used automatically as follows:

- `load` .fmt - matrix file or delimited ASCII file
- `loadm` .fmt - matrix file or delimited ASCII file
- `loads` .fst - string file
- `loadf` .fcg - user-defined function (fn) file
- `loadk` .fcg - user-defined keyword (keyword) file
- `loadp` .fcg - user-defined procedure (proc) file

These commands also signal to the compiler what type of object the symbol is so that later references to it will be compiled correctly.

A dummy definition must exist in the program for each symbol that is loaded in using `loadf`, `loadk`, or `loadp`. This resolves the need to have the symbol initialized at compile time. When the load executes, the dummy definition will be replaced with the saved definition:

```plaintext
proc corrmat;
endp;

loadp corrmat;
y = corrmat;

keyword regress(x); endp;
loadk regress;
regress x on y z t from data01;

fn sqrd=;
```
loadf sqrd;
y = sqrd(4.5);

To load GAUSS files created with the `save` command, no brackets are used with the symbol name.

If you use `save` to save a scalar error code 65535 (i.e., `error(65535)`), it will be interpreted as an empty matrix when you `load` it again.

**ASCII data files**

To load ASCII data files, square brackets follow the name of the symbol.

Numbers in ASCII files must be delimited with spaces, commas, tabs, or newlines. If the size of the matrix to be loaded is not explicitly given, as in:

```plaintext
load x[] = data.asc;
```

**GAUSS** will load as many elements as possible from the file and create an Nx1 matrix. This is the preferred method of loading ASCII data from a file, especially when you want to verify if the load was successful. Your program can then see how many elements were actually loaded by testing the matrix with the `rows` command, and if that is correct, the Nx1 matrix can be reshaped to the desired form. You could, for instance, put the number of rows and columns of the matrix right in the file as the first and second elements and `reshape` the remainder of the vector to the desired form using those values.

If the size of the matrix is explicitly given in the `load` command, then no checking will be done. If you use:

```plaintext
load x[500,6] = data.asc;
```

**GAUSS** will still load as many elements as possible from the file into an Nx1 matrix and then automatically reshape it using the dimensions given.
If you `load` data from a file, `data.asc`, which contains nine numbers (1 2 3 4 5 6 7 8 9), then the resulting matrix will be as follows:

```
load x[1,9] = data.asc;

x = 1 2 3 4 5 6 7 8 9
```

```
load x[3,3] = data.asc;

1 2 3
x = 4 5 6
7 8 9
```

```
load x[2,2] = data.asc;

x = 1 2
3 4
```

```
load x[2,9] = data.asc;

x = 1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
```

```
load x[3,5] = data.asc;

1 2 3 4 5
x = 6 7 8 9 1
2 3 4 5 6
```

`load` accepts pathnames. The following is legal:

```
loadm k = /gauss/x;
```

This will load `/gauss/x.fmt` into `k`. 
If the **path**= subcommand is used with **load** and **save**, the path string will be remembered until changed in a subsequent command. This path will be used whenever none is specified. There are four separate paths for:

1. **load**, **loadm**
2. **loadf**, **loadp**
3. **loads**
4. **save**

Setting any of the four paths will not affect the others. The current path settings can be obtained (and changed) with the **sysstate** function, cases 4-7.

```
loadm path = /data;
```

This will change the **loadm** path without loading anything.

```
load path = /gauss x,y,z;
```

This will load x.fmt, y.fmt, and z.fmt using /gauss as a path. This path will be used for the next load if none is specified.

The **load** path or **save** path can be overridden in any particular **load** or **save** by putting an explicit path on the filename given to **load** from or **save** to as follows:

```
loadm path = /miscdata;
loadm x = /data/mydata1, y, z = hisdata;
```

In the above program:

- /data/mydata1.fmt would be loaded into a matrix called x.
- /miscdata/y.fmt would be loaded into a matrix called y.
- /miscdata/hisdata.fmt would be loaded into a matrix called z.
oldmpath = \texttt{sysstate(5, ",/data")};  
\text{load} x, y;  
\text{call} \texttt{sysstate(5, oldmpath)};  

This will get the old loadm path, set it to /data, load \texttt{x.fmt} and \texttt{y.fmt}, and reset the loadm path to its original setting.

\textbf{See Also}

loadm, dataload, save, let, con, cons, sysstate

\textbf{loadarray}

\textbf{Purpose}

Loads an N-dimensional array from a disk file.

\textbf{Format}

\texttt{loadarray [[path=path]] x,y=filename;}

\textbf{Remarks}

If no filename is given, as with \texttt{x} above, then the symbol name the file is to be loaded into is used as the filename, and the proper extension is added.

If more than one item is to be loaded in a single statement, the names should be separated by commas.

The filename can be either a literal or a string. If the filename is in a string variable, then the ^ (caret) operator must precede the name of the string, as in:
\begin{verbatim}
filestr = "mydata/adat";
loadarray x = ^filestr;
\end{verbatim}

If no extension is supplied, then an .fmt extension will be assumed.

\begin{verbatim}
loadarray accepts pathnames. The following is legal:

loadarray k = /gauss/a;
\end{verbatim}

This will load /gauss/a.fmt into k.

If the \texttt{path=} subcommand is used, the path string will be remembered until changed in a subsequent command. This path will be used for all \texttt{loadarray, loadm}, and \texttt{load} calls whenever none is specified.

The current path setting can be obtained (and changed) with the \texttt{sysstate} function, case 5.

\begin{verbatim}
loadarray path = /data;
\end{verbatim}

This will change the \texttt{loadarray} path without loading anything.

\begin{verbatim}
loadarray path = /gauss a,b,c;
\end{verbatim}

This will load a.fmt, b.fmt, and c.fmt using /gauss as a path. This path will be used for the next \texttt{loadarray, loadm}, or \texttt{load} call if none is specified.

The \texttt{load} path or \texttt{save} path can be overridden in any particular \texttt{load} or \texttt{save} by putting an explicit path on the filename given to \texttt{load} from or \texttt{save} to as follows:

\begin{verbatim}
loadarray path = /miscdata;
loadarray a = /data/mydata1, b, c = hisdata;
\end{verbatim}

In the above program:

/data/mydata1.fmt would be loaded into an array called a.

/miscdata/b.fmt would be loaded into an array called b.
/miscdata/hisdata.fmt would be loaded into an array called c.

```
oldarraypath = sysstate(5,"/data");
loadarray a, b;
call sysstate(5,oldarraypath);
```

This will get the old loadarray path, set it to /data, load a.fmt and b.fmt, and reset the loadarray path to its original setting.

**See Also**

load, loadm, save, let, sysstate

### loadd

**Purpose**

Loads a data set.

**Format**

```
y = loadd(dataset);
```

**Input**

- **dataset** string, name of data set.

**Output**

- **y** NxK matrix of data.
Remarks

The data set must not be larger than a single GAUSS matrix.

If dataset is a null string or 0, the data set temp.dat will be loaded. To load a matrix file, use an .fmt extension on dataset.

Source

saveload.src

 Globals

__maxvec

loadstruct

Purpose

Loads a structure into memory from a file on the disk.

Format

\[
\{\text{instance, retcode}\} = \text{loadstruct}(\text{file\_name, structure\_type});
\]

Input

\begin{itemize}
  \item \text{file\_name} string, name of file containing structure.
  \item \text{structure\_type} string, structure type.
\end{itemize}
Output

\begin{itemize}
  \item \textit{instance} instance of the structure.
  \item \textit{retcode} scalar, 0 if successful, otherwise 1.
\end{itemize}

Remarks

\textit{instance} can be an array of structures.

Example

\begin{verbatim}
#include ds.sdf
struct DS p3;

{ p3, retc } = loadstruct("p2", "ds");
\end{verbatim}

loadwind

Purpose

Load a previously saved graphic panel configuration. Note: This function is for use with the deprecated PQG graphics.

Library

pgraph

Format

\begin{verbatim}
err = loadwind(namestr);
\end{verbatim}
## Input

| namestr | string, name of file to be loaded. |

## Output

| err | scalar, 0 if successful, 1 if graphic panel matrix is invalid. Note that the current graphic panel configuration will be overwritten in either case. |

## Source

pwindow.src

## Globals

_pwindmx

## See Also

savewind

## local

### Purpose

Declare variables that are to exist only inside a procedure.

### Format

```plaintext
local  x, y, f:proc;
```
Remarks

The statement above would place the names \( x, y, \) and \( f \) in the local symbol table for the current procedure being compiled. This statement is legal only between the `proc` statement and the `endp` statement of a procedure definition.

These symbols cannot be accessed outside of the procedure.

The symbol \( f \) in the statement above will be treated as a procedure whenever it is accessed in the current procedure. What is actually passed in is a pointer to a procedure.

See *Procedures and Keywords*, Chapter 1.

See Also

`proc`

`locate`

Purpose

Positions the cursor in the window.

Format

```
locate \( m, n; \)
```

Remarks

`locate` locates the cursor in the current output window.
$m$ and $n$ denote the row and column, respectively, at which the cursor is to be located.

The origin (1,1) is the upper left corner.

$m$ and $n$ may be any expressions that return scalars. Nonintegers will be truncated to an integer.

**Example**

```plaintext
r = csrlin;
c = csrcol;
cls;
locate r,c;
```

In this example the window is cleared without affecting the cursor position.

**See Also**

csrln, csrcol

**loess**

**Purpose**

Computes coefficients of locally weighted regression.

**Format**

```plaintext
{ yhat, ys, xs } = loess(depvar, indvars);
```
**Input**

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>depvar</td>
<td>Nx1 vector, dependent variable.</td>
</tr>
<tr>
<td>indvars</td>
<td>NxK matrix, independent variables.</td>
</tr>
</tbody>
</table>

**Global Input**

<table>
<thead>
<tr>
<th>Global Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_loess_Span</td>
<td>scalar, degree of smoothing. Must be greater than 2/N. Default = .67777.</td>
</tr>
<tr>
<td>_loess_NumEval</td>
<td>scalar, number of points in ys and xs. Default = 50.</td>
</tr>
<tr>
<td>_loess_Degree</td>
<td>scalar, if 2, quadratic fit, otherwise linear. Default = 1.</td>
</tr>
<tr>
<td>_loess_WgtType</td>
<td>scalar, type of weights. If 1, robust, symmetric weights, otherwise Gaussian. Default = 1.</td>
</tr>
<tr>
<td>__output</td>
<td>scalar, if 1, iteration information and results are printed, otherwise nothing is printed.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>yhat</td>
<td>Nx1 vector, predicted depvar given indvars.</td>
</tr>
<tr>
<td>ys</td>
<td>_loess_numEval x1 vector, ordinate values given abscissae values in xs.</td>
</tr>
<tr>
<td>xs</td>
<td>_loess_numEval x1 vector, equally spaced abscissae values.</td>
</tr>
</tbody>
</table>
Remarks

Based on Cleveland, William S. "Robust Locally Weighted Regression and Smoothing Scatterplots." JASA, Vol. 74, 1979, 829-836.

Source

loess.src

loessmt

Purpose

Computes coefficients of locally weighted regression.

Include

loessmt.sdf

Format

\{ yhat, ys, xs \} = \texttt{loessmt}(lc0, depvar, indvars);

Input

\texttt{lc0}  
an instance of a \texttt{loessmtControl} structure, containing the following members:

\texttt{lc0.Span}  
scalar, degree of smoothing. Must be greater than 2/N. Default = .67777.

\texttt{lc0.NumEval}  
scalar, number of points in \texttt{ys} and \texttt{xs}. Default = 50.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lc0.Degree</td>
<td>scalar, if 2, quadratic fit, otherwise linear. Default = 1.</td>
</tr>
<tr>
<td>lc0.WgtType</td>
<td>scalar, type of weights. If 1, robust, symmetric weights, otherwise Gaussian. Default = 1.</td>
</tr>
<tr>
<td>lc0.output</td>
<td>scalar, if 1, iteration information and results are printed, otherwise nothing is printed.</td>
</tr>
<tr>
<td>depvar</td>
<td>Nx1 vector, dependent variable.</td>
</tr>
<tr>
<td>indvars</td>
<td>NxK matrix, independent variables.</td>
</tr>
<tr>
<td>yhat</td>
<td>Nx1 vector, predicted depvar given indvars.</td>
</tr>
<tr>
<td>ys</td>
<td>lc0.numEval x 1 vector, ordinate values given abscissae values in xs.</td>
</tr>
<tr>
<td>xs</td>
<td>lc0.numEval x 1 vector, equally spaced abscissae values.</td>
</tr>
</tbody>
</table>

**Remarks**

Based on Cleveland, William S. "Robust Locally Weighted Regression and Smoothing Scatterplots." JASA, Vol. 74, 1979, 829-836.

**Source**

loessmt.src

**See Also**

loessmtControlCreate

38-897
loessmtControlCreate

Purpose

Creates default loessmtControl structure.

Include

loessmt.sdf

Format

\[ c = \text{loessmtControlCreate}(); \]

Output

\[ c \]

instance of a loessmtControl structure with members set to default values.

Example

\begin{verbatim}
struct loessmtControl lc;
lc = loessmtControlCreate();
\end{verbatim}

Source

loessmt.src

See Also

loessmt
### log

**Purpose**

Computes the log of all elements of \( x \).

**Format**

\[
y = \log(x);
\]

**Input**

\( x \)  
NxK matrix or N-dimensional array.

**Output**

\( y \)  
NxK matrix or N-dimensional array containing the log 10 values of the elements of \( x \).

**Remarks**

\( \log \) is defined for \( x \neq 0 \).

You can turn the generation of complex numbers for negative inputs on or off in the GAUSS configuration file, and with the `sysstate` function, case 8. If you turn it off, \( \log \) will generate an error for negative inputs.

If \( x \) is already complex, the complex number state doesn't matter; \( \log \) will compute a complex result.

\( x \) can be any expression that returns a matrix.
**Example**

```plaintext
//Create a 3x3 matrix of random uniform integers from 1 to 11
x = round(rndu(3,3)*10+1);
y = log(x);
```

If $x$ is equal to:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.000</td>
<td>9.000</td>
<td>2.000</td>
</tr>
<tr>
<td>5.000</td>
<td>3.000</td>
<td>7.000</td>
</tr>
<tr>
<td>2.000</td>
<td>6.000</td>
<td>10.000</td>
</tr>
</tbody>
</table>

Then $y$ will be equal to:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.602</td>
<td>0.954</td>
<td>0.301</td>
</tr>
<tr>
<td>0.699</td>
<td>0.477</td>
<td>0.845</td>
</tr>
<tr>
<td>0.301</td>
<td>0.778</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**See Also**

ln

loglog

**Purpose**

Graphs X vs. Y using log coordinates. Note: This function is for use with the deprecated PQG graphics. Use plotLogLog instead.

**Library**
pgraph
Format

\texttt{loglog(x, y);} \\

Input

<table>
<thead>
<tr>
<th>x</th>
<th>N×1 or N×M matrix. Each column contains the X values for a particular line.</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>N×1 or N×M matrix. Each column contains the Y values for a particular line.</td>
</tr>
</tbody>
</table>

Source

ploglog.src

See Also

xy, logx, logy

logx

Purpose

Graphs X vs. Y using log coordinates for the X axis. Note: This function is for use with the deprecated PQG graphics. Use \texttt{plotLogX} instead.

Library

pgraph
**Format**

\[ \text{logx}(x, y); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>Nx1 or NxM matrix. Each column contains the X values for a particular line.</td>
</tr>
<tr>
<td>( y )</td>
<td>Nx1 or NxM matrix. Each column contains the Y values for a particular line.</td>
</tr>
</tbody>
</table>

**Source**

plogx.src

**See Also**

xy, logy, loglog

**logy**

**Purpose**

Graphs X vs. Y using log coordinates for the Y axis. Note: This function is for use with the deprecated PQG graphics. Use `plotLogY` instead.

**Library**

pgraph
Format

logy(x, y);

Input

x  N x 1 or N x M matrix. Each column represents the X values for a particular line.

y  N x 1 or N x M matrix. Each column represents the Y values for a particular line.

Source

plogy.src

See Also

xy, logx, loglog

loopnextindex

Purpose

Increments an index vector to the next logical index and jumps to the specified label if the index did not wrap to the beginning.

Format

loopnextindex lab, i, o [, dim];
**Input**

- **lab**: literal, label to jump to if `loopnextindex` succeeds.
- **i**: Mx1 vector of indices into an array, where M<=N.
- **o**: Nx1 vector of orders of an N-dimensional array.
- **dim**: scalar [1-M], index into the vector of indices `i`, corresponding to the dimension to walk through, positive to walk the index forward, or negative to walk backward.

**Remarks**

If the argument `dim` is given, `loopnextindex` will walk through only the dimension indicated by `dim` in the specified direction. Otherwise, if `dim` is not given, each call to `loopnextindex` will increment `i` to index the next element or subarray of the corresponding array.

`loopnextindex` will jump to the label indicated by `lab` if the index can walk further in the specified dimension and direction, otherwise it will fall out of the loop and continue through the program.

When the index matches the vector of orders, the index will be reset to the beginning and program execution will resume at the statement following the `loopnextindex` statement.

**Example**

At its essence, `loopNextIndex` provides a simple way to iterate over the orders of a multi-dimensional array.

```cpp
//The orders of the array
orders = { 2, 3, 4 };
```
The starting index of the array
ind = { 1, 1, 1 };

lnilab:
print "ind = " ind;
loopNextIndex lnilab, ind, orders;

Running the code above, returns:

ind =
1.000
1.000
1.000
ind =
1.000
1.000
2.000
ind =
1.000
1.000
3.000
ind =
1.000
1.000
4.000
ind =
1.000
2.000
1.000
ind =
1.000
2.000
2.000
ind =
This next example uses the variable `ind` to iterate over and make assignments to the array, `a`.

```
orders = { 2,3,4,5,6,7 };  
a = arrayalloc(orders,0);  
ind = { 1,1,1,1 };  

loopni:
    setarray a, ind, rndn(6,7);  
    loopnextindex loopni, ind, orders;
```

This example sets each 6x7 subarray of array `a`, by incrementing the index at each call of `loopnextindex` and then going to the label `loopni`. When `ind` cannot be incremented, the program drops out of the loop and continues.

```
ind = { 1,1,4,5 };  

loopni2:
    setarray a, ind, rndn(6,7);  
    loopnextindex loopni2, ind, orders, 2;
```
Using the array and vector of orders from the example above, this example increments the second value of the index vector \( ind \) during each call to \( \text{loopnextindex} \). This loop will set the 6x7 subarrays of \( a \) that begin at \([1,1,4,5,1,1]\), \([1,2,4,5,1,1]\), and \([1,3,4,5,1,1]\), and then drop out of the loop.

See Also

nextindex, previousindex, walkindex

lower

Purpose

Converts a string or character matrix to lowercase.

Format

\[
y = \text{lower}(x);
\]

Input

\[
x \quad \text{string or } \text{NxK} \text{ matrix of character data to be converted to lowercase.}
\]

Output

\[
y \quad \text{string or } \text{NxK} \text{ matrix which contains the lowercase equivalent of the data in } x.
\]
Remarks

If \( x \) is a numeric matrix, \( y \) will contain garbage. No error message will be generated since \texttt{GAUSS} does not distinguish between numeric and character data in matrices.

Example

```gauss
x = "MATH 401";
y = lower(x);
print y;
```

produces:
```
  math 401
```

The \texttt{lower} function can be useful when performing case insensitive string comparisons. If you have a program that runs different code depending upon the variable name in a \texttt{GAUSS} dataset or spreadsheet file, you or your colleagues may want to analyze data with inconsistent use of case.

```gauss
var1 = "Consumption";

if lower(var1) == "gdp";  //code for gdp branch
    //code for gdp branch
else if lower(var1) == "consumption";
    //code for consumption branch
endif;
```

Using the \texttt{lower} function, the code above will operate correctly whether \( var1 \) is Consumption, CONSUMPTION or consumption.

See Also

\texttt{upper}
**lowmat, lowmat1**

**Purpose**

Returns the lower portion of a matrix. `lowmat` returns the main diagonal and every element below. `lowmat1` is the same except it replaces the main diagonal with ones.

**Format**

\[ L = \text{lowmat}(x); \]
\[ L = \text{lowmat1}(x); \]

**Input**

\( x \)  
NxN matrix.

**Output**

\( L \)  
NxN matrix containing the lower elements of the matrix. The upper elements are replaced with zeros. `lowmat` returns the main diagonal intact. `lowmat1` replaces the main diagonal with ones.

**Remarks**

The `lowmat` function along with `upmat1` can be used to extract the LU factors from the return
Example

\[x = \begin{pmatrix} 1 & 2 & -1, \\ 2 & 3 & -2, \\ 1 & -2 & 4 \end{pmatrix};\]

\[L = \text{lowmat}(x);\]
\[L1 = \text{lowmat1}(x);\]

The resulting matrices are

\[L = \begin{pmatrix} 1 & 0 & 0 \\ 2 & 3 & 0 \\ 1 & -2 & 4 \end{pmatrix},\]
\[L1 = \begin{pmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 1 & -2 & 1 \end{pmatrix}\]

Source
diag.src

See Also
upmat, upmat1, diag, diagrv, crout, croutp

Itrisol

Purpose

Computes the solution of \(Lx = b\) where \(L\) is a lower triangular matrix.

Format

\[x = \text{ltrisol}(b, L);\]
**Input**

\(b\)  
P\(x\)K matrix.

\(L\)  
P\(x\)P lower triangular matrix.

**Output**

\(x\)  
P\(x\)K matrix, solution of \(Lx = b\).

*ltrisol* applies a forward solve to \(Lx = b\) to solve for \(x\). If \(b\) has more than one column, each column will be solved for separately, i.e., *ltrisol* will apply a forward solve to \(L^i x[:, i] = b[:, i]\).

**lu**

**Purpose**

Computes the LU decomposition of a square matrix with partial (row) pivoting, such that: \(X = LU\).

**Format**

\[
\{ l, u \} = \text{lu}(x);
\]

**Input**

\(x\)  
N\(x\)N square nonsingular matrix.
**Output**

\( l \)

NxN "scrambled" lower triangular matrix. This is a lower triangular matrix that has been reordered based on the row pivoting.

\( u \)

NxN upper triangular matrix.

**Example**

```
// Set seed for repeatable random numbers
rndseed 13;

// Print format, display 4 digits after decimal point
format /rd 10,4;

A = rndn(3,3);
{ L, U } = lu(A);
A2 = L*U;
```

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.0195</td>
<td>0.4054</td>
<td>-0.0874</td>
</tr>
<tr>
<td>-1.2948</td>
<td>0.1734</td>
<td>1.9712</td>
</tr>
<tr>
<td>0.5408</td>
<td>-0.1294</td>
<td>0.7646</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0150</td>
<td>1.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>-0.4177</td>
<td>-0.1414</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1.2948</td>
<td>0.1734</td>
<td>1.9712</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.4028</td>
<td>-0.1170</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.0000</td>
<td>1.5714</td>
</tr>
<tr>
<td>-0.0195</td>
<td>0.4054</td>
<td>-0.0874</td>
</tr>
</tbody>
</table>
\[ L^*U = \begin{bmatrix} -1.2948 & 0.1734 & 1.9712 \\ 0.5408 & -0.1294 & 0.7646 \end{bmatrix} \]

**See Also**

`crout`, `croutp`, `chol`

**lusol**

**Purpose**

Computes the solution of \( LUx = b \) where \( L \) is a lower triangular matrix and \( U \) is an upper triangular matrix.

**Format**

\[ x = \text{lusol}(b, \ L, \ U); \]

**Input**

- \( b \) \( \text{PxK matrix.} \)
- \( L \) \( \text{PxP lower triangular matrix.} \)
- \( U \) \( \text{PxP upper triangular matrix.} \)

**Output**

- \( x \) \( \text{PxK matrix, solution of } LUx = b. \)
Remarks

If \( b \) has more than one column, each column is solved for separately, i.e., \texttt{lusol} solves \( LUx[, i] = b[, i] \).
**machEpsilon**

**Purpose**

Returns the smallest number such that $1 + \text{eps} > 1$.

**Format**

$\text{eps} = \text{machEpsilon};$

**Output**

$\text{eps}$  
scalar, machine epsilon.

**Source**

machconst.src

**make (dataloop)**

**Purpose**

Specifies the creation of a new variable within a data loop.
Format

make [#] numvar = numeric_expression;
make $charvar = character_expression;

Remarks

A numeric_expression is any valid expression returning a numeric vector. A character_expression is any valid expression returning a character vector. If neither '§' nor '#' is specified, '#' is assumed.

The expression may contain explicit variable names and/or GAUSS commands. Any variables referenced must already exist, either as elements of the source data set, as extern's, or as the result of a previous make, vector, or code statement. The variable name must be unique. A variable cannot be made more than once, or an error is generated.

Example

make sqvpt = sqrt(velocity * pressure * temp);
make $ gender = lower(gender);

See Also

vector (dataloop)

makevars

Purpose

Creates separate global vectors from the columns of a matrix.
Format

\texttt{makevars(x, vnames, xnames)};

Input

\begin{itemize}
\item \textit{x} \quad \text{NxK matrix whose columns will be converted into individual vectors.}
\item \textit{vnames} \quad \text{string or Mx1 character vector containing names of global vectors to create. If 0, all names in \textit{xnames} will be used.}
\item \textit{xnames} \quad \text{string or Kx1 character vector containing names to be associated with the columns of the matrix \textit{x}.}
\end{itemize}

Remarks

If \textit{xnames} = 0, the prefix X will be used to create names. Therefore, if there are 9 columns in \textit{x}, the names will be X1-X9, if there are 10, they will be X01-X10, and so on.

If \textit{xnames} or \textit{vnames} is a string, the individual names must be separated by spaces or commas:

\begin{verbatim}
  vnames = "age pay sex";
\end{verbatim}

Since these new vectors are created at execution time, the compiler will not know they exist until after \texttt{makevars} has executed once. This means that you cannot access them by name unless you previously \texttt{clear} them or otherwise add them to the symbol table. (See \texttt{setvars} for a quick interactive solution to this.)

This function is the opposite of \texttt{mergevar}. 
Example

```plaintext
let x[3,3] = 101 35 50000
     102 29 13000
     103 37 18000;
let xnames = id age pay;
let vnames = age pay;
makevars(x,vnames,xnames);
```

Two global vectors, called `age` and `pay`, are created from the columns of `x`.

```plaintext
let x[3,3] = 101 35 50000
     102 29 13000
     103 37 18000;
xnames = "id age pay";
vnames = "age pay";
makevars(x,vnames,xnames);
```

This is the same as the example above, except that strings are used for the variable names.

Source

`vars.src`

Globals

`_vpad`

See Also

`mergevar`, `setvars`
makewind

**Purpose**

Creates a graphic panel of specific size and position and adds it to the list of graphic panels. Note: This function is for the deprecated PQG graphics. For similar functionality, see `plotLayout` and `plotCustomLayout`.

**Library**

`pgraph`

**Format**

`makewind(xsize, ysize, xshft, yshft, typ);`

**Input**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>xsize</code></td>
<td>scalar, horizontal size of the graphic panel in inches.</td>
</tr>
<tr>
<td><code>ysize</code></td>
<td>scalar, vertical size of the graphic panel in inches.</td>
</tr>
<tr>
<td><code>xshft</code></td>
<td>scalar, horizontal distance from left edge of window in inches.</td>
</tr>
<tr>
<td><code>yshft</code></td>
<td>scalar, vertical distance from bottom edge of window in inches.</td>
</tr>
<tr>
<td><code>typ</code></td>
<td>scalar, graphic panel attribute type. If this value is 1, the graphic panels will be transparent. If 0, the graphic panels will be nontransparent.</td>
</tr>
</tbody>
</table>
Remarks

Note that if this procedure is used when rotating the page, the passed parameters are scaled appropriately to the newly oriented page. The size and shift values will not be true inches when printed, but the graphic panel size to page size ratio will remain the same. The result of this implementation automates the rotation and eliminates the required graphic panel recalculations by the user.

See the `window` command for creating tiled graphic panels. For more information on using graphic panels, see Tiled Graphic Panels, Section 1.0.1.

Source

`pwindow.src`

See Also

`window, endwind, setwind, getwind, begwind, nextwind`

margin

Purpose

Sets the margins for the current graph's graphic panel. Note: This function is for use with the deprecated PQG graphics. For similar functionality, use `plotCustomLayout`.

Library

`pgraph`

Format

```
margin(l, r, t, b);
```
**Input**

- \( l \) scalar, the left margin in inches.
- \( r \) scalar, the right margin in inches.
- \( t \) scalar, the top margin in inches.
- \( b \) scalar, the bottom margin in inches.

**Remarks**

By default, the dimensions of the graph are the same as the graphic panel dimensions. With this function the graph dimensions may be decreased. The result will be a smaller plot area surrounded by the specified margin. This procedure takes into consideration the axes labels and numbers for correct placement.

All input inch values for this procedure are based on a full size window of 9x6.855 inches. If this procedure is used with a graphic panel, the values will be scaled to "window inches" automatically.

If the axes must be placed an exact distance from the edge of the page, axmargin should be used.

**Source**

pgraph.src

**See Also**

axmargin
matalloc

Purpose

Allocates a matrix with unspecified contents.

Format

\[ y = \text{matalloc}(r, c); \]

Input

- \( r \) scalar, rows.
- \( c \) scalar, columns.

Output

- \( y \) \( r \times c \) matrix.

Remarks

The contents are unspecified. This function is used to allocate a matrix that will be written to in sections using indexing or used with the Foreign Language Interface as an output matrix for a function called with dllcall.

See Also

matinit, ones, zeros, eye
matinit

Purpose

Allocates a matrix with a specified fill value.

Format

\[ y = \text{matinit}(r, c, v); \]

Input

- **r**: scalar, rows.
- **c**: scalar, columns.
- **v**: scalar, value to initialize.

Output

\[ y \quad r \times c \text{ matrix with each element equal to the value of } v. \]

Example

```
format /rd 6,2;
print matinit(3, 4, pi);
```

```
3.14  3.14  3.14  3.14  
3.14  3.14  3.14  3.14  
3.14  3.14  3.14  3.14  
3.14  3.14  3.14  3.14  
```
See Also
matalloc, ones, zeros, eye

mattoarray

Purpose
Converts a matrix to a type array.

Format
\[ y = \text{mattoarray}(x); \]

Input
\( x \) matrix.

Output
\( y \) 1-or-2-dimensional array.

Remarks
If the argument \( x \) is a scalar, \texttt{mattoarray} will simply return the scalar, without changing it to a type array.

Example
\[ x = 5*\texttt{ones}(2, 3); \]
\begin{verbatim}
y = mattoarray(x);
\end{verbatim}

\textit{y} will be a 2x3 array of fives.

\textbf{See Also}

arraytomat

\textbf{maxbytes}

\textbf{Purpose}

Returns maximum memory to be used.

\textbf{Format}

\begin{verbatim}
y = maxbytes;
\end{verbatim}

\textbf{Global Input}

\begin{verbatim}
__maxbytes scalar, maximum memory to be used.
\end{verbatim}

\textbf{Output}

\begin{verbatim}
y scalar, maximum memory to be used.
\end{verbatim}

\textbf{Remarks}

\textbf{maxbytes} returns the value in the global scalar \textit{__maxbytes}, which can be reset
in the calling program.

maxbytes is called by Run-Time Library functions and applications when determining how many rows can be read from a data set in one call to readr.

maxbytes replaced the obsolete command coreleft. If coreleft returns a meaningful number for your operating system and if you wish to reference it, set \_\_maxbytes = 0 and then call maxbytes.

**Example**

```plaintext
y = maxbytes;
print y;
```

```
100000000.000
```

**Source**

system.src

**maxc**

**Purpose**

Returns a column vector containing the largest element in each column of a matrix.

**Format**

```
y = maxc(x);
```
**Input**

\[ x \quad \text{NxK matrix or sparse matrix.} \]

**Output**

\[ y \quad \text{Kx1 matrix containing the largest element in each column of} \ x. \]

**Remarks**

If \( x \) is complex, \texttt{maxc} uses the complex modulus (\texttt{abs}(x)) to determine the largest elements.

To find the maximum elements in each row of a matrix, transpose the matrix before applying the \texttt{maxc} function.

To find the maximum value in the whole matrix if the matrix has more than one column, nest two calls to \texttt{maxc}:

\[
y = \texttt{maxc}(\texttt{maxc}(x));
\]

**Example**

\[
x = \texttt{rndBeta}(4,2,3,1);
y = \texttt{maxc}(x);
\]

If \( x \) equals:

\[
0.87174453 \quad 0.70281291 \\
0.90393029 \quad 0.95919009
\]
then $y$ will equal:

```
0.90393029
0.95919009
```

### See Also

`mine`, `maxinde`, `minindc`

### maxindc

#### Purpose

Returns a column vector containing the index (i.e., row number) of the maximum element in each column of a matrix.

#### Format

```
y = maxindc(x);
```

#### Input

$x$  
NxK matrix.

#### Output

$y$  
Kx1 matrix containing the index of the maximum element in each column of $x$. 
Remarks

If \( x \) is complex, \texttt{maxindc} uses the complex modulus (\texttt{abs}(x)) to determine the largest elements.

To find the index of the maximum element in each row of a matrix, transpose the matrix before applying \texttt{maxindc}.

To find the indices of the largest element in a matrix \( x \), use:

\[
\text{colInd} = \texttt{maxindc} (\texttt{maxc}(x));
\text{rowInd} = \texttt{maxindc}(x[.,\text{colInd}]);
\]

If there are two or more "largest" elements in a column (i.e., two or more elements equal to each other and greater than all other elements), then \texttt{maxindc} returns the index of the first one found, which will be the smallest index.

Example

\[
x = \texttt{round} (\texttt{rndn}(4,4) * 5); \\
xm = \texttt{maxc}(x); \\
xmInd = \texttt{maxindc}(x);
\]

If \( x \) is equal to:

\[
\begin{array}{cccc}
-2 & -8 & -1 & -2 \\
-1 & 9  & 0  & 7  \\
9  & 0  & 4  & 8  \\
-2 & 6  & 6  & 1  \\
\end{array}
\]

then

\[
\begin{array}{cc}
9 & 3 \\
mx = 9 & mxInd = 2 \\
\end{array}
\]
See Also

maxc, mininde, minc

maxv

Purpose

Performs an element by element comparison of two matrices and returns the maximum value for each element.

Format

\[ z = \text{maxv}(x, y); \]

Global Input

\[ x \quad \text{NxK matrix} \]
\[ y \quad \text{NxK matrix} \]

Output

\[ z \quad \text{A NxK matrix whose values are the maximum of each element from the arguments } x \text{ and } y. \]
Remarks

\texttt{maxv} works for sparse matrices as well as arrays.

Example

\begin{verbatim}
//Create the sequence 1, 2, 3,...10
x = seqa(1, 1, 10);

//Set 'y' equal to the reverse order of 'x'
y = rev(x);

z = maxv(x, y);
\end{verbatim}

\begin{verbatim}
  1   10   10
  2    9    9
  3    8    8
  4    7    7
  5    5    6
  6    4    7
  7    3    8
  8    2    9
  9    1   10
10
\end{verbatim}

See Also

\texttt{minv}
# maxvec

## Purpose

Returns maximum vector length allowed.

## Format

\[ y = \text{maxvec}; \]

## Global Input

| __maxvec | scalar, maximum vector length allowed. |

## Output

| \( y \) | scalar, maximum vector length. |

## Remarks

maxvec returns the value in the global scalar __maxvec, which can be reset in the calling program.

maxvec is called by Run-Time Library functions and applications when determining how many rows can be read from a data set in one call to readr.

Using a value that is too large can cause excessive disk thrashing. The trick is to allow the algorithm making the disk reads to execute entirely in RAM.
Example

```plaintext
y = maxvec;
print y;
```

20000.000

Source

system.src

mbesseli

Purpose

Computes modified and exponentially scaled modified Bessels of the first kind of the nth order.

Format

```plaintext
y = mbesseli(x, n, alpha);
y = mbesseli0(x);
y = mbesseli1(x);
y = mbesselei(x, n, alpha);
y = mbesselei0(x);
y = mbesselei1(x);
```

Input

```plaintext
x       Kx1 vector, abscissae.
```
\( n \) scalar, highest order.

\( \alpha \) scalar, \( 0 \leq \alpha < 1 \).

**Output**

\( y \) K\( x \)N matrix, evaluations of the modified Bessel or the exponentially scaled modified Bessel of the first kind of the \( n \)th order.

**Remarks**

For the functions that permit you to specify the order, the returned matrix contains a sequence of modified or exponentially scaled modified Bessel values of different orders. For the \( i \)th row of \( y \):

\[
y[i, \cdot] = I_\alpha(x[i]) \ I_{\alpha+1}(x[i]) \ldots I_{\alpha+n-1}(x[i])
\]

The remaining functions generate modified Bessels of only the specified order.

The exponentially scaled modified Bessels are related to the unscaled modified Bessels in the following way:

\[
\text{mbesselei0}(x) = \exp(-x) \ * \ \text{mbesseli0}(x)
\]

The use of the scaled versions of the modified Bessel can improve the numerical properties of some calculations by keeping the intermediate numbers small in size.

**Example**

This example produces estimates for the "circular" response regression model (Fisher, N.I. *Statistical Analysis of Circular Data*. NY: Cambridge University Press, 1993.),
where the dependent variable varies between \(-\pi\) and \(\pi\) in a circular manner. The model is

\[ y = \mu + G(XB) \]

where \(B\) is a vector of regression coefficients, \(X\) a matrix of independent variables with a column of 1's included for a constant, and \(y\) a vector of "circular" dependent variables, and where \(G()\) is a function mapping \(XB\) onto the \([-\pi, \pi]\) interval.

The log-likelihood for this model is from Fisher, N.I. ... 1993, 159:

\[
\log L = -N \times \ln(I_0(\kappa)) + \kappa \sum_i^N \cos(y_i - \mu - G(X_iB))
\]

To generate estimates it is necessary to maximize this function using an iterative method. \texttt{QNNewton} is used here.

\(\kappa\) is required to be nonnegative and therefore in the example below, the exponential of this parameter is estimated instead. Also, the exponentially scaled modified Bessel is used to improve numerical properties of the calculations.

The \texttt{arctan} function is used in \(G()\) to map \(XB\) to the \([-\pi, \pi]\) interval as suggested by Fisher, N.I. ... 1993, 158.

```plaintext
proc G(u);
   retp(2*atan(u));
endp;

proc lpr(b);
   local dev;
   /*
   ** b[1] - kappa
   ** b[2] - mu
   ** b[3] - constant
   ** b[4:rows(b)] - coefficients
```
\[
\text{dev} = y - b[2] - G(b[3] + x \times b[4:rows(b)])
\]
\[
\text{retp}(\text{rows(dev)} \times \ln(\text{mbesselei0}(\exp(b[1]))) - \\
\text{sumc}(\exp(b[1]) \times (\cos(\text{dev}) - 1)))
\]

\[
\text{loadm data;}
\]
\[
y0 = \text{data}[.,1];
\]
\[
x0 = \text{data}[.,2:cols(data)];
\]
\[
b0 = 2\times\text{ones}(cols(x0),1);
\]
\[
\{ b, fct, grd, ret \} = \text{QNewton}(&lpr, b0);
\]
\[
\text{cov} = \text{invpd}(\text{hessp}(&lpr, b));
\]
\[
\text{print } "\text{estimates standard errors}";
\]
\[
\text{print;}
\]
\[
\text{print } b\sim\text{sqrt(diag(cov))};
\]

**Source**

ribes1.src

**meanc**

**Purpose**

Computes the mean of every column of a matrix.

**Format**

\[
y = \text{meanc}(x);
\]
**Input**

$x$  
NxK matrix.

**Output**

$y$  
Kx1 matrix containing the mean of every column of $x$.

**Example**

```matlab
x = mean(c(rndu(1e5,4)));
```

After the code above, $x$ is equal to:

```plaintext
0.5007
0.5004
0.4995
0.5016
```

In this example, 4 columns of uniform random numbers are generated in a matrix, and the mean is computed for each column. Due to the use of random input data in this example, your results may differ slightly.

**See Also**

stdc

edc

**median**

**Purpose**

Computes the medians of the columns of a matrix.
Format

\[ m = \text{median}(x); \]

Input

\( x \quad \text{N} \times \text{K matrix.} \)

Output

\[ m \quad \text{K} \times 1 \text{ vector containing the medians of the respective columns of} \ x. \]

Example

```c
//Set the seed for repeatable random data
rndseed 4320993;

//Create uniform random integers between 1 and 10
x = ceil(10*rndu(100,3));

//Calculate the median of each column of 'x'
md = median(x);
```

After the code above, \( md \) is equal to:

5.0000
5.0000
6.0000

Source

median.src
mergeby

Purpose

Merges two sorted files by a common variable.

Format

```
mergeby(infile1, infile2, outfile, keytyp);
```

Input

- `infile1`: string, name of input file 1.
- `infile2`: string, name of input file 2.
- `outfile`: string, name of output file.
- `keytyp`: scalar, data type of key variable.
  - `1` numeric
  - `2` character

Remarks

This will combine the variables in the two files to create a single large file. The following assumptions hold:

1. Both files have a single (key) variable in common and it is the first variable.
2. All of the values of the key variable are unique.
3. Each file is already sorted on the key variable.
The output file will contain the key variable in its first column.

It is not necessary for the two files to have the same number of rows. For each row for which the key variables match, a row will be created in the output file. outfile will contain the columns from infile1 followed by the columns from infile2 minus the key column from the second file.

If the inputs are null ("" or 0), the procedure will ask for them.

**Source**

sortd.src

**mergevar**

**Purpose**

Accepts a list of names of global matrices, and concatenates the corresponding matrices horizontally to form a single matrix.

**Format**

\[ x = \text{mergevar}(vnames); \]

**Input**

\[ vnames \] string or Kx1 column vector containing the names of K global matrices.
Output

$X$ \text{ NxM matrix that contains the concatenated matrices, where M is the sum of the columns in the K matrices specified in vnames.}

Remarks

The matrices specified in \textit{vnames} must be globals and they must all have the same number of rows.

This function is the opposite of \textit{makevars}.

Example

```plaintext
//Random integers between 1 and 72
age = \texttt{ceil}(72 * \texttt{rndu}(100, 1));

//Random normal numbers with a mean of 70 and a standard deviation of 10
income = 10 * \texttt{rndn}(100, 1) + 70;

//Vertically concatenate the strings
vnames = "$age"|"income";

//Merge the variables into 1 matrix
agInc = \texttt{mergevar}(vnames);
```

The column vectors \textit{age} and \textit{income} will be concatenated horizontally to create \textit{agInc}. The above call to \texttt{mergevar} is equivalent to:
//Combine the matrices using the horizontal concatenation operator
agInc = age~income;

Source
vars.src

See Also
makevars

minc

Purpose
Returns a column vector containing the smallest element in each column of a matrix.

Format
\[ y = \text{minc}(x); \]

Input
\( x \)  
NxK matrix or sparse matrix.

Output
\( y \)  
Kx1 matrix containing the smallest element in each column of \( x \).
Remarks

If \( x \) is complex, \texttt{minc} uses the complex modulus (\texttt{abs}(x)) to determine the smallest elements.

To find the minimum element in each row, transpose the matrix before applying the \texttt{minc} function.

To find the minimum value in the whole matrix, nest two calls to \texttt{minc}:

\[
y = \texttt{minc}(	exttt{minc}(x));
\]

Example

\[
\begin{align*}
x &= \texttt{rndn}(4,2); \\
y &= \texttt{minc}(x);
\end{align*}
\]

If \( x \) is equal to:

\[
\begin{pmatrix}
-1.9950 & -1.3477 \\
-0.4031 & -1.9137 \\
0.8136 & -2.3155 \\
-0.9947 & 1.4061
\end{pmatrix}
\]

then \( y \) will equal:

\[
\begin{pmatrix}
-1.9950 \\
-2.3155
\end{pmatrix}
\]

See Also

\texttt{maxc}, \texttt{mininde}, \texttt{maxinde}
minindc

Purpose

Returns a column vector containing the index (i.e., row number) of the smallest element in each column of a matrix.

Format

\[ y = \text{minindc}(x); \]

Input

\( x \)  
NxK matrix.

Output

\( y \)  
Kx1 matrix containing the index of the smallest element in each column of \( x \).

Remarks

If \( x \) is complex, \texttt{minindc} uses the complex modulus (\texttt{abs}(x)) to determine the smallest elements.

To find the index of the smallest element in each row, transpose the matrix before applying \texttt{minindc}.

To find the index of the smallest element in a matrix \( x \), use:
colInd = minindc(minc(x));
rowInd = minindc(x[.,colInd]);

If there are two or more "smallest" elements in a column (i.e., two or more elements equal to each other and less than all other elements), then minindc returns the index of the first one found, which will be the smallest index.

**Example**

\[
x = \text{round}(\text{rndn}(5,4)*5);
y = \text{minc}(x);
z = \text{minindc}(x);
\]

If \(x\) is equal to:

\[
\begin{bmatrix}
-5 & 4 & -4 & 0 \\
-2 & 3 & 4 & 3 \\
x = -11 & 5 & 5 & 5 \\
1 & 2 & 7 & 4 \\
-2 & 4 & -1 & -5
\end{bmatrix}
\]

then \(y\) and \(z\) are equal to:

\[
\begin{bmatrix}
-11 & 3 \\
y = 2 & z = 4 \\
-4 & 1 \\
-5 & 5
\end{bmatrix}
\]

**See Also**

mininde, mine, maxc
**minv**

**Purpose**

Performs an element by element comparison of two matrices and returns the minimum value for each element.

**Format**

\[ z = \text{minv}(x, y); \]

**Global Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>NxK matrix</td>
</tr>
<tr>
<td>(y)</td>
<td>NxK matrix</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(z)</td>
<td>A NxK matrix whose values are the minimum of each element from the arguments (x) and (y).</td>
</tr>
</tbody>
</table>

**Remarks**

\textbf{minv} works for sparse matrices as well as arrays.

**Example**

```
//Create the multiplicative sequence 1, 2, 4, 8
x = \text{seqm}(1, 2, 4);
```
//Reverse the order of the elements in 'x' and assign them //to 'y'

y = rev(x);

z = minv(x,y);

After the code above:

<table>
<thead>
<tr>
<th>x = 2</th>
<th>y = 4</th>
<th>z = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

See Also

maxv

miss, missrv

Purpose

miss converts specified elements in a matrix to GAUSS's missing value code. missrv is the reverse of this, and converts missing values into specified values.

Format

```plaintext
y = miss(x, v);
y = missrv(x, v);
```
**Input**

- $x$: NxK matrix.
- $v$: LxM matrix, ExE conformable with $x$.

**Output**

- $y$: max(N,L) by max(K,M) matrix.

**Remarks**

For **miss**, elements in $x$ that are equal to the corresponding elements in $v$ will be replaced with the **GAUSS** missing value code.

For **missrv**, elements in $x$ that are equal to the **GAUSS** missing value code will be replaced with the corresponding element of $v$.

For complex matrices, the missing value code is defined as a missing value entry in the real part of the matrix. For complex $x$, then, **miss** replaces elements with a ". + 0i" value, and **missrv** examines only the real part of $x$ for missing values. If, for example, an element of $x = 1 + .i$, **missrv** will not replace it.

These functions act like element-by-element operators. If $v$ is a scalar, for instance -1, then all -1's in $x$ are converted to missing. If $v$ is a row (column) vector with the same number of columns (rows) as $x$, then each column (row) in $x$ is transformed to missings according to the corresponding element in $v$. If $v$ is a matrix of the same size as $x$, then the transformation is done corresponding element by corresponding element.

Missing values are given special treatment in the following functions and operators: $b/A$ (matrix division when $a$ is not square and neither $a$ nor $b$ is scalar), **counts**,
scalmiss, maxc, maxindc, minc, minindc, miss, missex, missrv, moment, packr, scalmiss, sortc.

As long as you know a matrix contains no missings to begin with, miss and missrv can be used to convert one set of numbers into another. For example:

```
y = missrv(miss(x,0),1);
```

will convert 0's to 1's.

To convert a range of values, such as:

```
0.5 < x < 1.3
```

into missing values, use the missex function.
**Example**

**Example 1**

```plaintext
x = { 1, 2 };  
x_miss = miss(x, 2);
```

After the code above:

```plaintext
x_miss = 1
```

**Example 2**

```plaintext
//Create a 3x3 matrix with each element equal to 1  
x = ones(3, 3);

//Assign the diagonal of 'x' to be equal to pi  
x = diagrv(x, pi);

print "x = " x;

//Change all 1's in 'x' into missing values and assign to  
//x_miss  
x_miss = miss(x, 1);

print "x_miss = " x_miss;

//Change all missings in 'x_miss' into 2*pi and assign to x  
x2 = missrv(x_miss, 2*pi);

print "x2 = " x2;
```

The code above, will return:
Example 3

If the first input, $x$, is a matrix and the second input, $v$, is a column vector with the same number of rows as the matrix $x$, then $\text{miss}$ will check the first row of $x$ for instances of the value in the first element of the column vector. It will check the second row of $x$ for instances of the second element of the column vector, etc. For example:

```matlab
x = [3.1415927 1.0000000 1.0000000;
     1.0000000 3.1415927 1.0000000;
     1.0000000 1.0000000 3.1415927];
x_miss = [3.1415927 . . . .;
          . 3.1415927 . . .;
          . . . . 3.1415927];
x2 = [3.1415927 6.2831853 6.2831853;
      6.2831853 3.1415927 6.2831853;
      6.2831853 6.2831853 3.1415927];

x = [1 2 3 1,
     1 2 3 1,
     1 2 3 1];
v = [1,
     2,
     3];
x_miss = miss(x, v);
```

will create:

```matlab
x_miss = . 2 3 .
       1 . 3 1
       1 2 . 1
```
If \( v \) is a row vector, then \texttt{miss} will check each column of \( x \) for entries that are equal to the corresponding entry in \( v \). For example:

\[
x = \begin{pmatrix}
1 & 2 & 3, \\
1 & 2 & 3, \\
1 & 2 & 3, \\
4 & 5 & 6
\end{pmatrix};
\]
\[
v = \begin{pmatrix}
1 & 2 & 3
\end{pmatrix};
\]
\[
x_{\text{miss}} = \texttt{miss}(x, v);
\]

will create:

\[
x_{\text{miss}} = \ldots
\]
\[
\ldots
\]
\[
\ldots
\]
\[
4 & 5 & 6
\]

**See Also**

\texttt{counts}, \texttt{ismiss}, \texttt{maxe}, \texttt{maxinde}, \texttt{minc}, \texttt{mininde}, \texttt{missex}, \texttt{moment}, \texttt{packr}, \texttt{scalmiss}, \texttt{sorte}

**missex**

**Purpose**

Converts numeric values to the missing value code according to the values given in a logical expression.

**Format**

\[
y = \texttt{missex}(x, mask);
\]
**Input**

- **x**  
  NxK matrix.
- **mask**  
  NxK logical matrix (matrix of 0's and 1's) that serves as a "mask" for x; the 1's in mask correspond to the values in x that are to be converted into missing values.

**Output**

- **y**  
  NxK matrix that equals x, but with those elements that correspond to the 1's in e converted to missing.

**Remarks**

The matrix e will usually be created by a logical expression. For instance, to convert all numbers between 10 and 15 in x to missing, the following code could be used:

```
y = missex(x, (x .> 10) .and (x .< 15));
```

Note that "dot" operators MUST be used in constructing the logical expressions.

For complex matrices, the missing value code is defined as a missing value entry in the real part of the matrix. For complex x, then, **missex** replaces elements with a ".+0i" value.

This function is like **miss**, but is more general in that a range of values can be converted into missings.

**Example**

```
//Set seed for repeatable random numbers
```
rngseed 49728424;

x = rndu(3,2);

//Logical expression
mask = (x .> .30) .and (x .< .60);
y = missex(x, mask);

After the code above:

```
x = 0.525 0.419 1 1 . .
   0.869 0.973 mask = 0 0 y = 0.869 0.973
   0.021 0.357 0 1 0.021 .
```

A 3x2 matrix of uniform random numbers is created. All values in the interval (0.30, 0.60) are converted to missing.

**Source**
datatran.src

**See Also**
miss, missrv

**moment**

**Purpose**

Computes a cross-product matrix. This is the same as \( x'x \).

**Format**

\[ y = \text{moment}(x, d); \]
**Input**

$x$  
NxK matrix or M-dimensional array where the last two dimensions are NxK.

$d$  
scalar, controls handling of missing values.

- 0: missing values will not be checked for. This is the fastest option.
- 1: "listwise deletion" is used. Any row that contains a missing value in any of its elements is excluded from the computation of the moment matrix. If every row in $x$ contains missing values, then $\text{moment}(x, 1)$ will return a scalar zero.
- 2: "pairwise deletion" is used. Any element of $x$ that is missing is excluded from the computation of the moment matrix. Note that this is seldom a satisfactory method of handling missing values, and special care must be taken in computing the relevant number of observations and degrees of freedom.

**Output**

$y$  
KxK matrix or M-dimensional array where the last two dimensions are KxK, the cross-product of $x$.

**Remarks**

The fact that the moment matrix is symmetric is taken into account to cut execution
time almost in half.

If \( x \) is an array, the result will be an array containing the cross-products of each 2-dimensional array described by the two trailing dimensions of \( x \). In other words, for a 10x4x4 array \( x \), the resulting array \( y \) will contain the cross-products of each 4x4 arrays contained in \( x \), so \( y[n,\ldots] = x[n,\ldots]'x[n,\ldots] \) for \( 1 \leq n \leq 10 \).

If there is no missing data then \( d = 0 \) should be used because it will be faster.

The \( / \) operator (matrix division) will automatically form a moment matrix (performing pairwise deletions if \texttt{trap 2} is set) and will compute the \texttt{ols} coefficients of a regression. However, it can only be used for data sets that are small enough to fit into a single matrix. In addition, the moment matrix and its inverse cannot be recovered if the \( / \) operator is used.

**Example**

```gauss
xx = moment(x,2);
ixx = invpd(xx);
b = ixx*missrv(x,0)'y;
```

In this example, the regression of \( y \) on \( x \) is computed. The moment matrix \( (xx) \) is formed using the \texttt{moment} command (with pairwise deletion, since the second parameter is 2). Then \( xx \) is inverted using the \texttt{invpd} function. Finally, the \texttt{ols} coefficients are computed. \texttt{missrv} is used to emulate pairwise deletion by setting missing values to 0.

**momentd**

**Purpose**

Computes a moment \((x'x)\) matrix from a \texttt{GAUSS} data set.
Format

\[ m = \text{momentd}(\text{dataset}, \text{vars}); \]

**Input**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>dataset</strong></td>
<td>string, name of data set.</td>
</tr>
</tbody>
</table>
| **vars** | Kx1 character vector, names of variables - or - \[ \text{Kx1 numeric vector, indices of columns.} \]
|         | These can be any size subset of the variables in the data set, and can be in any order. If a scalar 0 is passed, all columns of the data set will be used. |

**Global Input**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>con</strong></td>
<td>scalar, default 1.</td>
</tr>
<tr>
<td>1</td>
<td>a constant term will be added.</td>
</tr>
<tr>
<td>0</td>
<td>no constant term will be added.</td>
</tr>
<tr>
<td><strong>miss</strong></td>
<td>scalar, default 0.</td>
</tr>
<tr>
<td>0</td>
<td>there are no missing values (fastest).</td>
</tr>
<tr>
<td>1</td>
<td>do listwise deletion; drop an observation if any missings occur in it.</td>
</tr>
<tr>
<td>2</td>
<td>do pairwise deletion; this is equivalent to setting missings to 0 when calculating [ m. ]</td>
</tr>
</tbody>
</table>
__row__ scalar, the number of rows to read per iteration of the read loop, default 0.

If 0, the number of rows will be calculated internally.

If you get an Insufficient memory error, or you want the rounding to be exactly the same between runs, you can set the number of rows to read before calling `momentd`.

**Output**

\[ M \times M \] matrix, where \( M = K + \_\_con \), the moment matrix constructed by calculating \( X'X \) where \( X \) is the data, with or without a constant vector of ones.

Error handling is controlled by the low order bit of the trap flag.

- \( \text{trap 0} \) terminate with error message
- \( \text{trap 1} \) return scalar error code in \( m \)

\[
\begin{align*}
33 & \text{ too many missings} \\
34 & \text{ file not found}
\end{align*}
\]

**Example**

```plaintext
z = { age, pay, sex }; 
m = momentd("freq", z);
```

**Source**

`momentd.src`
movingave

Purpose
Computes moving average of a series.

Format
\[ y = \text{movingave}(x, \ d); \]

Input
- \( x \): NxK matrix.
- \( d \): scalar, order of moving average.

Output
- \( y \): NxK matrix, filtered series. The first \( d-1 \) rows of \( x \) are set to missing values.

Remarks
\texttt{movingave} is essentially a smoothing time series filter. The moving average is performed by column and thus it treats the NxK matrix as K time series of length N.

See Also
\texttt{movingaveWgt}, \texttt{movingaveExpwgt}
movingaveExpwgt

Purpose

Computes exponentially weighted moving average of a series.

Format

\[ y = \text{movingaveExpwgt}(x, \ d, \ p); \]

Input

- \( x \) : NxK matrix.
- \( d \) : scalar, order of moving average.
- \( p \) : scalar, smoothing coefficient where \( 0 < p < 1 \).

Output

- \( y \) : NxK matrix, filtered series. The first \( d-1 \) rows of \( x \) are set to missing values.

Remarks

\textit{movingaveExpwgt} is a smoothing time series filter using exponential weights. The moving average as performed by column and thus it treats the NxK matrix as K time series of length N.

See Also

movingaveWgt, movingave
movingaveWgt

Purpose
Computes weighted moving average of a series

Format
\[ y = \text{movingaveWgt}(x, \ d, \ w); \]

Input
- \( x \) : NxK matrix.
- \( d \) : scalar, order of moving average.
- \( w \) : \( d \times 1 \) vector, weights.

Output
- \( y \) : NxK matrix, filtered series. The first \( d-1 \) rows of \( x \) are set to missing values.

Remarks
\text{movingaveWgt} is essentially a smoothing time series filter with weights. The moving average as performed by column and thus it treats the NxK matrix as K time series of length N.

See Also
movingave, movingaveExpwgt
**msym**

**Purpose**

Allows the user to set the symbol that GAUSS uses when missing values are converted to ASCII and vice versa.

**Format**

```
msym str;
```

**Input**

```
str
```

Literal or ^string (up to 8 letters) which, if not surrounded by quotes, is forced to uppercase. This is the string to be printed for missing values. The default is '.'.

**Remarks**

The entire string will be printed out when converting to ASCII in print and printfm statements.

When converting ASCII to binary in loadm and let statements, only the first character is significant. In other words,

```
msym HAT;
```

will cause 'H' to be converted to missing on input.

This does not affect writer, which outputs data in binary format.
Note that `msym` is a keyword and not a variable being assigned to, so there is no equals sign between `msym` and the string that is being passed to it.

**Example**

In the example below, you first create simulated data. The data represents the scores that a group of students received on a particular test and also the time that they took. For your calculations, you only want to consider data from students that completed the test in less than 80 minutes.

The code below replaces the scores from students that took more than 80 minutes with missing values. It uses the `msym` keyword to change the visual representation used for missing values from a `'.'` to a `'T'`. Though, note that the underlying elements are still missing values, not character or string elements.

```plaintext
//Set seed for repeatable random numbers
rndseed 543124;

//Random integers with a mean of 70 and range of 20 to
//represent time taken for test
testTime = ceil(30 * rndu(10, 1)) + 60;

//Random integers with a mean of 1000 and a standard
//deviation of 10
score = ceil(10 * rndn(10, 1)) + 1000;

//Maximum allowed time for test
maxTime = 80;

//Create a mask for times greater than maxTime
mask = testTime .> maxTime;

//Set scores to be missing values if testTime is greater
//than maxTime
mScores = missex(score, mask);
```
//Set missing values to print as 'T' to represent that the
//score was invalid because the student took too much time
msym "T";

format /rd 4,0;
print mScores;

The code above will return:

T
1010
997
1002
985
997
1007
995
T
T
T

See Also

print, printfm
new

Purpose

Erases everything in memory including the symbol table; closes all open files as well as the auxiliary output and turns the window on if it was off; also allows the size of the new symbol table and the main program space to be specified.

Format

```
new;
new nos;
```

Input

| nos       | scalar, optional input which indicates the maximum number of global symbols allowed. |

Remarks

Procedures, user-defined functions, and global matrices, strings, and string arrays are all global symbols.
If you would like your user-defined procedures to not be cleared after a `new` statement, you can either add them to a **GAUSS Library** or create a file in your `GAUSSHOME` directory with the same name as your procedure and a `.g` file extension. This file `.g` file should only contain your procedure.

This command can be used with arguments as the first statement in a program to clear the symbol table and to allocate only as much space for program code as your program actually needs. When used in this manner, the auxiliary output will not be closed. This will allow you to open the auxiliary output from the command level and run a program without having to remove the `new` at the beginning of the program. If this command is not the first statement in your program, it will cause the program to terminate.

**Example**

```
new; /* clear global symbols. */
```

```
new 300; /* clear global symbols, set maximum
** number of global symbols to 300,
** and leave program space unchanged.
*/
```

**See Also**

`clear`, `delete`, `output`

**nextindex**

**Purpose**

Returns the index of the next element or subarray in an array.
Format

\[ ni = \text{nextindex}(i, o); \]

Input

\[ i \]
Mx1 vector of indices into an array, where M<=N.

\[ o \]
Nx1 vector of orders of an N-dimensional array.

Output

\[ ni \]
Mx1 vector of indices, the index of the next element or subarray in the array corresponding to \( o \).

Remarks

\text{nextindex} will return a scalar error code if the index cannot be incremented.

Example

```c
//Dimensions of an array
orders = { 3, 4, 5, 6, 7};

//Starting index
ind = { 2, 3, 5 };

//Return the index for the next element
ind = \text{nextindex}(ind,orders);
```

After the code above, \textit{ind} will be equal to:
In this example, `nextindex` incremented `ind` to index the next 6x7 subarray in array `a`.

Using the same data from above, a subsequent call to `nextindex`:

```
ind = nextindex(ind, orders);
```

will assign `ind` to be equal to:

```
2
4
2
```

See Also

`previousindex`, `loopnextindex`, `walkindex`

`nextn, nextnevn`

Purpose

Returns allowable matrix dimensions for computing FFT's.

Format

```
n = nextn(n0);
n = nextnevn(n0);
```
**Input**

*n0* scalar, the length of a vector or the number of rows or columns in a matrix.

**Output**

*n* scalar, the next allowable size for the given dimension for computing an FFT or RFFT. \( n > n0 \).

**Remarks**

`nextn` and `nextnevn` determine allowable matrix dimensions for computing FFT's. The Temperton FFT routines (see table below) can handle any matrix whose dimensions can be expressed as:

\[
2^p \times 3^q \times 5^r \times 7^s
\]

where \( p, q \) and \( r \) are nonnegative integers and \( s \) is equal to 0 or 1.

with one restriction: the vector length or matrix column size must be even (\( p \) must be positive) when computing RFFT's.

`fftn`, etc., automatically pad matrices (with zeros) to the next allowable dimensions; `nextn` and `nextnevn` are provided in case you want to check or fix matrix sizes yourself.

Use the following table to determine what to call for a given function and matrix:

<table>
<thead>
<tr>
<th>FFT Function</th>
<th>Vector Length</th>
<th>Matrix Rows</th>
<th>Matrix Columns</th>
</tr>
</thead>
</table>
Example

```c
n = nextn(456);
```

The code above will assign `n` to be equal to 480.

Source

`optim.src`

See Also

`fftn, optn, optnevn, rfftn, rfftnp`

nextwind

Purpose

Set the current graphic panel to the next available graphic panel. Note: This function is for use with the deprecated PQG graphics. For similar functionality use `plotLayout` instead.

Library

`pgraph`
**Format**

```
nextwind;
```

**Remarks**

This function selects the next available graphic panel to be the current graphic panel. This is the graphic panel in which the next graph will be drawn.

See the discussion on using graphic panels in *Tiled Graphic Panels*, Section 1.0.1.

**Source**

*pwindow.src*

**See Also**

`endwind`, `begwind`, `setwind`, `getwind`, `makewind`, `window`

---

**null**

**Purpose**

Computes an orthonormal basis for the (right) null space of a matrix.

**Format**

```
b = null(x);
```

**Input**

```
x  N x M matrix.
```
**Output**

$b$  
MxK matrix, where K is the nullity of $x$, such that:

\[ x \ast b = 0 \quad //\text{MxK matrix of 0's} \]

and

\[ b'\,b = I \quad //\text{MxM identity matrix} \]

The error returns are returned in $b$:

<table>
<thead>
<tr>
<th>error code</th>
<th>reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>there is no null space</td>
</tr>
<tr>
<td>2</td>
<td>$b$ is too large to return in a single matrix</td>
</tr>
</tbody>
</table>

Use `scalerr` to test for error returns.

**Remarks**

The orthogonal complement of the column space of $x'$ is computed using the QR decomposition. This provides an orthonormal basis for the null space of $x$.

**Example**

```plaintext
let x[2,4] = 2 1 3 -1  
        3 5 1 2;

b = null(x);
z = x*b;
i = b'b;
```
After the code above:

\[
\begin{bmatrix}
-0.804 & 0.142 \\
0.331 & -0.473 \\
0.473 & 0.331 \\
0.142 & 0.804 \\
\end{bmatrix}
\]

\[
b = \begin{bmatrix}
0.331 & -0.473 & z = 0 & 0 & i = 1 & 0 \\
0.473 & 0.331 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

**Source**

null.src

**Globals**

_qrdc, _qrsl

**null1**

**Purpose**

Computes an orthonormal basis for the (right) null space of a matrix and writes it to a GAUSS dataset.

**Format**

\[
uu = \textbf{null1}(x, \text{ dataset});
\]

**Input**

\[
x \quad \text{NxM matrix.}
\]

\[
dataset \quad \text{string, the name of a data set \textbf{null1} will write.}
\]
Output

\[ nu \] scalar, the nullity of \( x \).

Remarks

\texttt{null1} computes an MxK matrix \( b \), where K is the nullity of \( x \), such that:

\[
x^* \ b = 0 \quad // \text{NxK matrix of 0's}
\]

and

\[
\ b'^* \ b = I \quad // \text{MxM identity matrix}
\]

The transpose of \( b \) is written to the data set named by \texttt{dataset}, unless the nullity of \( x \) is zero. If \( nu \) is zero, the data set is not written.

Source

\texttt{null.src}

Globals

\_qrdc, \_qrs1

\texttt{numCombinations}

Purpose

Computes number of combinations of \( n \) things taken \( k \) at a time.
Format

\[ y = \text{numCombinations}(n, k); \]

Input

\[ n \quad \text{scalar.} \]
\[ k \quad \text{scalar.} \]

Output

\[ y \quad \text{scalar, number of combinations of } n \text{ things take } k \text{ at a time.} \]

Remarks

To calculate all of the combinations, use the function `combinate`.

Example

\[ y = \text{numCombinations}(25,5); \]
\[ \text{print } y; \]

The code above, returns:

53130.0000

See Also

`combinate`, `combinated`
ols

Purpose

Computes a least squares regression.

Format

\{ vnam, m, b, stb, vc, stderr, sigma, cx, rsq, resid, dwstat \} = ols(dataset, depvar, indvars)

Input

dataset

string, name of data set or null string.

If dataset is a null string, the procedure assumes that the actual data has been passed in the next two arguments.

depvar

If dataset contains a string:

string, name of dependent variable

- or -

scalar, index of dependent variable. If scalar 0, the last column of the data set will be used.

If dataset is a null string or 0:
**Global Input**

Defaults are provided for the following global input variables, so they can be ignored unless you need control over the other options provided by this procedure.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>___altnam</td>
<td>character vector, default 0. This can be a (K+1)x1 or (K+2)x1 character vector of alternate variable names for the output. If ___con is 1, this must be (K+2) x1. The name of the dependent variable is the last element.</td>
</tr>
<tr>
<td>___con</td>
<td>scalar, default 1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a constant term will be added, ( D = K+1 ).</td>
</tr>
<tr>
<td>0</td>
<td>no constant term will be added, ( D = K ).</td>
</tr>
</tbody>
</table>
A constant term will always be used in constructing the moment matrix $m$.

### __**miss**__

Scalar, default 0.

- 0: There are no missing values (fastest).
- 1: Listwise deletion, drop any cases in which missings occur.
- 2: Pairwise deletion, this is equivalent to setting missings to 0 when calculating $m$. The number of cases computed is equal to the total number of cases in the data set.

### __**olsalg**__

String, default "cholup." Selects the algorithm used for computing the parameter estimates. The default Cholesky update method is more computationally efficient; however, accuracy can suffer for poorly conditioned data. For higher accuracy, set __**olsalg**__ to either qr or svd.

- **qr**: Solves for the parameter estimates using a qr decomposition.
- **svd**: Solves for the parameter estimates using a singular value decomposition.

### __**output**__

Scalar, default 1.

- 1: Print the statistics.
- 0: Do not print statistics.

### __**row**__

Scalar, the number of rows to read per iteration of the read
loop. Default 0.

If 0, the number of rows will be calculated internally. If you get an Insufficient memory error while executing ols, you can supply a value for \_row that works on your system.

The answers may vary slightly due to rounding error differences when a different number of rows is read per iteration. You can use \_row to control this if you want to get exactly the same rounding effects between several runs.

_olsres scalar, default 0.

1 compute residuals (resid) and Durbin-Watson statistic (dwstat).

0 resid = 0, dwstat = 0.

Output

vnam \( (K+2) \times 1 \) or \( (K+1) \times 1 \) character vector, the variable names used in the regression. If a constant term is used, this vector will be \( (K+2) \times 1 \), and the first name will be "CONSTANT". The last name will be the name of the dependent variable.

m MxM matrix, where M = K+2, the moment matrix constructed by calculating \( x'x \) where \( x \) is a matrix containing all useable observations and having columns in the order:

<table>
<thead>
<tr>
<th>1.0</th>
<th>indvars</th>
<th>depvar</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>(independent variables)</td>
<td>(dependent variable)</td>
</tr>
</tbody>
</table>

A constant term is always used in computing m.
The system can become underdetermined if you use listwise deletion and have missing values. In that case, it is possible to skip so many cases that there are fewer useable rows than columns in the data set.

$b$  
Dx1 vector, the least squares estimates of parameters

$\text{trap 0}$  
terminate with error message

$\text{trap 1}$  
return scalar error code in $b$

- 30 system singular
- 31 system underdetermined
- 32 same number of columns as rows
- 33 too many missings
- 34 file not found
- 35 no variance in an independent variable

$stb$  
Kx1 vector, the standardized coefficients.

$vc$  
DxD matrix, the variance-covariance matrix of estimates.

$stderr$  
Dx1 vector, the standard errors of the estimated parameters.

$sigma$  
scalar, standard deviation of residual.

$cx$  
$(K+1)x(K+1)$ matrix, correlation matrix of variables with the dependent variable as the last column.
**Remarks**

For poorly conditioned data the default setting for \_\_olsalg, using the Cholesky update, may produce only four or five digits of accuracy for the parameter estimates and standard error. For greater accuracy, use either the qr or singular value decomposition algorithm by setting \_\_olsalg to qr or svd. If you are unsure of the condition of your data, set \_\_olsalg to qr.

No output file is modified, opened, or closed by this procedure. If you want output to be placed in a file, you need to open an output file before calling ols.

**Example**

```plaintext
y = ( 2,
     3,
     1,
```
7,
5 );

x = { 1 3 2,
2 3 1,
7 1 7,
5 3 1,
3 5 5 }; 

output file = ols.out reset;
call ols(0,y,x);
output off;

In this example, the output from ols is put into a file called ols.out as well as being printed to the window. This example will compute a least squares regression of y on x. The return values are discarded by using a call statement.

data = "olsdat";
depvar = { score };
indvars = { region, age, marstat };
_olsres = 1;
output file = lpt1 on;
{ nam,m,b,stm,vc,std,sig,cx,rsq,resid,dbw } = ols(data,depvar,indvars);
output off;

In this example, the data set olsdat.dat is used to compute a regression. The dependent variable is score. The independent variables are: region, age, and marstat. The residuals and Durbin-Watson statistic will be computed. The output will be sent to the printer as well as the window and the returned values are assigned to variables.
**Source**
ols.src

**See Also**
olsqr

**olsmt**

**Purpose**
Computes a least squares regression.

**Format**

\[ oout = \texttt{olsmt}(oc0, \text{dataset}, \text{depvar}, \text{indvars}); \]

**Input**

\texttt{oc0} 
instance of an \texttt{olsmtControl} structure containing the following members:

\texttt{oc0.altnam} 
character vector, default 0.

This can be a \((K+1)x1\) or \((K+2)x1\) character vector of alternate variable names for the output. If \texttt{oc0.con} is 1, this must be \((K+2)x1\). The name of the dependent variable is the last element.

\texttt{oc0.con} 
scalar, default 1.

\texttt{1} 
a constant term will be added, D =
K + 1.

0 no constant term will be added, D = K.

A constant term will always be used in constructing the moment matrix m.

scalar, default 0.

0 there are no missing values (fastest).

1 listwise deletion, drop any cases in which missings occur.

2 pairwise deletion, this is equivalent to setting missings to 0 when calculating m. The number of cases computed is equal to the total number of cases in the data set.

scalar, the number of rows to read per iteration of the read loop. Default 0.

If 0, the number of rows will be calculated internally. If you get an Insufficient memory error message while executing **olsmt**, you can supply a value for **oc0.row** that works on your system.

The answers may vary slightly due to rounding error differences when a different number of rows is read per iteration. You can use **oc0.row** to control this if you want to get exactly the same rounding effects between
several runs.

\textit{oc0.vpad} \hspace{1cm} \text{scalar, default 1.}

If 0, internally created variable names are not padded to the same length (e.g. "X1, X2,..., X10").

If 1, they are padded with zeros to the same length (e.g., "X01, X02,..., X10").

\textit{oc0.output} \hspace{1cm} \text{scalar, default 1.}

1 \hspace{1cm} print the statistics.

0 \hspace{1cm} do not print statistics.

\textit{oc0.res} \hspace{1cm} \text{scalar, default 0.}

1 \hspace{1cm} compute residuals (\textit{resid}) and Durbin-Watson statistic (\textit{dwstat})

0 \hspace{1cm} \textit{oout.resid} = 0,
\hspace{1cm} \textit{oout.dwstat} = 0.

\textit{oc0.rnam} \hspace{1cm} \text{string, default "_olsmtres".}

If the data is taken from a data set, a new data set will be created for the residuals, using the name in \textit{oc0.rnam}.

\textit{oc0.maxvec} \hspace{1cm} \text{scalar, default 20000.}

The largest number of elements allowed in any one matrix.

\textit{oc0.fcmptol} \hspace{1cm} \text{scalar, default 1e-12.}

Tolerance used to fuzz the comparison
operations to allow for round off error.

$oc0.alg$ string, default "cholup".

Selects the algorithm used for computing the parameter estimates. The default Cholesky update method is more computationally efficient. However, accuracy can suffer for poorly conditioned data. For higher accuracy set $oc0.alg$ to either $qr$ or $svd$.

$qr$ Solves for the parameter estimates using a $qr$ decomposition.

$svd$ Solves for the parameter estimates using a singular value decomposition.

$dataset$ string, name of data set or null string.

If $dataset$ is a null string, the procedure assumes that the actual data has been passed in the next two arguments.

$depvar$ string, name of dependent variable
- or -
scalar, index of dependent variable. If scalar 0, the last column of the data set will be used.

If $dataset$ is a null string or 0:

$N \times 1$ vector, the dependent variable.

$indvars$ If $dataset$ contains a string:
Kx1 character vector, names of independent variables
- or -
Kx1 numeric vector, indices of independent variables.

These can be any size subset of the variables in the data set and can be in any order. If a scalar 0 is passed, all columns of the data set will be used except for the one used for the dependent variable.

If dataset is a null string or 0:

NxK matrix, the independent variables.

Output

instance of an olsmtOut structure containing the following members:

oout.vnam
(K+2)x1 or (K+1)x1 character vector, the variable names used in the regression. If a constant term is used, this vector will be (K+2)x1, and the first name will be "CONSTANT". The last name will be the name of the dependent variable.

oout.m
MxM matrix, where M = K+2, the moment matrix constructed by calculating X' X where X is a matrix containing all useable observations and having columns in the order:

1.0 indvars depvar
(constant) (independent) (dependent)
A constant term is always used in computing $m$. An $\texttt{Dx1}$ vector, the least squares estimates of parameters

Error handling is controlled by the low order bit of the trap flag.

| trap 0 | terminate with error message |
| trap 1 | return scalar error code in $b$ |
| 30     | system singular               |
| 31     | system underdetermined        |
| 32     | same number of columns as rows |
| 33     | too many missings             |
| 34     | file not found                |
| 35     | no variance in an independent variable |

The system can become underdetermined if you use listwise deletion and have missing values. In that case, it is possible to skip so many cases that there are fewer useable rows than columns in the data set.
### Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>oout.stb</code></td>
<td>Kx1 vector, the standardized coefficients.</td>
</tr>
<tr>
<td><code>oout.vc</code></td>
<td>DxD matrix, the variance-covariance matrix of estimates.</td>
</tr>
<tr>
<td><code>oout.stderr</code></td>
<td>Dx1 vector, the standard errors of the estimated parameters.</td>
</tr>
<tr>
<td><code>oout.sigma</code></td>
<td>scalar, standard deviation of residual.</td>
</tr>
<tr>
<td><code>oout.cx</code></td>
<td>(K+1)x(K+1) matrix, correlation matrix of variables with the dependent variable as the last column.</td>
</tr>
<tr>
<td><code>oout.rsq</code></td>
<td>scalar, R square, coefficient of determination.</td>
</tr>
<tr>
<td><code>oout.resid</code></td>
<td>residuals, <code>oout.resid = y - x * oout.b</code>.</td>
</tr>
<tr>
<td><code>oout.dwstat</code></td>
<td>scalar, Durbin-Watson statistic.</td>
</tr>
</tbody>
</table>

If `oc0.olsres = 1`, the residuals will be computed.

If the data is taken from a data set, a new data set will be created for the residuals, using the name in `oc0.rnam`. The residuals will be saved in this data set as an Nx1 column. The `oout.resid` return value will be a string containing the name of the new data set containing the residuals. If the data is passed in as a matrix, the `oout.resid` return value will be the Nx1 vector of residuals.
**Remarks**

For poorly conditioned data the default setting for $oc0.alg$, using the Cholesky update, may produce only four or five digits of accuracy for the parameter estimates and standard error. For greater accuracy, use either the $qr$ or singular value decomposition algorithm by setting $oc0.alg$ to $qr$ or $svd$. If you are unsure of the condition of your data, set $oc0.alg$ to $qr$.

No output file is modified, opened, or closed by this procedure. If you want output to be placed in a file, you need to open an output file before calling $olsmt$.

**Example**

```c
#include olsmt.sdf
struct olsmtControl oc0;
struct olsmtOut oOut;
oc0 = olsmtControlCreate;

y = { 2,
   3,
   1,
   7,
   5 };

x = { 1 3 2,
    2 3 1,
    7 1 7,
    5 3 1,
    3 5 5 };

output file = olsmt.out reset;
output file = olsmt.out reset;
output file = olsmt.out reset;
oOut = olsmt(oc0,0,y,x);
oOut = olsmt(oc0,0,y,x);
oOut = olsmt(oc0,0,y,x);
output off;
```

38-990
In this example, the output from olsmt is put into a file called olsmt.out as well as being printed to the window. This example will compute a least squares regression of $y$ on $x$.

```c
#include olsmt.sdf
struct olsmtControl oc0;
struct olsmtOut oOut;
oc0 = olsmtControlCreate;

data = "olsdat";
depvar = { score };
indvars = { region, age, marstat };
oc0.res = 1;
output file = lpt1 on;
oOut = olsmt(oc0, data, depvar, indvars);
output off;
```

In this example, the data set olsdat.dat is used to compute a regression. The dependent variable is score. The independent variables are: region, age, and marstat. The residuals and Durbin-Watson statistic will be computed. The output will be sent to the printer as well as the window and the returned values are assigned to variables.

**Source**

olsmt.src

**See Also**

olsmtControlCreate, olsqrmt
olsmtControlCreate

Purpose

Creates default olsmtControl structure.

Include

olsmt.sdf

Format

```
c = olsmtControlCreate();
```

Output

```
c instance of an olsmtControl structure with members set to default values.
```

Example

Since structures are strongly typed in GAUSS, each structure must be declared before it can be used.

```
// declare 'ctl' as an olsmtControl structure
struct olsmtControl ctl;

// initialize structure 'ctl'
ctl = olsmtControlCreate;
```
The members of the `olsmtControl` structure and their default values are described in the manual entry for `olsmt`.

**Source**

`olsmt.src`

**See Also**

`olsmt`

**olsqr**

**Purpose**

Computes OLS coefficients using QR decomposition.

**Format**

\[ b = \text{olsqr}(y, x); \]

**Input**

- \( y \): Nx1 vector containing dependent variable.
- \( x \): NxP matrix containing independent variables.

**Output**

- \( b \): Px1 vector of least squares estimates of regression of \( y \) on \( x \). If \( x \) does not have full rank, then the coefficients that cannot
be estimated will be zero.

Remarks

This provides an alternative to $y/x$ for computing least squares coefficients.

This procedure is slower than the / operator. However, for near singular matrices it may produce better results.

**olsqr** handles matrices that do not have full rank by returning zeros for the coefficients that cannot be estimated.

Example

```matlab
A = rndn(4,4);
b = rndn(4,1);
x = olsqr(b,A);
```

See Also

ols, olsqr2, orth, qqr

olsqr2

Purpose

Computes OLS coefficients, residuals, and predicted values using the QR decomposition.
Format

\[ \{ b, r, p \} = \text{olsqr2}(y, x); \]

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>Nx1 vector containing dependent variable.</td>
</tr>
<tr>
<td>( x )</td>
<td>NxP matrix containing independent variables.</td>
</tr>
</tbody>
</table>

Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( b )</td>
<td>Px1 vector of least squares estimates of regression of ( y ) on ( x ). If ( x ) does not have full rank, then the coefficients that cannot be estimated will be zero.</td>
</tr>
<tr>
<td>( r )</td>
<td>Px1 vector of residuals. ( (r = y - x \cdot b) )</td>
</tr>
<tr>
<td>( p )</td>
<td>Px1 vector of predicted values. ( (p = x \cdot b) )</td>
</tr>
</tbody>
</table>

Remarks

This provides an alternative to \( y/x \) for computing least squares coefficients.

This procedure is slower than the \( / \) operator. However, for near singular matrices, it may produce better results.

\texttt{olsqr2} handles matrices that do not have full rank by returning zeros for the coefficients that cannot be estimated.

See Also

\texttt{olsqr}, \texttt{orth}, \texttt{qqr}
olsqrmt

Purpose

Computes OLS coefficients using QR decomposition.

Format

\[ b = \text{olsqrmt}(y, x, \text{tol}); \]

Input

- \( y \)  
  Nx1 vector containing dependent variable.
- \( x \)  
  NxP matrix containing independent variables.
- \( \text{tol} \)  
  scalar, the tolerance for testing if diagonal elements are approaching zero. The default value is \( 10^{-14} \).

Output

- \( b \)  
  Px1 vector of least squares estimates of regression of \( y \) on \( x \). If \( x \) does not have full rank, then the coefficients that cannot be estimated will be zero.

Remarks

This provides an alternative to \( y/x \) for computing least squares coefficients.
This procedure is slower than the / operator. However, for near singular matrices it may produce better results.

\texttt{olsqrmt} handles matrices that do not have full rank by returning zeros for the coefficients that cannot be estimated.

\section*{Source}
\texttt{olsmt.src}

\section*{See Also}
\texttt{olsmt, olsqr2}

\section*{ones}

\subsection*{Purpose}
Creates a matrix of ones.

\subsection*{Format}
\[ y = \text{ones}(r, c); \]

\subsection*{Input}
\begin{itemize}
  \item \textit{r} \quad \text{scalar, number of rows.}
  \item \textit{c} \quad \text{scalar, number of columns.}
\end{itemize}
Output

\[ y \quad r \times c \text{ matrix of ones.} \]

Remarks

Noninteger arguments will be truncated to an integer.

Example

\[ x = \text{ones}(3,2); \]

The code above assigns \( x \) to be equal to:

\[
\begin{array}{cc}
1.000000 & 1.000000 \\
1.000000 & 1.000000 \\
1.000000 & 1.000000 \\
\end{array}
\]

See Also

zeros, eye

open

Purpose

Opens an existing GAUSS data file.
**Format**

```bash
open fh=filename;
open fh=filename for mode;
open fh=filename for mode varindexi offs;
```

**Input**

<table>
<thead>
<tr>
<th><code>filename</code></th>
<th>literal or <code>^string</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>filename</code></td>
<td>is the name of the file on the disk. The name can include a path if the directory to be used is not the current directory. This filename will automatically be given the extension <code>.dat</code>. If an extension is specified, the <code>.dat</code> will be overridden. If the file is an <code>.fmt</code> matrix file, the extension must be explicitly given. If the name of the file is to be taken from a string variable, the name of the string must be preceded by the <code>^</code> (caret) operator.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><code>mode</code></th>
<th>literal, the modes supported with the optional <code>for</code> subcommand are:</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>read</code></td>
<td>This is the default file opening mode and will be the one used if none is specified. Files opened in this mode cannot be written to. The pointer is set to the beginning of the file and the <code>writer</code> function is disabled for files opened in this way. This is the only mode available for matrix files (.fmt), which are always written in one piece with the <code>save</code> command.</td>
</tr>
<tr>
<td><code>append</code></td>
<td>Files opened in this mode cannot be read.</td>
</tr>
</tbody>
</table>
The pointer will be set to the end of the file so that a subsequent write to the file with the `writer` function will add data to the end of the file without overwriting any of the existing data in the file. The `readr` function is disabled for files opened in this way. This mode is used to add additional rows to the end of a file.

**update** Files opened in this mode can be read from and written to. The pointer will be set to the beginning of the file. This mode is used to make changes in a file.

**offs** scalar, offset added to "index variables."

The optional `varindxi` subcommand tells GAUSS to create a set of global scalars that contain the index (column position) of the variables in a GAUSS data file. These "index variables" will have the same names as the corresponding variables in the data file but with "i" added as a prefix. They can be used inside index brackets, and with functions like `submat` to access specific columns of a matrix without having to remember the column position.

The optional `offs` argument is an offset that will be added to the index variables. This is useful if data from multiple files are concatenated horizontally in one matrix. It can be any scalar expression. The default is 0.

The index variables are useful for creating submatrices of specific variables without requiring that the positions of the variables be known. For instance, if there are two variables,
xvar and yvar in the data set, the index variables will have the names ixvar, iyvar. If xvar is the first column in the data file, and yvar is the second, and if no offset, offs, has been specified, then ixvar and iyvar will equal 1 and 2 respectively. If an offset of 3 had been specified, then these variables would be assigned the values 4 and 5 respectively.

The varindxi option cannot be used with .fmt matrix files because no column names are stored with them.

If varindxi is used, GAUSS will ignore the Undefined symbol error for global symbols that start with "i". This makes it much more convenient to use index variables because they don’t have to be cleared before they are accessed in the program. Clearing is otherwise necessary because the index variables do not exist until execution time when the data file is actually opened and the names are read in from the header of the file. At compile time a statement like: y=x[.,ixvar]; will be illegal if the compiler has never heard of ixvar. If varindxi is used, this error will be ignored for symbols beginning with "i". Any symbols that are accessed before they have been initialized with a real value will be trapped at execution time with a Variable not initialized error.

Output

fh  scalar, file handle.

fh is the file handle which will be used by most commands to refer to the file within GAUSS. This file handle is actually a scalar containing an integer value that uniquely identifies each file. This value is assigned by GAUSS when the open command is executed. If the file was not successfully opened, the file handle will be set to -1.
Remarks

The file must exist before it can be opened with the open command. To create a new file, see create or save.

A file can be opened simultaneously under more than one handle. See the second example following.

If the value that is in the file handle when the open command begins to execute matches that of an already open file, the process will be aborted and a File already open message will be given. This gives you some protection against opening a second file with the same handle as a currently open file. If this happens, you would no longer be able to access the first file.

It is important to set unused file handles to zero because both open and create check the value that is in a file handle to see if it matches that of an open file before they proceed with the process of opening a file. This should be done with close or closeall.

Example

```plaintext
fname = "/data/rawdat";
open dt = ^fname for append;

if dt == -1;
   print "File not found";
   end;
endif;
y = writer(dt,x);
if y /= rows(x);
   print "Disk Full";
   end;
endif;
```
In the example above, the existing data set /data/rawdat.dat is opened for appending new data. The name of the file is in the string variable fname. In this example the file handle is tested to see if the file was opened successfully. The matrix x is written to this data set. The number of columns in x must be the same as the number of columns in the existing data set. The first row in x will be placed after the last row in the existing data set. The writer function will return the number of rows actually written. If this does not equal the number of rows that were attempted, then the disk is probably full.

```plaintext
open fin = mydata for read;
open fout = mydata for update;

do until eof(fin);
    x = readr(fin,100);
    x[,1 3] = ln(x[,1 3]);
    call writer(fout,x);
endo;

closeall fin,fout;
```

In the above example, the same file, mydata.dat, is opened twice with two different file handles. It is opened for read with the handle fin, and it is opened for update with the handle fout. This will allow the file to be transformed in place without taking up the extra space necessary for a separate output file. Notice that fin is used as the input handle and fout is used as the output handle. The loop will terminate as soon as the input handle has reached the end of the file. Inside the loop the file is read into a matrix called x using the input handle, the data are transformed (columns 1 and 3 are replaced with their natural logs), and the transformed data is written back out using the output handle. This type of operation works fine as long as the total number of rows and columns does not change.
The following example assumes a data file named `dat1.dat` that has the variables: 
`visc, temp, lub, and rpm`.

```plaintext
open f1 = dat1 varindxi;
dtx = readr(f1,100);
x = dtx[.,irpm ilub ivisc];
y = dtx[.,itemp];
call seekr(f1,1);
```

In this example, the data set `dat1.dat` is opened for reading (the `.dat` and the `for read` are implicit). `varindxi` is specified with no constant. Thus, index variables are created that give the positions of the variables in the data set. The first 100 rows of the data set are read into the matrix `dtx`. Then, specified variables in a specified order are assigned to the matrices `x` and `y` using the index variables. The last line uses the `seekr` function to reset the pointer to the beginning of the file.

```plaintext
open q1 = c:dat1 varindx;
open q2 = c:dat2 varindx colsf(q1);
nr = 100;
y = readr(q1,nr)~readr(q2,nr);
closeall q1,q2;
```

In this example, two data sets are opened for reading and index variables are created for each. A constant is added to the indices for the second data set (`q2`), equal to the number of variables (columns) in the first data set (`q1`). Thus, if there are three variables `x1, x2, x3` in `q1`, and three variables `y1, y2, y3` in `q2`, the index variables that were created when the files were opened would be `ix1, ix2, ix3, iy1, iy2, iy3`. The values of these index variables would be 1, 2, 3, 4, 5, 6, respectively. The first 100 rows of the two data sets are read in and concatenated to produce the matrix `y`. The index variables will thus give the correct positions of the variables in `y`.

```plaintext
open fx = x.fmt;
rf = rowsf(fx);
```
sampsize = round(rf*0.1);
rndsmpx = zeros(sampsize,colsf(fx));

for(1, sampsize, 1);
    r = ceil(rndu(1,1)*rf);
    call seekr(fx,r);
    rndsmpx[i,.] = readr(fx,1);
endfor;

fx = close(fx);

In this example, a 10% random sample of rows is drawn from the matrix file x.fmt and put into the matrix rndsmpx. Note that the extension .fmt must be specified explicitly in the open statement. The rowsf command is used to obtain the number of rows in x.fmt. This number is multiplied by 0.10 and the result is rounded to the nearest integer; this yields the desired sample size. Then random integers (r) in the range 1 to rf are generated. seekr is used to locate to the appropriate row in the matrix, and the row is read with readr and placed in the matrix rndsmpx. This is continued until the complete sample has been obtained.

**See Also**
dataopen, create, close, closeall, readr, writer, seekr, eof

**optn, optnevn**

**Purpose**

Returns optimal matrix dimensions for computing FFT's.
**Format**

\[
\begin{align*}
    n &= \text{optn}(n0); \\
    n &= \text{optnevn}(n0);
\end{align*}
\]

**Input**

\(n0\) scalar, the length of a vector or the number of rows or columns in a matrix.

**Output**

\(n\) scalar, the next optimal size for the given dimension for computing an FFT or RFFT. \(n > n0\).

**Remarks**

\texttt{optn} and \texttt{optnevn} determine optimal matrix dimensions for computing FFT's. The Temperton FFT routines (see table following) can handle any matrix whose dimensions can be expressed as:

\[2^p \times 3^q \times 5^r \times 7^s\]

where \(p\), \(q\) and \(r\) are nonnegative integers and \(s\) is equal to 0 or 1.

with one restriction: the vector length or matrix column size must be even (\(p\) must be positive) when computing RFFT's.

\texttt{fftn}, etc., pad matrices to the next allowable dimensions; however, they generally run faster for matrices whose dimensions are highly composite numbers, that is,
products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20% faster than a 32768x1 vector, because 33600 is a highly composite number, \(2^6 \times 3 \times 5^2 \times 7\), whereas 32768 is a simple power of 2, \(2^{15}\). `optn` and `optnev` are provided so you can take advantage of this fact by hand-sizing matrices to optimal dimensions before computing the FFT.

Use the following table to determine what to call for a given function and matrix:

<table>
<thead>
<tr>
<th>FFT</th>
<th>Vector</th>
<th>Matrix</th>
<th>Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Length</td>
<td>Rows</td>
<td>Columns</td>
</tr>
<tr>
<td><code>fftn</code></td>
<td><code>optn</code></td>
<td><code>optn</code></td>
<td><code>optn</code></td>
</tr>
<tr>
<td><code>rfftn</code></td>
<td><code>optnev</code></td>
<td><code>optn</code></td>
<td><code>optnev</code></td>
</tr>
<tr>
<td><code>rfftnp</code></td>
<td><code>optnev</code></td>
<td><code>optn</code></td>
<td><code>optnev</code></td>
</tr>
</tbody>
</table>

**Example**

```matlab
n = optn(231);
```

The above code assigns \(n\) to be equal to 240.

**See Also**

`fftn`, `nextn`, `nextnev`, `rfftn`, `rfftnp`

**orth**

**Purpose**

Computes an orthonormal basis for the column space of a matrix.
**Format**

\[ y = \text{orth}(x); \]

**Input**

\( x \)  
N\times K matrix.

**Global Input**

\_orthtol  
scalar, the tolerance for testing if diagonal elements are approaching zero. The default is 1.0e-14.

**Output**

\( y \)  
N\times L matrix such that \( y'y = \text{eye}(L) \) and whose columns span the same space as the columns of \( x \); \( L \) is the rank of \( x \).

**Example**

\[
\begin{align*}
  x &= \{ 6 \ 5 \ 4, \\
      & \ 2 \ 7 \ 5 \}; \\
  y &= \text{orth}(x);
\end{align*}
\]

After the code above:
\begin{align*}
y = -0.58123819 & \quad -0.81373347 \\
-0.81373347 & \quad 0.58123819 \\
\end{align*}
\[ y'y = 1 \quad 0 \]
\[ 0 \quad 1 \]

**Source**

qqr.src

**See Also**

qqr, olsqr

**output**

**Purpose**

This command makes it possible to direct the output of \texttt{print} statements to two different places simultaneously. One output device is always the window or standard output. The other can be selected by the user to be any disk file or other suitable output device such as a printer.

**Format**

\begin{verbatim}
output file=filename
output file=filename [on|off|reset];
\end{verbatim}

**Input**

\begin{verbatim}
filename literal or \^{}string.
\end{verbatim}

The \texttt{file=filename} subcommand selects the file or device to which output is to be sent.
If the name of the file is to be taken from a string variable, the name of the string must be preceded by the \(^\) (caret) operator.

The default file name is `output.out`.

<table>
<thead>
<tr>
<th>literal, mode flag:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>on, off, reset</strong></td>
</tr>
</tbody>
</table>

```
| **on** | opens the auxiliary output file or device and causes the results of all `print` statements to be sent to that file or device. If the file already exists, it will be opened for appending. If the file does not already exist, it will be created. |
| **off** | closes the auxiliary output file and turns off the auxiliary output. |
| **reset** | similar to the `on` subcommand, except that it always creates a new file. If the file already exists, it will be destroyed and a new file by that name will be created. If it does not exist, it will be created. |
```

**Remarks**

After you have written to an output file you have to close the file before you can print it or edit it with the **GAUSS** editor. Use

```
output off;
```

The selection of the auxiliary output file or device remains in effect until a new selection is made, or until you get out of **GAUSS**. Thus, if a file is named as the output
device in one program, it will remain the output device in subsequent programs until a new \texttt{file=filename} subcommand is encountered.

The command

\begin{verbatim}
output file=filename;
\end{verbatim}

will select the file or device but will not open it. A subsequent \texttt{output on} or \texttt{output reset} will open it and turn on the auxiliary output.

The command \texttt{output off} will close the file and turn off the auxiliary output. The filename will remain the same. A subsequent \texttt{output on} will cause the file to be opened again for appending. A subsequent \texttt{output reset} will cause the existing file to be destroyed and then recreated and will turn on the auxiliary output.

The command \texttt{output} by itself will cause the name and status (i.e., open or closed) of the current auxiliary output file to be printed to the window.

The output to the console can be turned off and on using the \texttt{screen off} and \texttt{screen on} commands. Output to the auxiliary file or device can be turned off or on using the \texttt{output off} or \texttt{output on} command. The defaults are \texttt{screen on} and \texttt{output off}.

The auxiliary file or device can be closed by an explicit \texttt{output off} statement, by an \texttt{end} statement, or by an interactive \texttt{new} statement. However, a \texttt{new} statement at the beginning of a program will not close the file. This allows programs with \texttt{new} statements in them to be run without reopening the auxiliary output file.

If a program sends data to a disk file, it will execute much faster if the window is off. The \texttt{outwidth} command will set the line width of the output file. The default is 80.

\section*{Example}

\begin{verbatim}
output file = out1.out on;
\end{verbatim}
This statement will open the file **out1.out** and will cause the results of all subsequent **print** statements to be sent to that file. If **out1.out** already exists, the new output will be appended.

```plaintext
output file = out2.out;
output on;
```

This is equivalent to the previous example.

```plaintext
output reset;
```

This statement will create a new output file using the current filename. If the file already exists, any data in it will be lost.

```plaintext
output file = mydata.asc reset;
screen off;
format /m1/rz 1,8;
open fp = mydata;

do until eof(fp);
   print readr(fp,200);;
endo;

fp = close(fp);
end;
```

The program above will write the contents of the **GAUSS** file **mydata.dat** into an ASCII file called **mydata.asc**. If there had been an existing file by the name of **mydata.asc**, it would have been overwritten.

The **/m1** parameter in the **format** statement in combination with the **;;** at the end of the **print** statement will cause one carriage return/line feed pair to be written at the beginning of each row of the output file. There will not be an extra line feed added at the end of each 200 row block.
The `end` statement above will automatically perform `output off` and `screen on`.

**See Also**

`outwidth`, `screen`, `end`, `new`

**outtyp (dataloop)**

**Purpose**

Specifies the precision of the output data set.

**Format**

```
outtyp num_constant;
```

**Input**

```
um_constant scalar, precision of output data set.
```

**Remarks**

`num_constant` must be 2, 4, or 8, to specify integer, single precision, or double precision, respectively.

If `outtyp` is not specified, the precision of the output data set will be that of the input data set. If character data is present in the data set, the precision will be forced to double.
Example

```plaintext
outtyp 8;
```

**outwidth**

**Purpose**

Specifies the width of the auxiliary output.

**Format**

```plaintext
outwidth n;
```

**Input**

```
n          scalar, width of auxiliary output.
```

**Remarks**

```
n specifies the width of the auxiliary output in columns (characters). After printing n characters on a line, GAUSS will output a line feed.

If a matrix is being printed, the line feed sequence will always be inserted between separate elements of the matrix rather than being inserted between digits of a single element.

n may be any scalar-valued expressions in the range of 2-256. Nonintegers will be truncated to an integer. If 256 is used, no additional lines will be inserted.
```
The default is 80 columns.

**Example**

```
outwidth 132;
```

This statement will change the auxiliary output width to 132 columns.

**See Also**

`output`, `print`
pacf

Purpose
Computes sample partial autocorrelations.

Format
\[ rkk = \text{pacf}(y, k, d); \]

Input
- \( y \) \hspace{1cm} \text{Nx1 vector, data.}
- \( k \) \hspace{1cm} \text{scalar, maximum number of partial autocorrelations to compute.}
- \( d \) \hspace{1cm} \text{scalar, order of differencing.}

Output
- \( rkk \) \hspace{1cm} \text{Kx1 vector, sample partial autocorrelations.}

Example
\[ \text{proc pacf}(y, k, d); \]
local a,l,j,r,t;
    r = acf(y,k,d);
    a = zeros(k,k);
    a[1,1] = r[1];
    t = 1;
    l = 2;

    do while l le k;
      a[l,l] = (r[1]-a[l-1,1:t]*rev(r[1:l-1]))/
                 (1-a[l-1,1:t]*r[1:t]);
      j = 1;

      do while j <= t;
        a[l,j] = a[l-1,j] - a[l,1]*a[l-1,1-j];
        j = j+1;
      endo;

      t = t+1;
      l = l+1;
    endo;

    retp(diag(a));
  endp;

Source

  tsutil.src

packedToSp

Purpose

  Creates a sparse matrix from a packed matrix of non-zero values and row and column indices.
**Format**

\[ y = \text{packedToSp}(r, c, p); \]

**Input**

- \( r \) scalar, rows of output matrix.
- \( c \) scalar, columns of output matrix.
- \( p \) Nx3 or Nx4 matrix, containing non-zero values and row and column indices.

**Output**

- \( y \) \( r \times c \) sparse matrix.

**Remarks**

If \( p \) is Nx3, \( y \) will be a real sparse matrix. Otherwise, if \( p \) is Nx4, \( y \) will be complex.

The format for \( p \) is as follows:

If \( p \) is Nx3:

- Column 1: non-zero values
- Column 2: row indices
- Column 3: column indices

If \( p \) is Nx4:

- Column 1
- Column 2
- Column 3
- Column 4
Note that \texttt{spCreate} may be faster.

Since sparse matrices are strongly typed in \texttt{GAUSS}, \( y \) must be defined as a sparse matrix before the call to \texttt{packedToSp}.

\textbf{Example}

```gauss
//Declare 'y' to be a sparse matrix
sparse matrix y;

//Create a 15x10 matrix 'y' in which:
//\( y[2,4] = 1.1; \ y[5,1] = 2.3; \ y[8,9] = 3.4; \)
//\( y[13,5] = 4.2 \)
//all other values in 'y' will be zeros
p = { 1.1 2 4, 2.3 5 1, 3.4 8 9, 4.2 13 5 };
y = \texttt{packedToSp}(15,10,p);
```

After the code above, \( y \) is a sparse matrix, containing the following non-zero values:

<table>
<thead>
<tr>
<th>Non-zero value</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>(2,4)</td>
</tr>
<tr>
<td>2.3</td>
<td>(5,1)</td>
</tr>
<tr>
<td>3.4</td>
<td>(8,9)</td>
</tr>
<tr>
<td>4.2</td>
<td>(13,5)</td>
</tr>
</tbody>
</table>

\textbf{See Also}

\texttt{spCreate, denseToSp}
packr

**Purpose**

Deletes the rows of a matrix that contain any missing values.

**Format**

\[ y = \text{packr}(x); \]

**Input**

\( x \)

NxK matrix.

**Output**

\( y \)

LxK submatrix of \( x \) containing only those rows that do not have missing values in any of their elements.

**Remarks**

This function is useful for handling missing values by "listwise deletion," particularly prior to using the / operator to compute least squares coefficients.

If all rows of a matrix contain missing values, \texttt{packr} returns a scalar missing value. This can be tested for quickly with the \texttt{scalmiss} function.

**Example**

Example 1
//Set the rng seed for repeatable random numbers
rndseed 7342692;

//Create a 3x3 matrix of random integers between 1 and 10
x = ceil(rndu(3, 3) * 10);

//Turn all elements with a value of 8 into missing values
x2 = miss(ceil(rndu(3,3)*10),8);

//Remove all rows that contain missing values
y = packr(x2);

After the code above:

\[
\begin{array}{ccc}
6 & 10 & 3 \\
8 & 7 & 8 \\
8 & 6 & 7 \\
\end{array}
\quad
\begin{array}{ccc}
6 & 10 & 3 \\
. & 7 & . \\
. & 6 & 7 \\
\end{array}
\]

Example 2

//Open a GAUSS data file for reading
open fp = mydata;
obsp = 0;
sum = 0;

//Continue looping until the end of the file has been reached
do until eof(fp);
  //Read in 100 lines of the data file and remove any rows with missing values
  x = packr(readr(fp,100));
  //Check to see if 'packr' returned a missing value; if not, update 'obs' and 'sum'
  if not scalmiss(x);
    obs = obs + rows(x);
sum = sum + \texttt{sumc}(x);
endif;
endo;
mean = sum/obs;

In this example the sums of each column in a data file are computed as well as a count of the rows that do not contain any missing values. \texttt{packr} is used to delete rows that contain missings and \texttt{scalmiss} is used to skip the two sum steps if all the rows are deleted for a particular iteration of the read loop. Then the sums are divided by the number of observations to obtain the means.

\textbf{See Also}

\texttt{scalmiss}, \texttt{miss}, \texttt{missrv}

\textbf{parse}

\textbf{Purpose}

Parses a string, returning a character vector of tokens.

\textbf{Format}

\[ \texttt{tok = parse(str, delim);} \]

\textbf{Input}

\begin{itemize}
  \item \texttt{str} \hspace{1cm} string consisting of a series of tokens and/or delimiters.
  \item \texttt{delim} \hspace{1cm} NxK character matrix of delimiters that might be found in \texttt{str}.
\end{itemize}
Output

\textit{tok} \hspace{1cm} \text{Mx1 character vector consisting of the tokens contained in \textit{str}. All tokens are returned; any delimiters found in \textit{str} are ignored.}

Remarks

The tokens in \textit{str} must be 8 characters or less in size. This is because they are returned in a character vector in which each element is represented as a double precision value. If they are longer, the contents of \textit{tok} is unpredictable. Use string arrays to create arrays of text with elements longer than 8 characters.

Example

Example 1

```verbatim
names = "GDP;GNP;M1;M2";
namesVec = \texttt{parse}(names, ";");

//The '\$' is used when printing character vectors
print $namesVec;
```

The code above will return:

GDP
GNP
M1
M2

Example 2

```verbatim
obs = 1000;
names = "Age,Weight,Height";
```
//Create uniform random integers between 1 and 77
data1 = ceil(77 * rndu(obs,1));

//Create normal random integers centered at 100 with a
//standard deviation of 9
data2 = ceil(100 + 9*rndn(obs,1));

//Create uniform random numbers between 0 and 60
data3 = ceil(60 * rndu(obs,1));

//Horizontally concatenate data into 'obs'*3 matrix
data = data1~data2~data3;

//Print the data using the procedure below
printStats(names, data);

//Create procedure to take our data, calculate some basic
//stats and print them
proc (0) = printStats( names, data);
    local title, vars, sepVars;

    //Set to print with 6 spaces between numbers and 0
    //digits after the decimal
    format /rd 6,0;

    //Create the titles to print for each column
    title = parse("var,mean,max,min", ",");

    //Extract the substrings from 'names' into a character
    //array using the comma as a separator between tokens
    sepVars = parse(names, ",");
    print "-----------------------------";

    //The '$' tells GAUSS to print as character data
```php
print $title';
print "-----------------------------"
//Loop through as many times as there are rows in //'sepVars'
for i( 1, rows(sepVars), 1);
   //Two semi-colons at the end of a print statement //prevents a new-line after the print
   print $sepVars[i];
   print meanc(data[.,i]);;
   print maxc(data[.,i]);;
   print minc(data[.,i]);;
endfor;
   print "-----------------------------";
endp;
```

The code above will produce output like this:

<table>
<thead>
<tr>
<th>var</th>
<th>mean</th>
<th>max</th>
<th>min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>38</td>
<td>77</td>
<td>1</td>
</tr>
<tr>
<td>Weight</td>
<td>101</td>
<td>135</td>
<td>75</td>
</tr>
<tr>
<td>Height</td>
<td>31</td>
<td>60</td>
<td>1</td>
</tr>
</tbody>
</table>

**See Also**

`token`

**pause**

**Purpose**

Pauses for a specified number of seconds.
Format

\texttt{pause(\textit{sec});}

Input

\textit{sec} \quad \text{scalar, seconds to pause.}

Remarks

This function can be used to delay a program, allowing users time to view graphics and/or data printed to the program output window.

Source

\texttt{pause.src}

See Also

\texttt{wait}

\textbf{pdfCauchy}

Purpose

Computes the probability density function for the Cauchy distribution.

Format

\[ y = \texttt{pdfCauchy}(x, a, b); \]
**Input**

- **x**: NxK matrix, an Nx1 vector or scalar.
- **a**: Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x.
- **b**: Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x. b must be greater than 0.

**Output**

- **y**: NxK matrix, Nx1 vector or scalar.

**Remarks**

The probability density function for the Cauchy distribution is defined as

\[
f(x) = \frac{\pi \sigma}{\pi \sigma + \left(\frac{x - \mu}{\sigma}\right)^2}\]

**See Also**

- **cdfCauchy**
- **pdfexp**

**Purpose**

Computes the probability density function for the exponential distribution.
Format

\[ y = \text{pdfexp}(x, a, m); \]

Input

- **x**: NxK matrix, Nx1 vector or scalar. \( x \) must be greater than \( a \).
- **a**: Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \).
- **m**: Scalar, mean parameter. \( m \) must be greater than 0.

Output

- **y**: NxK matrix, Nx1 vector or scalar.

Remarks

The probability density function for the exponential distribution is defined as

\[ f(x) = \lambda \exp(-\lambda(x - \gamma)) \]

See Also

cdfexp
pdfGenPareto

Purpose

Computes the probability density function for the Generalized Pareto distribution.

Format

\[ y = \text{pdfGenPareto}(x, a, o, k); \]

Input

- \( x \): NxK matrix, an Nx1 vector or scalar.
- \( a \): Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \).
- \( o \): Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( o \) must be greater than 0.
- \( k \): Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \).

Output

- \( y \): NxK matrix, Nx1 vector or scalar.

Remarks

The probability density function for the Generalized Pareto distribution is defined as
See Also

cdfGenPareto

pdfLaplace

Purpose

Computes the probability density function for the Laplace distribution.

Format

\[ y = \text{pdfLaplace}(x, a, b); \]

Input

\( x \)  
N\times K matrix, N\times 1 vector or scalar.

\( a \)  
Scalar, location parameter.

\( b \)  
Scalar, scale parameter.  \( b \) must be greater than 0.

Output

\( y \)  
N\times K matrix, N\times 1 vector or scalar.
Remarks

The probability density function for the Laplace distribution is defined as

\[ f(x) = \frac{\lambda}{2} \exp(-\lambda |x - \mu|) \]

See Also

cdfCauchy, pdfCauchy

pdflogistic

Purpose

Computes the probability density function for the logistic distribution.

Format

\[ y = \text{pdflogistic}(x,a,b); \]

Input

<table>
<thead>
<tr>
<th>x</th>
<th>NxK matrix, an Nx1 vector or scalar.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Location parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x.</td>
</tr>
<tr>
<td>b</td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x. ( b ) must be greater than 0.</td>
</tr>
</tbody>
</table>
Output

$y$  
NxK matrix, Nx1 vector or scalar.

Remarks

The probability density function for the logistic distribution is defined as

$$f(x) = \frac{\exp(-z)}{\sigma(1 + \exp(-z))^{-2}}$$

See Also

cdflogistic

pdfn

Purpose

Computes the standard Normal (scalar) probability density function.

Format

$y = \text{pdfn}(x)$;

Input

$x$  
NxK matrix.
Output

\( y \)  
N\( x \)K matrix containing the standard Normal probability density function of \( x \).

Remarks

This does not compute the joint Normal density function. Instead, the scalar Normal density function is computed element-by-element. \( y \) could be computed by the following \texttt{GAUSS} code:

\[
    y = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right);
\]

Example

\[
    x = \{ -3, -2, 0, 2, 3 \};
    y = \texttt{pdfn}(x);
\]

After the code above:

\[
    y =
    \begin{bmatrix}
        0.0044318484 \\
        0.053990967  \\
        0.39894228 \\
        0.053990967  \\
        0.0044318484
    \end{bmatrix}
\]

pdfRayleigh

Purpose

Computes the probability density function of the Rayleigh distribution.
## Format

\[ y = \text{pdfRayleigh}(x, b); \]

## Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>x</strong></td>
<td>NxK matrix, an Nx1 vector or scalar. x must be greater than 0.</td>
</tr>
<tr>
<td><strong>b</strong></td>
<td>Scale parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with x. b must be greater than 0.</td>
</tr>
</tbody>
</table>

## Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>y</strong></td>
<td>NxK matrix, Nx1 vector or scalar.</td>
</tr>
</tbody>
</table>

## Remarks

The probability density function of the Rayleigh distribution is defined as

\[
x \exp \left( \frac{-x^2}{2\sigma^2} \right) \frac{x}{\sigma^2}
\]

## See Also

cdfRayleighinv
**pdfWeibull**

**Purpose**

Computes the probability density function of a Weibull random variable.

**Format**

\[ y = \text{pdfWeibull}(x, k, \lambda); \]

**Input**

- \( x \): NxK matrix, Nx1 vector or scalar. \( x \) must be greater than 0.
- \( k \): Shape parameter; NxK matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( k \) must be greater than 0.
- \( \lambda \): Scale parameter; may be matrix, Nx1 vector or scalar, ExE conformable with \( x \). \( \lambda \) must be greater than 0.

**Output**

- \( y \): NxK matrix, Nx1 vector or scalar.

**Remarks**

The probability density function of a Weibull random variable is defined as
\[
    f(x, \lambda, k) = \begin{cases} 
    \frac{k}{\lambda} \left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k} & x \geq 0 \\
    0 & x < 0
    \end{cases}
\]

**See Also**

cdfWeibull, cdfWeibullInv

**pi**

**Purpose**

Returns the mathematical constant \(\pi\).

**Format**

\[
    y = \text{pi};
\]

**Output**

\(y\) scalar, the value of \(\pi\).

**Example**

```cpp
    //Print 14 digits and allow 16 digits worth of space for
    //each printed number
    format /rdn 16,14;
    print pi;
```
will return:

3.14159265358979

**pinv**

**Purpose**

Computes the Moore-Penrose pseudo-inverse of a matrix, using the singular value decomposition. This pseudo-inverse is one particular type of generalized inverse.

**Format**

\[ y = \text{pinv}(x); \]

**Input**

\[ x \quad \text{NxM matrix.} \]

**Global Input**

\[ _\text{svdtol} \quad \text{scalar, any singular values less than } _\text{svdtol} \text{ are treated as zero in determining the rank of the input matrix. The default value for } _\text{svdtol} \text{ is 1.0e-13.} \]
Output

\( y \)  
MxN matrix that satisfies the 4 Moore-Penrose conditions:

\[ xyx = x \]
\[ yxy = y \]
\[ xy \text{ is symmetric} \]
\[ yx \text{ is symmetric} \]

Global Output

\( \_\text{svderr} \)  
scalar, if not all of the singular values can be computed \( \_\text{svderr} \) will be nonzero.

Example

\texttt{pinv} can be used to solve an underdetermined least squares problem.

```matlab
//Create an underdetermined system of equations 'A'
A = \texttt{rndn}(4, 5);

//Create a right hand side
b = \texttt{rndn}(4, 1);

if rank(A) < cols(A);
    print "A does not have full rank, using \texttt{pinv} to solve";
    Api = \texttt{pinv}(A);
    x = Api*b;
else;
```

print "A has full rank, solve with '/ ' operator";
    x = b/A;
endif;

Least squares problems with full rank can also be solved with the GAUSS functions: \texttt{ols, olsqr} and \texttt{olsqr2}.

\textbf{Source}

\texttt{svd.src}

\textbf{pinvmt}

\textbf{Purpose}

Computes the Moore-Penrose pseudo-inverse of a matrix, using the singular value decomposition. This pseudo-inverse is one particular type of generalized inverse.

\textbf{Format}

\begin{verbatim}
{ y, err } = pinvmt(x, tol);
\end{verbatim}

\textbf{Input}

\begin{itemize}
    \item \texttt{x} \hspace{1cm} NxM matrix.
    \item \texttt{tol} \hspace{1cm} scalar, any singular values less than \texttt{tol} are treated as zero in determining the rank of the input matrix.
\end{itemize}
Output

$y$ MxN matrix that satisfies the 4 Moore-Penrose conditions:

\[ xyx = x \]
\[ yxy = y \]
\[ xy \text{ is symmetric} \]
\[ yx \text{ is symmetric} \]

$err$ scalar, if not all of the singular values can be computed $err$ will be nonzero.

`pinvmt` can be used to solve an underdetermined least squares problem.

```
tol = 1e-13;

//Create an underdetermined system of equations 'A'
A = randn(4, 5);

//Create a right hand side
b = randn(4,1);

if rank(A) < cols(A);
    print "A does not have full rank, using pinvmt to solve";
    Api = pinvmt(A, tol);
    x = Api*b;
else;
    print "A has full rank, solve with '/' operator";
    x = b/A;
endif;
```
Least squares problems with full rank can also be solved with the GAUSS functions: `ols, olsqr` and `olsqr2`.

**Source**

`svdmt.src`

**plotAddBar**

**Purpose**

Adds a bar or a set of bars to an existing graph.

**Format**

```gauss
plotAddBar(myPlot, val, ht);
plotAddBar(val, ht);
```

**Input**

- `myPlot` A `plotControl` structure.
- `val` Nx1 numeric vector, bar labels. If scalar 0, a sequence from 1 to `rows(ht)` will be created.
- `ht` NxK numeric vector, bar heights. K overlapping or side-by-side sets of N bars will be graphed.

**Remarks**

`plotAddBar` may only add bars to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

See Also

plotAddHist, plotAddHistF, plotAddHistP, plotAddPolar, plotAddXY

plotAddBox

Purpose

Adds a box graph to an existing graph.

Format

plotAddBox(myPlot, grp, y);
plotAddBox(grp, y);

Input

myPlot A plotControl structure.
grp 1xM vector. This contains the group numbers corresponding to each column of y data. If scalar 0, a sequence from 1 to cols(y) will be generated automatically for the X axis.
y NxM matrix. Each column represents the set of y values for an individual percentiles box symbol.

Remarks

plotAddBox may only add a box graph to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

See Also

plotAddHist, plotAddHistF, plotAddHistP, plotAddPolar, plotAddXY

plotAddHist

Purpose

Adds a histogram to an existing graph.

Format

plotAddHist(myPlot, x, v);
plotAddHist(x, v);

Input

<table>
<thead>
<tr>
<th>myPlot</th>
<th>A plotControl structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Mx1 vector of data.</td>
</tr>
<tr>
<td>v</td>
<td>Nx1 vector, the breakpoints to be used to compute the frequencies - or - scalar, the number of categories.</td>
</tr>
</tbody>
</table>

Remarks

plotAddHist may only add a histogram to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

**See Also**

plotAddBar, plotAddHistF, plotAddHistP, plotAddPolar, plotAddXY

**plotAddHistF**

**Purpose**

Adds a frequency histogram to an existing graph.

**Format**

```
plotAddHistF(myPlot, f, c);
plotAddHistF(f, c);
```

**Input**

- `myPlot` A `plotControl` structure.
- `f` Nx1 vector, frequencies to be graphed.
- `c` Nx1 vector, numeric labels for categories. If this is a scalar 0, a sequence from 1 to `rows(f)` will be created.

**Remarks**

`plotAddHistF` may only add a histogram to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

See Also

plotAddBar, plotAddHist, plotAddHistP, plotAddPolar, plotAddXY

**plotAddHistP**

**Purpose**

Adds a percent histogram to an existing graph.

**Format**

```plaintext
plotAddHistP(myPlot, x, v);
plotAddHistP(x, v);
```

**Input**

```plaintext
myPlot       A plotControl structure.

x            Mx1 vector of data.

v            Nx1 vector, the breakpoints to be used to compute the frequencies
             - or -
             scalar, the number of categories.
```

**Remarks**

**plotAddHistP** may only add a histogram to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

**See Also**

plotAddBar, plotAddHist, plotAddHistF, plotAddPolar, plotAddXY

**plotAddPolar**

**Purpose**

Adds a graph using polar coordinates to an existing polar graph.

**Format**

```
plotAddPolar(myPlot, radius, theta);
plotAddPolar(radius, theta);
```

**Input**

- **myPlot** A `plotControl` structure.
- **radius** Nx1 or NxM matrix. Each column contains the magnitude for a particular line.
- **theta** Nx1 or NxM matrix. Each column represents the angle values for a particular line.

**Remarks**

`plotAddPolar` may only add curves to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

See Also

plotAddBar, plotAddHist, plotAddHistF, plotAddHistP, plotAddXY

plotAddScatter

Purpose

Adds a 2-dimensional scatter plot to an existing graph.

Format

plotAddScatter(myPlot, x, y);
plotAddScatter(x, y);

Input

<table>
<thead>
<tr>
<th>myPlot</th>
<th>A plotControl structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Nx1 or NxM matrix. Each column contains the X values for a particular data point.</td>
</tr>
<tr>
<td>y</td>
<td>Nx1 or NxM matrix. Each column contains the Y values for a particular data point.</td>
</tr>
</tbody>
</table>

Remarks

plotAddScatter may only add a scatter plot to 2-D graphs.
This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

See Also

plotAddBar, plotAddHist, plotAddHistF, plotAddHistP, plotAddScatter, plotAddXY

plotAddTS

Purpose

Adds a curve of time series data to an existing time series plot.

Format

plotAddTS(myPlot, dtstart, frequency, y);
plotAddTS(dtstart, frequency, y);

Input

<table>
<thead>
<tr>
<th>myPlot</th>
<th>A plotControl structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>dtstart</td>
<td>Scalar, starting date in DT scalar format.</td>
</tr>
<tr>
<td>frequency</td>
<td>Scalar, frequency of the data per year. Valid options include:</td>
</tr>
<tr>
<td></td>
<td>1 Yearly</td>
</tr>
<tr>
<td></td>
<td>4 Quarterly</td>
</tr>
<tr>
<td></td>
<td>12 Monthly</td>
</tr>
<tr>
<td>y</td>
<td>Nx1 or NxM matrix. Each column contains the Y values for</td>
</tr>
</tbody>
</table>
a particular line.

Examples

Example 1

```gauss
//Create some data to plot
y = rndn(100, 1);

//The first input starts the series in January of 1982
//The second input specifies the data to be monthly
plotTS(1982, 12, y);

y2 = rndu(28, 1);

//Add the data from 'y2' as quarterly data
//starting in Q2 of 1980
plotAddTS(198004, 4, y2);
```

Remarks

You may only add time series graphs to other time series graphs. For more information on time series graphs, see Time Series Plots in GAUSS, Section 1.1.

By default missing values in the $y$ variable will be represented as gaps in the line.

See Also

plotSetXTicLabel, plotSetXTicInterval, plotTS
**plotAddXY**

**Purpose**

Adds an XY graph to an existing graph.

**Format**

```matlab
plotAddXY(myPlot, x, y);
plotAddXY(x, y);
```

**Input**

- **myPlot**
  
  A `plotControl` structure.

- **x**
  
  Nx1 or NxM matrix. Each column contains the X values for a particular line.

- **y**
  
  Nx1 or NxM matrix. Each column contains the Y values for a particular line.

**Remarks**

`plotAddXY` may only add curves to 2-D graphs.

This function will not change any of the current graph's settings other than to resize the view as necessary to display the new curve.

**See Also**

`plotAddBar`, `plotAddHist`, `plotAddHistF`, `plotAddHistP`, `plotAddPolar`
plotBar

Purpose

Generates a bar graph.

Format

\[
\text{plotBar}(\text{myPlot, val, ht}); \\
\text{plotBar}(\text{val, ht});
\]

Input

myPlot A plotControl structure.
val Nx1 numeric vector, bar labels. If scalar 0, a sequence from 1 to rows(ht) will be created.
ht NxK numeric vector, bar heights. K overlapping or side-by-side sets of N bars will be graphed.

Example

In this example, five bars will be created.

```c
// Create data
x = seqa(1, 1, 5);
y = { 1.5, 2, 3, 0.5, 1 };

// Draw bar graph
plotBar(x, y);
```
Remarks

To control the color and texture of the bars as well as whether they are stacked or side by side:

If you are passing a `plotControl` structure to your graph, you may use the function `plotSetBar`.

If you are not passing a `plotControl` structure, these properties are set in the Preferences. To access the, select **Tools->Preferences** from the **GAUSS** main menu. Select Graphics on the left side of the preferences and then select the radio button next to "Bar." A dropdown menu will be available under Group 1 for both of these options.

See Also

`plotXY`, `plotLogX`, `plotHist`

**plotBox**

**Purpose**

Graphs data using the box graph percentile method.

**Format**

```
plotBox(myPlot, grp, y);
plotBox(grp, y);
```

**Input**

- `myPlot` A `plotControl` structure.
- `grp` 1xM vector. This contains the group numbers corresponding
to each column of $y$ data. If scalar 0, a sequence from 1 to $\text{cols}(y)$ will be generated automatically for the X axis.

$y$  

NxM matrix. Each column represents the set of $y$ values for an individual percentiles box symbol.

**Remarks**

If missing values are encountered in the $y$ data, they will be ignored during calculations and will not be plotted.

**See Also**

`plotHistP`, `plotScatter`

**plotClearLayout**

**Purpose**

Clears any previously set plot layouts.

**Format**

```
plotClearLayout();
```

**Example**

```
//Create a 1x2 Plot Layout and insert a percentage
//histogram of some random normal numbers in the first
//cell.
plotLayout(1, 2, 1);
```
plotHistP(rndn(1000, 1), 30);

// Insert gamma distributed random numbers into the second cell.
plotLayout(1, 2, 2);
plotHistP(rndGamma(1000, 1, 3, 2), 30);

// Display the image for 2 seconds
pause(2);

// Clear the 1x2 layout
plotClearLayout();

// Plot percentage histogram of beta distributed random numbers. This graph will take up the entire plot window
// since the 1x2 plot layout has been cleared.
plotHistP(rndBeta(1000, 1, 2, 1), 30);

**Remarks**

After calling this function all subsequent graphs will be drawn to fill the entire graph window.

**See Also**

plotSetBar, plotBar, plotLayout, plotCustomLayout

**plotContour**

**Purpose**

Graphs a matrix of contour data.
Format

\[ \text{plotContour}(myPlot, x, y, z); \]
\[ \text{plotContour}(x, y, z); \]

Input

\begin{tabular}{|l|l|}
\hline
myPlot & Optional input: \texttt{plotControl} structure. \\
\hline
x & 1xK vector, the X axis data. \\
\hline
y & Nx1 vector, the Y axis data. \\
\hline
z & NxK matrix, the matrix of height data to be plotted. \\
\hline
\end{tabular}

Remarks

A vector of evenly spaced contour levels will be generated automatically from the \texttt{z} matrix data. Each contour level will be labeled. For unlabeled contours, use \texttt{ztics}.

To specify a vector of your own unequal contour levels, set the vector \_\texttt{plev} before calling \texttt{contour}.

To specify your own evenly spaced contour levels, see \texttt{ztics}.

See Also

\texttt{plotSurface}
**plotCustomLayout**

**Purpose**

Plots a graph of user-specified size at a user-specified location.

**Format**

```plaintext
plotCustomLayout(xStart, yStart, width, height);
```

**Input**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>xStart</code></td>
<td>scalar, the distance from the left edge of the canvas to the left edge of the custom plot expressed as a number between 0 and 1.</td>
</tr>
<tr>
<td><code>yStart</code></td>
<td>scalar, the distance from the bottom edge of the canvas to the bottom edge of the custom plot expressed as a number between 0 and 1.</td>
</tr>
<tr>
<td><code>width</code></td>
<td>scalar, the width of the custom plot expressed as a number between 0 and 1.</td>
</tr>
<tr>
<td><code>height</code></td>
<td>scalar, the height of the custom plot expressed as a number between 0 and 1.</td>
</tr>
</tbody>
</table>

**Example**

```plaintext
//Create an additive sequence starting from -pi and moving forward in 0.1 increments
x = seqa(-pi, 0.1, 63);  
```
//Plot the cosine of x
plotXY(x, cos(x));

//Create a custom section for the next graph starting 10%
//from the main graph's left edge, 10% from the bottom of
//the main graph, with a width and height both equalling
//30% of the width of the main graph.
plotCustomLayout(0.1, 0.1, 0.3, 0.3);

//Plot the next graph in the custom layout
plotXY(x[1:20], cos(x[1:20] ) );

//Prevent the next graph from being drawn in this custom
//region
plotClearLayout();

Remarks
After calling this function all subsequent graphs will be plotted inside of the specified
custom layout until the layout is reset with plotLayout, or the layout is cleared with plotClearLayout.

See Also
plotSetBar, plotBar, plotHistP, plotGetDefaults

plotGetDefaults

Purpose
Gets default settings for plotting graphs.
**Format**

\[ \text{myPlot} = \text{plotGetDefaults}(\text{graph}); \]

**Input**

| graph | String, name of graph type: bar, box, hist, polar, scatter, surface or xy. |

**Output**

| myPlot | A plotControl structure. |

**Example**

```plaintext
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure with defaults for an
//'xy' graph
myPlot = plotGetDefaults("xy");

//Create some data to plot
x = seqa(-5, 0.1, 50);
y = pdfn(x);

//Make a desired change to the plotControl structure
plotSetTitle(&myPlot, "Default XY Settings");

//Plot the data using the plotControl structure
plotXY(myPlot, x, y);
```
Remarks

The `plotGetDefaults` function will use the default settings for the specified graph type. These may be accessed from the main menu bar: 

```
Tools->Preferences->Graphics
```

See Also

`plotSetBkdColor`, `plotSetLineColor`, `plotSetLineSymbol`

**plotHist**

**Purpose**

Computes and graphs a frequency histogram for a vector. The actual frequencies are plotted for each category.

**Format**

```
plotHist(myPlot, x, v);
plotHist(x, v);
```

**Input**

- `myPlot` A `plotControl` structure.
- `x` Mx1 vector of data.
- `v` Nx1 vector, the breakpoints to be used to compute the frequencies
  - or -
  scalar, the number of categories
**Example**

```matlab
//Create some data to plot
dx = randn(5000, 1);

//Plot the data
plotHist(x, 20);
```

**See Also**

plotHistP, plotHistF, plotBar

**plotHistF**

**Purpose**

Graphs a histogram given a vector of frequency counts.

**Format**

```matlab
plotHistF(myPlot, f, c);
plotHistF(f, c);
```

**Input**

- **myPlot**
  - A `plotControl` structure.
- **f**
  - Nx1 vector, frequencies to be graphed.
- **c**
  - Nx1 vector, numeric labels for categories. If this is a scalar 0, a sequence from 1 to `rows(f)` will be created.
Remarks

The axes are not automatically labeled. Use the functions `plotSetXLabel` and `plotSetYLabel`.

See Also

`plotHist`, `plotBar`, `plotSetXLabel`

plotHistP

Purpose

Computes and graphs a percent frequency histogram of a vector. The percentages in each category are plotted.

Format

```plaintext
plotHistP(myPlot, x, v);
plotHistP(x, v);
```

Input

- **myPlot**: A plotControl structure.
- **x**: Mx1 vector of data.
- **v**: Nx1 vector, the breakpoints to be used to compute the frequencies
  - or -
  scalar, the number of categories.
See Also

plotHist, plotHistF, plotBar, plotBox, plotScatter

plotLayout

Purpose

Divides a plot into a grid of subplots and assigns the cell location in which to draw the next created graph.

Format

plotLayout(gRows, gCols, ind);

Input

<table>
<thead>
<tr>
<th>gRows</th>
<th>scalar, number of rows of the graph layout.</th>
</tr>
</thead>
<tbody>
<tr>
<td>gCols</td>
<td>scalar, number of columns of the graph layout.</td>
</tr>
<tr>
<td>ind</td>
<td>scalar, cell location in which to place the next created graph.</td>
</tr>
</tbody>
</table>

Example

```
//Create 10x4 matrix where each column is an additive
//sequence from 0.1 to 1.0
x = seqa(0.1, 0.1, 10);  
y = ones(10, 4).*x;

//Apply a function to each column of 'y'
```
y[.,1] = \text{cos}(x);
y[.,2] = \text{sin}(x);
y[.,3] = \text{cdfn}(x);
y[.,4] = \text{exp}(x);

\textbf{for } i(1, 4, 1);
    \text{//Divide plot canvas into a 2x2 grid of subplot locations and place each newly created graph in the next available cell location.}
    \text{plotLayout}(2, 2, i);

    \text{//Plot each column of } y \text{ in a separate subplot window.}
    \text{plotXY}(x, y[.,i]);
\textbf{endfor};

\text{//Clear the layout so the next plot will not be inside this layout}
\text{plotClearLayout}();

\textbf{Remarks}

After calling this function all subsequent graphs will be plotted inside of the specified layout until the layout is reset with \text{plotLayout}, or the layout is cleared with \text{plotClearLayout}.

\textbf{See Also}

\texttt{plotBar}, \texttt{plotClearLayout}, \texttt{plotCustomLayout}, \texttt{plotHist}
plotLogLog

**Purpose**

Graphs X vs. Y using log coordinates.

**Format**

```matlab
plotLogLog(myPlot, x, y);
plotLogLog(x, y);
```

**Input**

- `myPlot`: A `plotControl` structure.
- `x`: Nx1 or NxM matrix. Each column contains the X values for a particular line.
- `y`: Nx1 or NxM matrix. Each column contains the Y values for a particular line.

**See Also**

`plotXY`, `plotLogX`, `plotLogY`

plotLogX

**Purpose**

Graphs X vs. Y using log coordinates for the X axis.
**Format**

```matlab
plotLogX(myPlot, x, y);
plotLogX(x, y);
```

**Input**

- **myPlot**
  - A `plotControl` structure.
- **x**
  - Nx1 or NxM matrix. Each column contains the X values for a particular line.
- **y**
  - Nx1 or NxM matrix. Each column contains the Y values for a particular line.

**See Also**

`plotXY`, `plotLogY`, `plotLogLog`

**plotLogY**

**Purpose**

Graphs X vs. Y using log coordinates for the Y axis.

**Format**

```matlab
plotLogY(myPlot, x, y);
plotLogY(x, y);
```
**Input**

- `myPlot` - A `plotControl` structure.
- `x` - Nx1 or NxM matrix. Each column represents the X values for a particular line.
- `y` - Nx1 or NxM matrix. Each column represents the Y values for a particular line.

**See Also**

- `plotXY`, `plotLogX`, `plotLogLog`

**plotOpenWindow**

**Purpose**

Opens a new, empty graphic window to be used by the next drawn graph.

**Format**

```matlab
plotOpenWindow();
```

**Example**

```matlab
//Create data
x = rndn(10000, 1);
x2 = rndn(10000, 1);
x3 = rndn(10000, 1);

//Plot first vector as a percentage histogram with 30 bins
```
plotHistP(x, 30);

//Plot second vector, drawing over the previously created //graph.
plotHistP(x2, 30);

//Create a new graphic window and plot the second vector as //a percentage histogram with 30 bins inside this new //window.
plotOpenWindow();

//Draw the graph
plotHistP(x3, 30);

Remarks

To automatically open each new graph in a new graph window, use plotSetNewWindow or set the preference in the main application menu. This may be found by selecting Tools->Preferences and then clicking on Graphics on the left side of the preferences window.

If you select the radio button next to "New Window" at the top of the graphics preferences window, each new graph will be automatically drawn in a new graphics window.

See Also

plotSave, plotCustomLayout, plotSetLegend, plotSetNewWindow

plotPolar

Purpose

Graph data using polar coordinates.
**Format**

```
plotPolar(myPlot, radius, theta);
plotPolar(radius, theta);
```

**Input**

- `myPlot` A `plotControl` structure.
- `radius` Nx1 or NxM matrix. Each column contains the magnitude for a particular line.
- `theta` Nx1 or NxM matrix. Each column represents the angle values for a particular line.

**See Also**

- `plotXY`, `plotLogX`, `plotLayout`, `plotSetXLabel`

**plotSave**

**Purpose**

Saves the last created graph to a user specified file type.

**Format**

```
plotSave(filename, size);
```
**Input**

| filename | String, name of the file to create with a file type extension. Available file extensions include: .jpg, .plot, .png, .pdf, .svg, .tiff. |
| size     | 2x1 vector, dimensions of the saved graph in centimeters. |

**Example**

```gauss
//Create data
x = seqa(1, 1, 10);
y = cos(x);

//Plot the data
plotXY(x, y);

//Save the graph as a pdf with a width of 30 cm and a height of 18 cm
dim = {30, 18};
plotSave("mygraph.pdf", dim);
```

**Technical Notes**

The .plot file extension is an xml file that is the native format used by GAUSS to save graphs.

**See Also**

plotCustomLayout, plotSetLegend
**plotScatter**

**Purpose**

Creates a 2-dimensional scatter plot.

**Format**

```plaintext
plotScatter(myPlot, x, y);
plotScatter(x, y);
```

**Input**

- **myPlot** A `plotControl` structure.
- **x** Nx1 or NxM matrix. Each column contains the X values for a particular data point.
- **y** Nx1 or NxM matrix. Each column contains the Y values for a particular data point.

**Example**

```plaintext
//Create random normal data
x = randn(50, 1);

//Reverse the order of 'x' and set it to be the 'y' value
y = rev(x);

//Plot the data
plotScatter(x, y);
```
See Also

plotXY, plotLogLog, plotBox, plotHistP

plotSetBar

Purpose

Sets the fill style and format of bars in a histogram or bar graph.

Format

plotSetBar(&myPlot, fillType, barStacked);

Input

<table>
<thead>
<tr>
<th>&amp;myPlot</th>
<th>A plotControl structure pointer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>fillType</td>
<td>Nx1 vector, where N is the number of bar styles to set.</td>
</tr>
<tr>
<td></td>
<td>0 Solid, beveled edge</td>
</tr>
<tr>
<td></td>
<td>1 Solid</td>
</tr>
<tr>
<td></td>
<td>2 Dense 1</td>
</tr>
<tr>
<td></td>
<td>3 Dense 2</td>
</tr>
<tr>
<td></td>
<td>4 Dense 3</td>
</tr>
<tr>
<td></td>
<td>5 Dense 4</td>
</tr>
<tr>
<td></td>
<td>6 Dense 5</td>
</tr>
</tbody>
</table>
Example

```c
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("bar");

//Set the first set of bars to have a solid-fill, the
//second set to have a fill of horizontal lines, the third
//to have a diagonal cross fill and set the bars to be
//side-by-side.
textures = { 0, 8, 13 };  
plotSetBar(&myPlot, textures, 0);

//Create data
x = seqa(1, 1, 5);
y = { 1.5, 2, 3, 0.5, 1 };

//Draw bar graph
```
plotBar(myPlot, x, y);

**Remarks**

When graphing without the use of a `plotControl` structure, these settings may be chosen through the Tools->Preferences->Graphics menu, after selecting the Bar radio button. See *GAUSS Graphics*, Chapter 1, for more information on the methods available for customizing your graphs.

**See Also**

plotBar, plotGetDefaults, plotHist

**plotSetBkdColor**

**Purpose**

Sets the background color of a graph.

**Format**

\[
\text{plotSetBkdColor}(&\text{myPlot}, \text{color});
\]

**Input**

- `&myPlot` A `plotControl` structure pointer.
- `color` String, name or rgb value of the new color.
Example

```gauss
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("polar");

//Set new background color to light grey
plotSetBkdColor(&myPlot, "light grey");

//Create data
x = seqa(0.1, 0.1, 200);
y = x;

//Create a polar plot of the data with the new background color
plotPolar(myPlot, x, y);
```

Remarks

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

`plotGetDefaults`, `plotSetLineColor`, `plotSetLineSymbol`
**plotSetGrid**

**Purpose**

Controls the settings for the background grid of a plot.

**Format**

```latex
plotSetGrid(&myPlot, ticStyle, color);
plotSetGrid(&myPlot, ticStyle);
plotSetGrid(&myPlot, onOff);
```

**Input**

- **ticStyle**
  - String, specifies whether grid marks should be drawn on minor tic marks or only on major tic marks. Options: "major" or "minor."

- **color**
  - String, name or rgb value of the new color.

- **onOff**
  - String, turns the grid on or off. Options: "on" or "off." If used, this must be the only argument passed to the function besides the plotControl structure pointer.

**Example**

```latex
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("scatter");
```
//Set grid to be black and on the major tics only
plotSetGrid(&myPlot, "black", "major");

//Create a scatter plot of random data
plotScatter(myPlot, seqa(1, 1, 10), rndn(10, 1));

//Turn off the grid
plotSetGrid(&myPlot, "off");

See Also
plotCustomLayout, plotSetTitle

plotSetLegend

Purpose

Adds a legend to a graph.

Format

plotSetLegend(&myPlot, label, location, orientation);
plotSetLegend(&myPlot, label, location);
plotSetLegend(&myPlot, label);
plotSetLegend(&myPlot, onOff);

Input

&myPlot  A plotControl structure pointer.
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>label</strong></td>
<td>String array, names of the line labels.</td>
</tr>
<tr>
<td><strong>location</strong></td>
<td>String or 2x1 vector, the location to place the legend.</td>
</tr>
</tbody>
</table>

**String case:**

The location string may contain up to three tokens, or words.

1. Vertical location: top (default), middle or bottom.
2. Horizontal location: left, center or right (default).
3. Inside/Outside location: inside (default), below or outside.

**2x1 vector case:**

The first element sets the horizontal location and the second sets the vertical location of the bottom left corner of the graph; expressed as a percentage of the total height and width of the graph.

| **orientation** | scalar, 0 for a horizontal legend or 1 for a vertical legend. |
| **onOff**       | string, "on" or "off". "on" will add the default legend to each graph. "off" will stop GAUSS from adding the default legend to subsequent graphs. |
**Technical Notes**

The location parameter (in the string case) is a string with up to three tokens or words that are separated by a space. For example,

```plaintext
location = "top right";
location = "right top";
location = "inside top right";
```

will all set the legend to the top right position, inside the graph. To locate the bottom left corner of the legend at the origin:

```plaintext
location = { 0, 0 };
```

To place the bottom left corner of the legend in the center of the graph:

```plaintext
location = { 0.5, 0.5 };
```

**Example**

```plaintext
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("xy");

//Set labels, location, and orientation of legend
label = "sample A"|"sample B";
location = "top right";
orientation = 0;
plotSetLegend(&myPlot, label, location, orientation);

//Create data
x = seqa(1, 1, 10);
```
\[ y = \cos(x); \]

//Plot the data with the legend settings
plotXY(myplot, x, y);

See Also

plotLayout, plotCustomLayout, plotOpenWindow

plotSetLineColor

Purpose

Sets the line colors for a graph.

Format

plotSetLineColor(&myPlot, colors);

Input

\begin{itemize}
\item \textit{&myPlot} \quad A \texttt{plotControl} structure pointer.
\item \textit{colors} \quad String array, name or rgb value of the new colors.
\end{itemize}

Example

\begin{verbatim}
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
\end{verbatim}
myPlot = plotGetDefaults("xy");

//Set new line colors to aqua and midnight blue
clrs = "aqua"|$"midnight blue";
plotSetLineColor(&myPlot, clrs);

//Create data
x = seqa(0.1, 1, 50);
y = sin(x)~cos(x);

//Plot the data with the new line colors
plotXY(myPlot, x, y);

Remarks

This function sets an attribute in a plotControl structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

plotGetDefaults, plotSetLineSymbol

plotSetLineStyle

Purpose

Sets the line styles for a graph.

Format

plotSetLineStyle(&myPlot, newStyle);
**Input**

- `&myPlot`  
  A `plotControl` structure pointer.
- `newStyle`  
  Matrix, new line styles. Options include:
  
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solid line.</td>
</tr>
<tr>
<td>2</td>
<td>Dot line.</td>
</tr>
<tr>
<td>3</td>
<td>Dash line.</td>
</tr>
<tr>
<td>4</td>
<td>Dash-Dot line.</td>
</tr>
<tr>
<td>5</td>
<td>Dash-Dot-Dot line.</td>
</tr>
</tbody>
</table>

**Example**

```c
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("xy");

//Set line 1 as a solid line, set line 2 as a dot line, etc.
newStyle = { 1, 2, 3, 4, 5 };
plotSetLineStyle(&myPlot, newStyle);

//Create data
x = seqa(0.1, 1, 50);
y = sin(x)~cos(x);

//Plot the data with the new line styles
plotXY(myPlot, x, y);
```
Remarks

This function sets an attribute in a plotControl structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

plotGetDefaults, plotSetTitle, plotSetLineSymbol

plotSetLineSymbol

Purpose

Sets the symbols displayed on the plotted points of a graph.

Format

plotSetLineSymbol(&myPlot, newSymbol, symbolWidth);
plotSetLineSymbol(&myPlot, newSymbol);

Input

&myPlot  A plotControl structure pointer.
newSymbol  Matrix, new line symbol settings. Options include:
-1  None.
<table>
<thead>
<tr>
<th>Number</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Ellipse</td>
</tr>
<tr>
<td>1</td>
<td>Rectangle</td>
</tr>
<tr>
<td>2</td>
<td>Diamond</td>
</tr>
<tr>
<td>3</td>
<td>Upward pointing triangle</td>
</tr>
<tr>
<td>4</td>
<td>Downward pointing triangle</td>
</tr>
<tr>
<td>5</td>
<td>Triangle</td>
</tr>
<tr>
<td>6</td>
<td>Leftward pointing triangle</td>
</tr>
<tr>
<td>7</td>
<td>Rightward pointing triangle</td>
</tr>
<tr>
<td>8</td>
<td>Cross</td>
</tr>
<tr>
<td>9</td>
<td>Diagonal cross</td>
</tr>
<tr>
<td>10</td>
<td>Horizontal line</td>
</tr>
<tr>
<td>11</td>
<td>Vertical line</td>
</tr>
<tr>
<td>12</td>
<td>Star 1</td>
</tr>
<tr>
<td>13</td>
<td>Star 2</td>
</tr>
<tr>
<td>14</td>
<td>Hexagon</td>
</tr>
</tbody>
</table>

*symbolWidth*  
Scalar, width to draw line symbols.

**Example**

```c
//Declare plotControl structure
struct plotControl myPlot;
```
//Initialize plotControl structure
myPlot = plotGetDefaults("xy");

//Set line 1 to have no symbol
//Set line 2 to display an ellipse at each plotted point.
newSymbol = { -1, 0 };
symbolWidth = 5;
plotSetLineSymbol(&myPlot, newSymbol, symbolWidth);

//Create data
x = seqa(0.1, 0.1, 50);
y = sin(x)~cos(x);

//Plot the data with the new line symbols
plotXY(myPlot, x, y);

Remarks

This function sets an attribute in a plotControl structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

plotGetDefaults, plotSetXLabel, plotSetLineColor

plotSetLineThickness

Purpose

Sets the thickness of the lines on a graph.
**Format**

```
plotSetLineThickness(&myPlot, newTh);
```

**Input**

<table>
<thead>
<tr>
<th>&amp;myPlot</th>
<th>A <code>plotControl</code> structure pointer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>newTh</td>
<td>1 x N matrix, new line thickness settings.</td>
</tr>
</tbody>
</table>

**Example**

```c
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("xy");

//Set all lines to have a thickness of 2
newTh = 2;
plotSetLineThickness(&myPlot, newTh);

//Create data
x = seqa(0.1, 1, 50);
y = sin(x)~cos(x);

//Plot the data with the new line thickness settings
plotXY(myPlot, x, y);
```

**Remarks**

This function sets an attribute in a `plotControl` structure. It does not affect an existing
graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

plotGetDefaults, plotLayout, plotSetTitle

plotSetNewWindow

Purpose

Determines whether each new graph is drawn in a new graph tab or re-uses a pre-existing graph tab.

Format

plotSetNewWindow(&myPlot, newW);

Input

&myPlot A plotControl structure pointer.

newW Scalar, 1 to create a new graph tab or 0 to re-use.

Example

//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = \texttt{plotGetDefaults}("xy");

//Set graph to create a new graph tab
newW = 1;
\texttt{plotSetNewWindow}(&myPlot, newW);

//Create data
x = \texttt{seqa}(0.1, 1, 50);
y = \texttt{sin}(x) \sim \texttt{cos}(x);

//Plot the data in a new graph tab window
\texttt{plotXY}(myPlot, x, y);

\textbf{Remarks}

To open a new graph window once, use \texttt{plotOpenWindow}. This function sets an attribute in a \texttt{plotControl} structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible in the main application window from the \texttt{Tools->Graphics>Preferences} menu. See \textit{GAUSS Graphics}, Chapter 1, for more information on the methods available for customizing your graphs.

\textbf{See Also}

\texttt{plotGetDefaults}, \texttt{plotOpenWindow}, \texttt{plotSetTitle}, \texttt{plotSetLineColor}

\textbf{plotSetTitle}

\textbf{Purpose}

Controls the settings for the title for a graph.
**Format**

```
plotSetTitle(&myPlot, title, font, fontSize, fontColor);
plotSetTitle(&myPlot, title, font);
plotSetTitle(&myPlot, title);
```

**Input**

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;myPlot</td>
<td>A <code>plotControl</code> structure pointer.</td>
</tr>
<tr>
<td>title</td>
<td>String, the new title. This may contain HTML for the creation of Greek letters, mathematical symbols and text formatting.</td>
</tr>
<tr>
<td>font</td>
<td>String, font or font family name.</td>
</tr>
<tr>
<td>fontSize</td>
<td>Scalar, font size in points.</td>
</tr>
<tr>
<td>fontColor</td>
<td>String, named color or RGB value.</td>
</tr>
</tbody>
</table>
Example

Example 1

```c
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("hist");

//Set the title, title font and title font size
plotSetTitle(&myPlot, "GAUSS Example Graph", "verdana", 10);

//Create data
x = rndn(1e5,1);

//Plot a histogram of the x data spread over 50 bins
plotHist(myPlot, x, 50);
```

Example 2

You may add Greek letters, mathematical symbols, subscript and superscript to your title using HTML. To add HTML to a label, you need to wrap the text to be interpreted as HTML in HTML tags.

```
label_string = "<html>&beta;</html>";
plotSetTitle(&myPlot, label_string);
```

The code above will add the letter β to the graph title. The HTML 'sup' tag will create superscript and the 'sub' tag will create subscript. For example:

```
label_string = "<html>&sigma;<sup>2</sup></html>";
plotSetTitle(&myPlot, label_string);
```

will add σ² to your title. While,
label_string = "<html>Y<sub>t-1</sub></html>";
plotSetTitle(&myPlot, label_string);

will create $Y_{t-1}$.

Remarks

This function sets an attribute in a **plotControl** structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the **Tools->Preferences->Graphics** menu. See **GAUSS Graphics**, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

`plotGetDefaults`, `plotYLabel`, `plotLineColor`, `plotSetGrid`

### plotSetXLabel

**Purpose**

Controls the settings for the X-axis label on a graph.

**Format**

```
plotSetXLabel(&myPlot, label, font, fontSize, fontColor);
plotSetXLabel(&myPlot, label, font, fontSize);
plotSetXLabel(&myPlot, label, font);
plotSetXLabel(&myPlot, label);
```
## Input

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;myPlot</td>
<td>A <code>plotControl</code> structure pointer.</td>
</tr>
<tr>
<td>label</td>
<td>String, the new label. This may contain HTML for the creation of Greek letters, mathematical symbols and text formatting.</td>
</tr>
<tr>
<td>font</td>
<td>String, font or font family name.</td>
</tr>
<tr>
<td>fontSize</td>
<td>Scalar, font size in points.</td>
</tr>
<tr>
<td>fontColor</td>
<td>String, named color or RGB value.</td>
</tr>
</tbody>
</table>
Example

Example 1

```c
// Declare plotControl structure
struct plotControl myPlot;

// Initialize plotControl structure
myPlot = plotGetDefaults("hist");

// Set the X-axis label, label font, label font size, and label color
plotSetXLabel(&myPlot, "Time (sec)", "verdana", 10, "black");

// Create data
x = rndn(1e5, 1);

// Plot a histogram of the x data spread over 50 bins
plotHist(myPlot, x, 50);
```

Example 2

You may add Greek letters, mathematical symbols, subscript and superscript to your axis labels using HTML. To add HTML to a label, you need to wrap the text to be interpreted as HTML in HTML tags.

```c
label_string = "<html>&beta;</html>";
plotSetXLabel(&myPlot, label_string);
```

The code above will add the letter β to the x-axis label. The HTML 'sup' tag will create superscript and the 'sub' tag will create subscript. For example:

```c
label_string = "<html>&sigma;<sup>2</sup></html>";
plotSetXLabel(&myPlot, label_string);
```
will add $\sigma^2$ to your x-axis label. While,

```gauss
label_string = "<html>Y<sub>t-1</sub></html>";
plotSetXLabel(&myPlot, label_string);
```

will create $Y_{t-1}$.

**Remarks**

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

**See Also**

`plotGetDefaults`, `plotXTicInterval`, `plotXTicLabel`, `plotYLabel`, `plotZLabel`, `plotLineColor`, `plotSetGrid`

**plotSetXTicInterval**

**Purpose**

Controls the interval between X-axis tic labels and also allows the user to specify the first tic to be labeled for 2-D time series graphs.

**Format**

```gauss
plotSetXTicInterval(&myPlot, ticInterval, firstLabeled);
plotSetXTicInterval(&myPlot, ticInterval);
```
**Input**

<table>
<thead>
<tr>
<th>&amp;myPlot</th>
<th>A plotControl structure pointer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ticInterval</td>
<td>Scalar, the number of X-values between X-axis tic labels.</td>
</tr>
<tr>
<td>firstLabeled</td>
<td>Scalar, the value of the first X-value on which to place a tic label.</td>
</tr>
</tbody>
</table>

**Example**

**Time Series Example**

```c
//Declare and initialize plotControl structure
struct plotControl myPlot;
myPlot = plotGetDefaults("xy");

//Place one tic label every 4 x-values
ticInterval = 4;
plotSetXTicInterval(&myPlot, ticInterval);

//Start the time series in April of 2008
dtstart = 200804;

//Specify quarterly data
frequency = 4;

//Create the multiplicative sequence 1, 2, 4, 8...
y = seqm(1, 2, 10);

//Create a time series plot of the data.
plotTS(myPlot, dtstart, frequency, y);
```
If you would like to change the tic labels so that they start on the first full year, 2009, continuing with the example from above, execute the following lines:

```cpp
//Set the optional 'firstLabeled' parameter
plotSetXTicInterval(&myPlot, ticInterval, 2009);
plotTS(myPlot, dtstart, frequency, y);
```

This new plot should now have tic labels only on the first quarters of each year:
Remarks

`plotSetXTicInterval` is currently only supported for use with time series plots. It is ignored by other plot types.

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the `Tools->Preferences->Graphics` menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.

See Also

dttostr, strtodt, plotSetXLabel, plotSetXTicLabel
plotSetXTicLabel

**Purpose**

Controls the formatting and angle of X-axis tic labels for 2-D time series graphs.

**Format**

```plaintext
plotSetXTicLabel(&myPlot, fmt, angle);
plotSetXTicLabel(&myPlot, fmt);
```

**Input**

- **&myPlot** A plotControl structure pointer.
- **fmt** String, the desired formatting for the X-axis tic labels. See function `dttostr` for formatting options.
- **angle** Scalar, the angle in degrees at which to display the X-axis tic labels.

**Example**

**Example 1**

```plaintext
//Declare and initialize plotControl structure
struct plotControl myPlot;
myPlot = plotGetDefaults("xy");

y = rndn(5, 1);
```
```cpp
plotSetXTicLabel(&myPlot, "YYYY-MO");

//Start the series in January 1982
dtstart = 198201;

//Specify the data to be monthly
frequency = 12;

//Draw the time series plot
plotTS(myPlot, dtstart, frequency, y);
```

The code above produces a graph with X-tic labels like the image below:

![Time series plot example](image)

Figure 38.3: Time series plot example

Changing to format string to "MO/YYYY" will change the labels to appear like this:

```
01/1982
```

Changing to format string to "YYYY-QQ" will change the labels to appear like this:
Remarks

This function is currently only supported for time series graphs created with `plotTS`.

The following format specifiers are supported for the second input to `plotSetXTicLabel`, `fmt`:

- `YYYY` 4 digit year
- `YR` Last two digits of year
- `QQ` Quarter of the year. This is calculated from the month number.
- `MO` Number of month, 01-12
- `DD` Day of month, 01-31
- `HH` Hour of day, 00-23
- `MI` Minute of hour, 00-59
- `SS` Second of minute, 00-59

To learn more about DT scalar format and the using the format specifiers, see Date and Time Formats, Section 1.0.1, or the functions `dttostr` and `strtodt`.

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See GAUSS Graphics, Chapter 1, for more information on the methods available for customizing your graphs.
See Also
dttosr, strtodt, plotSetXLabel, plotSetXTicInterval

plotSetYLabel

Purpose

Controls the settings for the Y-axis label on a graph.

Format

plotSetYLabel(&myPlot, label, font, fontSize, fontColor);
plotSetYLabel(&myPlot, label, font, fontSize);
plotSetYLabel(&myPlot, label, font);
plotSetYLabel(&myPlot, label);

Input

&myPlot        A plotControl structure pointer.
label          String, the new label. This may contain HTML for the creation of Greek letters, mathematical symbols and text formatting.
font           String, font or font family name.
fontSize       Scalar, font size in points.
fontColor      String, named color or RGB value.
Example

Example 1

```cpp
//Declare plotControl structure
class plotControl
{
    //Initialize plotControl structure
    myPlot = plotGetDefaults("hist");

    //Set the Y-axis label, label font, font size, and color
    plotSetYLabel(&myPlot, "Time (sec)", "verdana", 10, "black");

    //Create data
    x = rndn(1e5, 1);

    //Plot a histogram of the x data spread over 50 bins
    plotHist(myPlot, x, 50);
}
```

Example 2

You may add Greek letters, mathematical symbols, subscript and superscript to your axis labels using HTML. To add HTML to a label, you need to wrap the text to be interpreted as HTML in HTML tags.

```cpp
label_string = "<html>&beta;</html>";
plotSetYLabel(&myPlot, label_string);
```

The code above will add the letter β to the y-axis label. The HTML 'sup' tag will create superscript and the 'sub' tag will create subscript. For example:

```cpp
label_string = "<html>&sigma;<sup>2</sup></html>";
plotSetYLabel(&myPlot, label_string);
```

will add $\sigma^2$ to your y-axis label. While,
plotSetYLabel(&myPlot, label_string);

will create $Y_{t-1}$.

**Remarks**

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the `Tools->Preferences->Graphics` menu. See *GAUSS Graphics*, Chapter 1, for more information on the methods available for customizing your graphs.

**See Also**

`plotGetDefaults`, `plotSetXLabel`, `plotSetXTicInterval`, `plotSetXTicLabel`, `plotSetZLabel`, `plotSetLineColor`, `plotSetGrid`

**plotSetZLabel**

**Purpose**

Controls the settings for the Z-axis label on a graph.

**Format**

```gauss
plotSetZLabel(&myPlot, label, font, fontSize, fontColor);
plotSetZLabel(&myPlot, label, font, fontSize);
plotSetZLabel(&myPlot, label, font);
plotSetZLabel(&myPlot, label);
```
### Input

<table>
<thead>
<tr>
<th>&amp;myPlot</th>
<th>A plotControl structure pointer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>String, the new label. This may contain HTML for the creation of Greek letters, mathematical symbols and text formatting. As of the release of this document, HTML is supported for contour plots, but it is not supported for surface plots.</td>
</tr>
<tr>
<td>font</td>
<td>String, font or font family name.</td>
</tr>
<tr>
<td>fontSize</td>
<td>Scalar, font size in points.</td>
</tr>
<tr>
<td>fontColor</td>
<td>String, named color or RGB value.</td>
</tr>
</tbody>
</table>

### Example

#### Example 1

```c
//Declare plotControl structure
struct plotControl myPlot;

//Initialize plotControl structure
myPlot = plotGetDefaults("surface");

//Set the Z-axis label, label font, font size, and color
plotSetZLabel(&myPlot, "Depth", "verdana", 10, "black");

//Create data
x = seqa(-10.6, .3, 71);
y = seqa(-12.4, .35, 71);
z = sin(sqrt((x/2)^2+(y/2)^2)) ./ sqrt(x^2+y^4);
```
\[
z = z \cdot \sin(x/3);
\]

//Plot the data
plotSurface(myPlot, x, y, z);

**Example 2**

You may add Greek letters, mathematical symbols, subscript and superscript to your axis labels using HTML. To add HTML to a label, you need to wrap the text to be interpreted as HTML in HTML tags.

```gauss
label_string = "<html>&beta;</html>";
plotSetZLabel(&myPlot, label_string);
```

The code above will add the letter β to the z-axis label. The HTML 'sup' tag will create superscript and the 'sub' tag will create subscript. For example:

```gauss
label_string = "<html>&sigma;<sup>2</sup></html>";
plotSetZLabel(&myPlot, label_string);
```

will add σ² to your z-axis label. While,

```gauss
label_string = "<html>Y<sub>t-1</sub></html>";
plotSetZLabel(&myPlot, label_string);
```

will create \(Y_{t-1}\).

**Remarks**

This function sets an attribute in a `plotControl` structure. It does not affect an existing graph, or a new graph drawn using the default settings that are accessible from the Tools->Preferences->Graphics menu. See **GAUSS Graphics**, Chapter 1, for more information on the methods available for customizing your graphs.
See Also

plotGetDefaults, plotSetXLabel, plotSetXTicInterval, plotSetXTicLabel, plotSetYLabel, plotSetLineColor, plotSetGrid

plotSurface

Purpose

Graphs a 3-D surface.

Format

plotSurface(myPlot, x, y, z);
plotSurface(x, y, z);

Input

myPlot A plotControl structure.
x 1xK vector, the X axis data.
y Nx1 vector, the Y axis data.
z NxK matrix, the matrix of height data to be plotted.

See Also

plotPolar, plotSetBkdColor
plotTS

Purpose

Creates a graph of time series data.

Format

```
plotTS(myPlot, dtstart, frequency, y);
plotTS(dtstart, frequency, y);
```

Input

- **myPlot**: A `plotControl` structure.
- **dtstart**: Scalar, starting date in DT scalar format.
- **frequency**: Scalar, frequency of the data per year. Valid options include:
  - 1: Yearly
  - 4: Quarterly
  - 12: Monthly
- **y**: Nx1 or NxM matrix. Each column contains the Y values for a particular line.

Examples

Example 1

```
//Create some data to plot
```
y = \texttt{rndn}(100, 1);

//The first input starts the series in January of 1982
//The second input specifies the data to be monthly
\texttt{plotTS}(1982, 12, y);

Example 2

//The first input starts the series in April 2005
//The second input specifies the data to be monthly
\texttt{plotTS}(200504, 12, y);

Example 3

In DT Scalar format, quarters are represented by supplying the first month of the quarter for the sixth and seventh leading digits. As we see below, 200504 represents April of 2005, but it also represents the second quarter of April 2005.

//The first input starts the series in the second quarter of 2005
//The second input specifies the data to be quarterly
\texttt{plotTS}(200504, 4, y);

Remarks

Formatting for the X-tic labels can be set with the function \texttt{plotSetXTicLabel}. If a \texttt{plotControl} structure is not passed in to \texttt{plotTS}, or the format specifier is not set with \texttt{plotSetXTicLabel} the default formatting: for annual data is "YYYY", for quarterly data "YYYY-QQ" and for monthly data is "YYYY-MO".

By default missing values in the $y$ variable will be represented as gaps in the line.

See Also

\texttt{plotSetXTicLabel}, \texttt{plotSetXTicInterval}, \texttt{plotScatter}
plotXY

**Purpose**

Graphs X vs. Y using Cartesian coordinates.

**Format**

```
plotXY(myPlot, x, y);
plotXY(x, y);
```

**Input**

- **myPlot**
  A `plotControl` structure.
- **x**
  Nx1 or NxM matrix. Each column contains the X values for a particular line.
- **y**
  Nx1 or NxM matrix. Each column contains the Y values for a particular line.

**Remarks**

By default missing values in the `y` variable will be represented as gaps in the line.

**See Also**

`plotLogX`, `plotLogLog`, `plotScatter`
polar

**Purpose**

Graph data using polar coordinates. NOTE: This function is for use only with the deprecated PQG graphics.

**Library**

pgraph

**Format**

```plaintext
polar(radius, theta);
```

**Input**

- `radius` Nx1 or NxM matrix. Each column contains the magnitude for a particular line.
- `theta` Nx1 or NxM matrix. Each column represents the angle values for a particular line.

**Source**

polar.src

**See Also**

xy, logx, logy, loglog, scale, xtics, ytics
**polychar**

**Purpose**

Computes the characteristic polynomial of a square matrix.

**Format**

\[
c = \text{polychar}(x);
\]

**Input**

\(x\) \quad \text{NxN matrix.}

**Output**

\(c\) \quad (N+1)x1 vector of coefficients of the Nth order characteristic polynomial of \(x\):

\[
p(x) = c[1]x^n + c[2]x^{n-1} + \ldots + c[n]x + c[n+1];
\]

**Remarks**

The coefficient of \(x^n\) is set to unity (\(c[1]=1\)).

**Source**

poly.src
See Also

polymake, polymult, polyroot, polyeval

polyeval

Purpose

Evaluates polynomials. Can either be one or more scalar polynomials or a single matrix polynomial.

Format

\[ y = \text{polyeval}(x, c); \]

Input

- \( x \) 1xK or NxN; that is, \( x \) can either represent K separate scalar values at which to evaluate the (scalar) polynomial(s), or it can represent a single NxN matrix.

- \( c \) (P+1)xK or (P+1)x1 matrix of coefficients of polynomials to evaluate. If \( x \) is 1xK, then \( c \) must be (P+1)xK. If \( x \) is NxN, \( c \) must be (P+1)x1. That is, if \( x \) is a matrix, it can only be evaluated at a single set of coefficients.

Output

- \( y \) Kx1 vector (if \( c \) is (P+1)xK) or NxN matrix (if \( c \) is (P+1)x1 and \( x \) is NxN):
\[ y = ( c[1,.]*x^p + c[2,.]*x^{(p-1)} + \ldots + c[p+1,.] )'; \]

**Remarks**

In both the scalar and the matrix case, Horner's rule is used to do the evaluation. In the scalar case, the function `recsercp` is called (this implements an elaboration of Horner's rule).

**Example**

```plaintext
x = 2;
let c = 1 1 0 1 1;
y = polyeval(x, c);
```

The result is 27. Note that this is the decimal value of the binary number 11011.

```plaintext
y = polyeval(x, 1|zeros(n,1));
```

This will raise the matrix \(x\) to the \(n\)th power (e.g: \(x*x*x*x*\ldots*x\)).

**Source**

`poly.src`

**See Also**

`polymake`, `polychar`, `polymult`, `polyroot`
polygamma

Purpose

Computes the polygamma function of order $n$.

Format

$f = \text{polygamma}(z,n);$  

Input

- $z$  
  
  NxK matrix; $z$ may be complex.

- $n$  
  
  The order of the function. If $n$ is 2 then $f$ will be the Digamma function. If $n = 3, 4, 5$, etc., then $f$ will be the tri-, tetra-, penta-, hexa-, hepta-, etc., Gamma function. Real $(n)$ must be positive.

Output

- $f$  
  
  NxK matrix; $f$ may be complex.

Example

\[
\text{polygamma}(-45.6-i*29.4, 101); \quad \text{is near } 12.5 + 9*i
\]

\[
\text{polygamma}(-11.5-i*0.577007813568142, 10);  
\]
is near a root of the decagamma function

Remarks

This program uses the partial fraction expansion of the derivative of the log of the Lanczos series approximation for the Gamma function. Accurate to about 12 digits.

References

5. W. Press, "Numerical Recipes."
7. Abramowitz & Stegun, section eq 6.4.6
8. Original code by Paul Godfrey

polyint

Purpose

Calculates an Nth order polynomial interpolation.

Format

\[ y = \text{polyint}(xa, ya, x); \]
**Input**

- $xa$: Nx1 vector, $x$ values.
- $ya$: Nx1 vector, $y$ values.
- $x$: scalar, $x$ value to solve for.

**Global Input**

- $_poldeg$: scalar, the degree of polynomial required, default 6.

**Output**

- $y$: result of interpolation or extrapolation.

**Global Output**

- $_polerr$: scalar, interpolation error.

**Remarks**

Calculates an Nth order polynomial interpolation or extrapolation of $x$ on $y$ given the vectors $xa$ and $ya$ and the scalar $x$. The procedure uses Neville's algorithm to determine an up to Nth order polynomial and an error estimate.

Polynomials above degree 6 are not likely to increase the accuracy for most data. Test $_polerr$ to determine the required $_poldeg$ for your problem.
Source
polyint.src

Technical Notes

polymake

Purpose
Computes the coefficients of a polynomial given the roots.

Format
\[ c = \text{polymake}(r); \]

Input
\[ r \]
Nx1 vector containing roots of the desired polynomial.

Output
\[ c \]
(N+1)x1 vector containing the coefficients of the Nth order polynomial with roots \( r \):
\[ p(z) = c[1]z^n + c[2]z^{n-1} + \ldots + c[n]z + c[n+1] \]
Remarks

The coefficient of $z^n$ is set to unity ($c[1]=1$).

Example

```plaintext
//Assign values for the roots of the polynomial
r = { 2, 1, 3 };

//Calculate the coefficients
c = polymake(r);

//Print 3 spaces for each number and 1 digit after the decimal place
format /rd 3,1;

//Iterate through each root in 'r'
for i(1, 3, 1);
    rtmp = r[i];
    //Calculate the polynomial
    rout = c[1]*rtmp^3 + c[2]*rtmp^2 + c[3]*rtmp + c[4];
    print "rtmp = " rtmp " rout = " rout;
endfor;
```

Since the values of $r$ are roots for this polynomial, $rout$ should equal 0. Thus the code above gives the following output:

- $rtmp = 2.0$ $rout = 0.0$
- $rtmp = 1.0$ $rout = 0.0$
- $rtmp = 3.0$ $rout = 0.0$

This example assigns $c$ to be equal to:

- $1.0$
- $c = -6.0$
This represents the polynomial:

\[ x^3 - 6x^2 + 11x - 6 \]

**Source**

poly.src

**See Also**

polychar, polymult, polyroot, polyeval

**polymat**

**Purpose**

Returns a matrix containing the powers of the elements of \( x \) from 1 to \( p \).

**Format**

\[ y = \text{polymat}(x, \ p); \]

**Input**

\( x \)  \quad \text{NxK matrix.}

\( p \)  \quad \text{scalar, positive integer.}
Output

\[ y \]  
\[ \text{Nx}(p\times K) \text{ matrix containing powers of the elements of } x \text{ from 1 to } p. \text{ The first } K \text{ columns will contain first powers, the second } K \text{ columns second powers, and so on.} \]

Remarks

To do polynomial regression use \texttt{ols}:

\[
\{ \text{vnam,m,b,stab,vc,stderr,sigma,cx,rsq,rsid,dsstat} \} = \texttt{ols}(0,y, \texttt{polymat}(x,p));
\]

Source

\texttt{polymat.src}

\texttt{polymroot}

Purpose

Computes the roots of the determinant of a matrix polynomial.

Format

\[ r = \texttt{polymroot}(c); \]

Input

\[ c \]  
\[ (N+1)\times K \times K \text{ matrix of coefficients of an } N\text{th order} \]
polynomial of rank K.

**Output**

\[ r \] K*N vector containing the roots of the determinantal equation.

**Remarks**

\( c \) is constructed of \( N+1 \) KxK coefficient matrices stacked vertically with the coefficient matrix of the \( t^n \) at the top, \( t^{(n-1)} \) next, down to the \( t^0 \) matrix at the bottom.

Note that this procedure solves the scalar problem as well, that is, the one that POLYROOT solves.

**Example**

Solve

\[
\text{det}(A2*t^2 + A1*t + A0) = 0
\]

where:

\[
\begin{align*}
A2 &= \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix} \\
A1 &= \begin{pmatrix} 5 & 8 \\ 10 & 7 \end{pmatrix} \\
A0 &= \begin{pmatrix} 3 & 4 \\ 6 & 5 \end{pmatrix}
\end{align*}
\]

\[
a2 = \{1, 2, 2, 1\}; \\
a1 = \{5, 8, 10, 7\}; \\
a0 = \{3, 4, 6, 5\};
\]

//The pipe operator '|' provides vertical concatenation
print polymroot(a2|a1|a0);
**polymult**

**Purpose**

Multiplies polynomials.

**Format**

\[ c = \text{polymult}(c1, c2); \]

**Input**

| \(c1\) | (D1+1)x1 vector containing the coefficients of the first polynomial. |
|\(c2\) | (D2+1)x1 vector containing the coefficients of the second polynomial. |

**Output**

| \(c\) | (D1+D2)x1 vector containing the coefficients of the product of the two polynomials. |
**Example**

This example multiplies the polynomials:

\[(2x + 1)(2x^2 + 1)\]

and returns the answer:

\[4x^3 + 2x^2 + 2x + 1\]

//Assign c1 to represent 2x + 1
c1 = { 2, 1 };

//Assign c2 to represent 2x^2 + 1
c2 = { 2, 0, 1 };
c = polymult(c1,c2);

After the code above:

<table>
<thead>
<tr>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>c = 2</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

**Technical Notes**

If the degree of \(c1\) is \(D1\) (e.g., if \(D1=3\), then the polynomial corresponding to \(c1\) is cubic), then there must be \(D1+1\) elements in \(c1\) (e.g., 4 elements for a cubic). Thus, for instance the coefficients for the polynomial

\[5x^3 + 6x + 3\]

would be:

//Using the pipe operator for vertical concatenation
c1 = 5|0|6|3;
or

//Using an array assignment
c1 = { 5, 0, 6, 3 };

(Note that zeros must be explicitly given if there are powers of \(x\) missing.)

**Source**

tpoly.src

**See Also**
polymake, polychar, polyroot, polyeval

**polyroot**

**Purpose**

Computes the roots of a polynomial given the coefficients.

**Format**

\[ y = \text{polyroot}(c); \]

**Input**

\( c \) (N+1)x1 vector of coefficients of an Nth order polynomial:

\[ p(z) = c[1]*z^n + c[2]*z^{n-1} + \ldots + c[n]*z + c[n+1] \]
Output

\[ y \]  \quad \text{Nx1 vector, the roots of } c. \\

Remarks

Zero leading terms will be stripped from \( c \). When that occurs the order of \( y \) will be the order of the polynomial after the leading zeros have been stripped.

\( c[1] \) need not be normalized to unity.

Source

poly.src

See Also

polymake, polychar, polymult, polyeval

pop

Purpose

Provides access to a last-in, first-out stack for matrices.

Format

\[
\begin{align*}
\text{pop } & b; \\
\text{pop } & a;
\end{align*}
\]
Remarks

This is used with `gosub`, `goto`, and `return` statements with parameters. It permits passing parameters to subroutines or labels, and returning parameters from subroutines.

The `gosub` syntax allows an implicit `push` statement. This syntax is almost the same as that of a standard `gosub`, except that the matrices to be `push`ed "into the subroutine" are in parentheses following the label name. The matrices to be `push`ed back to the main body of the program are in parentheses following the `return` statement. The only limit on the number of matrices that can be passed to and from subroutines in this way is the amount of room on the stack.

No matrix expressions can be executed between the (implicit) `push` and the `pop`. Execution of such expressions will alter what is on the stack.

Matrices must be `pop`'ped in the reverse order that they are `push`'ed, therefore in the statements:

```plaintext
  goto label(x,y,z);
  .
  .
  .
  label:
  pop c;
  pop b;
  pop a;
```

After the code above:

```plaintext
  c = z
  b = y
  a = x
```

Note that there must be a separate `pop` statement for each matrix popped.
See Also

gosub, goto, return

pqgwin

Purpose

Sets the graphics viewer mode. NOTE: This function is for use only with the deprecated PQG graphics.

Library

pgraph

Format

pqgwin one;
pqgwin many;

Remarks

If you call:

pqgwin one

only a single viewer will be used. If you call

pqgwin many

a new viewer will be used for each graph.

pqgwin manual and pqgwin auto are supported for backwards compatibility,
manual=one, auto=many.
Example

```c
pqgwin many;
```

Source

`pgraph.src`

See Also

`setvwrmode`

**previousindex**

**Purpose**

Returns the index of the previous element or subarray in an array.

**Format**

```c
pi = previousindex(i, o);
```

**Input**

- `i` Mx1 vector of indices into an array, where M <= N.
- `o` Nx1 vector of orders of an N-dimensional array.

**Output**

- `pi` Mx1 vector of indices, the index of the previous element or
subarray in the array corresponding to \( o \).

**Remarks**

`previousindex` will return a scalar error code if the index cannot be decremented.

**Example**

```matlab
orders = {3,4,5,6,7};
a = areshape(1,orders);
orders = getorders(a);
ind = [2,3,1];
ind = previousindex(ind,orders);
```

After the code above, `ind` is equal to:

```
2
ind = 2
5
```

In this example, `previousindex` decremented `ind` to index the previous 6x7 subarray in array `a`.

**See Also**

`nextindex`, `loopnextindex`, `walkindex`
princomp

Purpose

Computes principal components of a data matrix.

Format

\[
\{ p, v, a \} = \text{princomp}(x, j);
\]

Input

- \( x \): NxK data matrix, N>K, full rank.
- \( j \): scalar, number of principal components to be computed (\( j \leq K \)).

Output

- \( p \): NxJ matrix of the first \( j \) principal components of \( x \) in descending order of amount of variance explained.
- \( v \): Jx1 vector of fractions of variance explained.
- \( a \): JxK matrix of factor loadings, such that:
  \[
  x = p \times a + \text{error}.
  \]

Remarks

Adapted from a program written by Mico Loretan.

**print**

**Purpose**

Prints matrices, arrays, strings and string arrays to the screen and/or auxiliary output.

**Format**

```
print [[/flush]] [[/typ]] [[/fmted]] [[/mf]] [[/jnt]] list_of_expressions[;];
```

**Input**

- **/typ** literal, symbol type flag.
  - `/mat`, `/sa`, `/str` Indicate which symbol types you are setting the output format for: matrices and arrays (`/mat`), string arrays (`/sa`), and/or strings (`/str`). You can specify more than one `/typ` flag; the format will be set for all types indicated. If no `/typ` flag is listed, `print` assumes `/mat`.

- **/fmted** literal, enable formatting flag.
  - `/on, /off` Enable/disable formatting. When formatting is disabled, the contents of a variable are dumped
to the screen in a "raw" format. /off is currently supported only for strings. "Raw" format for strings means that the entire string is printed, starting at the current cursor position. When formatting is enabled for strings, they are handled the same as string arrays. This shouldn't be too surprising, since a string is actually a 1x1 string array.

<table>
<thead>
<tr>
<th>Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/mf</td>
<td>literal, matrix format. It controls the way rows of a matrix are separated from one another. The possibilities are:</td>
</tr>
<tr>
<td>/m0</td>
<td>no delimiters before or after rows when printing out matrices.</td>
</tr>
<tr>
<td>/m1 or /mb1</td>
<td>print 1 carriage return/line feed pair before each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td>/m2 or /mb2</td>
<td>print 2 carriage return/line feed pairs before each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td>/m3 or /mb3</td>
<td>print &quot;Row 1&quot;, &quot;Row 2&quot;...before each row of a matrix with more than one row.</td>
</tr>
<tr>
<td>/ma1</td>
<td>print 1 carriage return/line feed pair after each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td>/ma2</td>
<td>print 2 carriage return/line feed pairs after each row of a matrix with more than 1 row.</td>
</tr>
<tr>
<td>/a1</td>
<td>print 1 carriage return/line feed pair after each row of a matrix.</td>
</tr>
<tr>
<td>/a2</td>
<td>print 2 carriage return/line feed pairs after each row of a matrix.</td>
</tr>
</tbody>
</table>
/b1: print 1 carriage return/line feed pair before each row of a matrix.

/b2: print 2 carriage return/line feed pairs before each row of a matrix.

/b3: print "Row 1", "Row 2"... before each row of a matrix.

/jnt: literal, controls justification, notation, and the trailing character.

**Right-Justified**

/rd: Signed decimal number in the form [[-]]
     #####.#####", where ##### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed.

/re: Signed number in the form [[-]]#.##E±###, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [[-]]#E±### with no decimal point printed.

/ro: This will give a format like /rd or /re depending on which is most compact for the number being printed. A format like /re will be used only if the exponent value is less than -4 or greater than the precision. If a /re format is used, a decimal point will always appear.
The precision signifies the number of significant digits displayed.

/rz

This will give a format like /rd or /re depending on which is most compact for the number being printed. A format like /re will be used only if the exponent value is less than -4 or greater than the precision. If a /re format is used, trailing zeros will be suppressed and a decimal point will appear only if one or more digits follow it. The precision signifies the number of significant digits displayed.

Left-Justified

/ld

Signed decimal number in the form [[-]] #.#.###, where ### is one or more decimal digits. The number of digits before the decimal point depends on the magnitude of the number, and the number of digits after the decimal point depends on the precision. If the precision is 0, no decimal point will be printed. If the number is positive, a space character will replace the leading minus sign.

/le

Signed number in the form [[-]]#.###E±###, where # is one decimal digit, ## is one or more decimal digits depending on the precision, and ### is three decimal digits. If precision is 0, the form will be [[-]]#E±### with no decimal point printed. If the number is positive, a space character will replace the leading minus sign.
<table>
<thead>
<tr>
<th>Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/lo</td>
<td>This will give a format like /ld or /le depending on which is most compact for the number being printed. A format like /le will be used only if the exponent value is less than -4 or greater than the precision. If a /le format is used, a decimal point will always appear. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.</td>
</tr>
<tr>
<td>/lz</td>
<td>This will give a format like /ld or /le depending on which is most compact for the number being printed. A format like /le will be used only if the exponent value is less than -4 or greater than the precision. If a /le format is used, trailing zeros will be suppressed and a decimal point will appear only if one or more digits follow it. If the number is positive, a space character will replace the leading minus sign. The precision specifies the number of significant digits displayed.</td>
</tr>
</tbody>
</table>

**Trailing Character**

The following characters can be added to the / jnt parameters above to control the trailing character if any:

```plaintext
format /rdn 1,3;
```

`s` The number will be followed immediately by a space character. This is the default.
The number will be followed immediately by a comma.

The number will be followed immediately by a tab character.

No trailing character.

The default when GAUSS is first started is:

```
form
at /ml /ro 16,8;
```

Double semicolons following a print statement will suppress the final carriage return/line feed.

Any GAUSS expressions that produce matrices, arrays, strings, or string arrays and/or names of variables to print, separated by spaces.

**Remarks**

The list of expressions MUST be separated by spaces. In print statements, because a space is the delimiter between expressions, NO SPACES are allowed inside expressions unless they are within index brackets, quotes, or parentheses.

The printing of special characters is accomplished by the use of the backslash (\) within double quotes. The options are:

- \b backspace (ASCII 8)
- \e escape (ASCII 27)
\f form feed (ASCII 12)
\g beep (ASCII 7)
\l line feed (ASCII 10)
\r carriage return (ASCII 13)
\t tab (ASCII 9)
\### the character whose ASCII value is "###" (decimal).

Thus, \r\l is a carriage return/line feed sequence. The first three digits will be picked up here. So if the character to follow a special character is a digit, be sure to use three digits in the escape sequence. For example: \0074 will be interpreted as 2 characters (ASCII 7, "4")

An expression with no assignment operator is an implicit print statement.

If output on has been specified, then all subsequent print statements will be directed to the auxiliary output as well as the window. (See output.) The locate statement has no effect on what will be sent to the auxiliary output, so all formatting must be accomplished using tab characters or some other form of serial output.

If the name of the symbol to be printed is prefixed with a $, it is assumed that the symbol is a matrix of characters.

```
print $x;
```

Note that GAUSS makes no distinction between matrices containing character data and those containing numeric data, so it is the responsibility of the user to use functions which operate on character matrices only on those matrices containing character data.

These matrices of character strings have a maximum of 8 characters per element. A precision of 8 or more should be set when printing out character matrices or the elements will be truncated.
Complex numbers are printed with the sign of the imaginary half separating them and an "i" appended to the imaginary half. Also, the current field width setting (see format) refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print.

print'ing a sparse matrix results in a table of the non-zero values contained in the sparse matrix, followed by their corresponding row and column indices, respectively.

A print statement by itself will cause a blank line to be printed:

```plaintext
print;
```

**Example**

```plaintext
x = rndn(3,3);
format /rd 16,8;
print x;

format /re 12,2;
print x;

print /rd /m3 x;
```

```
0.14357994 -1.39272762 -0.91942414
0.51061645 -0.02332207 -0.02511298
-1.55E+000 -1.05E+000 7.99E-002

1.44E-001 -1.39E+000 -9.19E-001
5.11E-001 -2.33E-002 -2.51E-002
1.05E+000 -1.05E+000 7.99E-002

Row 1
0.14 -1.39 -0.92
Row 2
0.51 -0.02 -0.03
```
In this example, a 3x3 random matrix is printed using 3 different formats. Notice that in the last statement, the format is overridden in the `print` statement itself but the field and precision remain the same.

```plaintext
let x = AGE PAY SEX;
format /ml 8,8;
print $x;
```

<table>
<thead>
<tr>
<th>Row 3</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.55</td>
<td>-1.05</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**See Also**

`printfm`, `printdos`

**printdos**

**Purpose**

Prints a string to the standard output.

**Format**

```plaintext
printdos s;
```

**Input**

```plaintext
s  string to be printed to the standard output.
```
Remarks

This function is useful for printing messages to the screen when `screen off` is in effect. The output of this function will not go to the auxiliary output.

This function was used in the past to send escape sequences to the `ansi.sys` device driver on DOS. It still works on some terminals.

Example

```c
printdos "\27[7m"; /* set for reverse video */
printdos "\27[0m"; /* set for normal text */
```

See Also

`print`, `printfm`, `screen`

printfm

Purpose

Prints a matrix using a different format for each column of the matrix.

Format

```c
y = printfm(x, mask, fmt);
```

Input

- `x` N×K matrix which is to be printed and which may contain both character and numeric data.
**mask**

LxM matrix, ExE conformable with \( x \), containing ones and zeros, which is used to specify whether the particular row, column, or element is to be printed as a character (0) or numeric (1) value.

**fmt**

Kx3 or 1x3 matrix where each row specifies the format for the respective column of \( x \).

**Output**

**y**

scalar, 1 if the function is successful and 0 if it fails.

**Remarks**

The mask is applied to the matrix \( x \) following the rules of standard element-by-element operations. If the corresponding element of \( mask \) is 0, then that element of \( x \) is printed as a character string of up to 8 characters. If mask contains a 1, then that element of \( x \) is assumed to be a double precision floating point number.

The contents of \( fmt \) are as follows:

\[
[K, 1] \quad \text{format string, a string 8 characters maximum.}
\]

\[
[K, 2] \quad \text{field width, a number < 80.}
\]

\[
[K, 3] \quad \text{precision, a number < 17.}
\]

The format strings correspond to the \texttt{format} slash commands as follows:

\[
/rdn \quad "*.1f"
\]

\[
/ren \quad "*.1E"
\]
Complex numbers are printed with the sign of the imaginary half separating them and an "i" appended to the imaginary half. The field width refers to the width of field for each half of the number, so a complex number printed with a field of 8 will actually take (at least) 20 spaces to print.

If the precision = 0, the decimal point will be suppressed.

The format string can be a maximum of 8 characters and is appended to a % sign and passed directly to the `fprintf` function in the standard C language I/O library. The `lf`, etc., are case sensitive. If you know C, you will easily be able to use this.

If you want special characters to be printed after x, then include them as the last characters of the format string. For example:

```
"*.*lf,"
"-*.*s "
"*.*lf"
```

right-justified decimal followed by a comma.

left-justified string followed by a space.

right-justified decimal followed by nothing.

If you want the beginning of the field padded with zeros, then put a "0" before the first "*" in the format string:

```
"0*.*lf"
```

right-justified decimal.

**Example**

Here is an example of `printfm` being used to print a mixed numeric and character
matrix:

```c
let x[4,3] = "AGE" 5.12345564 2.23456788
"PAY" 1.23456677 1.23456789
"SEX" 1.14454345 3.44718234
"JOB" 4.11429432 8.55649341;
```

```c
let mask[1,3] = 0 1 1;  /* character numeric numeric */
let fmt[3,3] = "-*.s" 8 8 /* first column format */
"*.lf," 10 3       /* second column format */
"*.le" 12 4;       /* third column format */
```

```c
d = printfm(x,mask,fmt);
```

The output looks like this:

```
AGE 5.123, 2.2346E+00
PAY 1.235, 1.2346E+00
SEX 1.145, 3.4471E+00
JOB 4.114, 8.5564E+00
```

When the column of x to be printed contains all character elements, use a format string of "*.s" if you want it right-justified, or "-*.s" if you want it left-justified. If the column is mixed character and numeric elements, then use the correct numeric format and printfm will substitute a default format string for those elements in the column that are character.

Remember, the mask value controls whether an element will be printed as a number or a character string.

**See Also**

print, printdos
printfmt

Purpose

Prints character, numeric, or mixed matrix using a default format controlled by the functions `formatcv` and `formatnv`.

Format

\[ y = \text{printfmt}(x, \ mask); \]

Input

\begin{itemize}
  \item \textbf{x} \quad \text{N}\times\text{K} \text{ matrix which is to be printed.}
  \item \textbf{mask} \quad \text{scalar, 1 if } x \text{ is numeric or 0 if } x \text{ is character.}
    \begin{itemize}
      \item - or -
      \item 1\times\text{K} \text{ vector of 1's and 0's.}
    \end{itemize}
\end{itemize}

The corresponding column of \textbf{x} will be printed as numeric where \textbf{mask} = 1 and as character where \textbf{mask} = 0.

Output

\begin{itemize}
  \item \textbf{y} \quad \text{scalar, 1 if the function is successful and 0 if it fails.}
\end{itemize}

Remarks

Default format for numeric data is: `''*.*lg'' 16 8`
Default format for character data is: ' '*.*s ' 8 8

Example

c1 = { "age", "height", "weight" };  
c2 = { 31, 70, 160 };  

// Horizontally concatenate c1 and c2  
c = c1~c2;  

// Print 'c' as numeric data  
print c;  

// Print 'c' as character data  
print $c;  

// Print column 1 of 'c' as character data and column 2 as numeric data  
// Note: call disregards the return value  
mask = { 0 1 };  
call printfmt(c, mask);  

The output from the three different print statements will be:

+DEN 31.000000  
+DEN 70.000000  
+DEN 160.000000

age
height
weight
<table>
<thead>
<tr>
<th>age</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>height</td>
<td>70</td>
</tr>
<tr>
<td>weight</td>
<td>160</td>
</tr>
</tbody>
</table>

Only the final print statement from `printfmt` correctly prints both columns.

**Source**

gauss.src

**Globals**

`__fmtcv, __fmtnv`

**See Also**

`formatcv, formatnv`

**proc**

**Purpose**

Begins the definition of a multi-line recursive procedure. Procedures are user-defined functions with local or global variables.

**Format**

```
proc nrets = name(arglist);
proc name(arglist);
```
Input

\textbf{Input}

\textit{nrets} constant, number of objects returned by the procedure. If \textit{nrets} is not explicitly given, the default is 1. Legal values are 0 to 1023. The \textbf{retp} statement is used to return values from a procedure.

\textit{name} literal, name of the procedure. This name will be a global symbol.

\textit{arglist} a list of names, separated by commas, to be used inside the procedure to refer to the arguments that are passed to the procedure when the procedure is called. These will always be local to the procedure, and cannot be accessed from outside the procedure or from other procedures.

Remarks

A procedure definition begins with the \textbf{proc} statement and ends with the \textbf{endp} statement.

An example of a procedure definition is:

\begin{verbatim}
proc dog(x,y,z); /* procedure declaration */
local a,b; /* local variable declarations */
    a = x .* x;
    b = y .* y;
    a = a ./ x;
    b = b ./ y;
    z = z .* z;
    z = inv(z);
retp(a'b*z); /* return with value of a'b*z */
\end{verbatim}
Procedures can be used just as if they were functions intrinsic to the language. Below are the possible variations depending on the number of items the procedure returns.

Returns 1 item:

```plaintext
y = dog(i, j, k);
```

Returns multiple items:

```plaintext
{ x, y, z } = cat(i, j, k);
```

Returns no items:

```plaintext
fish(i, j, k);
```

If the procedure does not return any items or you want to discard the returned items:

```plaintext
call dog(i, j, k);
```

Procedure definitions may not be nested.

For more details on writing procedures, see **Procedures and Keywords**, Chapter 1.

**See Also**

`keyword`, `call`, `endp`, `local`, `retp`

**prodc**

**Purpose**

Computes the products of all elements in each column of a matrix.
**Format**

\[ y = \text{prodc}(x); \]

**Input**

\[ x \quad \text{NxK matrix.} \]

**Output**

\[ y \quad \text{Kx1 matrix containing the products of all elements in each column of } x. \]

**Remarks**

To find the products of the elements in each row of a matrix, transpose before applying `prodc`. If \( x \) is complex, use the bookkeeping transpose (\( . ' \)).

To find the products of all of the elements in a matrix, use the `vecr` function before applying `prodc`.

**Example**

\[
\begin{align*}
x &= \{ 1 & 2 & 3, \\
& 4 & 5 & 6, \\
& 7 & 8 & 9 \}; \\
y &= \text{prodc}(x);
\end{align*}
\]

The code above assigns \( y \) to be equal to:
psi

Purpose

Computes the Psi (or Digamma) function.

Format

\[ f = \text{psi}(z); \]

Input

\[ z \quad \text{NxK matrix; } z \text{ may be complex.} \]

Output

\[ f \quad \text{NxK matrix.} \]

Remarks

This program uses the analytical derivative of the log of the Lanczos series.
approximation for the Gamma function.

References

5. W. Press, "Numerical Recipes."
7. Original code by Paul Godfrey

putarray

Purpose

Puts a contiguous subarray into an N-dimensional array and returns the resulting array.

Format

\[ y = \text{putarray}(a, \text{loc}, \text{src}); \]

Input

\[ a \] N-dimensional array.
\[ \text{loc} \] Mx1 vector of indices into the array to locate the subarray of
interest, where $M$ is a value from 1 to $N$.

**src**

$[N-M]$-dimensional array, matrix, or scalar.

**Output**

$y$

N-dimensional array.

**Remarks**

If $loc$ is an $N \times 1$ vector, then $src$ must be a scalar. If $loc$ is an $[N-1] \times 1$ vector, then $src$ must be a 1-dimensional array or a $1 \times L$ vector, where $L$ is the size of the fastest moving dimension of the array. If $loc$ is an $[N-2] \times 1$ vector, then $src$ must be a $K \times L$ matrix, or a $K \times L$ 2-dimensional array, where $K$ is the size of the second fastest moving dimension.

Otherwise, if $loc$ is an $M \times 1$ vector, then $src$ must be an $[N-M]$-dimensional array, whose dimensions are the same size as the corresponding dimensions of array $a$.

**Example**

```c
//Create a 2x3x4x5x6 dimensional array with unspecified 
//contents
a = arrayalloc(2|3|4|5|6,0);

//Create a 4x5x6 dimensional array with all elements equal 
//to 5
src = arrayinit(4|5|6,5);

loc = { 2,1 };

a = putarray(a,loc,src);
```

This example sets the contiguous $4 \times 5 \times 6$ subarray of $a$ beginning at $[2,1,1,1,1]$ to
the array $src$, in which each element is set to the specified value 5.

See Also

setarray

**putf**

**Purpose**

Writes the contents of a string to a file.

**Format**

```
ret = putt(filename, str, start, len, mode, append);
```

**Input**

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>string, name of output file.</td>
</tr>
<tr>
<td>str</td>
<td>string to be written to $filename$. All or part of $str$ may be written out.</td>
</tr>
<tr>
<td>start</td>
<td>scalar, beginning position in $str$ of output string.</td>
</tr>
<tr>
<td>len</td>
<td>scalar, length of output string.</td>
</tr>
<tr>
<td>mode</td>
<td>scalar, output mode, (0) ASCII or (1) binary.</td>
</tr>
<tr>
<td>append</td>
<td>scalar, file write mode, (0) overwrite or (1) append.</td>
</tr>
</tbody>
</table>
Output

ret scalar, return code.

0 normal return
1 null file name
2 file open error
3 file write error
4 output string too long
5 null output string, or illegal mode value
6 illegal append value
16 (1) append specified but file did not exist; file was created (warning only)

Remarks

If mode is set to (1) binary, a string of length len will be written to filename. If mode is set to (0) ASCII, the string will be output up to length len or until printf encounters a ^Z (ASCII 26) in str. The ^Z will not be written to filename.

If append is set to (0) overwrite, the current contents of filename will be destroyed. If append is set to (1) append, filename will be created if it does not already exist.

If an error occurs, printf will either return an error code or terminate the program with an error message, depending on the trap state. If bit 2 (the 4’s bit) of the trap flag is
0, `putf` will terminate with an error message. If bit 2 of the trap flag is 1, `putf` will return an error code. The value of the trap flag can be tested with `trapchk`.

**Source**

`putf.src`

**See Also**

`getf`

**putvals**

**Purpose**

Inserts values into a matrix or N-dimensional array.

**Format**

```plaintext
y = putvals(x, inds, vals);
```

**Input**

<table>
<thead>
<tr>
<th>x</th>
<th>MxK matrix or N-dimensional array.</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>inds</code></td>
<td>LxD matrix of indices, specifying where the new values are to be inserted, where D is the number of dimensions in <code>x</code>.</td>
</tr>
<tr>
<td><code>vals</code></td>
<td>Lx1 vector, new values to insert.</td>
</tr>
</tbody>
</table>
Output

\[ y \]  
MxK matrix or N-dimensional array, copy of \( x \) containing the new values in \( \text{vals} \).

Remarks

If \( x \) is a vector, \( \text{inds} \) should be an Lx1 vector. If \( x \) is a matrix, \( \text{inds} \) should be an Lx2 matrix. Otherwise if \( x \) is an N-dimensional array, \( \text{inds} \) should be an LxN matrix.

\text{putvals} \text{ allows you to insert multiple values into a matrix or N-dimensional array at one time. This could also be accomplished using indexing inside a for loop.}

Example

\[ x = \begin{bmatrix} -0.8750 & 0.3616 & 0.6032 & -0.3974, \\ 0.7644 & -1.8509 & -0.2703 & -0.8190, \\ 0.7886 & 1.2678 & -1.4998 & -0.5876, \\ 0.6639 & -0.7972 & 1.2713 & 0.1896, \\ 0.6303 & 0.7879 & -0.7451 & -0.5419 \end{bmatrix}; \]
\[ \text{inds} = \{1,1,2,4,3,2,3,4,5,3\}; \]
\[ v = \text{seqa}(1,1,5); \]
\[ y = \text{putvals}(x,\text{inds},v); \]

After the code above:

\[ y = \begin{bmatrix} 1.000 & 0.362 & 0.603 & -0.397 & 1.000 \\ 0.764 & -1.851 & -0.270 & 2.000 & 2.000 \\ 0.789 & 3.000 & -1.500 & 4.000 & v = 3.000 \\ 0.664 & -0.797 & 1.271 & 0.190 & 4.000 \\ 0.630 & 0.788 & 5.000 & -0.542 & 5.000 \end{bmatrix} \]
pvCreate

**Purpose**

Returns an initialized instance of structure of type PV.

**Format**

\[ p1 = \text{pvCreate}(); \]

**Output**

| \( p1 \) | an instance of structure of type PV |

**Example**

```c
//Declare 'p1' as an instance of a 'PV' structure
struct PV p1;

//Fill in 'p1' with default values
p1 = pvCreate();
```

**Source**

pv.src
**pvGetIndex**

**Purpose**

Gets row indices of a matrix in a parameter vector.

**Format**

\[ id = \text{pvGetIndex}(p1, nml); \]

**Input**

- **p1**: an instance of structure of type **PV**.
- **nml**: name or row number of matrix.

**Output**

- **id**: Kx1 vector, row indices of matrix described by **nml** in parameter vector.

**Source**

**pv.src**

---

**pvGetParNames**

**Purpose**

Generates names for parameter vector stored in structure of type **PV**.
Include

pv.sdf

Format

\[ s = \text{pvGetParNames}(p1); \]

Input

\( p1 \)

an instance of structure of type PV.

Output

\( s \)

Kx1 string array, names of parameters.

Remarks

If the vector in the structure of type PV was generated with matrix names, the parameter names will be concatenations of the matrix name with row and column numbers of the parameters in the matrix. Otherwise the names will have a generic prefix with concatenated row and column numbers.

Example

```c
//Define PV structure
#include pv.sdf
//Declare 'p1' as an instance of a 'PV' structure
struct PV p1;

//Initialize 'p1' with default values
p1 = pvCreate;
```
// Data to pack into the 'PV' struct
x = { 1 2,
     3 4 };  

// 1's indicate an element to pack into the structure
// 0's indicate elements to NOT pack into the structure
mask = { 1 0,
        0 1 };  

// Pack values of 'x' selected by 'mask' into 'pi' and name
// this resulting vector, 'P'
pl = pvPackm(p1,x,"P",mask);

print pvGetParNames(pl);

Since mask has ones in the [1,1] and [2,2] locations, the code above, produces:

P[1,1]
P[2,2]

Source
pv.src

pvGetParVector

Purpose

Retrieves parameter vector from structure of type PV.

Include

pv.sdf
**Format**

\[ p = \text{pvGetParVector}(p1); \]

**Input**

\( p1 \)

an instance of structure of type \textbf{PV}.

**Output**

\( p \)

Kx1 vector, parameter vector.

**Remarks**

Matrices or portions of matrices (stored using a mask) are stored in the structure of type \textbf{PV} as a vector in the \( p \) member.

**Example**

```c
#include pv.sdf
struct PV p1;

p1 = pvCreate;

x = { 1 2,
      3 4
};

// 1's indicate elements to pack into 'p1' parameter vector
```
mask = { 1 1,
         0 0 };

pl = pvPackm(pl, x, "X", mask);

print pvUnpack(pl, "X");

pvUnpack returns the entire value of \( x \) that was packed in. Therefore, the print statement above, produces:

<table>
<thead>
<tr>
<th>1.000</th>
<th>2.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.000</td>
<td>4.000</td>
</tr>
</tbody>
</table>

print pvGetParVector(pl);

pvGetParVector returns only those elements indicated by the \( mask \) variable and therefore the print statement above, returns:

| 1.000 |
| 2.000 |

**Source**

pv.src

**pvLength**

**Purpose**

Returns the length of a parameter vector.
**Format**

\[ n = \text{pvLength}(p1); \]

**Input**

\[ p1 \]

an instance of structure of type PV.

**Output**

\[ n \]

scalar, length of parameter vector in \( p1 \).

**Source**

\( \text{pv.src} \)

**pvList**

**Purpose**

Retrieves names of packed matrices in structure of type PV.

**Format**

\[ n = \text{pvList}(p1); \]

**Input**

\[ p1 \]

an instance of structure of type PV.
**Output**

$n$  
Kx1 string vector, names of packed matrices.

**Source**

pv.src

**pvPack**

**Purpose**

Packs general matrix into a structure of type PV with matrix name.

**Include**

pv.sdf

**Format**

$p1 = \text{pvPack}(p1, x, nm)$;

**Input**

$p1$  
an instance of structure of type PV.

$x$  
MxN matrix or N-dimensional array.

$nm$  
string, name of matrix/array.
**Output**

\( p1 \)  
an instance of structure of type \texttt{PV}.

**Example**

```c
//Define the 'PV' structure
#include pv.sdf

y = \texttt{rndn}(100,1);
x = \texttt{rndn}(100,5);

//Declare 'p1' as an instance of a 'PV' structure
struct PV p1;

//Initialize 'p1' with default values
p1 = \texttt{pvCreate};

p1 = \texttt{pvPack}(p1,x,"Y");
p1 = \texttt{pvPack}(p1,y,"X");
```

These matrices can be extracted using the \texttt{pvUnpack} command:

```c
y = \texttt{pvUnpack}(p1,"Y");
x = \texttt{pvUnpack}(p1,"X");
```

**Source**

\texttt{pv.src}

**See Also**

\texttt{pvPackm, pvPacks, pvUnpack}
**pvPacki**

**Purpose**

Packs general matrix or array into a **PV** instance with name and index.

**Include**

pv.sdf

**Format**

\[ p1 = \text{pvPacki}(p1, x, nm, i); \]

**Input**

- **p1**: an instance of structure of type **PV**.
- **x**: MxN matrix or N-dimensional array.
- **nm**: string, name of matrix or array, or null string.
- **i**: scalar, index of matrix or array in lookup table.

**Output**

- **p1**: an instance of structure of type **PV**.

**Example**

```
//Define the 'PV' structure
#include pv.sdf
```
y = \texttt{rnndn}(100,1);
x = \texttt{rnndn}(100,5);

//Declare 'pl' as an instance of a 'PV' structure
struct PV pl;

//Initialize 'pl' with default values
pl = \texttt{pvCreate};

//Pack the variables in with a variable name and an index
pl = \texttt{pvPacki}(p1,y,"Y",1);
pl = \texttt{pvPacki}(p1,x,"X",2);

These matrices can be extracted using the \texttt{pvUnpack} command, indicating the variable to unpack either by index or by variable name:

//Unpack variables by index
y = \texttt{pvUnpack}(p1,1);
x = \texttt{pvUnpack}(p1,2);

//Unpack variables by variable name
y = \texttt{pvUnpack}(p1,"Y");
x = \texttt{pvUnpack}(p1,"X");

\textbf{See Also}

pvPack, pvUnpack
pvPackm

**Purpose**

Packs general matrix into a structure of type PV with a mask and matrix name.

**Include**

`pv.sdf`

**Format**

```
pl = pvPackm(pl, x, nm, mask);
```

**Input**

- `pl` an instance of structure of type PV.
- `x` MxN matrix or N-dimensional array.
- `nm` string, name of matrix/array or N-dimensional array.
- `mask` MxN matrix, mask matrix of zeros and ones.

**Output**

- `pl` an instance of structure of type PV.

**Remarks**

The `mask` argument allows storing a selected portion of a matrix into the packed
vector. The ones in \textit{mask} indicate an element to be stored in the packed matrix. When the matrix is unpacked (using \texttt{pvUnpack}) the elements corresponding to the zeros are restored. Elements corresponding to the ones come from the packed vector which may have been changed.

If the mask is all zeros, the matrix or array is packed with the specified elements in the second argument but no elements of the matrix or array are entered into the parameter vector. When unpacked the matrix or array in the second argument is returned without modification.

\textbf{Example}

\begin{verbatim}
#include pv.sdf
struct PV p1;
p1 = pvCreate;

x = { 1 2, 3 4 };

mask = { 1 0, 0 1 };

p1 = pvPackm(p1,x,"X",mask);

print pvUnpack(p1,1);

1.000 2.000 3.000 4.000

p1 = pvPutParVector(p1,5|6);
\end{verbatim}
print \textsf{pvUnpack}(p1,"X");

\begin{verbatim}
  5.000 2.000
  3.000 6.000
\end{verbatim}

\textbf{Source}
\textit{pv.src}

\textbf{pvPackmi}

\textbf{Purpose}
Packs general matrix or array into a PV instance with a mask, name, and index.

\textbf{Include}
\textit{pv.sdf}

\textbf{Format}

\begin{verbatim}
pl = pvPackmi(pl, x, nm, mask, i);
\end{verbatim}

\textbf{Input}

\begin{itemize}
  \item \textit{pl} \quad an instance of structure of type PV.
  \item \textit{x} \quad MxN matrix or N-dimensional array.
  \item \textit{nm} \quad string, matrix or array name.
\end{itemize}
**mask**
MxN matrix or N-dimensional array, mask of zeros and ones.

**i**
scalar, index of matrix or array in lookup table.

**Output**

**p1**
an instance of structure of type PV.

**Remarks**

The mask allows storing a selected portion of a matrix into the parameter vector. The ones in the mask matrix indicate an element to be stored in the parameter matrix. When the matrix is unpacked (using `pvUnpackm`) the elements corresponding to the zeros are restored. Elements corresponding to the ones come from the parameter vector.

If the mask is all zeros, the matrix or array is packed with the specified elements in the second argument but no elements of the matrix or array are entered into the parameter vector. When unpacked the matrix or array in the second argument is returned without modification.

**Example**

```c
#include pv.sdf

struct PV p1;
p1 = pvCreate;

x = { 1 2,
     3 4 };`
mask = \{ 1 \ 0, \\
0 \ 1 \};

pl = \texttt{pvPackmi}(pl, x, "X", mask, 1);

\texttt{print} \ \texttt{pvUnpack}(pl, 1);

\begin{verbatim}
1.000 2.000
3.000 4.000
\end{verbatim}

pl = \texttt{pvPutParVector}(pl, 5|6);

\texttt{print} \ \texttt{pvUnpack}(pl, 1);

\begin{verbatim}
5.000 2.000
3.000 6.000
\end{verbatim}

\textbf{See Also}

\texttt{pvPackm}, \texttt{pvUnpack}

\section*{pvPacks}

\section*{Purpose}

Packs symmetric matrix into a structure of type \texttt{PV}.

\section*{Include}

\texttt{pv.sdf}
**Format**

\[ p1 = \texttt{pvPacks}(p1, x, \text{nm}); \]

**Input**

- \( p1 \): an instance of structure of type \( \text{PV} \).
- \( x \): MxM symmetric matrix.
- \( \text{nm} \): string, matrix name.

**Output**

- \( p1 \): an instance of structure of type \( \text{PV} \).

**Remarks**

\( \texttt{pvPacks} \) does not support the packing of arrays.

**Example**

```c
#include pv.sdf

struct PV p1;
p1 = \texttt{pvCreate};

x = { 1 2,
     2 1 };

p1 = \texttt{pvPacks}(p1, x, "A");
```
pl = pvPacks(pl, eye(2), "I");

These matrices can be extracted using the \texttt{pvUnpack} command:

\begin{verbatim}
print pvUnpack(pl, "A");

1.000 2.000
2.000 1.000

print pvUnpack(pl, "I");

1.000 0.000
0.000 1.000
\end{verbatim}

\textbf{Source}

\texttt{pv.src}

\textbf{See Also}

\texttt{pvPacksm, pvUnpack}

\textbf{pvPacks}\texttt{i}

\textbf{Purpose}

Packs symmetric matrix into a \texttt{PV} instance with matrix name and index.

\textbf{Include}

\texttt{pv.sdf}
**Format**

\[ pl = \text{pvPacks}(p1, x, \ nm, \ i); \]

**Input**

- \( p1 \) an instance of structure of type \( \text{PV} \).
- \( x \) MxM symmetric matrix.
- \( nm \) string, matrix name.
- \( i \) scalar, index of matrix in lookup table.

**Output**

- \( p1 \) an instance of structure of type \( \text{PV} \).

**Remarks**

\( \text{pvPacks} \) does not support the packing of arrays.

**Example**

```
#include pv.sdf

struct PV p1;
p1 = pvCreate;

x = { 1 2, 2 1 };

p1 = \text{pvPacks}(p1,x, "A",1);
```
\[ p_1 = \text{pvPacksi}(p_1, \text{eye}(2), \text{"I"}, 2); \]

These matrices can be extracted using the \texttt{pvUnpack} command.

\begin{verbatim}
print pvUnpack(p1,1);
\end{verbatim}

\begin{verbatim}
  1.000 2.000
  2.000 1.000
\end{verbatim}

\begin{verbatim}
print pvUnpack(p1,2);
\end{verbatim}

\begin{verbatim}
  1.000 0.000
  0.000 1.000
\end{verbatim}

\textbf{See Also}

\texttt{pvPacks}, \texttt{pvUnpack}

\section*{pvPacksm}

\textbf{Purpose}

Packs symmetric matrix into a structure of type \texttt{PV} with a mask.

\textbf{Include}

\texttt{pv.sdf}

\textbf{Format}

\begin{verbatim}
p1 = pvPacksm(p1, x, nm, mask);
\end{verbatim}
**Input**

- \( p1 \): an instance of structure of type `PV`.
- \( x \): MxM symmetric matrix.
- \( nm \): string, matrix name.
- \( mask \): MxM matrix, mask matrix of zeros and ones.

**Output**

- \( p1 \): an instance of structure of type `PV`.

**Remarks**

`pvPacksm` does not support the packing of arrays.

The mask allows storing a selected portion of a matrix into the packed vector. The ones in `mask` indicate an element to be stored in the packed matrix. When the matrix is unpacked (using `pvUnpack`) the elements corresponding to the zeros are restored. Elements corresponding to the ones come from the packed vector which may have been changed.

Only the lower left portion of the `mask` matrix is used, and only the lower left portion of the \( x \) matrix is stored in the packed vector.

If the mask is all zeros, the matrix is packed with the specified elements in the second argument but no elements of the matrix are entered into the parameter vector. When unpacked the matrix in the second argument is returned without modification.

**Example**

```cpp
#include pv.sdf
```
struct PV p1;
p1 = pvCreate;

x = { 1 2 4,
     2 3 5,
     4 5 6};

mask = { 1 0 1,
         0 1 0,
         1 0 1 };

p1 = pvPacksm(p1, x, "A", mask);

print pvUnpack(p1, "A");

1.000 2.000 4.000
2.000 3.000 5.000
4.000 5.000 6.000

p2 = pvGetParVector(p1);

print p2;

1.000
3.000
4.000
6.000

p3 = { 10, 11, 12, 13 };
p1 = pvPutParVector(p1, p3);

print pvUnpack(p1, "A");
Source
pv.src

pvPacksmi

Purpose
Packs symmetric matrix into a PV instance with a mask, matrix name, and index.

Include
pv.sdf

Format
\[ pl = \text{pvPacksmi}(p1, x, nm, mask, i); \]

Input
\begin{itemize}
  \item \textit{p1} \quad \text{an instance of structure of type PV.}
  \item \textit{x} \quad \text{MxM symmetric matrix.}
  \item \textit{nm} \quad \text{string, matrix name.}
  \item \textit{mask} \quad \text{MxM matrix, symmetric mask matrix of zeros and ones.}
\end{itemize}
| $i$ | scalar, index of matrix in lookup table. |

**Output**

| $pl$ | an instance of structure of type PV. |

**Remarks**

$pvPacks$mi does not support the packing of arrays.

The $mask$ allows storing a selected portion of a matrix into the parameter vector. The ones in the $mask$ matrix indicate an element to be stored in the parameter vector. When the matrix is unpacked (using $pvUnpackm$) the elements corresponding to the zeros are restored. Elements corresponding to the ones come from the parameter vector.

Only the lower left portion of the $mask$ matrix is used, and only the lower left portion of the $x$ matrix is stored in the packed vector.

If the mask is all zeros, the matrix is packed with the specified elements in the second argument but no elements of the matrix are entered into the parameter vector. When unpacked the matrix in the second argument is returned without modification.

**Example**

```c
#include pv.sdf

struct PV pl;
pl = pvCreate;

x = { 1 2 4,
     2 3 5,
};
```
4 5 6);

mask = { 1 0 1,
        0 1 0,
        1 0 1 };

pl = pvPacksmi(pl, x, "A", mask, 1);

print pvUnpack(pl, 1);

1.000 2.000 4.000
2.000 3.000 5.000
4.000 5.000 6.000

p2 = pvGetParVector(pl);

print p2;

1.000
3.000
4.000
6.000

p3 = { 10, 11, 12, 13 };
p1 = pvPutParVector(pl, p3);

print pvUnpack(pl, 1);

10.000 2.000 12.000
2.000 11.000 5.000
12.000 5.000 13.000

See Also

pvPacksm, pvUnpack
pvPutParVector

Purpose

Inserts parameter vector into structure of type PV.

Include

pv.sdf

Format

\[ p1 = \text{pvPutParVector}(p1, \ p); \]

Input

\[ p1 \] an instance of structure of type PV.
\[ p \] Kx1 vector, parameter vector.

Output

\[ p1 \] an instance of structure of type PV.

Remarks

Matrices or portions of matrices (stored using a mask) are stored in the structure of type PV as a vector in the \( p \) member.
Example

```c
#include pv.sdf

struct PV p1;
p1 = pvCreate;

x = { 1 2 4,
     2 3 5,
     4 5 6};

mask = { 1 0 1,
         0 1 0,
         1 0 1};

// Packed as square matrix
p1 = pvPackm(p1,x,"A",mask);

print pvUnpack(p1,"A");

1.000 2.000 4.000
2.000 3.000 5.000
4.000 5.000 6.000

p3 = { 10, 11, 12, 13, 14 }; 
pl = pvPutParVector(p1,p3);

print pvUnpack(p1,"A");

10.000 2.000 11.000
2.000 12.000 5.000
13.000 5.000 14.000
```

Source

pv.src
pvTest

Purpose

Tests an instance of structure of type PV to determine if it is a proper structure of type PV.

Format

\[ i = \text{pvTest}(p1); \]

Input

\( p1 \) an instance of structure of type PV.

Output

\( i \) scalar, if 0, \( p1 \) is a proper structure of type PV, else if 1, an improper or uninitialized structure of type PV.

Source

pv.src

pvUnpack

Purpose

Unpacks matrices stored in a structure of type PV.
Format

\[ x = \text{pvUnpack}(p1, \ m); \]

Input

- **p1**: an instance of structure of type \(\text{PV}\).
- **m**: string, name of matrix, or integer, index of matrix.

Output

- **x**: MxN general matrix or MxM symmetric matrix or N-dimensional array.

Source

pv.src
QNewton

Purpose

Optimizes a function using the BFGS descent algorithm.

Format

\[
\{ x, f, g, ret \} = \text{QNewton}(&fct, start);
\]

Input

- **&fct**
  pointer to a procedure that computes the function to be minimized. This procedure must have one input argument, a vector of parameter values, and one output argument, the value of the function evaluated at the input vector of parameter values.

- **start**
  Kx1 vector, start values.

Global Input

- **_qn_RelGradTol**
  scalar, convergence tolerance for relative gradient of
estimated coefficients. Default = 1e-5.

\_qn\_GradProc scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. This procedure must have a single input argument, a Kx1 vector of parameter values, and a single output argument, a Kx1 vector of gradients of the function with respect to the parameters evaluated at the vector of parameter values. If \_qn\_GradProc is 0, QNewton uses gradp.

\_qn\_MaxIters scalar, maximum number of iterations. Default = 1e+5. Termination can be forced by pressing C on the keyboard.

\_qn\_PrintIters scalar, if 1, print iteration information. Default = 0. Can be toggled during iterations by pressing P on the keyboard.

\_qn\_ParNames Kx1 vector, labels for parameters.

\_qn\_PrintResults scalar, if 1, results are printed.

**Output**

<table>
<thead>
<tr>
<th>( x )</th>
<th>Kx1 vector, coefficients at the minimum of the function.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f )</td>
<td>scalar, value of function at minimum.</td>
</tr>
<tr>
<td>( g )</td>
<td>Kx1 vector, gradient at the minimum of the function.</td>
</tr>
<tr>
<td>( \text{ret} )</td>
<td>scalar, return code.</td>
</tr>
<tr>
<td>0</td>
<td>normal convergence</td>
</tr>
<tr>
<td>1</td>
<td>forced termination</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>max iterations exceeded</td>
</tr>
<tr>
<td>3</td>
<td>function calculation failed</td>
</tr>
<tr>
<td>4</td>
<td>gradient calculation failed</td>
</tr>
<tr>
<td>5</td>
<td>step length calculation failed</td>
</tr>
<tr>
<td>6</td>
<td>function cannot be evaluated at initial parameter values</td>
</tr>
</tbody>
</table>

**Remarks**

If you are running in terminal mode, **GAUSS** will not see any input until you press ENTER. Pressing C on the keyboard will terminate iterations, and pressing P will toggle iteration output.

To reset global variables for this function to their default values, call **QNewtonSet**.

**Example**

This example computes maximum likelihood coefficients and standard errors for a Tobit model:

```gauss
/***qnewton.e - a Tobit model***/
//Get data
z = loadd("tobit");
b0 = { 1, 1, 1, 1 };
{b,f,g,retcode} = qnewton(&lpr,b0);

//Covariance matrix of parameters
h = hessp(&lpr,b);
output file = qnewton.out reset;

print "Tobit Model";
print;
```
print "coefficients standard errors";
print b~sqrt(diag(invpd(h)));

output off;

//Log-likelihood proc
proc lpr(b);
    local s,m,u;
    s = b[4];
    if s <= 1e-4;
        retp(error(0));
    endif;
    m = z[.,2:4]*b[1:3,.];
    u = z[.,1] ./= 0;
    retp(-sumc(u.*lnpdfn2(z[.,1]-m,s) + (1-u).*(ln(cdfnc(m/sqrt(s))));)

produces:

Tobit Model
coefficients standard errors

0.010417884  0.080220019
-0.20805753   0.094551107
-0.099749592  0.080006676
 0.65223067   0.099827309

Source

qnewton.src
QNewtonmt

Purpose

Minimize an arbitrary function.

Include

qnewtonmt.sdf

Format

\[
out = \text{QNewtonmt}(&fct, par, data, c);
\]

Input

\begin{itemize}
\item \texttt{&fct} pointer to a procedure that computes the function to be minimized. This procedure must have two input arguments, an instance of a \texttt{PV} structure containing the parameters, and a \texttt{DS} structure containing data, if any. And, one output argument, the value of the function evaluated at the input vector of parameter values.
\item \texttt{par} an instance of a \texttt{PV} structure. The \texttt{par} instance is passed to the user-provided procedure pointed to by \texttt{&fct}. \texttt{par} is constructed using the \texttt{pvPack} functions.
\item \texttt{data} an array of instances of a \texttt{DS} structure. This array is passed to the user-provided pointed by \texttt{&fct} to be used in the objective function. \texttt{QNewtonmt} does not look at this structure. Each instance contains the the following members which can be set in whatever way that is convenient for
computing the objective function:

\[ \text{data[i].dataMatrix} \]

NxK matrix, data matrix.

\[ \text{data[i].dataArray} \]

NxKxL \( \text{[arg1, arg2...argN]} \) array, data array.

\[ \text{data[i].vnames} \]

string array, variable names (optional).

\[ \text{data[i].dsname} \]

string, data name (optional).

\[ \text{data[i].type} \]

scalar, type of data (optional).

\( c \)

an instance of a \texttt{QNewtonmtControl} structure. Normally an instance is initialized by calling \texttt{QNewtonmtControlCreate} and members of this instance can be set to other values by the user. For an instance named \( c \), the members are:

\[ \text{c.CovType} \]

scalar, if 1, ML covariance matrix, else if 2, QML covariance matrix is computed. Default is 0, no covariance matrix.

\[ \text{c.GradProc} \]

scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. Default = ., i.e., no gradient procedure has been provided.

\[ \text{c.MaxIters} \]

scalar, maximum number of iterations. Default = 1e+5.

\[ \text{c.MaxTries} \]

scalar, maximum number of attempts in random search. Default = 100.

\[ \text{c.relGradTol} \]

 scalar, convergence tolerance for gradient of estimated coefficients. Default = 1e-5. When
this criterion has been satisfied

QNewtonmt

exits the iterations.

c.randRadius scalar, If zero, no random search is attempted. If nonzero, it is the radius of the random search. Default = .001.

c.output scalar, if nonzero, results are printed. Default = 0.

c.PrintIters scalar, if nonzero, prints iteration information. Default = 0.

c.disableKey scalar, if nonzero, keyboard input disabled

Output

an instance of an QNewtonmtOut structure. For an instance named out, the members are:

out.par instance of a PV structure containing the parameter estimates will be placed in the member matrix out.par.

out.fct scalar, function evaluated at x.

out.retcode scalar, return code:

0 normal convergence.

1 forced exit.

2 maximum number of iterations exceeded.
3 function calculation failed.
4 gradient calculation failed.
5 Hessian calculation failed.
6 line search failed.
7 error with constraints.
8 function complex.

\textit{out.moment} \hspace{1cm} KxK matrix, covariance matrix of parameters, if \texttt{c.covType} > 0.

\textit{out.hessian} \hspace{1cm} KxK matrix, matrix of second derivatives of objective function with respect to parameters.

\textbf{Remarks}

There is one required user-provided procedure, the one computing the objective function to be minimized, and another optional functions, the gradient of the objective function.

These functions have one input argument that is an instance of type \texttt{struct PV} and a second argument that is an instance of type \texttt{struct DS}. On input to the call to \texttt{QNewtonmt}, the first argument contains starting values for the parameters and the second argument any required data. The data are passed in a separate argument because the structure in the first argument will be copied as it is passed through procedure calls which would be very costly if it contained large data matrices. Since \texttt{QNewtonmt} makes no changes to the second argument it will be passed by pointer thus saving time because its contents aren't copied.
The PV structures are set up using the PV pack procedures, `pvPack`, `pvPackm`, `pvPack`s, and `pvPacksm`. These procedures allow for setting up a parameter vector in a variety of ways.

For example, we might have the following objective function for fitting a nonlinear curve to data:

```plaintext
proc Micherlitz(struct PV par1, struct DS data1);
    local p0,e,s2,x,y;
    p0 = pvUnpack(par1, "parameters");
    y = data1.dataMatrix[.,1];
    x = data1.dataMatrix[.,2];
    e = y - p0[1] - p0[2]*exp(-p0[3] * x);
    retp(-lnpdfmvn(e,e'//rows(e));
endp;
```

In this example the dependent and independent variables are passed to the procedure as the first and second columns of a data matrix stored in a single DS structure. Alternatively these two columns of data can be entered into a vector of DS structures one for each column of data:

If the objective function is the negative of a proper log-likelihood, and if `c.covType` is set to 1, the covariance matrix of the parameters is computed and returned in `out.moment`, and standard errors, t-statistics and probabilities are printed if `c.output = 1`.

If the objective function returns the negative of a vector of log-likelihoods, and if `c.covType` is set to 2, the quasi-maximum likelihood (QML) covariance matrix of the parameters is computed.

**Example**

The following is a complete example for estimating the parameters of the Micherlitz equation in data on the parameters and where an optional gradient procedure has been provided.
```c
#include QNewtonmt.sdf

struct DS d0;
d0 = dsCreate;

y = 3.183 |
   3.059 |
   2.871 |
   2.622 |
   2.541 |
   2.184 |
   2.110 |
   2.075 |
   2.018 |
   1.903 |
   1.770 |
   1.762 |
   1.550;

x = seqa(1,1,13);
d0.dataMatrix = y~x;

struct QNewtonmtControl c0;
c0 = QNewtonmtControlCreate;
c0.output = 1;       //Print results
c0.covType = 1;     //Compute moment matrix of parameters

struct PV parcel;
parcel = pvCreate;
parcel = pvPack(parcel,1|1|0, "parameters");

struct QNewtonmt out1;
out1 = QNewtonmt(&Micherlitz,parcel,d0,c0);
```
Source
qnewtonmt.src

See Also
QNewtonmtControlCreate, QNewtonmtOutCreate

QNewtonmtControlCreate

Purpose

Creates default QNewtonmtControl structure.

Include

qnewtonmt.sdf

Format

\[ c = \text{QNewtonmtControlCreate}(); \]

Output

\[ c \]

instance of QNewtonmtControl structure with members set to default values.

Source

qnewtonmt.src
See Also
QNewtonmt

QNewtonmtOutCreate

Purpose
Creates default QNewtonmtOut structure.

Format
\[ \texttt{c = QNewtonmtOutCreate();} \]

Output
\[ \texttt{c} \quad \text{instance of QNewtonmtOut structure with members set to default values.} \]

Source
qnewtonmt.src

See Also
QNewtonmt
QNewtonSet

Purpose
Resets global variables used by QNewton to default values.

Format
QNewtonSet;

Source
qnewton.src

QProg

Purpose
Solves the quadratic programming problem.

Format
\{ x, u1, u2, u3, u4, u5 \} = QProg(start, q, r, a, b, c, d, bnds);

Input

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>start</td>
<td>Kx1 vector, start values.</td>
</tr>
<tr>
<td>q</td>
<td>KxK matrix, symmetric model matrix.</td>
</tr>
<tr>
<td>r</td>
<td>Kx1 vector, model constant vector.</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>(a)</td>
<td>M(x)K matrix, equality constraint coefficient matrix, or scalar 0, no equality constraints.</td>
</tr>
<tr>
<td>(b)</td>
<td>M(x)1 vector, equality constraint constant vector, or scalar 0, will be expanded to M(x)1 vector of zeros.</td>
</tr>
<tr>
<td>(c)</td>
<td>N(x)K matrix, inequality constraint coefficient matrix, or scalar 0, no inequality constraints.</td>
</tr>
<tr>
<td>(d)</td>
<td>N(x)1 vector, inequality constraint constant vector, or scalar 0, will be expanded to N(x)1 vector of zeros.</td>
</tr>
<tr>
<td>(bnds)</td>
<td>K(x)2 matrix, bounds on (x), the first column contains the lower bounds on (x), and the second column the upper bounds. If scalar 0, the bounds for all elements will default to (\pm 1)e200.</td>
</tr>
</tbody>
</table>

**Global Input**

\[qprog\_maxit\] scalar, maximum number of iterations. Default = 1000.

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>K(x)1 vector, coefficients at the minimum of the function.</td>
</tr>
<tr>
<td>(u1)</td>
<td>M(x)1 vector, Lagrangian coefficients of equality constraints.</td>
</tr>
<tr>
<td>(u2)</td>
<td>N(x)1 vector, Lagrangian coefficients of inequality constraints.</td>
</tr>
<tr>
<td>(u3)</td>
<td>K(x)1 vector, Lagrangian coefficients of lower bounds.</td>
</tr>
<tr>
<td>(u4)</td>
<td>K(x)1 vector, Lagrangian coefficients of upper bounds.</td>
</tr>
<tr>
<td>(ret)</td>
<td>scalar, return code.</td>
</tr>
</tbody>
</table>
**Remarks**

**QProg** solves the standard quadratic programming problem:

\[
\min \frac{1}{2} x^T Q x - x^T R
\]

subject to constraints,

\[
A x = B C x \leq D
\]

and bounds,

\[
x_{low} \leq x \leq x_{up}
\]

**Source**

qprog.src

**QProgmt**

**Purpose**

Solves the quadratic programming problem.
Include
qprogmt.sdf

Format

\[ qOut = \text{QProgmt}(qIn) ; \]

Input

<table>
<thead>
<tr>
<th>qIn</th>
<th>instance of a \text{qprogMTIn} structure containing the following members:</th>
</tr>
</thead>
<tbody>
<tr>
<td>qIn.start</td>
<td>Kx1 vector, start values.</td>
</tr>
<tr>
<td>qIn.q</td>
<td>KxK matrix, symmetric model matrix.</td>
</tr>
<tr>
<td>qIn.r</td>
<td>Kx1 vector, model constant vector.</td>
</tr>
<tr>
<td>qIn.a</td>
<td>MxK matrix, equality constraint coefficient matrix, or scalar 0, no equality constraints.</td>
</tr>
<tr>
<td>qIn.b</td>
<td>Mx1 vector, equality constraint constant vector, or scalar 0, will be expanded to Mx1 vector of zeros.</td>
</tr>
<tr>
<td>qIn.c</td>
<td>NxK matrix, inequality constraint coefficient matrix, or scalar 0, no inequality constraints.</td>
</tr>
<tr>
<td>qIn.d</td>
<td>Nx1 vector, inequality constraint constant vector, or scalar 0, will be expanded to Nx1 vector of zeros.</td>
</tr>
<tr>
<td>$qIn.bounds$</td>
<td>Kx2 matrix, bounds on $qOut.x$, the first column contains the lower bounds on $qOut.x$, and the second column the upper bounds. If scalar 0, the bounds for all elements will default to ±1e200.</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>$qIn.maxit$</td>
<td>scalar, maximum number of iterations. Default = 1000.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>$qOut$</th>
<th>instance of a <code>qprogMTOut</code> structure containing the following members:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$qOut.x$</td>
<td>Kx1 vector, coefficients at the minimum of the function.</td>
</tr>
<tr>
<td>$qOut.lagrange$</td>
<td>instance of a <code>qprogMTLagrange</code> structure containing the following members:</td>
</tr>
<tr>
<td>$qOut.lagrange.lineq$</td>
<td>Mx1 vector, Lagrangian coefficients of equality constraints.</td>
</tr>
<tr>
<td>$qOut.lagrange.linineq$</td>
<td>Nx1 vector, Lagrangian coefficients of inequality constraints.</td>
</tr>
<tr>
<td>$qOut.lagrange.bounds$</td>
<td>Kx2 matrix, Lagrangian coefficients of bounds, the first column contains the lower bounds and the second the upper bounds.</td>
</tr>
<tr>
<td>$qOut.ret$</td>
<td>scalar, return code.</td>
</tr>
</tbody>
</table>
0  successful termination
1  max iterations exceeded
2  machine accuracy is insufficient to maintain decreasing function values
3  model matrices not conformable
< 0  active constraints inconsistent

**Remarks**

**QProgmt** solves the standard quadratic programming problem:

\[ \min \frac{1}{2} x'Qx - x'R \]

subject to constraints,

\[ Ax = BCx \leq D \]

and bounds,

\[ x_{low} \leq x \leq x_{up} \]

**Source**

qprogmt.src

**See Also**

QProgmtInCreate
QProgmtInCreate

Purpose

Creates an instance of a structure of type QProgmtInCreate with the maxit member set to a default value.

Include

qprogmt.sdf

Format

s = QProgmtInCreate();

Output

s instance of structure of type QProgmtIn.

Source

qprogmt.src

See Also

QProgmt
qqr

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix $x$, such that: $X = Q'R$

**Format**

$$\{ q1, r \} = \text{qqr}(x);$$

**Input**

$x$  
NxP matrix.

**Output**

$q1$  
NxK unitary matrix, $K = \min(N,P)$.

$r$  
KxP upper triangular matrix.

**Remarks**

Given $X$, there is an orthogonal matrix $Q$ such that $Q'x$ is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

38-1204
\[ Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix} \]

where \( Q_1 \) has \( P \) columns, then

\[ X = Q_1 R \]

is the QR decomposition of \( X \). If \( X \) has linearly independent columns, \( R \) is also the Cholesky factorization of the moment matrix of \( X \), i.e., of \( X'X \).

If you want only the \( R \) matrix, see the function `qr`. Not computing \( Q_1 \) can produce significant improvements in computing time and memory usage.

An unpivoted \( R \) matrix can also be generated using `cholup`:

\[
r = \text{cholup}(\text{zeros}(\text{cols}(x), \text{cols}(x)), x);
\]

For linear equation or least squares problems, which require \( Q_2 \) for computing residuals and residual sums of squares, see `olsqr` and `qyr`.

For most problems an explicit copy of \( Q_1 \) or \( Q_2 \) is not required. Instead one of the following, \( Q'Y, QY, Q_1'Y, Q_1Y, Q_2'Y, \) or \( Q_2Y \), for some \( Y \), is required. These cases are all handled by `qyr` and `qyr`. These functions are available because \( Q \) and \( Q_1 \) are typically very large matrices while their products with \( Y \) are more manageable.

If \( N < P \), the factorization assumes the form:

\[ Q'X = \begin{bmatrix} R_1 & R_2 \end{bmatrix} \]

where \( R_1 \) is a \( P \times P \) upper triangular matrix and \( R_2 \) is \( P \times (N-P) \). Thus \( Q \) is a \( P \times P \) matrix and \( R \) is a \( P \times N \) matrix containing \( R_1 \) and \( R_2 \). This type of factorization is useful for the solution of underdetermined systems. However, unless the linearly independent columns happen to be the initial rows, such an analysis also requires pivoting (see `qre` and `qrep`).

---

38-1205
**Source**

qqr.src

**See Also**

qre, qrep, qtyr, qtyre, qtyrep, qyr, qyre, qyrep, olsqr

**qqre**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix \( x \), such that: \( X[:,E] = Q R \)

**Format**

\[
\{ q1, r, e \} = \text{qqre}(x);
\]

**Input**

\( x \)  
NxP matrix.

**Output**

\( q1 \)  
NxK unitary matrix, \( K = \text{min}(N,P) \).

\( r \)  
KxP upper triangular matrix.

\( e \)  
Px1 permutation vector.
Remarks

Given $X[.,E]$, where $E$ is a permutation vector that permutes the columns of $X$, there is an orthogonal matrix $Q$ such that $Q'X[.,E]$ is zero below its diagonal, i.e.,

$$Q'R[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 \quad Q_2 \end{bmatrix}$$

where $Q_1$ has $P$ columns, then

$$X[.,E] = Q_1R$$

is the QR decomposition of $X[.,E]$.

If you want only the $R$ matrix, see qre. Not computing $Q_1$ can produce significant improvements in computing time and memory usage.

If $X$ has rank $P$, then the columns of $X$ will not be permuted. If $X$ has rank $M < P$, then the $M$ linearly independent columns are permuted to the front of $X$ by $E$. Partition the permuted $X$ in the following way:

$$X[.,E] = [X_1 \quad X_2]$$

where $X$ is $N \times M$ and $X_2$ is $N \times (P-M)$. Further partition $R$ in the following way:

$$R = \begin{bmatrix} R_{11} & R_{12} \\ 0 & 0 \end{bmatrix}$$

where $R_{11}$ is $M \times M$ and $R_{12}$ is $M \times (P-M)$. Then
\[ A = R^{-1}_{11}R_{12} \]

and

\[ X_2 = X_1A \]

that is, \( A \) is an \( M \times (P-N) \) matrix defining the linear combinations of \( X_2 \) with respect to \( X_1 \).

If \( N < P \), the factorization assumes the form:

\[ Q'X = [R_1R_2] \]

where \( R_1 \) is a \( P \times P \) upper triangular matrix and \( R_2 \) is \( P \times (N-P) \). Thus \( Q \) is a \( P \times P \) matrix and \( R \) is a \( P \times N \) matrix containing \( R_1 \) and \( R_2 \). This type of factorization is useful for the solution of underdetermined systems. For the solution of

\[ X[.,E]b = Y \]

it can be shown that

\[ b = \text{qrsol}(Q'Y, R1)|\text{zeros}(N-P,1); \]

The explicit formation here of \( Q \), which can be a very large matrix, can be avoided by using the function \texttt{qtyre}.

For further discussion of QR factorizations see the remarks under \texttt{qqr}.

**Source**

\texttt{qqr.src}

**See Also**

\texttt{qqr}, \texttt{qtyre}, \texttt{olsqr}
qqrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix \( x \), such that: \( X[.,E] = Q_f R \)

Format

\[
\{ q1, r, e \} = \text{qqrep}(x, pvt);
\]

Input

\( x \)  
\text{NxP matrix.}

\( pvt \)  
\text{Px1 vector, controls the selection of the pivot columns:}

- if \( pvt[i] > 0 \), \( x[i] \) is an initial column
- if \( pvt[i] = 0 \), \( x[i] \) is a free column
- if \( pvt[i] < 0 \), \( x[i] \) is a final column

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

\( q1 \)  
\text{NxK unitary matrix, } K = \text{min}(N,P).

\( r \)  
\text{KxP upper triangular matrix.}

\( e \)  
\text{Px1 permutation vector.}
**Remarks**

Given $X[.,E]$, where $E$ is a permutation vector that permutes the columns of $X$, there is an orthogonal matrix $Q$ such that $Q'X[.,E]$ is zero below its diagonal, i.e.,

$$Q'R[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1Q_2 \end{bmatrix}$$

where $Q_1$ has $P$ columns, then

$$X[.,E] = Q_1R$$

is the QR decomposition of $X[.,E]$.

*qqrep* allows you to control the pivoting. For example, suppose that $x$ is a data set with a column of ones in the first column. If there are linear dependencies among the columns of $x$, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using *pvt*.

If you want only the $R$ matrix, see *qrep*. Not computing $Q_1$ can produce significant improvements in computing time and memory usage.

**Source**

*qqr.src*

**See Also**

*qqr, qre, olsqr*
**qr**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix $x$, such that: $X = Q'R$

**Format**

$r = qr(x);$

**Input**

$x$  
NxP matrix.

**Output**

$r$  
KxP upper triangular matrix, $K = \min(N,P)$.

**Remarks**

$qr$ is the same as $qqr$ but doesn't return the $Q_I$ matrix. If $Q_I$ is not wanted, $qr$ will save a significant amount of time and memory usage, especially for large problems.

Given $X$, there is an orthogonal matrix $Q$ such that $Q'X$ is zero below its diagonal, i.e.,

$$Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition
where $Q_1$ has $P$ columns, then

$$X = Q_1 R$$

is the QR decomposition of $X$. If $X$ has linearly independent columns, $R$ is also the Cholesky factorization of the moment matrix of $X$, i.e., of $XX'$.

$qr$ does not return the $Q_1$ matrix because in most cases it is not required and can be very large. If you need the $Q_1$ matrix, see the function $qqr$. If you need the entire $Q$ matrix, call $qyr$ with $Y$ set to a conformable identity matrix.

For most problems $Q'Y$, $Q_1'Y$, or $QY$, $Q_1Y$, for some $Y$, are required. For these cases see $qtyr$ and $qyr$.

For linear equation or least squares problems, which require $Q_2$ for computing residuals and residual sums of squares, see $olsqr$.

If $N<P$, the factorization assumes the form:

$$Q'X = [R_1 R_2]$$

where $R_1$ is a PxP upper triangular matrix and $R_2$ is Px(P-N). Thus $Q$ is a PxP matrix and $R$ is a PxN matrix containing $R_1$ and $R_2$. This type of factorization is useful for the solution of underdetermined systems. However, unless the linearly independent columns happen to be the initial rows, such an analysis also requires pivoting (see $qre$ and $qrep$).

**Source**

$qr$ src

**See Also**

$qqr$, $qrep$, $qtyr$
**qre**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix \( x \), such that:

\[
x[:,E] = Q'R
\]

**Format**

\[
\{ r, e \} = \text{qre}(x);
\]

**Input**

\( x \)  
NxP matrix.

**Output**

\( r \)  
KxP upper triangular matrix, \( K = \text{min}(N,P) \).

\( e \)  
Px1 permutation vector.

**Remarks**

\texttt{qre} is the same as \texttt{qqre} but doesn't return the \( Q_l \) matrix. If \( Q_l \) is not wanted, \texttt{qre} will save a significant amount of time and memory usage, especially for large problems.

Given \( X[:,E] \), where \( E \) is a permutation vector that permutes the columns of \( x \), there is an orthogonal matrix \( Q \) such that \( Q'X[:,E] \) is zero below its diagonal, i.e.,
where \( R \) is upper triangular. If we partition

\[
Q'[\cdot,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}
\]

is the QR decomposition of \( X[\cdot,E] \).

\texttt{qre} does not return the \( Q_I \) matrix because in most cases it is not required and can be very large. If you need the \( Q_I \) matrix, see the function \texttt{qqre}. If you need the entire \( Q \) matrix, call \texttt{qyre} with \( Y \) set to a conformable identity matrix. For most problems \( Q'Y \), \( Q_I'Y \), or \( QY \), \( Q_IY \), for some \( y \), are required. For these cases see \texttt{qtyre} and \texttt{qyre}.

If \( X \) has rank \( P \), then the columns of \( X \) will not be permuted. If \( X \) has rank \( M<P \), then the \( M \) linearly independent columns are permuted to the front of \( X \) by \( E \). Partition the permuted \( X \) in the following way:

\[
X[\cdot,E] = \begin{bmatrix} X_I \\ X_2 \end{bmatrix}
\]

where \( X_I \) is NxM and \( X_2 \) is Nx(P-M). Further partition \( R \) in the following way:

where \( R_{11} \) is MxM and \( R_{12} \) is Mx(P-M). Then

\[
A = R_{11}^{-1}R_{12}
\]

and

\[
X_2 = X_I A
\]
that is, $A$ is an $M \times (P-N)$ matrix defining the linear combinations of $X_2$ with respect to $X_1$

If $N<P$ the factorization assumes the form:

\[
    Q' X = \begin{bmatrix} R_1 & R_2 \end{bmatrix}
\]

where $R_1$ is a $P \times P$ upper triangular matrix and $R_2$ is $P \times (N-P)$. Thus $Q$ is a $P \times P$ matrix and $R$ is a $P \times N$ matrix containing $R_1$ and $R_2$. This type of factorization is useful for the solution of underdetermined systems. For the solution of

\[
    X[:, E]b = Y
\]

it can be shown that

\[
    b = \text{qr sol}(Q'Y, R1) | \text{zeros}(N-P, 1);
\]

The explicit formation here of $Q$, which can be a very large matrix, can be avoided by using the function `qtyre`.

For further discussion of QR factorizations see the remarks under `qqr`.

**Source**

`qr.src`

**See Also**

`qqr`, `olsqr`
qrep

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix $X$, such that:

$$X[.,E] = Q_1 R$$

Format

$$\{ r, e \} = \text{qrep}(X, pvt);$$

Input

- $X$ \quad N\times P matrix.
- $pvt$ \quad P\times 1 vector, controls the selection of the pivot columns:
  
  - if $pvt[i] > 0$, $X[i]$ is an initial column.
  
  - if $pvt[i] = 0$, $X[i]$ is a free column.
  
  - if $pvt[i] < 0$, $X[i]$ is a final column.

  The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

Output

- $r$ \quad K\times P upper triangular matrix, $K = \text{min}(N,P)$. 
e \quad P \times 1 \text{ permutation vector.}

Remarks

$qrep$ is the same as $qqrep$ but doesn't return the $Q_I$ matrix. If $Q_I$ is not wanted, $qrep$ will save a significant amount of time and memory usage, especially for large problems.

Given $X[.,E]$, where $E$ is a permutation vector that permutes the columns of $X$, there is an orthogonal matrix $Q$ such that $Q'X[.,E]$ is zero below its diagonal, i.e.,

$$Q'X[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 \, Q_2 \end{bmatrix}$$

where $Q_1$ has $P$ columns, then

$$X[.,E] = Q_1 R$$

is the QR decomposition of $X[.,E]$.

$qrep$ does not return the $Q_I$ matrix because in most cases it is not required and can be very large. If you need the $Q_I$ matrix, see the function $qqrep$. If you need the entire $Q$ matrix, call $qyrep$ with $Y$ set to a conformable identity matrix. For most problems $Q'Y$, $Q_I'Y$, or $QY$, $Q_IY$, for some $Y$, are required. For these cases see $qtyrep$ and $qyrep$.

$qrep$ allows you to control the pivoting. For example, suppose that $X$ is a data set with a column of ones in the first column. If there are linear dependencies among the

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columns of $X$, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using $pvt$.

**Source**

qr.src

**See Also**

qr, qre, qgrep

**qrsol**

**Purpose**

Computes the solution of $Rx = b$ where $R$ is an upper triangular matrix.

**Format**

$$x = \text{qrsol}(b, \ R);$$

**Input**

- $b$ : PxL matrix.
- $R$ : PxP upper triangular matrix.

**Output**

- $x$ : PxL matrix.
Remarks

qrsol applies a backsolve to \( Rx = b \) to solve for \( x \). Generally \( R \) will be the \( R \) matrix from a QR factorization. qrsol may be used, however, in any situation where \( R \) is upper triangular.

Source

qrsol.src

See Also

qqr, qr, qtyr, qrtsol

qrtsol

Purpose

Computes the solution of \( R'x = b \) where \( R \) is an upper triangular matrix.

Format

\[
x = \text{qrtsol}(b, R);
\]

Input

| \( b \) | PxL matrix. |
| \( R \) | PxP upper triangular matrix. |
Output

\[ x \quad \text{P}\times\text{L matrix.} \]

Remarks

\texttt{qrtsol} applies a forward solve to \( R'x = b \) to solve for \( x \). Generally \( R \) will be the \( R \) matrix from a QR factorization. \texttt{qrtsol} may be used, however, in any situation where \( R \) is upper triangular. If \( R \) is lower triangular, transpose before calling \texttt{qrtsol}.

If \( R \) is not transposed, use \texttt{qrsol}.

Source

\texttt{qrsol.src}

See Also

\texttt{qqr, qr, qtyr, qrsol}

qtyr

Purpose

Computes the orthogonal-triangular (QR) decomposition of a matrix \( X \) and returns \( Q'Y \) and \( R \).

Format

\[
\{ \texttt{qty}, r \} = \texttt{qtyr}(y, X);\]
**Input**

\[ y \]  \( \text{NxL matrix.} \)

\[ X \]  \( \text{NxP matrix.} \)

**Output**

\[ qty \]  \( \text{NxL unitary matrix.} \)

\[ r \]  \( \text{KxP upper triangular matrix, } K = \min(N,P). \)

**Remarks**

Given \( X \), there is an orthogonal matrix \( Q \) such that \( Q'X \) is zero below its diagonal, i.e.,

\[
Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}
\]

where \( R \) is upper triangular. If we partition

\[
Q = \begin{bmatrix} Q_1 \mid Q_2 \end{bmatrix}
\]

where \( Q_1 \) has P columns, then

\[
X = Q_1R
\]

is the QR decomposition of \( X \). If \( X \) has linearly independent columns, \( R \) is also the Cholesky factorization of the moment matrix of \( X \), i.e., of \( X'X \). For most problems \( Q \) or \( Q_1 \) is not what is required. Rather, we require \( Q'Y \) or \( Q_1'Y \) where \( Y \) is an NxL matrix (if either \( QY \) or \( Q_1Y \) are required, see \( qyr \)). Since \( Q \) can be a very large matrix,
\texttt{qtyr} has been provided for the calculation of $Q'Y$ which will be a much smaller matrix. $Q_1'Y$ will be a submatrix of $Q'Y$. In particular,

$$ G = Q_1'Y = q_{tY} [1 : P, .] $$

and $Q_2'Y$ is the remaining submatrix:

$$ H = Q_2'Y = q_{tY} [P + 1 : N, .] $$

Suppose that $X$ is an $N \times K$ data set of independent variables, and $Y$ is an $N \times 1$ vector of dependent variables. Then it can be shown that

$$ b = R^{-1}G $$

and

$$ s_j = \sum_{i = 1}^{N - P} H_{i,j} = 1, 2, \ldots L $$

where $b$ is a $P \times L$ matrix of least squares coefficients and $s$ is a $1 \times L$ vector of residual sums of squares. Rather than invert $R$ directly, however, it is better to apply $\texttt{qrsol}$ to

$$ Rb = Q_1'Y $$

For rank deficient least squares problems, see $\texttt{qtyre}$ and $\texttt{qtyrep}$.

**Example**

The QR algorithm is the numerically superior method for the solution of least squares problems:
```c
loadm x, y;
{ qty, r } = qtyr(y, x);
qlty = qty[1:rows(r),..];
q2ty = qty[rows(r)+1:rows(qty),..];

//LS coefficients
b = qrsol(qlty,r);

//Residual sums of squares
s2 = sumc(q2ty^2);
```

**Source**

`qtyr.src`

**See Also**

`qqr, qtyre, qtyrep, olsqr`

**qtyr**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix $X$ and returns $Q'Y$ and $R$.

**Format**

```c
{ qty, r, e } = qtyre(y, x);
```
**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>NxL matrix.</td>
</tr>
<tr>
<td>$x$</td>
<td>NxP matrix.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$qty$</td>
<td>NxL unitary matrix.</td>
</tr>
<tr>
<td>$r$</td>
<td>KxP upper triangular matrix, $K = \min(N, P)$.</td>
</tr>
<tr>
<td>$e$</td>
<td>Px1 permutation vector.</td>
</tr>
</tbody>
</table>

**Remarks**

Given $X[.,E]$, where $E$ is a permutation vector that permutes the columns of $X$, there is an orthogonal matrix $Q$ such that $Q'X[.,E]$ is zero below its diagonal, i.e.,

$$Q'X[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

$$Q = [Q_1 Q_2]$$

where $Q_1$ has P columns, then

$$X[.,E] = Q_1 R$$

is the QR decomposition of $X[.,E]$. 

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If \( X \) has rank \( P \), then the columns of \( X \) will not be permuted. If \( X \) has rank \( M<P \), then the \( M \) linearly independent columns are permuted to the front of \( X \) by \( E \). Partition the permuted \( X \) in the following way:

\[
X[:, E] = [X_1 X_2]
\]

where \( X_1 \) is \( N \times M \) and \( X_2 \) is \( N \times (P-M) \). Further partition \( R \) in the following way:

\[
R = \begin{bmatrix}
R_{11} & R_{12} \\
0 & 0
\end{bmatrix}
\]

where \( R_{11} \) is \( M \times M \) and \( R_{12} \) is \( M \times (P-M) \). Then

\[
A = R_{11}^{-1} R_{12}
\]

and

\[
X_2 = X_1 A
\]

that is, \( A \) is an \( M \times (P-N) \) matrix defining the linear combinations of \( X_2 \) with respect to \( X_1 \).

For most problems \( Q \) or \( Q_1 \) is not it is required. Rather, we require \( Q'Y \) or \( Q_1'Y \) where \( Y \) is an \( N \times L \) matrix. Since \( Q \) can be a very large matrix, \texttt{qtyre} has been provided for the calculation of \( Q'Y \) which will be a much smaller matrix. \( Q_1'Y \) will be a submatrix of \( Q'Y \). In particular,

\[
Q_1' Y = \texttt{qtyre}[1:P, \cdot]
\]

and \( Q_2'Y \) is the remaining submatrix:

\[
Q_2' Y = \texttt{qtyre}[P+1:N, \cdot]
\]
Suppose that $X$ is an $N \times K$ data set of independent variables and $Y$ is an $N \times 1$ vector of dependent variables. Suppose further that $X$ contains linearly dependent columns, i.e., $X$ has rank $M < P$. Then define

\[ C = Q_1^T Y[1 : M, .] \]
\[ A = R[1 : M, 1 : M] \]

and the vector (or matrix of $L > 1$) of least squares coefficients of the reduced, linearly independent problem is the solution of

\[ Ab = C \]

To solve for $b$ use $\text{qrsol}$:

\[ b = \text{qrsol}(C, A); \]

If $N < P$, the factorization assumes the form:

\[ Q' X[., E] = [R_1 \ R_2] \]

where $R_1$ is a $P \times P$ upper triangular matrix and $R_2$ is $P \times (N-P)$. Thus $Q$ is a $P \times P$ matrix and $R$ is a $P \times N$ matrix containing $R_1$ and $R_2$. This type of factorization is useful for the solution of underdetermined systems. For the solution of

\[ X[., E]b = Y \]

it can be shown that

\[ b = \text{qrsol}(Q'Y, R1) | \text{zeros}(N-P, 1); \]

**Source**

qtyr.src
See Also
qqr, qre, qtyr

qtyrep

Purpose
Computes the orthogonal-triangular (QR) decomposition of a matrix $X$ using a pivot vector and returns $Q'Y$ and $R$.

Format
\[
\{ qty, r, e \} = \text{qtyrep}(y, x, pvt);
\]

Input

<table>
<thead>
<tr>
<th>$y$</th>
<th>NxL matrix.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>NxP matrix.</td>
</tr>
<tr>
<td>$pvt$</td>
<td>Px1 vector, controls the selection of the pivot columns:</td>
</tr>
<tr>
<td></td>
<td>if $pvt[i] &gt; 0$, $x[i]$ is an initial column.</td>
</tr>
<tr>
<td></td>
<td>if $pvt[i] = 0$, $x[i]$ is a free column.</td>
</tr>
<tr>
<td></td>
<td>if $pvt[i] &lt; 0$, $x[i]$ is a final column.</td>
</tr>
</tbody>
</table>

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.
Output

\begin{align*}
\text{qty} & \quad \text{N} \times \text{L} \text{ unitary matrix.} \\
\text{r} & \quad \text{K} \times \text{P} \text{ upper triangular matrix, } K = \min(\text{N}, \text{P}). \\
\text{e} & \quad \text{P} \times 1 \text{ permutation vector.}
\end{align*}

Remarks

Given \(X[.,E]\), where \(E\) is a permutation vector that permutes the columns of \(X\), there is an orthogonal matrix \(Q\) such that \(Q'X[.,E]\) is zero below its diagonal, i.e.,

\[
Q'X[.,E]=\begin{bmatrix} R \\ 0 \end{bmatrix}
\]

where \(R\) is upper triangular. If we partition

\[
Q=\begin{bmatrix} Q_1Q_2 \end{bmatrix}
\]

where \(Q_1\) has \(P\) columns, then

\[
X[.,E]=Q_1R
\]

is the QR decomposition of \(X[.,E]\).

\texttt{qtyrep} allows you to control the pivoting. For example, suppose that \(X\) is a data set with a column of ones in the first column. If there are linear dependencies among the columns of \(X\), the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using \texttt{pvt}.

Source

\texttt{qtyr.src}
quantile

Purpose

Computes quantiles from data in a matrix, given specified probabilities.

Format

\[ y = \text{quantile}(x, e) \]

Input

\begin{align*}
 x & \quad \text{NxK matrix of data.} \\
 e & \quad \text{Lx1 vector, quantile levels or probabilities.}
\end{align*}

Output

\begin{align*}
 y & \quad \text{LxK matrix, quantiles.}
\end{align*}

Remarks

\texttt{quantile} will not succeed if N*\textbf{minc}(e) is less than 1, or N*\textbf{maxc}(e) is greater than N - 1. In other words, to produce a \texttt{quantile} for a level of .001, the input matrix must have more than 1000 rows.
Example

```plaintext
//Set the rng seed for repeatable random numbers
dseed 345567;

//Create a 1000x4 random normal matrix
x = rndn(1000,4);

//Quantile levels
e = { .025, .5, .975 };
y = quantile(x,e);

print "medians";
print y[2,.];
print;
print "95 percentiles";
print y[1,.];
print y[3,.];
```

Produces the following output:

```
medians
   -0.037801917  0.029923972 -0.010477829  0.023937160

95 percentiles
   -2.0074122   -2.0798579  -1.9982702  -1.9605009
      2.0437573   2.0271770   1.9025695   1.9228044
```

Source

quantile.src
**quantiled**

**Purpose**

Computes quantiles from data in a data set, given specified probabilities.

**Format**

\[ y = \text{quantiled}(dataset, \ e, \ var); \]

**Input**

- **dataset**: string, data set name, or NxM matrix of data.
- **e**: Lx1 vector, quantile levels or probabilities.
- **var**: Kx1 vector or scalar zero. If Kx1, character vector of labels selected for analysis, or numeric vector of column numbers in data set of variables selected for analysis. If scalar zero, all columns are selected.
  
  If *dataset* is a matrix *var* cannot be a character vector.

**Output**

- **y**: LxK matrix, quantiles.

**Remarks**

*quantiled* will not succeed if \( N^{\min_c}(e) \) is less than 1, or \( N^{\max_c}(e) \) is greater than \( N - 1 \). In other words, to produce a *quantile* for a level of .001, the input
matrix must have more than 1000 rows.

Example:

```plaintext
y = quantiled("tobit", e, 0);

print "medians";
print y[2,.];
print;
print "95 percentiles";
print y[1,.];
print y[3,.];
```

produces:

```
medians

  0.0000 1.0000 -0.0021 -0.1228

95 percentiles

-1.1198 1.0000 -1.8139 -2.3143
  2.3066 1.0000 1.4590 1.6954
```

**Source**

quantile.src

**qyr**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix $X$ and returns $QY$ and $R$. 
**Format**

\[
\{ q_y, r \} = qyr(y, x);
\]

**Input**

- \( y \) \( N \times L \) matrix.
- \( X \) \( N \times P \) matrix.

**Output**

- \( qy \) \( N \times L \) unitary matrix.
- \( r \) \( K \times P \) upper triangular matrix, \( K = \min(N,P) \).

**Remarks**

Given \( X \), there is an orthogonal matrix \( Q \) such that \( Q'X \) is zero below its diagonal, i.e.,

\[
Q'X = \begin{bmatrix} R \\ 0 \end{bmatrix}
\]

where \( R \) is upper triangular. If we partition

\[
Q = \begin{bmatrix} Q_1Q_2 \end{bmatrix}
\]

where \( Q_1 \) has \( P \) columns, then

\[
X = Q_1R
\]
is the QR decomposition of \( X \). If \( X \) has linearly independent columns, \( R \) is also the Cholesky factorization of the moment matrix of \( X \), i.e., of \( X'X \).

For most problems \( Q \) or \( Q_1 \) is not what is required. Since \( Q \) can be a very large matrix, \texttt{qyr} has been provided for the calculation of \( QY \), where \( Y \) is some NxL matrix, which will be a much smaller matrix.

If either \( Q'Y \) or \( Q_1 'Y \) are required, see \texttt{qtyr}.

**Source**

\texttt{qyr.src}

**See Also**

\texttt{qqr, qyre, qyrep, olsqr}

**qyre**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix \( x \) and returns \( QY \) and \( R \).

**Format**

\[
\{ qy, r, e \} = \texttt{qyre}(y, x);
\]

**Input**

- \( y \) \quad NxL matrix.
- \( x \) \quad NxP matrix.
**Output**

- $qy$: Nxl unitary matrix.
- $r$: KxP upper triangular matrix, $K = \min(N,P)$.
- $e$: Px1 permutation vector.

**Remarks**

Given $X[.,E]$, where $E$ is a permutation vector that permutes the columns of $X$, there is an orthogonal matrix $Q$ such that $Q'X[.,E]$ is zero below its diagonal, i.e.,

$$Q'X[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}$$

where $R$ is upper triangular. If we partition

$$Q = \begin{bmatrix} Q_1 \mid Q_2 \end{bmatrix}$$

where $Q_1$ has $P$ columns, then

$$X[.,E] = Q_1R$$

is the QR decomposition of $X[.,E]$.

For most problems $Q$ or $Q_1$ is not what is required. Since $Q$ can be a very large matrix, $qyre$ has been provided for the calculation of $QY$, where $Y$ is some Nxl matrix, which will be a much smaller matrix.

If either $Q'Y$ or $Q_1'Y$ are required, see $qtyre$.

If $N < P$, the factorization assumes the form:
where \( R_1 \) is a \( P \times P \) upper triangular matrix and \( R_2 \) is \( P \times (N-P) \). Thus \( Q \) is a \( P \times P \) matrix and \( R \) is a \( P \times N \) matrix containing \( R_1 \) and \( R_2 \).

**Source**

qyr.src

**See Also**

qqr, qre, qyr

**qyrep**

**Purpose**

Computes the orthogonal-triangular (QR) decomposition of a matrix \( X \) using a pivot vector and returns \( QY \) and \( R \).

**Format**

\[
\{ qy, r, e \} = \text{qyre}(y, x, \ pvt);
\]

**Input**

- \( y \) \( \text{NxL} \) matrix.
- \( x \) \( \text{NxP} \) matrix.
- \( pvt \) \( \text{Px1} \) vector, controls the selection of the pivot columns:
  
  \[
  \text{if } pvt[i] > 0, \ x[i] \text{ is an initial column.}
  \]
if \( pvt[i] = 0 \), \( x[i] \) is a free column.

if \( pvt[i] < 0 \), \( x[i] \) is a final column.

The initial columns are placed at the beginning of the matrix and the final columns are placed at the end. Only the free columns will be moved during the decomposition.

**Output**

\( qy \)  
NxL unitary matrix.

\( r \)  
KxP upper triangular matrix, \( K = \min(N,P) \).

\( e \)  
Px1 permutation vector.

**Remarks**

Given \( X[.,E] \), where \( E \) is a permutation vector that permutes the columns of \( X \), there is an orthogonal matrix \( Q \) such that \( Q'X[.,E] \) is zero below its diagonal, i.e.,

\[
Q'X[.,E] = \begin{bmatrix} R \\ 0 \end{bmatrix}
\]

where \( R \) is upper triangular. If we partition

\[
Q = \begin{bmatrix} Q_1 & Q_2 \end{bmatrix}
\]

where \( Q_1 \) has \( P \) columns, then

\[
X[.,E] = Q_1R
\]
is the QR decomposition of $X[.,E]$.

`qyrep` allows you to control the pivoting. For example, suppose that $X$ is a data set with a column of ones in the first column. If there are linear dependencies among the columns of $X$, the column of ones for the constant may get pivoted away. This column can be forced to be included among the linearly independent columns using `pvt`.

For most problems $Q$ or $Q_1$ is not what is required. Since $Q$ can be a very large matrix, `qyrep` has been provided for the calculation of $QY$, where $Y$ is some $N\times L$ matrix, which will be a much smaller matrix.

If either $Q'Y$ or $Q'_1Y$ are required, see `qtyrep`.

If $N<P$, the factorization assumes the form:

\[
Q'X[.,E] = [R_1 R_2]
\]

where $R_1$ is a $P\times P$ upper triangular matrix and $R_2$ is $P\times (N-P)$. Thus $Q$ is a $P\times P$ matrix and $R$ is a $P\times N$ matrix containing $R_1$ and $R_2$.

**Source**

`qyr.src`

**See Also**

`qr`, `qqrep`, `qrep`, `qtyrep`
**Purpose**

Computes the rank of a matrix, using the singular value decomposition.

**Format**

\[ k = \text{rank}(x); \]

**Input**

\[ x \quad \text{NxP matrix.} \]

**Global Input**

\[ _{svdTo1} \quad \text{scalar, the tolerance used in determining if any of the singular values are effectively 0. The default value is } 10^{-13}. \text{ This can be changed before calling the procedure.} \]

**Output**

\[ k \quad \text{an estimate of the rank of } x. \text{ This equals the} \]
number of singular values of x that exceed a prespecified tolerance in absolute value.

**Global Output**

`_svderr` scalar, if not all of the singular values can be computed `_svderr` will be nonzero.

**Source**

`svd.src`

**rankindx**

**Purpose**

Returns the vector of ranks of a vector.

**Format**

```matlab
y = rankindx(x, flag);
```

**Input**

- `x` : Nx1 vector.
- `flag` : scalar, 1 for numeric data or 0 for character data.
Output

\[ y \]  
N\times1 \text{ vector containing the ranks of } x. \text{ That is, the rank of the largest element is } N \text{ and the rank of the smallest is } 1. (\text{To get ranks in descending order, subtract } y \text{ from } N+1).

Remarks

`rankindx` assigns different ranks to elements that have equal values (ties). Missing values are assigned the lowest ranks.

Example

\[
x = \{ 12, 4, 15, 7, 8 \};
\]
\[
r = \text{rankindx}(x,1);
\]

After the code above, \( r \) is equal to:

\[
\begin{align*}
4 \\
1 \\
r = 5 \\
2 \\
3
\end{align*}
\]

readr

Purpose

Reads a specified number of rows of data from a \texttt{GAUSS} data set (.dat) file or a \texttt{GAUSS} matrix (.fmt) file.
Format

\[ y = \textbf{readr}(f1, r); \]

Input

<table>
<thead>
<tr>
<th>f1</th>
<th>scalar, file handle of an open file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>scalar, number of rows to read.</td>
</tr>
</tbody>
</table>

Output

| y   | NxK matrix, the data read from the file. |

Remarks

The first time a \textbf{readr} statement is encountered, the first \( r \) rows will be read. The next time it is encountered, the next \( r \) rows will be read in, and so on. If the end of the data set is reached before \( r \) rows can be read, then only those rows remaining will be read.

After the last row has been read, the pointer is placed immediately after the end of the file. An attempt to read the file in these circumstances will cause an error message.

To move the pointer to a specific place in the file use \textbf{seekr}.

Example

```r
open dt = dat1.dat;
m = 0;

do until \texttt{eof}(dt);
```
This code reads data from a data set 400 rows at a time. The moment matrix for each set of rows is computed and added to the sum of the previous moment matrices. The result is the moment matrix for the entire data set. \texttt{eof}(dt) returns 1 when the end of the data set is encountered.

\textbf{See Also}

\texttt{open}, \texttt{create}, \texttt{writer}, \texttt{seekr}, \texttt{eof}

\textbf{real}

\textbf{Purpose}

Returns the real part of \(x\).

\textbf{Format}

\(zr = \text{real}(x);\)

\textbf{Input}

\(x\) \hspace{1cm} \text{NxK matrix or N-dimensional array.}
Output

\[ zr \]  
N×K matrix or N-dimensional array, the real part of \( x \).

Remarks

If \( x \) is not complex, \( zr \) will be equal to \( x \).

Example

\[
\begin{align*}
\text{x} &= \{ 1 \; 11+2i, \\
& \quad 7i \; 3, \\
& \quad 2+1i \; 1 \}; \\
\text{zr} &= \text{real}(x); \\
\end{align*}
\]

After the code above, \( x \) and \( zr \) are equal to:

\[
\begin{align*}
\text{x} &= \begin{pmatrix}
1+0i & 11+2i & 1+0i \\
0+7i & 3+0i & 2+1i \\
\end{pmatrix}, \\
\text{zr} &= \begin{pmatrix}
1 & 11 \\
0 & 3 \\
2 & 1 \\
\end{pmatrix}
\end{align*}
\]

See Also

complex, imag

recode

Purpose

Changes the values of an existing vector from a vector of new values. Used in data transformations.
Format

\[ y = \text{recode}(x, e, v); \]

Input

- \( x \): Nx1 vector to be recoded (changed).
- \( e \): NxK matrix of 1's and 0's.
- \( v \): Kx1 vector containing the new values to be assigned to the recoded variable.

Output

- \( y \): Nx1 vector containing the recoded values of \( x \).

Remarks

There should be no more than a single 1 in any row of \( e \).

For any given row \( N \) of \( x \) and \( e \), if the \( K \)th column of \( e \) is 1, the \( K \)th element of \( v \) will replace the original element of \( x \).

If every column of \( e \) contains a 0, the original value of \( x \) will be unchanged.

Example

\[
\begin{align*}
x &= \{ 20, \\
& \quad 45, \\
& \quad 32, \\
& \quad 63,
\end{align*}
\]
29;

//Create 4 column vectors with a 1 where the statement 
//evaluates as 'true'
e1 = (20 .lt x) .and (x .le 30);
e2 = (30 .lt x) .and (x .le 40);
e3 = (40 .lt x) .and (x .le 50);
e4 = (50 .lt x) .and (x .le 60);

//Horizontally concatenate the column vectors into a 5x4 
//matrix
e = e1~e2~e3~e4;

v = { 1.2,
     2.4,
     3.1,
     4.6 };

//Replace elements of 'x' with elements from 'v' based upon 
//the 0's and 1's in 'e'
y = recode(x,e,v);

The above code assigns e and y as follows:

```
0 0 0 0 0
0 0 1 0 0
0 1 0 0 0
0 0 0 0 0
1 0 0 0 0
```

//Since the third column of the second row of 'e' is equal 
//to 1, the second row of 'y' is set equal to the third 
//element of 'v', etc.

20.000000
3.1000000
y = 2.4000000
  63.000000
  1.2000000

Source
datatran.src

See Also
code, substute

recode (dataloop)

Purpose
Changes the value of a variable with different values based on a set of logical expressions.

Format

recode var with
  or
recode #var with
  or
recode $var with
  val1 for expression_1,
  val2 for expression_2,
  .
  .
  .
  .
valn for expression_n;

**Input**

- **var**: literal, the new variable name.
- **val**: scalar, value to be used if corresponding expression is TRUE.
- **expression**: logical scalar-returning expression that returns nonzero TRUE or zero FALSE.

**Remarks**

If '§' is specified, the variable will be considered a character variable. If '#' is specified, the variable will be considered numeric. If neither is specified, the type of the variable will be left unchanged.

The logical expressions must be mutually exclusive, that is only one may return TRUE for a given row (observation).

If none of the expressions is TRUE for a given row (observation), its value will remain unchanged.

Any variables referenced must already exist, either as elements of the source data set, as extern's, or as the result of a previous make, vector, or code statement.

**Example**

```
recode age with
    1 for age < 21,
    2 for age >= 21 and age < 35,
    3 for age >= 35 and age < 50,
```

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4 for age >= 50 and age < 65,
5 for age >= 65;

```
recode $ sex with
   "MALE" for sex =\,= 1,
   "FEMALE" for sex =\,= 0;
```

```
recode # sex with
1 for sex $=\,= "MALE",
0 for sex $=\,= "FEMALE";
```

**See Also**

*code (dataloop)*

**recserar**

**Purpose**

Computes a vector of autoregressive recursive series.

**Format**

```
y = recserar(x, y0, rho);
```

**Input**

- `x` : NxK matrix
- `y0` : PxK matrix.
- `rho` : PxK matrix.
Output

\( y \)  
\( \text{NxK matrix containing the series.} \)

Remarks

`recserar` is particularly useful in dealing with time series.

Typically, the result would be thought of as \( K \) vectors of length \( N \).

\( y0 \) contains the first \( P \) values of each of these vectors (thus, these are prespecified). The remaining elements are constructed by computing a \( P \)th order "autoregressive" recursion, with weights given by \( rho \), and then by adding the result to the corresponding elements of \( x \). That is, the \( t \)th row of \( y \) is given by:

\[
y[t,.] = x[t,.] + rho[1,.] * y[t-1,.] + ... + rho[P,.] * y[t-p,.], \quad t = P + 1, \ldots N
\]

and

\[
y[t,.] = y0[t,.], \quad t = 1, \ldots, P
\]

Note that the first \( P \) rows of \( x \) are not used.

Example

Example 1

```plaintext
y0 = 0;
rho = 0.4;
err = randn(20, 1);

y = recserar(err, y0, rho);
```

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In this basic example, one autoregressive series is formed. The general form of the series can be written:

\[ y[t] = \rho y[t-1] + err[t] \]

**Example 2**

\[
\begin{align*}
n &= 10; \\
\text{fn} \ &\text{multnorm}(n,\text{sigma}) &= \text{rndn}(n, \text{rows}(\text{sigma}))*\text{chol}(\text{sigma}); \\
\text{sig} &= \{1 -0.3, \\
& \quad -0.3 \ 1 \}; \\
\text{rho} &= \{0.5 \ 0.3\}; \\
\text{y0} &= \{0 \ \ 0\}; \\
\text{e} &= \text{multnorm}(n,\text{sig}); \\
\text{x} &= \text{ones}(n,1)\sim\text{rndn}(n,3); \\
\text{b} &= \{1, \ 2, \ 3, \ 4\}; \\
\text{y} &= \text{recserar}(x*\text{b}+\text{e},\text{y0},\text{rho});
\end{align*}
\]

In this example, two autoregressive series are formed using simulated data. The general form of the series can be written:

\[
\begin{align*}
y[t,1] &= \rho[1,1]y[t-1,1] + x[t,.]*\text{b} + \text{e}[t,1] \\
y[t,2] &= \rho[2,1]y[t-1,2] + x[t,.]*\text{b} + \text{e}[t,2]
\end{align*}
\]

The error terms (\(e[t,1]\) and \(e[t,2]\)) are not individually serially correlated, but they are contemporaneously correlated with each other. The variance-covariance matrix is \(\text{sig}\).

**See Also**

recsercp, recserrc
**recsercp**

**Purpose**

Computes a recursive series involving products. Can be used to compute cumulative products, to evaluate polynomials using Horner's rule, and to convert from base $b$ representations of numbers to decimal representations among other things.

**Format**

$$y = \texttt{recsercp}(x, \ z);$$

**Input**

- $x$ NxK or 1xK matrix
- $z$ NxK or 1xK matrix.

**Output**

- $y$ NxK matrix in which each column is a series generated by a recursion of the form:

$$y(1) = x(1) + z(1)$$
$$y(t) = y(t-1) \times x(t) + z(t), \ t=2, \ldots N$$

**Remarks**

The following **GAUSS** code could be used to emulate **recsercp** when the number of
rows in $x$ and $z$ is the same:

```matlab
/* assume here that rows(z) is also n */
n = rows(x);
y = zeros(n, 1);
y[1,..] = x[1,..] + z[1,..];

i = 2;
    do until i > n;
        y[i,..] = y[i-1,..] .* x[i,..] + z[i,..];
        i = i + 1;
    end;
```

Note that K series can be computed simultaneously, since $x$ and $z$ can have K columns (they must both have the same number of columns).

`recsercp` allows either $x$ or $z$ to have only 1 row.

`recsercp(x, 0)` will produce the cumulative products of the elements in $x$.

### Example

```matlab
c1 = c[1,..];
n = rows(c) - 1;
y = recsercp(x, trimr(c ./ c1,1,0));
p = c1 .* y[n,..];
```

If $x$ is a scalar and $c$ is an $(N+1)x1$ vector, the result $p$ will contain the value of the polynomial whose coefficients are given in $c$. That is:

$$p = c[1,..] \cdot x^n + c[2,..] \cdot x^{(n-1)} + \ldots + c[n+1,..];$$

Note that both $x$ and $c$ could contain more than 1 column, and then this code would evaluate the entire set of polynomials at the same time. Note also that if $x = 2$, and if
If \( c \) contains the digits of the binary representation of a number, then \( p \) will be the decimal representation of that number.

**See Also**

`recesrar`, `recesrcc`

**recesrcc**

**Purpose**

Computes a recursive series involving division.

**Format**

\[
y = \text{recesrcc}(x, \ z);
\]

**Input**

- \( x \) 1xK or Kx1 vector.
- \( z \) NxK matrix.

**Output**

- \( y \) NxK matrix in which each column is a series generated by a recursion of the form:

\[
y[1] = x \mod z[1], \quad x = \text{trunc}(x/z[1])
\]
\[ y[2] = x \mod z[2], \quad x = \text{trunc}(x/z[2]) \]
\[ y[3] = x \mod z[3], \quad x = \text{trunc}(x/z[3]) \]

\[ y[n] = x \mod z[n] \]

**Remarks**

Can be used to convert from decimal to other number systems (radix conversion).

**Example**

```plaintext
x = 2|8|10;
b = 2;
n = \maxc(\log(x) \div \log(b)) + 1;
z = \text{reshape}(b, n, \text{rows}(x));
y = \text{rev}(\text{recserrc}(x, z))';
```

The result, \( y \), will contain in its rows (note that it is transposed in the last step) the digits representing the decimal numbers \( 2, 8, \) and \( 10 \) in base \( 2 \):

```
  0 0 1 0
  1 0 0 0
  1 0 1 0
```

**Source**

recserrc.src
### See Also

recserar, recsercp

### renamefile

#### Purpose
Changes file name.

#### Format

```plaintext
ret = renamefile("oldname","newname");
```

#### Input

- **oldname**
  - string, existing file name.
- **newname**
  - string, new file name.

#### Output

- **ret**
  - scalar, 0 if successful.

#### Example

```plaintext
ret = renamefile("myfile.gss","mynewfile.gss");
```
In this example, a file in the current working directory with the name "myfile.gss" will be renamed "mynewfile.gss" in the same directory. Full path information may also be included:

```c
// On Windows
ret = renamefile("c:\\gauss13\\myfile.gss",
    "c:\\gauss13\\mynewfile.gss");

// On Linux/Mac
ret = renamefile("/home/user/gauss13/myfile.gss",
    "/home/user/gauss13/mynewfile.gss");
```

### rerun

#### Purpose
Displays the most recently created graphics file.

#### Library
pgraph

#### Format
`rerun;`

#### Remarks
`rerun` is used by the `endwind` function.

#### Source
pcart.src
**Globals**

_pcmdlin, pnotify, psilent, ptek, pzoom

**reshape**

**Purpose**

Reshapes a matrix.

**Format**

\[ y = \text{reshape}(x, \ r, \ c); \]

**Input**

- \( x \)  
  N\times K matrix.
- \( r \)  
  scalar, new row dimension.
- \( c \)  
  scalar, new column dimension.

**Output**

- \( y \)  
  \( r \times c \) matrix created from the elements of \( x \).

**Remarks**

Matrices are stored in row major order.
The first $c$ elements are put into the first row of $y$, the second in the second row, and so on. If there are more elements in $x$ than in $y$, the remaining elements are discarded. If there are not enough elements in $x$ to fill $y$, then when `reshape` runs out of elements, it goes back to the first element of $x$ and starts getting additional elements from there.

**Example**

```
if x = 5 6 7 8 then y = 1 2 3 4 5 6
    9 10 11 12
```

```
if x = 4 5 6 then y = 1 2 3 4 5 6
    7 8 9 1 2 3
```

```
if x = 6 7 8 9 10 then y = 1 2 3 4 5 6
    11 12 13 14 15
```

```
if x = 1 2 then y = 1 2 3 4 1 2
    3 4
```

```
if x = 1 then y = 1 1 1 1 1 1
    1 1 1 1 1 1
```

**See Also**

`submat`, `vec`
retp

**Purpose**

Returns from a procedure or keyword.

**Format**

```plaintext
retp;
retp(x, y, ...);
```

**Remarks**

For more details, see *Procedures and Keywords*, Chapter 1.

In a `retp` statement 0-1023 items may be returned. The items may be expressions. Items are separated by commas.

It is legal to return with no arguments, as long as the procedure is defined to return 0 arguments.

**See Also**

`proc, keyword, endp`

---

**return**

**Purpose**

Returns from a subroutine.
Format

```c
return;
return(x, y,...);
```

Remarks

The number of items that may be returned from a subroutine in a `return` statement is limited only by stack space. The items may be expressions. Items are separated by commas.

It is legal to return with no arguments and therefore return nothing.

See Also

gosub, pop

rev

Purpose

Reverses the order of the rows in a matrix.

Format

```c
y = rev(x);
```

Input

```c
x       NxK matrix.
```
Output

\[ Y \]  \text{NxK matrix containing the reversed rows of } x. 

Remarks

The first row of \( y \) will be where the last row of \( x \) was and the last row will be where the first was and so on. This can be used to put a sorted matrix in descending order.

Example

```plaintext
//Set the rng seed for repeatable results
rndseed 345345;

//Set print formatting to print 4 spaces for each column
//and 0 numbers after the decimal
format /rd 4,0

//Create some random integers
x = round(rndn(5,3)*10);

//Reverse the order of the columns
y = rev(x);

print "x = " x;
pnint "y = " y;
```

The code above produces the following output:

\[
x =
\begin{array}{ccc}
10 & -14 & -7 \\
3 & -1 & -5 \\
-7 & 4 & 2
\end{array}
\]
\[
\begin{bmatrix}
1 & 1 & 1 \\
7 & -7 & 2 \\
y = \\
7 & -7 & 2 \\
1 & 1 & 1 \\
-7 & 4 & 2 \\
3 & -1 & -5 \\
10 & -14 & -7
\end{bmatrix}
\]

**See Also**

sortc

**rfft**

**Purpose**

Computes a real 1- or 2-D Fast Fourier transform.

**Format**

\[
y = \text{rfft}(x);
\]

**Input**

\[
x \quad \text{NxK real matrix.}
\]

**Output**

\[
y \quad \text{LxM matrix, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.}
\]
Remarks

Computes the RFFT of \( x \), scaled by \( 1/(L*M) \).

This uses a Temperton Fast Fourier algorithm.

If N or K is not a power of 2, \( x \) will be padded out with zeros before computing the transform.

See Also

rfft, fft, ffli, fftm, fftmi

rfft

Purpose

Computes inverse real 1- or 2-D Fast Fourier transform.

Format

\[ y = \text{rfft}(x); \]

Input

\( x \)  
NxK matrix.

Output

\( y \)  
LxM real matrix, where L and M are the smallest prime factor products greater than or equal to N and K.
Remarks

It is up to the user to guarantee that the input will return a real result. If in doubt, use `ffti`.

See Also

`rfft`, `fft`, `ffti`, `fftm`, `fftm`i

rfftip

Purpose

Computes an inverse real 1- or 2-D FFT. Takes a packed format FFT as input.

Format

\[ y = \text{rfftip}(x); \]

Input

\[ x \quad \text{NxD matrix or K-length vector.} \]

Output

\[ y \quad \text{LxD real matrix or M-length vector.} \]

Remarks

\[ \text{rfftip} \] assumes that its input is of the same form as that output by \[ \text{rfft} \] and
**rfftnp.**

*rfftip* uses the Temperton prime factor FFT algorithm. This algorithm can compute the inverse FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. **GAUSS** implements the Temperton algorithm for any integer power of 2, 3, and 5, and one factor of 7. Thus, *rfftip* can handle any matrix whose dimensions can be expressed as:

\[2^p \times 3^q \times 5^r \times 7^s\]

\[p, q, r \geq 0\]

\[s = 0 \text{ or } 1\]

If a dimension of \(x\) does not meet this requirement, it will be padded with zeros to the next allowable size before the inverse FFT is computed. Note that *rfftip* assumes the length (for vectors) or column dimension (for matrices) of \(x\) is \(K-1\) rather than \(K\), since the last element or column does not hold FFT information, but the Nyquist frequencies.

The sizes of \(x\) and \(y\) are related as follows: \(L\) will be the smallest prime factor product greater than or equal to \(N\), and \(M\) will be twice the smallest prime factor product greater than or equal to \(K-1\). This takes into account the fact that \(x\) contains both positive and negative frequencies in the row dimension (matrices only), but only positive frequencies, and those only in the first \(K-1\) elements or columns, in the length or column dimension.

It is up to the user to guarantee that the input will return a real result. If in doubt, use *ffti*. Note, however, that *ffti* expects a full FFT, including negative frequency information, for input.

Do not pass *rfftip* the output from *rfft* or *rfftn*—it will return incorrect results. Use *rffti* with those routines.

**See Also**

*fli*, *ffti*, *fftm*, *fftn*, *rfft*, *rffti*, *rfftn*, *rfftnp*, *rfftp*
**rfftn**

**Purpose**
Computes a real 1- or 2-D FFT.

**Format**

\[ y = \text{rfftn}(x); \]

**Input**

| \( x \) | NxK real matrix. |

**Output**

| \( y \) | LxM matrix, where L and M are the smallest prime factor products greater than or equal to N and K, respectively. |

**Remarks**

`rfftn` uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. **Gauss** implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, `rfftn` can handle any matrix whose dimensions can be expressed as:

\[ 2^p \times 3^q \times 5^r \times 7^s \]

\[ p, q, r \geq 0 \quad -- \text{for rows of matrix} \]
p > 0, q, r ≥ 0 -- for columns of matrix
p > 0, q, r ≥ 0 -- for length of a vector
s = 0 or 1 -- for all dimensions

If a dimension of x does not meet these requirements, it will be padded with zeros to the next allowable size before the FFT is computed.

rfftn pads matrices to the next allowable size; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20 percent faster than a 32768x1 vector, because 33600 is a highly composite number, $2^6 \times 3 \times 5^2 \times 7$, whereas 32768 is a simple power of 2, $2^{15}$. For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to rfftn. The Run-Time Library includes two routines, optn and optnevn, for determining optimum dimensions. Use optn to determine optimum rows for matrices, and optnevn to determine optimum columns for matrices and optimum lengths for vectors.

The Run-Time Library also includes the nextn and nextnevn routines, for determining allowable dimensions for matrices and vectors. (You can use these to see the dimensions to which rfftn would pad a matrix or vector.)

rfftn scales the computed FFT by $1/(L*M)$.

See Also

fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftip, rfftnp, rfftp
**rfftnp**

**Purpose**

Computes a real 1- or 2-D FFT. Returns the results in a packed format.

**Format**

\[ y = \text{rfftnp}(x); \]

**Input**

\[ x \]

NxBB real matrix or K-length real vector.

**Output**

\[ y \]

Lx(M/2+1) matrix or (M/2+1)-length vector, where L and M are the smallest prime factor products greater than or equal to N and K, respectively.

**Remarks**

For 1-D FFT's, **rfftnp** returns the positive frequencies in ascending order in the first M/2 elements, and the Nyquist frequency in the last element. For 2-D FFT's, **rfftnp** returns the positive and negative frequencies for the row dimension, and for the column dimension, it returns the positive frequencies in ascending order in the first M/2 columns, and the Nyquist frequencies in the last column. Usually the FFT of a real function is calculated to find the power density spectrum or to perform filtering on the waveform. In both these cases only the positive frequencies are required. (See also **rfft** and **rfftn** for routines that return the negative frequencies as well.)
\texttt{rfftnp} uses the Temperton prime factor FFT algorithm. This algorithm can compute the FFT of any vector or matrix whose dimensions can be expressed as the product of selected prime number factors. \texttt{GAUSS} implements the Temperton algorithm for any power of 2, 3, and 5, and one factor of 7. Thus, \texttt{rfftnp} can handle any matrix whose dimensions can be expressed as:

\[ 2^p \times 3^q \times 5^r \times 7^s \]

\[ p, q, r \geq 0 \quad \text{-- for rows of matrix} \]

\[ p > 0, q, r \geq 0 \quad \text{-- for columns of matrix} \]

\[ p > 0, q, r \geq 0 \quad \text{-- for length of a vector} \]

\[ s = 0 \text{ or } 1 \quad \text{-- for all dimensions} \]

If a dimension of \( x \) does not meet these requirements, it will be padded with zeros to the next allowable size before the FFT is computed.

\texttt{rfftnp} pads matrices to the next allowable size; however, it generally runs faster for matrices whose dimensions are highly composite numbers, i.e., products of several factors (to various powers), rather than powers of a single factor. For example, even though it is bigger, a 33600x1 vector can compute as much as 20 percent faster than a 32768x1 vector, because 33600 is a highly composite number, \( 2^6 \times 3 \times 5^2 \times 7 \), whereas 32768 is a simple power of 2, \( 2^{15} \). For this reason, you may want to hand-pad matrices to optimum dimensions before passing them to \texttt{rfftnp}. The \texttt{Run-Time Library} includes two routines, \texttt{optn} and \texttt{optnevn}, for determining optimum dimensions. Use \texttt{optn} to determine optimum rows for matrices, and \texttt{optnevn} to determine optimum columns for matrices and optimum lengths for vectors.

The \texttt{Run-Time Library} also includes the \texttt{nextn} and \texttt{nextnevn} routines, for determining allowable dimensions for matrices and vectors. (You can use these to see the dimensions to which \texttt{rfftnp} would pad a matrix or vector.)

\texttt{rfftnp} scales the computed FFT by \( 1/(L*M) \).
See Also

fft, ffti, fftm, fftmi, fftn, rfft, rffti, rfftp, rfftm, rfftn, rfftp

**rfftp**

**Purpose**

Computes a real 1- or 2-D FFT. Returns the results in a packed format.

**Format**

\[ y = \text{rfftp}(x); \]

**Input**

\[ x \]  
NxK real matrix or K-length real vector.

**Output**

\[ y \]  
Lx(M/2+1) matrix or (M/2+1)-length vector, where L and M are the smallest powers of 2 greater than or equal to N and K, respectively.

**Remarks**

If a dimension of \( x \) is not a power of 2, it will be padded with zeros to the next allowable size before the FFT is computed.
For 1-D FFT's, \texttt{rfftp} returns the positive frequencies in ascending order in the first M/2 elements, and the Nyquist frequency in the last element. For 2-D FFT's, \texttt{rfftp} returns the positive and negative frequencies for the row dimension, and for the column dimension, it returns the positive frequencies in ascending order in the first M/2 columns, and the Nyquist frequencies in the last column. Usually the FFT of a real function is calculated to find the power density spectrum or to perform filtering on the waveform. In both these cases only the positive frequencies are required. (See also \texttt{rfft} and \texttt{rfftn} for routines that return the negative frequencies as well.)

\texttt{rfftp} scales the computed FFT by 1/(L*M).

\texttt{rfftp} uses the Temperton FFT algorithm.

\textbf{See Also}

\texttt{fft, ffti, fftm, fftmi, fftn, rfft, rfftii, rfftp, rfftn, rfftnp}

\textbf{rndBernoulli}

\textbf{Purpose}

Computes Bernoulli distributed random numbers.

\textbf{Format}

\[
\{ r, \text{newstate} \} = \text{rndBernoulli}(r, c, \text{prob}, \text{state});
\]

\[
r = \text{rndBernoulli}(r, c, \text{prob});
\]

\textbf{Input}

\[
r \quad \text{Scalar, number of rows of the output matrix.}
\]
c <Scalar, number of columns of the output matrix.>
prob<Scalar, probability parameter.>
stateOptional argument - scalar or opaque vector.

Scalar case:

state = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.

Opaque vector case:

state = the state vector returned from a previous call to one of the \texttt{rnd} random number functions.

Output

r\texttt{r x c} matrix, Bernoulli random numbers.
newstateOpaque vector, the updated state.

Example

//Bernoulli random numbers can be used to model qualitative
//binary data (i.e., yes/no, true/false), such as marital
//status.

//Set the random seed for repeatable numbers.
rndseed 723940439;

//The percentage of married people in the population we
//would like to model.
prob = 0.7;
//Create 10,000 Bernoulli random numbers
r = rndBernoulli(10000, 1, prob);

//The mean of 'r' should approximately equal 'prob'
mu = meanc(r);
print mu;
0.70270000

See Also
rndMVn, rndCreateState

rndBeta

Purpose
Computes beta pseudo-random numbers with a choice of underlying random number generator.

Format
{x, newstate} = rndBeta(r, c, a, b, state);
x = rndBeta(r, c, a, b);

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(r)</td>
<td>Scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td>(c)</td>
<td>Scalar, number of columns of resulting matrix.</td>
</tr>
</tbody>
</table>
**a**
r x c matrix, or r x 1 vector, or 1 x c vector, or scalar, first shape argument for beta distribution.

**b**
r x c matrix, or r x 1 vector, or 1 x c vector, or scalar, second shape argument for beta distribution.

**state**
Optional argument - scalar or opaque vector.

**Scalar case:**

\[ state = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]

**Opaque vector case:**

\[ state = \text{the state vector returned from a previous call to one of the } \texttt{rnd} \text{ random number functions.} \]

**Output**

**x**
r x c matrix, beta distributed random numbers.

**newstate**
Opaque vector, the updated state.

**Remarks**

The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \frac{a}{(a+b)} \\
Var(x) = \frac{ab}{((a+b+1) \times (a+b^2)} \\
0 < x < 1 \text{ for } a > 0, b > 0
\]

\( r \) and \( c \) will be truncated to integers if necessary.
Technical Notes

The default generator for **rndBeta** is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function **rndCreateState**.

**See Also**

**rndCreateState, rndStateSkip**

**rndCauchy**

**Purpose**

Computes Cauchy random numbers with a choice of underlying random number generator.

**Format**

\[
\{ r, \text{newstate} \} = \text{rndCauchy}(\text{rows}, \text{cols}, \text{location}, \text{scale}, \text{state}); \\
\]

\[
r = \text{rndCauchy}(\text{rows}, \text{cols}, \text{location}, \text{scale});
\]

**Input**

- **rows**: Scalar, number of rows of resulting matrix.
- **cols**: Scalar, number of columns of resulting matrix.
- **location**: Scalar or ExE conformable matrix with rows and cols.
- **scale**: Scalar or ExE conformable matrix with rows and cols.
**state**

Optional argument - scalar or opaque vector.

**Scalar case:**

\[ state = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]

**Opaque vector case:**

\[ state = \text{the state vector returned from a previous call to one of the standard random number functions.} \]

### Output

- **r**
  
  \[ rows \times cols \text{ matrix, Cauchy distributed random numbers.} \]

- **newstate**
  
  Opaque vector, the updated state.

### See Also

- `rndCreateState`, `rndStateSkip`

### `rndcon`, `rndmult`, `rndseed`

### Purpose

Resets the parameters of the linear congruential random number generator (RNG) that is the basis for `rndu`, `rndi` and `rndn`. 
Format

```
rndcon  c;
rndmult  a;
rndseed  seed;
```

Input

c
scalar, constant for the random number generator.

a
scalar, multiplier for the random number generator.

seed
scalar, initial seed for the random number generator.

Parameter default values and ranges:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>seed</td>
<td>time(0)</td>
<td>0 &lt; seed &lt; 2³²</td>
</tr>
<tr>
<td>a</td>
<td>1664525</td>
<td>0 &lt; a &lt; 2³²</td>
</tr>
<tr>
<td>c</td>
<td>1013904223</td>
<td>0 &lt; a &lt; 2³²</td>
</tr>
</tbody>
</table>

Remarks

A linear congruential uniform random number generator is used by `rndLCu`, and is also called by `rndLCn`. These statements (`rndcon`, `rndmult` and `rndseed`) allow the parameters of this generator to be changed. Prior to GAUSS version 12, the functions `rndn` and `rndu` also used a linear congruential generator. The current version of `rndn` and `rndu` use the Mersenne-Twister by default. `rndseed` will set the seed for the `rndn` and `rndu` if they are used without passing in a state variable. However, `rndcon` and `rndmult` do not change any of their parameters.

The procedure used by the linear congruential RNG's to generate the uniform random numbers is as follows. First, the current "seed" is used to generate a new seed:

```
new_seed = ((((a * seed) % 2³²) + c) % 2³²
```
(where \( \% \) is the mod operator). Then a number between 0 and 1 is created by dividing the new seed by \( 2^{32} \):

\[
x = \text{new\_seed} / 2^{32}
\]

\textbf{rndcon} resets \( c \).

\textbf{rndmult} resets \( a \).

\textbf{rndseed} resets \( seed \). This is the initial seed for the generator. The default is that \textbf{GAUSS} uses the clock to generate an initial seed when \textbf{GAUSS} is invoked.

\textbf{GAUSS} goes to the clock to seed the generator only when it is first started up. Therefore when using the older linear congruential generators, if \textbf{GAUSS} is allowed to run for a long time, and if large numbers of random numbers are generated, there is a possibility of recycling (that is, the sequence of "random numbers" will repeat itself). However, the generator used has an extremely long cycle, so that should not usually be a problem. NOTE: The default RNG for \textbf{rndn} and \textbf{rndu}, the Mersenne-Twister, has an extremely long period of \( 2^{19937} \).

The parameters set by these commands remain in effect until new commands are encountered, or until \textbf{GAUSS} is restarted.

\textbf{See Also}

\textbf{rndu}, \textbf{rndn}, \textbf{rndi}, \textbf{rndLCi}, \textbf{rndKMi}

\textbf{rndCreateState}

\textbf{Purpose}

Creates a new random number stream for a specified generator type from a seed value.
Format

\[ \text{state} = \text{rndCreateState}(\text{brng}, \text{seed}); \]

Input

<table>
<thead>
<tr>
<th>brng</th>
<th>String, generator name. Options include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;mrg32k3a&quot;</td>
<td>L'Ecuyer's MRG32K3A</td>
</tr>
<tr>
<td>&quot;mt19937&quot;</td>
<td>Mersenne-Twister 19937</td>
</tr>
<tr>
<td>&quot;sfmt19937&quot;</td>
<td>optimized Mersenne-Twister 19937</td>
</tr>
<tr>
<td>&quot;mt2203-01&quot;</td>
<td>Mersenne-Twister 2203</td>
</tr>
<tr>
<td>&quot;wh-01&quot;</td>
<td>Wichmann-Hill</td>
</tr>
</tbody>
</table>

| seed  | Scalar, starting seed value. if -1, GAUSS computes the starting seed based on the system clock. |

Output

| state  | Opaque vector, the newly created state. |

Example

```gauss
seed = 123456;
state = \text{rndCreateState}(\"mrg32k3a\", \text{seed});
\{ r, \text{newstate} \} = \text{rndn}(5, 1, \text{state});
```
seed = 123456;

//Create a state from the 1028th substream of the //Mersenne-Twister 2203 RNG
stateMT = _rndCreateState("mt2203-1028", seed);

//Create a state from the 112th substream of the //Wichmann-Hill RNG
stateWH = _rndCreateState("wh-112", seed);

//Generate numbers using the states
{ r1, stateMT } = _rndu(4, 1, stateMT);
{ r2, stateWH } = _rndu(4, 1, stateWH);

Remarks

The states returned from this function may NOT be used with _rndMTu or any of the _rndKM or _rndLC functions.

See Also

_rndStateSkip, _rndn, _rndu, _rndBeta
**rndExp**

**Purpose**
Computes exponentially distributed random numbers with a choice of underlying random number generator.

**Format**

\[
\{ r, newstate \} = \text{rndExp}(rows, \ cols, scale, state); \\
r = \text{rndExp}(rows, cols, scale);
\]

**Input**

- **rows**
  Scalar, number of rows of resulting matrix.

- **cols**
  Scalar, number of columns of resulting matrix.

- **location**
  Scalar or ExE conformable matrix with \( \text{rows} \) and \( \text{cols} \).

- **scale**
  Scalar or ExE conformable matrix with \( \text{rows} \) and \( \text{cols} \).

- **state**
  Optional argument - scalar or opaque vector.

  **Scalar case:**
  
  \( state = \) starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

  **Opaque vector case:**
  
  \( state = \) the state vector returned from a previous call to one of the **rnd** random number functions.
Output

\[ r \]\hspace{1em} \textit{rows x cols} matrix, exponentially distributed random numbers.

\textit{newstate} \hspace{1em} Opaque vector, the updated state.

See Also

\texttt{rndCreateState, rndStateSkip}

\texttt{rndgam}

Purpose

Computes pseudo-random numbers with gamma distribution.

Format

\[ x = \texttt{rndgam}(r, c, alpha); \]

Input

\[ r \] \hspace{1em} scalar, number of rows of resulting matrix.

\[ c \] \hspace{1em} scalar, number of columns of resulting matrix.

\[ alpha \] \hspace{1em} M\times N matrix, ExE conformable with \[ r \times c \] resulting matrix, shape parameters for gamma distribution.
Output

\( x \)  
\( r \times c \) matrix, gamma distributed pseudo-random numbers.

Remarks

The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \alpha \quad \text{Var}(x) = \alpha x > 0 \quad \alpha > 0
\]

Source

random.src

\textbf{rndGamma}

Purpose

Computes gamma pseudo-random numbers with a choice of underlying random number generator.

Format

\[
\{ x, \text{newstate} \} = \text{rndGamma}(r, c, \text{shape}, \text{scale}, \text{state});
\]

\[
x = \text{rndGamma}(r, c, \text{shape}, \text{scale});
\]

Input

\( r \)  
Scalar, number of rows of resulting matrix.
### $c$
Scalar, number of columns of resulting matrix.

### `shape`
$r \times c$ matrix, or $r \times 1$ vector, or $1 \times c$ vector, or scalar, shape argument for gamma distribution.

### `scale`
$r \times c$ matrix, or $r \times 1$ vector, or $1 \times c$ vector, or scalar, scale argument for gamma distribution.

### `state`
Optional argument - scalar or opaque vector.

**Scalar case:**

$state = $ starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

**Opaque vector case:**

$state = $ the state vector returned from a previous call to one of the **rnd** random number functions.

### Output

**$x$**
$r \times c$ matrix, gamma distributed random numbers.

**`newstate`**
Opaque vector, the updated state.

### Remarks
The properties of the pseudo-random numbers in $x$ are:

\[
E(x) = \alpha \quad \text{Var}(x) = \alpha x > 0 \quad \alpha > 0
\]
Technical Notes

The default generator for **rndGamma** is the SFMT Mersenne-Twister 1993. You can specify a different underlying random number generator with the function **rndCreateState**.

See Also

**rndCreateState**, **rndStateSkip**

**rndGeo**

Purpose

Computes geometric pseudo-random numbers with a choice of underlying random number generator.

Format

\[
\{ y, \text{newstate} \} = \text{rndGeo}(r, c, \text{prob}, \text{state});
\]
\[
y = \text{rndGeo}(r, c, \text{prob});
\]

Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>r</em></td>
<td>Scalar, row dimension.</td>
</tr>
<tr>
<td><em>c</em></td>
<td>Scalar, column dimension.</td>
</tr>
<tr>
<td><em>prob</em></td>
<td>Scalar or matrix: ExE conformatble with <em>r</em> and <em>c</em> columns.</td>
</tr>
<tr>
<td><em>state</em></td>
<td>Optional argument - scalar or opaque vector.</td>
</tr>
</tbody>
</table>

Scalar case:
\[ \text{state} = \text{starting seed value. If -1, GAUSS computes the starting seed based on the system clock.} \]

**Opaque vector case:**

\[ \text{state} = \text{the state vector returned from a previous call to one of the \texttt{rnd} random number generators.} \]

### Output

- \( y \) \( r \times c \) matrix of geometrically distributed random numbers.
- \( \text{newstate} \) Opaque vector, the updated state.

### Remarks

\( r \) and \( c \) will be truncated to integers if necessary.

### See Also

- \texttt{rndCreateState}, \texttt{rndStateSkip}

### Technical Notes

The default generator for \texttt{rndGeo} is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function \texttt{rndCreateState}. 
**rndGumbel**

**Purpose**

Computes Gumbel distributed random numbers with a choice of underlying random number generator.

**Format**

\[
\begin{align*}
\{ r, \text{newstate} \} &= \text{rndGumbel}(\text{rows}, \text{cols}, \text{location}, \text{scale}, \text{state}); \\
r &= \text{rndGumbel}(\text{rows}, \text{cols}, \text{scale});
\end{align*}
\]

**Input**

- **rows**: Scalar, number of rows of resulting matrix.
- **cols**: Scalar, number of columns of resulting matrix.
- **location**: Scalar or ExE conformable matrix with \( \text{rows} \) and \( \text{cols} \).
- **scale**: Scalar or ExE conformable matrix with \( \text{rows} \) and \( \text{cols} \).
- **state**: Optional argument - scalar or opaque vector.

**Scalar case:**

\( \text{state} = \) starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

**Opaque vector case:**

\( \text{state} = \) the state vector returned from a previous call to one of the **rnd** random number functions.
Output

\( r \) \( \text{rows x cols} \) matrix, Gumbel distributed random numbers.

\text{newstate} \quad \text{Opaque vector, the updated state.}

See Also

\text{rndCreateState, rndStateSkip}

\textbf{rndi}

Purpose

Returns a matrix of random integers, \( 0 \leq y < 2^{32} \).

Format

\[ y = \text{rndi}(r, c); \]

Input

\( r \) \quad \text{scalar, row dimension.}

\( c \) \quad \text{scalar, column dimension.}

Output

\( y \) \quad r \times c \text{ matrix of random integers between 0 and } 2^{32}-1, \text{ inclusive.}
Remarks

\( r \) and \( c \) will be truncated to integers if necessary.

This generator is automatically seeded using the system clock when GAUSS first starts. However, that can be overridden using the \texttt{rndseed} statement.

Each seed is generated from the preceding seed, using the formula

\[
\text{new}_\text{seed} = (((a * \text{seed}) \mod 2^{32}) + c) \mod 2^{32}
\]

where \( \mod \) is the mod operator. The new seeds are the values returned. The multiplicative constant and the additive constant may be changed using \texttt{rndmult} and \texttt{rndcon} respectively.

See Also

\texttt{rndu}, \texttt{rndn}, \texttt{rndcon}, \texttt{rndmult}

\textbf{rndKMBeta}

Purpose

Computes beta pseudo-random numbers.

Format

\[
\{ x, \text{newstate} \} = \texttt{rndKMBeta}(r, c, a, b, \text{state});
\]

Input

\( r \quad \) scalar, number of rows of resulting matrix.
\( c \)
scaler, number of columns of resulting matrix.

\( a \)
\( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, first shape argument for beta distribution.

\( b \)
\( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, second shape argument for beta distribution.

\( state \)
scalar or 500x1 vector.

**Scalar case:**
\[ state = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]

**500x1 vector case:**
\[ state = \text{the state vector returned from a previous call to one of the \{rn\} random number functions.} \]

**Output**

\( x \)
\( r \times c \) matrix, beta distributed random numbers.

\( newstate \)
500x1 vector, the updated state.

**Remarks**
The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \frac{a}{(a+b)} \\
Var(x) = \frac{ab}{(a+b+1) \cdot (a+b^2)} \\
0 < x < 1 \\ a > 0, b > 0
\]

\( r \) and \( c \) will be truncated to integers if necessary.
Source
randkm.src

Technical Notes

rndKMbêta uses the recur-with-carry KISS+Monster algorithm described in the
rndKMi Technical Notes.

rndKMGam

Purpose
Computes Gamma pseudo-random numbers.

Format

\[ \{ x, \text{newstate} \} = \text{rndKMGam}(r, c, \alpha, \text{state}); \]

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
<td>scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td><strong>c</strong></td>
<td>scalar, number of columns of resulting matrix.</td>
</tr>
<tr>
<td><strong>alpha</strong></td>
<td>( r \times c ) matrix, or ( r \times 1 ) vector, or ( 1 \times c ) vector, or scalar, shape argument for gamma distribution.</td>
</tr>
<tr>
<td><strong>state</strong></td>
<td>scalar or 500x1 vector.</td>
</tr>
</tbody>
</table>

Scalar case:

\[ \text{state} = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]
500x1 vector case:

\[ state = \text{the state vector returned from a previous call to one of the } \texttt{rndKM} \text{ random number functions.} \]

**Output**

- **\( x \)**: \( r \times c \) matrix, gamma distributed random numbers.
- **\( \text{newstate} \)**: 500x1 vector, the updated state.

**Remarks**

The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \alpha \quad \text{Var}(x) = \alpha x > 0 \quad \alpha > 0
\]

To generate \( \text{gamma}(\alpha, \theta) \) pseudo-random numbers where \( \theta \) is a scale parameter, multiply the result of \( \texttt{rndKMgam} \) by \( \theta \).

Thus

\[
z = \theta \times \text{rndgam}(1,1, \alpha);
\]

has the properties

\[
E(z) = \alpha \theta \quad \text{Var}(z) = \alpha \theta^2 z > 0 \quad \alpha > 0 \theta > 0
\]

\( r \) and \( c \) will be truncated to integers if necessary.

**Source**

\texttt{randkm.src}
**Technical Notes**

*rndKMgam* uses the recur-with-carry KISS+Monster algorithm described in the *rndKMi* Technical Notes.

**rndKMi**

**Purpose**

Returns a matrix of random integers, \(0 \leq y < 2^{32}\), and the state of the random number generator.

**Format**

\[
\{y, \text{newstate}\} = \text{rndKMi}(r, c, \text{state});
\]

**Input**

- \(r\) scalar, row dimension.
- \(c\) scalar, column dimension.
- \(\text{state}\) scalar or 500x1 vector.

**Scalar case:**

\(\text{state}\) = starting seed value. If -1, **GAUSS** computes the starting seed based on the system clock.

**500x1 vector case:**

\(\text{state}\) = the state vector returned from a previous call to one of the *rndKM* random number generators.
Output

<table>
<thead>
<tr>
<th>Y</th>
<th>r x c matrix of random integers between 0 and $2^{32}$ - 1, inclusive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>newstate</td>
<td>500x1 vector, the updated state.</td>
</tr>
</tbody>
</table>

Remarks

r and c will be truncated to integers if necessary.

Example

This example generates two thousand vectors of random integers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```
state = 13;
n = 2000;
k = 1000000;
c = 0;
min = 2^32+1;
max = -1;

do while c < n;
    { y,state } = rndKMi(k,l,state);
    min = minc(min | minc(y));
    max = maxc(max | maxc(y));
    c = c + k;
endo;

print "min " min;
print "max " max;
```
See Also

rndKMn, rndKMu

Technical Notes

**rndKMi** generates random integers using a KISS+Monster algorithm developed by George Marsaglia. KISS initializes the sequence used in the recur-with-carry Monster random number generator. For more information on this generator see http://www.Aptech.com/random.

**rndKMn**

**Purpose**

Returns a matrix of standard normal (pseudo) random variables and the state of the random number generator.

**Format**

\[ \{ y, newstate \} = \text{rndKMn}(r, c, state); \]

**Input**

- **r**
  
  scalar, row dimension.

- **c**
  
  scalar, column dimension.

- **state**
  
  scalar or 500x1 vector.

  **Scalar case:**

  \[ state = \text{starting seed value. If -1, GAUSS computes the starting seed based on the system clock.} \]
500x1 vector case:

\[ state = \] the state vector returned from a previous call to one of the \texttt{rndKM} random number generators.

Output

\begin{itemize}
  \item \( y \) \( r \times c \) matrix of standard normal random numbers.
  \item \( newstate \) 500x1 vector, the updated state.
\end{itemize}

Remarks

\( r \) and \( c \) will be truncated to integers if necessary.

Example

This example generates two thousand vectors of standard normal random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

\begin{verbatim}
state = 13;
n = 2000;
k = 1000000;
c = 0;
submean = {};

  do while c < n;
    \{ y, state \} = \texttt{rndKMn}(k,1,state);
    submean = submean | \texttt{meanc}(y);
    c = c + k;
  endo;
\end{verbatim}
mean = meanc(submean);
print mean;

See Also

rndKMu, rndKMi

Technical Notes


**rndKMnb**

Purpose

Computes negative binomial pseudo-random numbers.

Format

\[
\{ x, \text{newstate} \} = \text{rndKMnb}(r, c, k, p, state);
\]
**Input**

- $r$: scalar, number of rows of resulting matrix.
- $c$: scalar, number of columns of resulting matrix.
- $k$: $r 	imes c$ matrix, or $r 	imes 1$ vector, or $1 	imes c$ vector, or scalar, "event" argument for negative binomial distribution.
- $p$: $r 	imes c$ matrix, or $r 	imes 1$ vector, or $1 	imes c$ vector, or scalar, "probability" argument for negative binomial distribution.
- $state$: scalar or 500x1 vector.

**Scalar case:**

$state =$ starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.

**500x1 vector case:**

$state =$ the state vector returned from a previous call to one of the **rndKM** random number functions.

**Output**

- $x$: $r 	imes c$ matrix, negative binomial distributed random numbers.
- $newstate$: 500x1 vector, the updated state.

**Remarks**

The properties of the pseudo-random numbers in $x$ are:
\[ E(x) = \frac{k \cdot p}{1 - p} \]
\[ \text{Var}(x) = \frac{(k \cdot p)}{(1 - p)^2} \]

\[ x = 0, 1, \ldots, k > 0 < p < 1 \]

\( r \) and \( c \) will be truncated to integers if necessary.

**Source**

*randkm.src*

**Technical Notes**

*randKMnb* uses the recur-with-carry KISS+Monster algorithm described in the *rndKMi* Technical Notes.

**rndKMp**

**Purpose**

Computes Poisson pseudo-random numbers.

**Format**

\[
\{ x, \text{newstate} \} = \text{rndKMp}(r, c, \text{lambda}, \text{state});
\]

**Input**

- \( r \) : scalar, number of rows of resulting matrix.
- \( c \) : scalar, number of columns of resulting matrix.
- \( \text{lambda} \) : \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, shape argument for Poisson distribution.
### state
scalar or 500x1 vector.

**Scalar case:**

\( \text{state} = \) starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

**500x1 vector case:**

\( \text{state} = \) the state vector returned from a previous call to one of the **rndKM** random number functions.

### Output

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( r \times c ) matrix, Poisson distributed random numbers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{newstate} )</td>
<td>500x1 vector, the updated state.</td>
</tr>
</tbody>
</table>

### Remarks

The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \lambda, \quad \text{Var}(x) = \lambda, \quad x = 0, 1, \ldots, \lambda > 0
\]

\( r \) and \( c \) will be truncated to integers if necessary.

### Source

randkm.src

### Technical Notes

**rndKMP** uses the recur-with-carry KISS+Monster algorithm described in the **rndKMi** Technical Notes.
rndKMu

Purpose

Returns a matrix of uniform (pseudo) random variables and the state of the random number generator.

Format

\[ \{ y, \text{newstate} \} = \text{rndKMu}(r, c, \text{state}); \]

Input

- **r**
  - scalar, row dimension.
- **c**
  - scalar, column dimension.
- **state**
  - scalar, 2x1 vector, or 500x1 vector.

**Scalar case:**

- \( \text{state} \) = starting seed value. If -1, GAUSS computes the starting seed based on the system clock.

**2x1 vector case:**

- \( [1] \) the starting seed, uses the system clock if -1
- \( [2] \) 0 for \( 0 \leq y < 1 \)
  - 1 for \( 0 \leq y \leq 1 \)

**500x1 vector case:**

- \( \text{state} \) = the state vector returned from a previous call to one of the \text{rndKM} random number generators.
Output

\( y \) \( r \times c \) matrix of uniform random numbers, \( 0 \leq y < 1 \).

\( \text{newstate} \) 500x1 vector, the updated state.

Remarks

\( r \) and \( c \) will be truncated to integers if necessary.

Example

This example generates two thousand vectors of uniform random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```
state = 13;
n = 2000;
k = 1000000;
c = 0;
submean = {};

do while c < n;
   \{ y, state \} = \text{rndKMu}(k,1,state);
   submean = submean | \text{meanc}(y);
   c = c + k;
endo;

mean = \text{meanc}(submean);
print 0.5-mean;
```

See Also

\text{rndKMn}, \text{rndKMi}
Technical Notes

\texttt{rndKMu} uses the recur-with-carry KISS-Monster algorithm described in the \texttt{rndKMi} Technical Notes. Random integer seeds from 0 to $2^{32}-1$ are generated. Each integer is divided by $2^{32}$ or $2^{32}-1$.

\textbf{rndKMvc}

\textbf{Purpose}

Computes von Mises pseudo-random numbers.

\textbf{Format}

\[{x, newstate} = \texttt{rndKMvc}(r, c, m, k, state);\]

\textbf{Input}

\begin{itemize}
  \item \textit{r} \quad \text{scalar, number of rows of resulting matrix.}
  \item \textit{c} \quad \text{scalar, number of columns of resulting matrix.}
  \item \textit{m} \quad \text{\texttt{r x c} matrix, or \texttt{r x 1} vector, or \texttt{1 x c} vector, or scalar, means for \texttt{vm} distribution.}
  \item \textit{k} \quad \text{\texttt{r x c} matrix, or \texttt{r x 1} vector, or \texttt{1 x c} vector, or scalar, shape argument for \texttt{vm} distribution.}
  \item \textit{state} \quad \text{scalar or \texttt{500 x 1} vector.}
\end{itemize}

\textbf{Scalar case:}

\textit{state} = starting seed value only. If -1, \textbf{GAUSS} computes the starting seed based on the system clock.
500x1 vector case:

\[ state = \text{the state vector returned from a previous call to one of the \textbf{rndKM} random number functions.} \]

**Output**

\[ x \quad r \times c \text{ matrix, von Mises distributed random numbers.} \]

\[ \textit{newstate} \quad 500\times1 \text{ vector, the updated state.} \]

**Remarks**

\[ r \text{ and } c \text{ will be truncated to integers if necessary.} \]

**Source**

randkm.src

**Technical Notes**

\textbf{rndKMvm} uses the recur-with-carry KISS+Monster algorithm described in the \textbf{rndKMI} Technical Notes.

**rndLaplace**

**Purpose**

Computes Laplacian pseudo-random numbers with the choice of underlying random number generator.
**Format**

\[
\{ x, \text{newstate} \} = \text{rndLaplace}(r, c, loc, scale, state); \\
x = \text{rndLaplace}(r, c, loc, scale);
\]

**Input**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>Scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td>( c )</td>
<td>Scalar, number of columns of resulting matrix.</td>
</tr>
<tr>
<td>( loc )</td>
<td>( r \times c ) matrix, or ( r \times 1 ) vector, or ( 1 \times c ) vector, or scalar, location parameter.</td>
</tr>
<tr>
<td>( scale )</td>
<td>( r \times c ) matrix, or ( r \times 1 ) vector, or ( 1 \times c ) vector, or scalar, scale parameter.</td>
</tr>
<tr>
<td>( state )</td>
<td>Optional argument - scalar or opaque vector.</td>
</tr>
</tbody>
</table>

**Scalar case:**

\( state = \) starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

**Opaque vector case:**

\( state = \) the state vector returned from a previous call to one of the **rnd** random number functions.

**Output**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( r \times c ) matrix, Laplacian distributed random numbers.</td>
</tr>
<tr>
<td>( \text{newstate} )</td>
<td>Opaque vector, the updated state.</td>
</tr>
</tbody>
</table>
Remarks

$r$ and $c$ will be truncated to integers if necessary.

Technical Notes

The default generator for $\text{rndLaplace}$ is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function $\text{rndCreateState}$.

See Also

$\text{rndCreateState}$, $\text{rndStateSkip}$

$r\text{ndLCbeta}$

Purpose

Computes beta pseudo-random numbers. NOTE: This function is deprecated--use $\text{rndBeta}$--but remains for backward compatibility.

Format

$$\{x,\text{newstate}\} = r\text{ndLCbeta}(r, c, a, b, state);$$

Input

- $r$ scalar, number of rows of resulting matrix.
- $c$ scalar, number of columns of resulting matrix.
- $a$ $r \times c$ matrix, or $r \times 1$ vector, or $1 \times c$ vector, or scalar, first shape argument for beta distribution.
\[ b \]
\[ r \times c \text{ matrix, or } r \times 1 \text{ vector, or } 1 \times c \text{ vector, or scalar, second shape argument for beta distribution.} \]

\[ state \]
\[ \text{scalar, or } 3 \times 1 \text{ vector, or } 4 \times 1 \text{ vector.} \]

**Scalar case:**

\[ state = \text{starting seed value only. System default values are used for the additive and multiplicative constants.} \]

The defaults are 1013904223, and 1664525, respectively. These may be changed with \texttt{rndcon} and \texttt{rndmult}.

If \[ state = -1 \], \texttt{GAUSS} computes the starting seed based on the system clock.

**3x1 vector case:**

\[ [1] \text{ the starting seed, uses the system clock if } -1 \]
\[ [2] \text{ the multiplicative constant} \]
\[ [3] \text{ the additive constant} \]

**4x1 vector case:**

\[ state = \text{the state vector returned from a previous call to one of the } \texttt{rndLC} \text{ random number generators.} \]

---

**Output**

\[ x \]
\[ r \times c \text{ matrix, beta distributed random numbers.} \]

\[ newstate \]
\[ 4 \times 1 \text{ vector:} \]
\[ [1] \text{ the updated seed} \]
\[ [2] \text{ the multiplicative constant} \]
the additive constant

the original initialization seed

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, *Statistical Computing*, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

\[
new\_seed = ((a * seed) \mod 2^{32}) + c \mod 2^{32}
\]

where \( \mod \) is the mod operator and where \( a \) is the multiplicative constant and \( c \) is the additive constant.

rndLCgam

Purpose

Computes Gamma pseudo-random numbers. NOTE: This function is deprecated--use rndGamma--but remains for backward compatibility.

Format

\[
\{ x, newstate \} = \text{rndLCgam}(r, c, alpha, state);
\]
Input

\( r \) scalar, number of rows of resulting matrix.

\( c \) scalar, number of columns of resulting matrix.

\( \alpha \) \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, shape argument for gamma distribution.

\( \text{state} \) scalar, or \( 3 \times 1 \) vector, or \( 4 \times 1 \) vector.

**Scalar case:**

\( \text{state} = \) starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with `rndcon` and `rndmult`.

If \( \text{state} = -1 \), GAUSS computes the starting seed based on the system clock.

**3x1 vector case:**

\[ [1] \quad \text{the starting seed, uses the system clock if } -1 \]

\[ [2] \quad \text{the multiplicative constant} \]

\[ [3] \quad \text{the additive constant} \]

**4x1 vector case:**

\( \text{state} = \) the state vector returned from a previous call to one of the \texttt{rndLC} random number generators.
Output

\[ x \] \( r \times c \) matrix, gamma distributed random numbers.

\[ newstate \] 4x1 vector:

- [1] the updated seed
- [2] the multiplicative constant
- [3] the additive constant
- [4] the original initialization seed

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, *Statistical Computing*, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

\[ new\_seed = (((a \times seed) \% 2^{32}) + c) \% 2^{32} \]

where \( \% \) is the mod operator and where \( a \) is the multiplicative constant and \( c \) is the additive constant.

rndLCi

Purpose

Returns a matrix of random integers, \( 0 \leq y < 2^{32} \), and the state of the random number generator. NOTE: This function is deprecated but remains for
backward compatibility.

**Format**

\[ \{ y, \text{newstate} \} = \text{rndLCl}(r, c, \text{state}); \]

**Input**

- **r**: scalar, row dimension.
- **c**: scalar, column dimension.
- **state**: scalar, or 3x1 vector, or 4x1 vector.

**Scalar case:**

\( \text{state} = \) starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with \text{rndcon} and \text{rndmult}.

If \( \text{state} < 0 \), \text{GAUSS} computes the starting seed based on the system clock.

**3x1 vector case:**

- [1] the starting seed, uses the system clock if \( < 0 \)
- [2] the multiplicative constant
- [3] the additive constant

**4x1 vector case:**

\( \text{state} = \) the state vector returned from a previous call to one of the \text{rndLC} random number generators.
**Output**

\[ y \]

\[ r \times c \] matrix of random integers between 0 and \( 2^{32} - 1 \), inclusive.

\[ \text{newstate} \]

4x1 vector:

- [1] the updated seed
- [2] the multiplicative constant
- [3] the additive constant
- [4] the original initialization seed

**Remarks**

\( r \) and \( c \) will be truncated to integers if necessary.

Each seed is generated from the preceding seed, using the formula

\[
\text{new}_\text{seed} = (((a \times \text{seed}) \mod 2^{32}) + c) \mod 2^{32}
\]

where \( \mod \) is the mod operator and where \( a \) is the multiplicative constant and \( c \) is the additive constant. The new seeds are the values returned.

**Example**

```plaintext
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
min = 2**32+1;
max = -1;
```
do while c < n;
    { y, state } = rndLCi(k,1,state);
    min = min | minc(y));
    max = max | maxc(y));
    c = c + k;
end;

print "min " min;
print "max " max;

See Also

rndLCn, rndLCu, rndcon, rndmult

rndLCn

Purpose

Returns a matrix of standard normal (pseudo) random variables and the state of the random number generator. NOTE: This function is deprecated--use rndn--but remains for backward compatibility.

Format

{ y, newstate } = rndLCn(r, c, state);

Input

r

scalar, row dimension.
Scalar, column dimension.

scalar, or 3x1 vector, or 4x1 vector.

**Scalar case:**

\[state = \text{starting seed value only. System default values are used for the additive and multiplicative constants.}\]

The defaults are 1013904223, and 1664525, respectively. These may be changed with `rndcon` and `rndmult`.

**3x1 vector case:**

[1] the starting seed, uses the system clock if \(< 0\)

If \(state < 0\), **GAUSS** computes the starting seed based on the system clock.

[2] the multiplicative constant

[3] the additive constant

**4x1 vector case:**

\[state = \text{the state vector returned from a previous call to one of the } \texttt{rndLC} \text{ random number generators.}\]

**Output**

\[y \quad r \times c \text{ matrix of standard normal random numbers.}\]

\[\text{newstate} \quad 4x1 \text{ vector:}\]

[1] the updated seed

[2] the multiplicative constant
Remarks

r and c will be truncated to integers if necessary.

Example

```plaintext
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
submean = {};

  do while c < n;
    { y,state } = rndLCn(k,1,state);
    submean = submean | meanc(y);
    c = c + k;
  endo;

mean = meanc(submean);
print mean;
```

See Also

rndLCu, rndLCi, rndcon, rndmult

Technical Notes

The normal random number generator is based on the uniform random number generator, using the fast acceptance-rejection algorithm proposed by Kinderman, A.J. and J.G. Ramage, "Computer Generation of Normal Random Numbers," Journal of the American
This algorithm calls the linear congruential uniform random number generator multiple times for each normal random number generated. See \texttt{rndLCu} for a description of the uniform random number generator algorithm.

\textbf{rndLCnb}

\textbf{Purpose}

Computes negative binomial pseudo-random numbers. NOTE: This function is deprecated--use \texttt{rndNegBinomial}--but remains for backward compatibility.

\textbf{Format}

\[
\begin{align*}
\{ x, newstate \} &= \textit{rndLCnb}(r, c, k, p, state) ;
\end{align*}
\]

\textbf{Input}

\begin{itemize}
\item \textit{r} \quad \text{scalar, number of rows of resulting matrix.}
\item \textit{c} \quad \text{scalar, number of columns of resulting matrix.}
\item \textit{k} \quad r \times c \text{ matrix, or } r \times 1 \text{ vector, or } 1 \times c \text{ vector, or scalar, "event" argument for negative binomial distribution.}
\item \textit{p} \quad r \times c \text{ matrix, or } r \times 1 \text{ vector, or } 1 \times c \text{ vector, or scalar, "probability" argument for negative binomial distribution.}
\item \textit{state} \quad \text{scalar, or } 3 \times 1 \text{ vector, or } 4 \times 1 \text{ vector.}
\end{itemize}

\textbf{Scalar case:}

\textit{state} = \text{starting seed value only. System default values are}
used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with \texttt{rndcon} and \texttt{rndmult}.

If $\texttt{state} = -1$, \texttt{GAUSS} computes the starting seed based on the system clock.

\textbf{3x1 vector case:}

[1] the starting seed, uses the system clock if -1
[2] the multiplicative constant
[3] the additive constant

\textbf{4x1 vector case:}

\texttt{state} = the state vector returned from a previous call to one of the \texttt{rndLC} random number generators.

\textbf{Output}

\begin{tabular}{ll}
\textit{x} & $r \times c$ matrix, negative binomial distributed random numbers. \\
\textit{newstate} & 4x1 vector:
\end{tabular}

[1] the updated seed
[2] the multiplicative constant
[3] the additive constant
[4] the original initialization seed

\textbf{Source}

\texttt{randlc.src}

38-1318
**Technical Notes**

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, *Statistical Computing*, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

\[
new\_seed = ((a \times seed) \mod 2^{32}) + c \mod 2^{32}
\]

where \( \mod \) is the mod operator and where \( a \) is the multiplicative constant and \( c \) is the additive constant.

**rndLCp**

**Purpose**

Computes Poisson pseudo-random numbers. NOTE: This function is deprecated--use **rndPoisson**--but remains for backward compatibility.

**Format**

\[
\{ x, newstate \} = \text{rndLCp}(r, c, \lambda, state);
\]

**Input**

- \( r \)  
  scalar, row dimension.
- \( c \)  
  scalar, column dimension.
- \( \lambda \)  
  scalar, mean parameter.
- \( state \)  
  scalar, or 3x1 vector, or 4x1 vector.

**Scalar case:**
state = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with rndcon and rndmult.

3x1 vector case:

[1] the starting seed, uses the system clock if < 0

If state < 0, GAUSS computes the starting seed based on the system clock.

[2] the multiplicative constant

[3] the additive constant

4x1 vector case:

state = the state vector returned from a previous call to one of the rndLC random number generators.

Output

x

r x c matrix of Poisson distributed random numbers.

newstate

4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant

[4] the original initialization seed
**Source**
randlc.src

**Technical Notes**
This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, *Statistical Computing*, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

\[ new\_seed = ((a \ast seed) \mod 2^{32}) + c \mod 2^{32} \]

where \( \mod \) is the mod operator and where \( a \) is the multiplicative constant and \( c \) is the additive constant.

**rndLCu**

**Purpose**
Returns a matrix of uniform (pseudo) random variables and the state of the random number generator. NOTE: This function is deprecated but remains for backward compatibility.

**Format**

\[
\{ y, newstate \} = \text{rndLCu}(r, c, state);
\]

**Input**

\[ r \]
scalar, row dimension.

\[ c \]
scalar, column dimension.
`state` scalar, or 3x1 vector, or 4x1 vector.

**Scalar case:**

`state` = starting seed value only. System default values are used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with `rndcon` and `rndmult`.

**3x1 vector case:**

[1] the starting seed, uses the system clock if < 0

If `state` < 0, GAUSS computes the starting seed based on the system clock.

[2] the multiplicative constant

[3] the additive constant

**4x1 vector case:**

`state` = the state vector returned from a previous call to one of the `rndLC` random number generators.

**Output**

`y` $r \times c$ matrix of uniform (0 < $x$ < 1) random numbers.

`newstate` 4x1 vector:

[1] the updated seed

[2] the multiplicative constant

[3] the additive constant
Remarks

$r$ and $c$ will be truncated to integers if necessary.

Each seed is generated from the preceding seed, using the formula

\[ new\textunderscore seed = (((a \times seed) \mod 2^{32}) + c) \mod 2^{32} \]

where % is the mod operator and where $a$ is the multiplicative constant and $c$ is the additive constant. A number between 0 and 1 is created by dividing $new\textunderscore seed$ by $2^{32}$.

Example

```plaintext
state = 13;
n = 2000000000;
k = 1000000;
c = 0;
submean = {};

do while c < n;
    { y, state } = rndLCu(k, 1, state);
    submean = submean | mean(y);
    c = c + k;
end;

mean = mean(submean);
print 0.5-mean;
```

See Also

rndLCn, rndLCi, rndcon, rndmult
Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W. J. Jr., and J. E. Gentle, Statistical Computing, Marcel Dekker, Inc., 1980, pp. 136-147.

rndLCvm

Purpose

Computes von Mises pseudo-random numbers. NOTE: This function is deprecated but remains for backward compatibility.

Format

\[ \{ x, newstate \} = \text{rndLCvm}(r, c, m, k, state); \]

Input

- \( r \): scalar, number of rows of resulting matrix.
- \( c \): scalar, number of columns of resulting matrix.
- \( m \): \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, means for vm distribution.
- \( k \): \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, shape argument for vm distribution.
- \( state \): scalar, or \( 3 \times 1 \) vector, or \( 4 \times 1 \) vector.

Scalar case:

\( state = \) starting seed value only. System default values are

38-1324
used for the additive and multiplicative constants.

The defaults are 1013904223, and 1664525, respectively. These may be changed with `rndcon` and `rndmult`.

If `state` = -1, **GAUSS** computes the starting seed based on the system clock.

### 3x1 vector case:

- [1] the starting seed, uses the system clock if -1
- [2] the multiplicative constant
- [3] the additive constant

### 4x1 vector case:

`state` = the state vector returned from a previous call to one of the `rndLC` random number generators.

---

**Output**

- `x` \( x \times c \) matrix, von Mises distributed random numbers.
- `newstate` 4x1 vector:
  - [1] the updated seed
  - [2] the multiplicative constant
  - [3] the additive constant
  - [4] the original initialization seed
Remarks

$r$ and $c$ will be truncated to integers if necessary.

Source

randlc.src

Technical Notes

This function uses a linear congruential method, discussed in Kennedy, W.J. Jr., and J.E. Gentle, *Statistical Computing*, Marcel Dekker, Inc. 1980, pp. 136-147. Each seed is generated from the preceding seed using the formula

$$\text{new\_seed} = (((a \times \text{seed}) \mod 2^{32}) + c) \mod 2^{32}$$

where $\mod$ is the mod operator and where $a$ is the multiplicative constant and $c$ is the additive constant.

rndLogNorm

Purpose

Computes lognormal pseudo-random numbers with the choice of underlying random number generator.

Format

```plaintext
{x, newstate} = rndLogNorm(r, c, mu, sigma, state);
x = rndLogNorm(r, c, mu, sigma);
```
### Input

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>Scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td>( c )</td>
<td>Scalar, number of columns of resulting matrix.</td>
</tr>
<tr>
<td>( \mu )</td>
<td>( r \times c ) matrix, or ( r \times 1 ) vector, or ( 1 \times c ) vector, or scalar, mean.</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>( r \times c ) matrix, or ( r \times 1 ) vector, or ( 1 \times c ) vector, or scalar, standard deviation.</td>
</tr>
</tbody>
</table>
| \( state \) | Optional argument - scalar or opaque vector. 

**Scalar case:**

\( state = \) starting seed value only. If -1, **GAUSS** computes the starting seed based on the system clock.

**Opaque vector case:**

\( state = \) the state vector returned from a previous call to one of the **rnd** random number functions.

### Output

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( r \times c ) matrix, lognormal distributed random numbers.</td>
</tr>
<tr>
<td>( newstate )</td>
<td>Opaque vector, the updated state.</td>
</tr>
</tbody>
</table>

### Remarks

\( r \) and \( c \) will be truncated to integers if necessary.
Technical Notes

The default generator for `rndLogNorm` is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function `rndCreateState`.

See Also

`rndCreateState`, `rndStateSkip`

rndMVn

Purpose

Computes multivariate normal random numbers given a covariance matrix.

Format

\[
\begin{align*}
\{ r, newstate \} &= \text{rndMVn}(num, \ mu, \ cov, \ state); \\
r &= \text{rndMVn}(num, \ mu, \ cov); \\
\end{align*}
\]

Input

- `num`  
  Scalar, number of random vectors to create.
- `mu`  
  Nx1 matrix, mean vector.
- `cov`  
  NxN covariance matrix.
- `state`  
  Optional argument - scalar or opaque vector.

Scalar case:

\[ state = \text{starting seed value only. If } -1, \text{ GAUSS computes the} \]
starting seed based on the system clock.

**Opaque vector case:**

\[ state = \text{the state vector returned from a previous call to one of the \texttt{rnd} random number functions.} \]

### Output

<table>
<thead>
<tr>
<th>( r )</th>
<th>( \text{numxN matrix, multivariate normal random numbers.} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{newstate} )</td>
<td>( \text{Opaque vector, the updated state.} )</td>
</tr>
</tbody>
</table>

### See Also

\texttt{rndCreateState, rndStateSkip}

### \texttt{rndMVt}

#### Purpose

Computes multivariate Student-t distributed random numbers given a covariance matrix.

#### Format

\[
\{ r, \text{newstate} \} = \texttt{rndMVt}(\text{num, cov, df, state});
\]

\[
r = \texttt{rndMVt}(\text{num, cov, df});
\]
## Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>num</strong></td>
<td>Scalar, number of random vectors to create.</td>
</tr>
<tr>
<td><strong>cov</strong></td>
<td>NxN covariance matrix.</td>
</tr>
<tr>
<td><strong>df</strong></td>
<td>Scalar, degrees of freedom.</td>
</tr>
</tbody>
</table>
| **state** | Optional argument - scalar or opaque vector.  
**Scalar case:**  
\[ state = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]  
**Opaque vector case:**  
\[ state = \text{the state vector returned from a previous call to one of the } \texttt{rnd} \text{ random number functions.} \] |

## Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
<td>num x N matrix, multivariate student-t distributed random numbers.</td>
</tr>
<tr>
<td><strong>newstate</strong></td>
<td>Opaque vector, the updated state.</td>
</tr>
</tbody>
</table>

## See Also

`rndMVn`, `rndCreateState`
**rndn**

**Purpose**

Computes normally distributed pseudo-random numbers with a choice of underlying random number generator.

**Format**

```plaintext
{ y, newstate } = rndn(r, c, state);
y = rndn(r, c);
```

**Input**

- `r`  
  Scalar, row dimension.

- `c`  
  Scalar, column dimension.

- `state`  
  Optional argument - scalar or opaque vector.

  **Scalar case:**

  ```plaintext
  state = starting seed value. If -1, GAUSS computes the starting seed based on the system clock.
  ```

  **Opaque vector case:**

  ```plaintext
  state = the state vector returned from a previous call to one of the **rndn** random number generators.
  ```

**Output**

- `y`  
  `r x c` matrix of standard normal random numbers.
newstate  Opaque vector, the updated state.

Remarks

$r$ and $c$ will be truncated to integers if necessary.

Example

This example generates two thousand vectors of standard normal random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.

```r
state = 13;
n = 2000;
k = 1000000;
c = 0;
submean = { };

do while c < n;
    { y,state } = rndn(k,1,state);
    submean = submean | meanc(y);
    c = c + k;
endo;

mean = meanc(submean);
print mean;
```

Technical Notes

The default generator for `rndn` is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function `rndCreateState`.

See Also

`rndCreateState`, `rndStateSkip`
**rndnb**

**Purpose**

Computes pseudo-random numbers with negative binomial distribution.

**Format**

\[ x = \text{rndnb}(r, c, k, p) \; ; \]

**Input**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td>( c )</td>
<td>scalar, number of columns of resulting matrix.</td>
</tr>
<tr>
<td>( k )</td>
<td>MxN matrix, ExE conformable with ( r \times c ) resulting matrix, &quot;event&quot; parameters for negative binomial distribution.</td>
</tr>
<tr>
<td>( p )</td>
<td>KxL matrix, ExE conformable with ( r \times c ) resulting matrix, &quot;probability&quot; parameters for negative binomial distribution.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( r \times c ) matrix, negative binomial distributed pseudo-random numbers.</td>
</tr>
</tbody>
</table>

**Remarks**

The properties of the pseudo-random numbers in \( x \) are:
### Source

random.src

### rndNegBinomial

#### Purpose

Computes negative binomial pseudo-random numbers with a choice of underlying random number generator.

#### Format

```
\{ x, \text{newstate} \} = \text{rndNegBinomial}(r, c, \ ns, \text{prob, state});
x = \text{rndNegBinomial}(r, c, \ ns, \text{prob});
```

#### Input

- \(r\) Scalar, number of rows of resulting matrix.
- \(c\) Scalar, number of columns of resulting matrix.
ns  \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, "event" argument for negative binomial distribution.

prob \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, "probability" argument for negative binomial distribution.

state Optional argument - scalar or opaque vector.

**Scalar case:**

\( state = \) starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.

**Opaque vector case:**

\( state = \) the state vector returned from a previous call to one of the state returning random number functions.

**Output**

x \( r \times c \) matrix, negative binomial distributed random numbers.

newstate Opaque vector, the updated state.

**Remarks**

The properties of the pseudo-random numbers in \( x \) are:

\[
E(x) = \frac{k \cdot p}{(1 - p)}, Var(x) = \frac{k \cdot p}{(1 - p)^2}
\]

\( x = 0, 1, \ldots, k > 0, 0 < p < 1 \)

\( r \) and \( c \) will be truncated to integers if necessary.
**Technical Notes**

The default generator for `rndNegBinomial` is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function `rndCreateState`.

**See Also**

`rndCreateState`, `rndStateSkip`

---

**rndp**

**Purpose**

Computes pseudo-random numbers with Poisson distribution.

**Format**

\[ x = \text{rndp}(r, c, \lambda); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>scalar, number of rows of resulting matrix.</td>
</tr>
<tr>
<td>( c )</td>
<td>scalar, number of columns of resulting matrix.</td>
</tr>
<tr>
<td>( \lambda )</td>
<td>MxN matrix, ExE conformable with ( r \times c ) resulting matrix, shape parameters for Poisson distribution.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( r \times c ) matrix, Poisson distributed pseudo-random numbers.</td>
</tr>
</tbody>
</table>
Remarks

The properties of the pseudo-random numbers in \( x \) are:

\[
\begin{align*}
E(x) & = \lambda \\
Var(x) & = \lambda \\
x & = 0,1,2,... \\
\lambda & > 0
\end{align*}
\]

Source

random.src

**rndPoisson**

**Purpose**

Computes Poisson pseudo-random numbers with a choice of underlying random number generator.

**Format**

\[
\{ x, newstate \} = \text{rndPoisson}(r, c, \lambda, \text{state});
\]

\[
x = \text{rndPoisson}(r, c, \lambda);
\]

**Input**

\( r \)  
Scalar, number of rows of resulting matrix.

\( c \)  
Scalar, number of columns of resulting matrix.

\( \lambda \)  
\( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, mean
parameter for Poisson distribution.

\[ state \]

Optional argument, scalar or opaque vector.

**Scalar case:**

\[ state = \text{starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.} \]

**Opaque vector case:**

\[ state = \text{the state vector returned from a previous call to one of the \texttt{rndMT} random number functions.} \]

### Output

\[ x \]

\[ r \times c \text{ matrix, Poisson distributed random numbers.} \]

\[ newstate \]

Opaque vector, the updated state.

### Remarks

\[ r \text{ and } c \text{ will be truncated to integers if necessary.} \]

### Technical Notes

The default generator for \texttt{rndPoisson} is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function \texttt{rndCreateState}.

### See Also

\texttt{rndCreateState, rndStateSkip}
**rndStateSkip**

**Purpose**
To advance a state vector by a specified number of values.

**Format**

```plaintext
newState = rndStateSkip(numSkip, state);
```

**Input**

- `numSkip` Scalar, the number of values to skip.
- `state` Opaque state vector.

**Output**

- `newState` Opaque vector, the advanced state.

**Example**

```plaintext
seed = 9192834;

// Create a state from the 118th substream of the
// Wichmann-Hill RNG
state = rndCreateState("wh-118", seed);

// Create a new state that is advanced by 2 numbers.
newState = rndStateSkip(2, state);

// Create and compare numbers from the two state vectors
```
\begin{verbatim}
{ r, state } = rndu(4, 1, state);
{ r2, newState } = rndu(2, 1, newState);
\end{verbatim}

\begin{verbatim}
0.54973563
r = 0.81642451
  0.68583300
  0.09105558

r2 = 0.68583300
  0.09105558
\end{verbatim}

**Technical Notes**

This function applies ONLY to the MRG32K3A and Wichmann-Hill random number generators.

**See Also**

rndCreateState, rnd, rndu, rndBeta, rndGamma

**rndu**

**Purpose**

Computes uniform random numbers with a choice of underlying random number generator.

**Format**

\begin{verbatim}
{ y, newState } = rndu(r, c, state);
y = rndu(r, c);
\end{verbatim}
Input

\( r \)
Scalar, row dimension.

\( c \)
Scalar, column dimension.

\( state \)
Optional argument - scalar, or opaque vector.

**Scalar case:**

\( state = \) starting seed value. If -1, **GAUSS** computes the starting seed based on the system clock.

**Opaque vector case:**

\( state = \) the state vector returned from a previous call to one of the **rnd** random number generators.

Output

\( y \)
\( r \times c \) matrix of uniform random numbers, \( 0 \leq y < 1 \).

\( newstate \)
Opaque vector, the updated state.

Remarks

\( r \) and \( c \) will be truncated to integers if necessary.

Example

This example generates two thousand vectors of uniform random numbers, each with one million elements. The state of the random number generator after each iteration is used as an input to the next generation of random numbers.
state = 13;
n = 2000;
k = 1000000;
c = 0;
submean = {};

do while c < n;
    { y, state } = rndu(k, 1, state);
    submean = submean | meanc(y);
    c = c + k;
endo;

mean = meanc(submean);
print 0.5-mean;

See Also

rndCreateState, rndStateSkip

Technical Notes

The default generator for rndu is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function rndCreateState.

rndvm

Purpose

Computes von Mises pseudo-random numbers.
Format

\[ x = \text{rndvm}(r, c, m, k); \]

Input

- \( r \): scalar, number of rows of resulting matrix.
- \( c \): scalar, number of columns of resulting matrix.
- \( m \): NxK matrix, ExE conformable with \( r \times c \), means for von Mises distribution.
- \( k \): LxM matrix, ExE conformable with \( r \times c \), shape argument for von Mises distribution.

Output

- \( x \): \( r \times c \) matrix, von Mises distributed random numbers.

Source

random.src

rotater

Purpose

Rotates the rows of a matrix.
Format

\[ y = \text{rotater}(x, r); \]

Input

- \( x \): NxK matrix to be rotated.
- \( r \): Nx1 or 1x1 matrix specifying the amount of rotation.

Output

- \( y \): NxK rotated matrix.

Remarks

The rotation is performed horizontally within each row of the matrix. A positive rotation value will cause the elements to move to the right. A negative rotation value will cause the elements to move to the left. In either case, the elements that are pushed off the end of the row will wrap around to the opposite end of the same row.

If the rotation value is greater than or equal to the number of columns in \( x \), then the rotation value will be calculated using (\( r \mod \text{cols}(x) \)).

Example

\[ y = \text{rotater}(x, r); \]

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td>-1</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

If \( x = \) and \( r = \), then \( y = \).
If \( x = 1 \) and \( r = 1 \) Then \( y = 2 \)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
<td>2</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>12</td>
<td>3</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

**See Also**

*shiftr*

**rndWeibull**

**Purpose**

Computes Weibull pseudo-random numbers with the choice of underlying random number generator.

**Format**

\[
\{ x, \text{newstate} \} = \text{rndWeibull}(r, c, \text{shape, scale, state});
\]

\[
x = \text{rndWeibull}(r, c, \text{shape, scale});
\]

**Input**

- \( r \)  
  Scalar, number of rows of resulting matrix.
- \( c \)  
  Scalar, number of columns of resulting matrix.
- \( \text{shape} \)  
  \( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, shape
Parameter.

\( \text{scale} \)  
\( r \times c \) matrix, or \( r \times 1 \) vector, or \( 1 \times c \) vector, or scalar, scale parameter.

\( \text{state} \)  
Optional argument - scalar or opaque vector.

**Scalar case:**

\( \text{state} = \) starting seed value only. If -1, **Gauss** computes the starting seed based on the system clock.

**Opaque vector case:**

\( \text{state} = \) the state vector returned from a previous call to one of the \textbf{rnd} random number functions.

**Output**

\( \text{x} \)  
\( r \times c \) matrix, Weibull distributed random numbers.

\( \text{newstate} \)  
Opaque vector, the updated state.

**Remarks**

\( r \) and \( c \) will be truncated to integers if necessary.

**Technical Notes**

The default generator for \textbf{rndWeibull} is the SFMT Mersenne-Twister 19937. You can specify a different underlying random number generator with the function \textbf{rndCreateState}.

**See Also**

\textbf{rndCreateState}, \textbf{rndStateSkip}
**rndWishart**

**Purpose**

Computes Wishart distributed random numbers given a covariance matrix.

**Format**

```markdown
{ r, newstate } = rndWishart(numMats, cov, df, state);
```

```markdown
r = rndWishart(numMats, cov, df);
```

**Input**

<table>
<thead>
<tr>
<th>numMats</th>
<th>Scalar, number of Wishart random matrices to create.</th>
</tr>
</thead>
<tbody>
<tr>
<td>cov</td>
<td>NxM covariance matrix.</td>
</tr>
<tr>
<td>df</td>
<td>Scalar, degrees of freedom.</td>
</tr>
<tr>
<td>state</td>
<td>Optional argument - scalar or opaque vector.</td>
</tr>
</tbody>
</table>

**Scalar case:**

```markdown
state = starting seed value only. If -1, GAUSS computes the starting seed based on the system clock.
```

**Opaque vector case:**

```markdown
state = the state vector returned from a previous call to one of the `rnd` random number functions.
```

**Output**

| r         | numMats * rows(cov) x N matrix, wishart random      |
matrices.

\textit{newstate} Opaque vector, the updated state.

**Example**

```r
cov = \{ 1 0.5, 0.5 1 \};
df = 7;
r = \texttt{rndWishart}(1, cov, df);
```

```
r = 7.6019339 4.7744799 4.7744799 7.7341260
```

**See Also**

\texttt{rndMVn}, \texttt{rndCreateState}

**round**

**Purpose**

Round to the nearest integer.

**Format**

\[ y = \texttt{round}(x); \]

**Input**

\( x \) \hspace{1cm} \text{NxK matrix or N-dimensional array.}
Output

\[ y \text{ NxK matrix or N-dimensional array containing the rounded elements of } x. \]

Example

```javascript
let x = { 77.68 -14.10,
         4.73 -158.88
};

y = round(x);
print y;
```

78.00 -14.00
5.00 -159.00

See Also

trunc, floor, ceil

rows

Purpose

Returns the number of rows in a matrix.

Format

\[ y = \text{rows}(x); \]
Input

\( x \) \hspace{1cm} \text{NxK matrix or sparse matrix.}

Output

\( y \) \hspace{1cm} \text{scalar, number of rows in the specified matrix.}

Remarks

If \( x \) is an empty matrix, \( \text{rows}(x) \) and \( \text{cols}(x) \) return 0.

Example

\begin{verbatim}
x = \text{ones}(3,5);
y = \text{rows}(x);
print x;
\end{verbatim}

\begin{verbatim}
1.00 1.00 1.00
1.00 1.00 1.00
1.00 1.00 1.00
\end{verbatim}

\begin{verbatim}
print y;
\end{verbatim}

3.00

See Also

cols, show
**rowsf**

**Purpose**

Returns the number of rows in a **GAUSS** data set (.dat) file or **GAUSS** matrix (.fmt) file.

**Format**

\[ y = \text{rowsf}(f); \]

**Input**

\[ f \]

file handle of an open file.

**Output**

\[ y \]

scalar, number of rows in the specified file.

**Example**

```
open fp = wilshire.dat;
 r = rowsf(fp);
c = colsf(fp);
print r;
```

```
324.00
```

```
print c;
```
**See Also**
colsf, open, typef

**rref**

**Purpose**
Computes the reduced row echelon form of a matrix.

**Format**

\[ y = \text{rref}(x); \]

**Input**

\( x \)  
MxN matrix.

**Output**

\( y \)  
MxN matrix containing reduced row echelon form of \( x \).

**Remarks**
The tolerance used for zeroing elements is computed inside the procedure using:

\[ tol = \text{maxc}(m|n) \times \text{eps} \times \text{maxc}(\text{abs}(\text{sumc}(x'))); \]
where \( \epsilon = 2.24 \times 10^{-16} \).

This procedure can be used to find the rank of a matrix. It is not as stable numerically as the singular value decomposition (which is used in the `rank` function), but it is faster for large matrices.

There is some speed advantage in having the number of rows be greater than the number of columns, so you may want to transpose if all you care about is the rank.

The following code can be used to compute the rank of a matrix:

\[
r = \text{sumc} \left( \text{sumc} \left( \text{abs} \left( y' \right) \right) \right) > \text{tol};
\]

where \( y \) is the output from `rref`, and \( \text{tol} \) is the tolerance used. This finds the number of rows with any nonzero elements, which gives the rank of the matrix, disregarding numeric problems.

**Example**

```plaintext
// Since (row 2) = 2*(row 1), we do not expect this
// matrix to have full rank
x[3,3] = 1 2 3
   2 4 6
   3 5 2;
y = rref(x);

// compute rank of x
r = \text{sumc} \left( \text{sumc} \left( \text{abs} \left( \text{rref}(x)' \right) \right) \right) > 1e-15;
print "The rank of x = " r;
```

The rank of \( x \) = 2.000

**Source**

`rref.src`
run

**Purpose**

Runs a source code or compiled code program.

**Format**

```
run filename;
run -r filename;
```

**Input**

<table>
<thead>
<tr>
<th>filename</th>
<th>literal or ^string, name of file to run.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-r</td>
<td>flag, returns control to the calling program.</td>
</tr>
</tbody>
</table>

**Remarks**

The filename can be any legal file name. Filename extensions can be whatever you want, except for the compiled file extension, .gcg. Pathnames are okay. If the name is to be taken from a string variable, then the name of the string variable must be preceded by the ^ (caret) operator.

The `run` statement can be used both from the command line and within a program. If used in a program, once control is given to another program through the `run` statement, there is no return to the original program unless the flag `-r` is used.

If you specify a filename without an extension, **GAUSS** will first look for a compiled code program (i.e., a .gcg file) by that name, then a source code program by that name. For example, if you enter

```
run dog;
```
**GAUSS** will first look for the compiled code file *dog.gcg*, and run that if it finds it. If **GAUSS** cannot find *dog.gcg*, it will then look for the source code file *dog* with no extension.

If a path is specified for the file, then no additional searching will be attempted if the file is not found.

If a path is not specified, the current directory will be searched first, then each directory listed in *src_path*. The first instance found is run. *src_path* is defined in *gauss.cfg*.

```
run /gauss/myprog.prg;  // No additional search will be made if the file is not found.
run myprog.prg;          // The directories listed in *src_path* will be searched for *myprog.prg* if the file is not found in the current directory.
```

Programs can also be run by typing the filename on the OS command line when starting **GAUSS**.

**Example**

**Example 1**
```
run myprog.prg;
```

**Example 2**
```
name = "myprog.prg";
run ^name;
```

**Example 3**
x = rndn(3,3);  
run -r myprog.prg;  
y = inv(x);  
e = x*y;

In this case, **GAUSS** will execute the lines after the `run` command. If the the `-r` is omitted, the lines following the `run` command will not be executed within a program.

**See Also**

#include
**satostrC**

**Purpose**
Copies from one string array to another using a C language format specifier string for each element.

**Format**

\[ y = \text{satostrC}(sa, \ fmt); \]

**Input**

- **sa**: NxM string array.
- **fmt**: 1x1, 1xM, or Mx1 format specifier for each element copy.

**Output**

- **y**: NxM formatted string array.

**Source**

strfns.src
**See Also**

*strcombine*

**save**

**Purpose**

Saves matrices, strings, or procedures to a disk file.

**Format**

```
save vflag path=path x, lpath=y;
save path=path x;
save x;
```

**Input**

- **vflag**
  - version flag.
  - `-v89` not supported
  - `-v92` supported on UNIX, Windows
  - `-v96` supported on all platforms

See also *Foreign Language Interface*, Chapter 1, for details on the various versions. The default format can be specified in `gauss.cfg` by setting the `dat(fmt)_version` configuration variable. If `dat(fmt)_version` is not set, the default is `v96`. 
### Remarks

`save` can be used to save matrices, strings, procedures, and functions. Procedures and functions must be compiled and resident in memory before they can be `save'd.`

The following extensions will be given to files that are `save'd`:

- **matrix** .fmt
- **string** .fst
- **procedure** .fcg
- **function** .fcg
- **keyword** .fcg

If the `path=` subcommand is used with `save`, the path string will be remembered until changed in a subsequent command. This path will be used whenever none is specified. The `save` path can be overridden in any particular `save` by specifying an explicit path and filename.
Example

spath = "/gauss";
save path = ^spath x,y,z;

Save $x$, $y$, and $z$ using /gauss as the path. This path will be used for the next $\text{save}$ if none is specified.

svp = "/gauss/data";
save path = ^svp n, k, /gauss/quad1=quad;

$n$ and $k$ will be saved using /gauss/data as the $\text{save}$ path, $\text{quad}$ will be saved in /gauss with the name quad1.fmt. On platforms that use the backslash as the path separator, the double backslash is required inside double quotes to produce a backslash because it is the escape character in quoted strings. It is not required when specifying literals.

save path=/procs;

Change $\text{save}$ path to /procs.

save path = /miscdata;
save /data/mydata1 = x, y, hisdata = z;

In the above program:

$x$ would be saved in /data/mydata1.fmt
$y$ would be saved in /miscdata/y.fmt
$z$ would be saved in /miscdata/hisdata.fmt

See Also

datasave, load, saveall, saved
saveall

Purpose

Saves the current state of the machine to a compiled file. All procedures, global matrices and strings will be saved.

Format

```
saveall fname;
```

Input

```
fname          literal or ^string, the path and filename of the compiled file to be created.
```

Remarks

The file extension will be .gcg.

A file will be created containing all your matrices, strings, and procedures. No main code segment will be saved. This just means it will be a .gcg file with no main program code (see compile). The rest of the contents of memory will be saved, including all global matrices, strings, functions and procedures. Local variables are not saved. This can be used inside a program to take a snapshot of the state of your global variables and procedures. To reload the compiled image, use run or use.

```
library pgraph;
external proc xy,logx,logy,loglog,hist;
saveall pgraph;
```
This would create a file called pgraph.gcg, containing all the procedures, strings and matrices needed to run Publication Quality Graphics programs. Other programs could be compiled very quickly with the following statement at the top of each:

use pgraph;

**See Also**

compile, run, use

**saved**

**Purpose**

Writes a matrix in memory to a GAUSS data set on disk.

**Format**

\[ y = \text{saved}(x, \text{dataset}, \text{vnames}); \]

**Input**

- \(x\) \quad NxK matrix to save in .dat file.
- \(\text{dataset}\) \quad string, name of data set.
- \(\text{vnames}\) \quad string or Kx1 character vector, names for the columns of the data set.
Output

$y$ scalar, 1 if successful, otherwise 0.

Remarks

If $dataset$ is null or 0, the data set name will be $temp.dat$.

If $vnames$ is a null or 0, the variable names will begin with "X" and be numbered 1-K.

If $vnames$ is a string or has fewer elements than $x$ has columns, it will be expanded as explained under $create$.

The output data type is double precision.

Example

```plaintext
x = rndn(100,3);
dataset = "mydata";
vnames = { height, weight, age };

if not saved(x,dataset,vnames);
   errorlog "Write error";
   end;
endif;
```

Source

savload.src

See Also

load, writer, create
**savestruct**

**Purpose**
Saves a matrix of structures to a file on the disk.

**Format**

```
retcode = saveStruct(instance, file_name);
```

**Input**

- **instance**  
  MxN matrix, instances of a structure.
- **file_name**  
  string, name of file on disk to contain matrix of structures.

**Output**

- **retcode**  
  scalar, 0 if successful, otherwise it will be non-zero.

**Remarks**

The file on the disk will be given a `.fsr` extension

**Example**

```c
#include ds.sdf
struct DS p0;
p0 = reshape(dsCreate,2,3);
retc = saveStruct(p2, "p2");
```
### savewind

#### Purpose
Save the current graphic panel configuration to a file. Note: This function is for use with the deprecated PQG graphics.

#### Library
pgraph

#### Format

```c
err = savewind(filename);
```

#### Input

| filename | string, name of file |

#### Output

| err | scalar, 0 if successful, 1 if graphic panel matrix is invalid. Note that the file is written in either case. |

#### Remarks
See the discussion on using graphics panels in *Tiled Graphic Panels*, Section 1.0.1.

#### Source
pwindow.src
See Also

loadwind

scale

Purpose

Fixes the scaling for subsequent graphs. The axes endpoints and increments are computed as a best guess based on the data passed to it. Note: This function is for use with the deprecated PQG graphics.

Library

pgraph

Format

scale(x, y);

Input

\textbf{x} \quad \text{matrix, the X axis data.}
\textbf{y} \quad \text{matrix, the Y axis data.}

Remarks

\textbf{x} \text{ and } \textbf{y} \text{ must each have at least 2 elements. Only the minimum and maximum values are necessary.}
This routine fixes the scaling for all subsequent graphs until `graphset` is called. This also clears `xtics` and `ytics` whenever it is called.

If either of the arguments is a scalar missing, the main graphics function will set the scaling for that axis using the actual data.

If an argument has 2 elements, the first will be used for the minimum and the last will be used for the maximum.

If an argument has 2 elements, and contains a missing value, that end of the axis will be scaled from the data by the main graphics function.

If you want direct control over the axes endpoints and tick marks, use `xtics` or `ytics`. If `xtics` or `ytics` have been called after `scale`, they will override `scale`.

**Source**

`pscale.src`

**See Also**

`xtics`, `ytics`, `ztics`, `scale3d`

**scale3d**

**Purpose**

Fixes the scaling for subsequent graphs. The axes endpoints and increments are computed as a best guess based on the data passed to it. Note: This function is for use with the deprecated PQG graphics.
**Library**

pgraph

**Format**

```plaintext
scale3d(x, y, z);
```

**Input**

- `x`: matrix, the X axis data.
- `y`: matrix, the Y axis data.
- `z`: matrix, the Z axis data.

**Remarks**

- `x`, `y` and `z` must each have at least 2 elements. Only the minimum and maximum values are necessary.

- This routine fixes the scaling for all subsequent graphs until `graphset` is called. This also clears `xtics`, `ytics` and `ztics` whenever it is called.

- If any of the arguments is a scalar missing, the main graphics function will set the scaling for that axis using the actual data.

- If an argument has 2 elements, the first will be used for the minimum and the last will be used for the maximum.

- If an argument has 2 elements, and contains a missing value, that end of the axis will be scaled from the data by the main graphics function.
If you want direct control over the axes endpoints and tick marks, use \texttt{xtics}, \texttt{ytics}, or \texttt{ztics}. If one of these functions have been called, they will override \texttt{scale3d}.

**Source**

\texttt{pscale.src}

**See Also**

\texttt{scale, xtics, ytics, ztics}

**scalerr**

**Purpose**

Tests for a scalar error code.

**Format**

\[ y = \texttt{scalerr}(c); \]

**Input**

\[ c \]

NxK matrix or sparse matrix or N-dimensional array, generally the return argument of a function or procedure call.

**Output**

\[ y \]

Scalar or [N-2]-dimensional array, 0 if the argument is not a
scalar error code, or the value of the error code as an integer if the argument is an error code.

Remarks

Error codes in GAUSS are NaN's (Not A Number). These are not just scalar integer values. They are special floating point encodings that the math chip recognizes as not representing a valid number. See also error. scalerr can be used to test for either those error codes that are predefined in GAUSS or an error code that the user has defined using error.

If \( c \) is an N-dimensional array, \( y \) will be an [N-2]-dimensional array, where each element corresponds to a 2-dimensional array described by the last two dimensions of \( c \). For each 2-dimensional array in \( c \) that does not contain a scalar error code, its corresponding element in \( y \) will be set to zero. For each 2-dimensional array in \( c \) that does contain a scalar error code, its corresponding element in \( y \) will be set to the value of that error code as an integer. In other words, if \( c \) is a 5x5x10x10 array, \( y \) will be a 5x5 array, in which each element corresponds to a 10x10 array in \( c \) and contains either a zero or the integer value of a scalar error code.

If \( c \) is an empty matrix, scalerr will return 65535.

Certain functions will either return an error code or terminate a program with an error message, depending on the trap state. The trap command is used to set the trap state. The error code that will be returned will appear to most commands as a missing value code, but the scalerr function can distinguish between missing values and error codes and will return the value of the error code.

Following are some of the functions that are affected by the trap state:

<table>
<thead>
<tr>
<th>function</th>
<th>trap 1</th>
<th>trap 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>chol</td>
<td>10</td>
<td>Matrix not positive definite</td>
</tr>
</tbody>
</table>
invpd 20  Matrix not positive definite
solpd 30  Matrix not positive definite
/ 40  Matrix not positive definite
    (second argument not square)
41  Matrix singular
    (second argument is square)
inv 50  Matrix singular

**Example**

```plaintext
trap 1;
cm = invpd(x);
trap 0;

if scalerr(cm);
    cm = inv(x);
endif;
```

In this example, `invpd` will return a scalar error code if the matrix `x` is not positive definite. If `scalerr` returns with a nonzero value, the program will use the `inv` function, which is slower, to compute the inverse. Since the trap state has been turned off, if `inv` fails, the program will terminate with a Matrix singular error message.

**See Also**

`error`, `trap`, `trapchk`
### scalinfnanmiss

**Purpose**

Returns true if the argument is a scalar infinity, NaN, or missing value.

**Format**

\[ y = \text{scalinfnanmiss}(x); \]

**Input**

\[ x \]

NxK matrix.

**Output**

\[ y \]

Scalar, 1 if \( x \) is a scalar, infinity, NaN, or missing value, else 0.

**Example**

```plaintext
//Create an infinity
x = 1/0;

if scalInfNanMiss(x);
    print "x = " x;
else;
    print "x is Not: a Nan, Infinity, or Missing";
endif;
```
**See Also**

`isinfnanmiss`, `ismiss`, `scalmiss`

**scalmiss**

**Purpose**

Tests to see if its argument is a scalar missing value.

**Format**

\[ y = \text{scalmiss}(x); \]

**Input**

\[ x \] NxK matrix.

**Output**

\[ y \] scalar, 1 if argument is a scalar missing value, 0 if not.

**Remarks**

`scalmiss` first tests to see if the argument is a scalar. If it is not scalar, `scalmiss` returns a 0 without testing any of the elements.
To test whether any element of a matrix is a missing value, use `ismiss`. `scalmiss` will execute much faster if the argument is a large matrix, since it will not test each element of the matrix but will simply return a 0.

An element of $x$ is considered to be a missing if and only if it contains a missing value in the real part. Thus, `scalmiss` and `scalmiss` would return a 1 for complex $x = 1 + 1i$, and a 0 for $x = 1 + .i$.

**Example**

```plaintext
clear s;
do until eof(fp);
    y = readr(fp,nr);
    y = packr(y);
    if scalmiss(y);
        continue;
    endif;
    s = s+sumc(y);
endo;
```

In this example the `packr` function will return a scalar missing if every row of its argument contains missing values, otherwise it will return a matrix that contains no missing values. `scalmiss` is used here to test for a scalar missing returned from `packr`. If the test returns true, then the sum step will be skipped for that iteration of the read loop because there were no rows left after the rows containing missings were packed out.

**schtoc**

**Purpose**

Reduces any 2x2 blocks on the diagonal of the real Schur matrix returned from `schur`. The transformation matrix is also updated.
**Format**

\[
\{ \text{schc}, \text{transc} \} = \text{schtoc}(\text{sch}, \text{trans});
\]

**Input**

<table>
<thead>
<tr>
<th>\text{sch}</th>
<th>real NxN matrix in Real Schur form, i.e., upper triangular except for possibly 2x2 blocks on the diagonal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{trans}</td>
<td>real NxN matrix, the associated transformation matrix.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>\text{schc}</th>
<th>NxN matrix, possibly complex, strictly upper triangular. The diagonal entries are the eigenvalues.</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{transc}</td>
<td>NxN matrix, possibly complex, the associated transformation matrix.</td>
</tr>
</tbody>
</table>

**Remarks**

Other than checking that the inputs are strictly real matrices, no other checks are made. If the input matrix \text{sch} is already upper triangular, it is not changed. Small off-diagonal elements are considered to be zero. See the source code for the test used.

**Example**

\[
\{ \text{schc}, \text{transc} \} = \text{schtoc}(\text{schur}(a));
\]

This example calculates the complex Schur form for a real matrix \text{a}.
**Source**

`schtoc.src`

**See Also**

`schur`

**schur**

**Purpose**

Computes the Schur form of a square matrix.

**Format**

\[
\{ s, z \} = \text{schur}(x)
\]

**Input**

\(x\)

KxK matrix.

**Output**

\(s\)

KxK matrix, Schur form.

\(z\)

KxK matrix, transformation matrix.

**Remarks**

`schur` computes the real Schur form of a square matrix. The real Schur form is an
upper quasi-triangular matrix, that is, it is block triangular where the blocks are 2x2 submatrices which correspond to complex eigenvalues of \( x \). If \( x \) has no complex eigenvalues, \( s \) will be strictly upper triangular. To convert \( s \) to the complex Schur form, use the Run-Time Library function \texttt{schtoc}.

\( x \) is first reduced to upper Hessenberg form using orthogonal similarity transformations, then reduced to Schur form through a sequence of QR decompositions.

\texttt{schur} uses the ORTRAN, ORTHES and HQR2 functions from EISPACK.

\( z \) is an orthogonal matrix that transforms \( x \) into \( s \) and vice versa. Thus

\[
s = z'^*x*z;
\]

and since \( z \) is orthogonal,

\[
x = z*s*z';
\]

**Example**

```plaintext
//Generate a 5 x 5 matrix of random normal numbers
x = rndn(5, 5);
{ s, z } = schur(x);

//From formula above in Remarks section
newx = z*s*z';

//Calculate the largest difference between the elements of //x and newx
dif = maxc(maxc(abs(newx-x)));
print dif;
```

```
1.33e-14
```
See Also

hess

screen

Purpose

Controls output to the screen.

Format

\begin{verbatim}
screen on;
screen off;
screen;
\end{verbatim}

Remarks

When this is \textit{on}, the results of all print statements will be directed to the window. When this is \textit{off}, print statements will not be sent to the window. This is independent of the statement \texttt{output on}, which will cause the results of all print statements to be routed to the current auxiliary output file.

If you are sending a lot of output to the auxiliary output file on a disk drive, turning the window off will speed things up.

The \texttt{end} statement will automatically perform \texttt{output off} and \texttt{screen on}.

\texttt{screen} with no arguments will print "Screen is on" or "Screen is off" on the console.
Example

```gauss
output file = mydata.asc reset;
screen off;

format /ml/rz 1,8;
open fp = mydata;
do until eof(fp);
    print readr(fp,200);
endo;
fp = close(fp);
end;
```

The program above will write the contents of the GAUSS file mydata.dat into an ASCII file called mydata.asc. If mydata.asc already exists, it will be overwritten.

Turning the window off will speed up execution. The `end` statement above will automatically perform `output off` and `screen on`.

See Also

*output*, *end*, *new*

`searchsourcepath`

Purpose

Searches the source path and (if specified) the src subdirectory of the GAUSS installation directory for a specified file.
Format

\[ fpath = \text{searchsourcepath}(fname, \ srcdir); \]

Input

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(fname)</td>
<td>string, name of file to search for.</td>
</tr>
<tr>
<td>(srcdir)</td>
<td>scalar, one of the following:</td>
</tr>
<tr>
<td>0</td>
<td>do not search in the (src) subdirectory of the \text{GAUSS} installation directory.</td>
</tr>
<tr>
<td>1</td>
<td>search the (src) subdirectory first.</td>
</tr>
<tr>
<td>2</td>
<td>search the (src) subdirectory last.</td>
</tr>
</tbody>
</table>

Output

| \(fpath\) | string, the path of \(fname\), or null string if \(fname\) is not found. |

Remarks

The source path is set by the \(src\_path\) configuration variable in your \text{GAUSS} configuration file, \text{gauss.cfg}.

\(\text{seekr}\)

Purpose

Moves the pointer in a \text{.dat} or \text{.fmt} file to a particular row.
Format

\[ y = \text{seekr}(fh, r); \]

Input

\( fh \) scalar, file handle of an open file.
\( r \) scalar, the row number to which the pointer is to be moved.

Output

\( y \) scalar, the row number to which the pointer has been moved.

Remarks

If \( r = -1 \), the current row number will be returned.

If \( r = 0 \), the pointer will be moved to the end of the file, just past the end of the last row.

\( \text{rowsf} \) returns the number of rows in a file.

\[ \text{seekr}(fh, 0) = \text{rowsf}(fh) + 1; \]

Do NOT try to seek beyond the end of a file.

See Also

open, readr, rowsf
select (dataloop)

**Purpose**

Selects specific rows (observations) in a data loop based on a logical expression.

**Format**

```plaintext
select logical_expression;
```

**Remarks**

Selects only those rows for which `logical_expression` is TRUE. Any variables referenced must already exist, either as elements of the source data set, as extern's, or as the result of a previous `make`, `vector`, or `code` statement.

**Example**

```plaintext
select age > 40 AND sex $== 'MALE';
```

**See Also**

- delete (dataloop)

**selif**

**Purpose**

Selects rows from a matrix. Those selected are the rows for which there is a 1 in the corresponding row of `e`. 
**Format**

\[ y = \text{selif}(x, e); \]

**Input**

- **x**: NxK matrix or string array.
- **e**: Nx1 vector of 1's and 0's.

**Output**

- **y**: MxK matrix or string array consisting of the rows of \( x \) for which there is a 1 in the corresponding row of \( e \).

**Remarks**

The argument \( e \) will usually be generated by a logical expression using "dot" operators.

\( y \) will be a scalar missing if no rows are selected.

**Example**

\[ y = \text{selif}(x, x[.,2] .gt 100); \]

This example selects all rows of \( x \) in which the second column is greater than 100.

\[ \text{let } x[3,3] = 0 10 20 \]
The resulting matrix \( y \) is:

\[
\begin{array}{ccc}
30 & 40 & 50 \\
60 & 70 & 80 \\
\end{array}
\]

All rows for which the element in column 1 is greater than 0 and the element in column 3 is less than 100 are placed into the matrix \( y \).

See Also
delif, scalmiss

seqa, seqm

Purpose

\texttt{seqa} creates an additive sequence. \texttt{seqm} creates a multiplicative sequence.

Format

\[
y = \texttt{seqa(start, inc, n)};
\]

\[
y = \texttt{seqm(start, inc, n)};
\]

Input

\texttt{start} scalar specifying the first element.
\[ inc \]
scalar specifying increment.

\[ n \]
scalar specifying the number of elements in the sequence.

**Output**

\[ y \]
\( n \times 1 \) vector containing the specified sequence.

**Remarks**

For \texttt{seqa}, \( y \) will contain a first element equal to \( start \), the second equal to \( start + inc \), and the last equal to \( start + inc^{(n-1)} \).

For instance,

\begin{verbatim}
  seqa(1,1,10);
\end{verbatim}

will create a column vector containing the numbers 1, 2, ...10.

For \texttt{seqm}, \( y \) will contain a first element equal to \( start \), the second equal to \( start \times inc \), and the last equal to \( start \times inc^{n-1} \).

For instance,

\begin{verbatim}
  seqm(10,10,10);
\end{verbatim}

will create a column vector containing the numbers 10, 100,...10^{10}.

**Example**

\begin{verbatim}
  a = seqa(2,2,10)';
  print a;
\end{verbatim}
\[ m = \text{seqm}(2,2,10)'; \\
print m; \\
\]

\[
\begin{array}{cccccccccc}
2 & 4 & 6 & 8 & 10 & 12 & 14 & 16 & 18 & 20 \\
\end{array}
\]

Note that the results have been transposed in this example. Both functions return N\times1 (column) vectors.

**See Also**

recserar, recsercp

**setarray**

**Purpose**

Sets a contiguous subarray of an N-dimensional array.

**Format**

\[ \text{setarray } a, \text{ loc, src}; \]

**Input**

\(a\) N-dimensional array.

\(loc\) M\times1 vector of indices into the array to locate the subarray of interest, where M is a value from 1 to N.

\(src\) \([N-M]\)-dimensional array, matrix, or scalar.
Remarks

Setarray resets the specified subarray of \( a \) in place, without making a copy of the entire array. Therefore, it is faster than putarray.

If \( \text{loc} \) is an \( N \times 1 \) vector, then \( \text{src} \) must be a scalar. If \( \text{loc} \) is an \([N-1] \times 1\) vector, then \( \text{src} \) must be a 1-dimensional array or a \( 1 \times L \) vector, where \( L \) is the size of the fastest moving dimension of the array. If \( \text{loc} \) is an \([N-2] \times 1\) vector, then \( \text{src} \) must be a \( K \times L \) matrix, or a \( K \times L \) 2-dimensional array, where \( K \) is the size of the second fastest moving dimension.

Otherwise, if \( \text{loc} \) is an \( M \times 1 \) vector, then \( \text{src} \) must be an \([N-M]\)-dimensional array, whose dimensions are the same size as the corresponding dimensions of array \( a \).

Example

```c
a = arrayalloc(2|3|4|5|6,0);
src = arrayinit(4|5|6,5);
loc = { 2,1 };  
setarray a,loc,sr
```

This example sets the contiguous 4x5x6 subarray of a beginning at \([2,1,1,1]\) to the array \( \text{src} \), in which each element is set to the specified value 5.

See Also

putarray
setdif

**Purpose**

Returns the unique elements in one vector that are not present in a second vector.

**Format**

\[ y = \text{setdif}(v1, v2, typ); \]

**Input**

- \( v1 \)  
  
  \( \text{Nx1 vector.} \)

- \( v2 \)  
  
  \( \text{Mx1 vector.} \)

- \( typ \)  
  
  \( \text{scalar, type of data.} \)
  
  - \( 0 \) character, case sensitive.
  
  - \( 1 \) numeric.
  
  - \( 2 \) character, case insensitive.

**Output**

- \( y \)  
  
  \( \text{Lx1 vector containing all unique values that are in } v1 \text{ and are not in } v2, \text{ sorted in ascending order.} \)

**Remarks**

Place smaller vector first for fastest operation.
When there are a lot of duplicates, it is faster to remove them first with unique before calling this function.

**Example**

```javascript
let v1 = mary jane linda john;
let v2 = mary sally;
typr = 0;
y = setdif(v1,v2,typ);
```

Now, `y` is equal to:

```
  jane
  linda
  john
```

**Source**

setdif.src

**See Also**

setdifsa

**Purpose**

Returns the unique elements in one string vector that are not present in a second string vector.
Format

\[ sy = \text{setdifsa}(sv1, sv2); \]

Input

- \( sv1 \): Nx1 or 1xN string vector.
- \( sv2 \): Mx1 or 1xM string vector.

Output

- \( sy \): Lx1 vector containing all unique values that are in \( sv1 \) and are not in \( sv2 \), sorted in ascending order.

Remarks

Place smaller vector first for fastest operation.

When there are a lot of duplicates it is faster to remove them first with \texttt{unique} before calling this function.

Example

```c
string sv1 = { "mary", "jane", "linda", "john" };  
string sv2 = { "mary", "sally" };  

sy = \text{setdifsa}(sv1,sv2);  
```

Now \( sy \) is equal to:
jane
john
linda

**Source**
setdif.src

**See Also**
setdif

**setvars**

**Purpose**
Reads the variable names from a data set header and creates global matrices
with the same names.

**Format**

\[ nvec = \text{setvars}(\text{dataset}); \]

**Input**

`dataset` string, the name of the GAUSS data set. Do not use a file
extension.
Output

\( nvec \)  
N\times1 \) character vector, containing the variable names defined in the data set.

Remarks

\texttt{setvars} is designed to be used interactively.

Example

\begin{verbatim}
nvec = setvars("freq");
\end{verbatim}

Source

\texttt{vars.src}

See Also

\texttt{makevars}

\texttt{setvwrmode}

Purpose

Sets the graphics viewer mode. NOTE: This function is for use with the deprecated PQG graphics.

Library

\texttt{pgraph}
**Format**

\[
\text{oldmode} = \text{setvwrmode}(\text{mode});
\]

**Input**

<table>
<thead>
<tr>
<th>mode</th>
<th>string, new mode or null string.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;one&quot;</td>
<td>Use only one viewer.</td>
</tr>
<tr>
<td>&quot;many&quot;</td>
<td>Use a new viewer for each graph.</td>
</tr>
</tbody>
</table>

**Output**

| oldmode | string, previous \( \text{mode} \). |

**Remarks**

If \( \text{mode} \) is a null string, the current \( \text{mode} \) will be returned with no changes made.

If "one" is set, the viewer executable will be \( \text{vwr.exe} \).  

**Example**

\[
\text{oldmode} = \text{setvwrmode}("one"); \\
\text{call setvwrmode(\text{oldmode});}
\]

**Source**

pgraph.src
See Also

pqgwin

setwind

Purpose

Sets the current graphic panel to a previously created graphic panel number. NOTE: This function is for use with the deprecated PQG graphics. Use plotLayout instead.

Library

pgraph

Format

setwind(n);

Input

\( n \)  scalar, graphic panel number.

Remarks

This function selects the specified graphic panel to be the current graphic panel. This is the graphic panel in which the next graph will be drawn.

See the discussion on using graphic panels in Graphic Panels, Section 1.1.
Source

pwindow.src

See Also

begwind, endwind, getwind, nextwind, makewind, window

shell

Purpose

Executes an operating system command.

Format

shell stmt;

Input

stmt literal or ^string, the command to be executed.

Remarks

shell lets you run shell commands and programs from inside GAUSS. If a command is specified, it is executed; when it finishes, you automatically return to GAUSS. If no command is specified, the shell is executed and control passes to it, so you can issue commands interactively. You have to type exit to get back to GAUSS in that case.
If you specify a command in a string variable, precede it with the ^ (caret) as shown in the examples below.

**Example**

```plaintext
comstr = "ls ./src";
shell ^comstr;
```

This lists the contents of the ./src subdirectory, then returns to **GAUSS**.

```plaintext
shell cmp n1.fmt n1.fmt.old;
```

This compares the matrix file `n1.fmt` to an older version of itself, `n1.fmt.old`, to see if it has changed. When `cmp` finishes, control is returned to **GAUSS**.

```plaintext
shell;
```

This executes an interactive shell. The OS prompt will appear and OS commands or other programs can be executed. To return to **GAUSS**, type `exit`.

**See Also**

*exec*

*shiftr*

**Purpose**

Shifts the rows of a matrix.

**Format**

```plaintext
y = shiftr(x, s, f);
```
**Input**

- \( x \)  
  NxK matrix to be shifted.

- \( s \)  
  scalar or Nx1 vector specifying the amount of shift.

- \( f \)  
  scalar or Nx1 vector specifying the value to fill in.

**Output**

- \( y \)  
  NxK shifted matrix.

**Remarks**

The shift is performed within each row of the matrix, horizontally. If the shift value is positive, the elements in the row will be moved to the right. A negative shift value causes the elements to be moved to the left. The elements that are pushed off the end of the row are lost, and the fill value will be used for the new elements on the other end.

**Example**

```matlab
x = [1 2,
     3 4];
s = [1,
     1];
f = [99,
     999];
y = shiftr(x, s, f);
```

Now \( y \) is equal to:
99  1
4  999

x = { 1 2 3,
     4 5 6,
     7 8 9 };
s = { 0,
     1,
     2 };
f = 0;
y2 = shiftr(x,s,f);

Now y2 is equal to:

1 2 3
0 4 5
0 0 7

See Also

rotater

show

Purpose

Displays the global symbol table.
Format

```bash
show -flagssymbol;
show -flags;
show symbol;
show;
```

Input

- **flags**: flags to specify the symbol type that is shown.
  - `k`: keywords
  - `p`: procedures
  - `f`: `fn` functions
  - `m`: matrices
  - `s`: strings
  - `g`: show only symbols with global references
  - `l`: show only symbols with all local references

- **symbol**: the name of the symbol to be shown. If the last character is an asterisk (*), all symbols beginning with the supplied characters will be shown.

Remarks

If there are no arguments, the entire symbol table will be displayed.

`show` is directed to the auxiliary output if it is open.
Here is an example listing with an explanation of the columns. Note that `show` does not display the column titles shown here:

<table>
<thead>
<tr>
<th>Memory used</th>
<th>Name</th>
<th>Cplx</th>
<th>Type</th>
<th>References</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 bytes</td>
<td>a</td>
<td></td>
<td>MATRIX 4,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>672 bytes</td>
<td>add</td>
<td></td>
<td>KEYWORD</td>
<td>global</td>
<td>refs 0=1</td>
</tr>
<tr>
<td>192 bytes</td>
<td>area</td>
<td></td>
<td>FUNCTION</td>
<td>local</td>
<td>refs 1=1</td>
</tr>
<tr>
<td>256 bytes</td>
<td>c</td>
<td></td>
<td>C MATRIX 4,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>296 bytes</td>
<td>p1</td>
<td></td>
<td>PROCEDURE</td>
<td>local</td>
<td>refs 1=1</td>
</tr>
<tr>
<td>384 bytes</td>
<td>p2</td>
<td></td>
<td>PROCEDURE</td>
<td>global</td>
<td>refs 0=1</td>
</tr>
<tr>
<td>8 bytes</td>
<td>ps1</td>
<td></td>
<td>STRUCT</td>
<td>sdat</td>
<td>*</td>
</tr>
<tr>
<td>16 bytes</td>
<td>s</td>
<td></td>
<td>STRING</td>
<td>8 char</td>
<td></td>
</tr>
<tr>
<td>312 bytes</td>
<td>s1</td>
<td></td>
<td>STRUCT</td>
<td>sdat</td>
<td>1,1</td>
</tr>
<tr>
<td>40 bytes</td>
<td>sa</td>
<td></td>
<td>STRING</td>
<td>ARRAY</td>
<td>3,1</td>
</tr>
<tr>
<td>56 bytes</td>
<td>sm</td>
<td></td>
<td>SPARSE MATRIX</td>
<td>15,15</td>
<td></td>
</tr>
<tr>
<td>2104 bytes</td>
<td>token</td>
<td></td>
<td>PROCEDURE</td>
<td>local</td>
<td>refs 2=1</td>
</tr>
<tr>
<td>216 bytes</td>
<td>y</td>
<td></td>
<td>ARRAY</td>
<td>3 dims</td>
<td>2,3,4</td>
</tr>
<tr>
<td>672 bytes</td>
<td>program</td>
<td></td>
<td>space</td>
<td>used</td>
<td></td>
</tr>
<tr>
<td>12 bytes</td>
<td>global</td>
<td></td>
<td>symbols,</td>
<td>2000</td>
<td>maximum</td>
</tr>
<tr>
<td>0 bytes</td>
<td>active</td>
<td></td>
<td>locals,</td>
<td>2000</td>
<td>maximum</td>
</tr>
<tr>
<td>1 bytes</td>
<td>structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The 'Memory used' column gives the amount of memory used by each item.

The 'Name' column gives the name of each symbol.

The 'Cplx' column contains a 'C' if the symbol is a complex matrix.

The 'Type' column specifies the type of the symbol. It can be ARRAY, FUNCTION, KEYWORD, MATRIX, PROCEDURE, STRING, STRING ARRAY, or STRUCT.

If the symbol is a procedure, keyword or function, the 'References' column will show if it makes any global references. If it makes only local references, the procedure or function can be saved to disk in an `.fcg` file with the `save` command. If the function or procedure makes any global references, it cannot be saved in an `.fcg` file.
If the symbol is a structure, the 'References' column will contain the structure type. A structure pointer is indicated by a * following the structure type.

The 'Info' column depends on the type of the symbol. If the symbol is a procedure or a function, it gives the number of values that the function or procedure returns and the number of arguments that need to be passed to it when it is called. If the symbol is a matrix, sparse matrix, string array or array of structures, then the 'Info' column gives the number of rows and columns. If the symbol is a string, then it gives the number of characters in the string. If the symbol is an N-dimensional array, then it gives the orders of each dimension. As follows:

<table>
<thead>
<tr>
<th>Info</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rets=Args</td>
<td>if procedure, keyword, or function</td>
</tr>
<tr>
<td>Row,Col</td>
<td>if matrix, sparse matrix, string array, or structure</td>
</tr>
<tr>
<td>Length</td>
<td>if string</td>
</tr>
<tr>
<td>OrdN,...,Ord2,Ord1</td>
<td>if array, where N is the slowest moving dimension of the array, and Ord is the order (or size) of a dimension</td>
</tr>
</tbody>
</table>

If the symbol is an array of structures, the 'Info' column will display the size of the array. A scalar structure instance is treated as a 1x1 array of structures. If the symbol is a structure pointer, the 'Info' column will be blank.

The program space is the area of space reserved for all nonprocedure, nonfunction program code. The maximum program space can be controlled by the `new` command.

The maximum number of global and local symbols is controlled by the `maxglobals` and `maxlocals` configuration variables in `gauss.cfg`. 
**Example**

```bash
show -fpg eig*;
```

This command will show all functions and procedures that have global references and begin with `eig`.

```bash
show -m;
```

This command will show all matrices.

**See Also**

`new`, `delete`

**sin**

**Purpose**

Returns the sine of its argument.

**Format**

```plaintext
y = sin(x);
```

**Input**

`x`  
NxK matrix or N-dimensional array.
Output

\[ y \]  
N\times K\text{ matrix or N-dimensional array containing the sine of } x.

Remarks

For real data, \( x \) should contain angles measured in radians.

To convert degrees to radians, multiply the degrees by \( \pi/180 \).

Example

```plaintext
let x = { 0, .5, 1, 1.5 };  
y = \sin(x);  
print y;
```

```
0.000000  
0.479426  
0.841471  
0.997495
```

See Also

atan, cos, sinh, pi

singleindex

Purpose

Converts a vector of indices for an N-dimensional array to a scalar vector index.
Format

\[ si = \text{singleindex}(i, o); \]

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>i</code></td>
<td>Nx1 vector of indices into an N-dimensional array.</td>
</tr>
<tr>
<td><code>o</code></td>
<td>Nx1 vector of orders of an N-dimensional array.</td>
</tr>
</tbody>
</table>

Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>si</code></td>
<td>scalar, index of corresponding element in 1-dimensional array or vector.</td>
</tr>
</tbody>
</table>

Remarks

This function and its opposite, `arrayindex`, allow you to convert between an N-dimensional index and its corresponding location in a 1-dimensional object of the same size.

Example

```plaintext
orders = { 2,3,4 };

a = arrayalloc(orders,0);
ai = { 2,1,3 };
setarray a, ai, 49;
v = vecr(a);
vi = singleindex(ai,orders);

print "ai = " ai;
```
print "vi = " vi;
print "getarray(a,ai) = " getarray(a,ai);
print "v[vi] = " v[vi];

produces:

   ai =
       2.000000
       1.000000
       3.000000
   vi = 15.000000
   getarray(a,ai) = 49.000000
   v[vi] = 49.000000

This example allocates a 3-dimensional array a and sets the element corresponding to the index vector ai to 49. It then creates a vector, v, with the same data. The element in the array a that is indexed by ai corresponds to the element of the vector v that is indexed by vi.

**See Also**

arrayindex

**sinh**

**Purpose**

Computes the hyperbolic sine.

**Format**

y = sinh(x);
## Input

| $x$ | NxK matrix. |

## Output

| $y$ | NxK matrix containing the hyperbolic sines of the elements of $x$. |

## Example

```javascript
let x = { -0.5, -0.25, 0, 0.25, 0.5, 1 };
x = x * pi;
y = sinh(x);
```

The above statement produces, $y$ equal to:

| -2.301299 |
| -0.868671 |
| 0.000000  |
| 0.868671  |
| 2.301299  |
| 11.548739 |

## Source

`trig.src`
sleep

Purpose

Sleeps for a specified number of seconds.

Format

unslept = sleep(secs);

Input

secs  scalar, number of seconds to sleep.

Output

unslept  scalar, number of seconds not slept.

Remarks

secs does not have to be an integer. If your system does not permit sleeping for a fractional number of seconds, secs will be rounded to the nearest integer, with a minimum value of 1.

If a program sleeps for the full number of secs specified, sleep returns 0; otherwise, if the program is awakened early (e.g., by a signal), sleep returns the amount of time not slept.

A program may sleep for longer than secs seconds, due to system scheduling.
**solpd**

**Purpose**

Solves a set of positive definite linear equations.

**Format**

\[ x = \text{solpd}(b, A); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>NxK matrix or M-dimensional array where the last two dimensions are NxK.</td>
</tr>
<tr>
<td>(A)</td>
<td>NxN symmetric positive definite matrix or M-dimensional array where the NxN 2-dimensional arrays described by the last two dimensions are symmetric and positive definite.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>NxK matrix or M-dimensional array where the last two dimensions are NxK, the solutions for the system of equations, (Ax = b).</td>
</tr>
</tbody>
</table>

**Remarks**

\(b\) can have more than one column. If so, the system of equations is solved for each column, i.e., \(A^{\star}x[., i] = b[., i]\).
This function uses the Cholesky decomposition to solve the system directly. Therefore it is more efficient than using \( \text{inv}(A) \times b \).

If \( b \) and \( A \) are \( M \)-dimensional arrays, the sizes of their corresponding \( M-2 \) leading dimensions must be the same. The resulting array will contain the solutions for the system of equations given by each of the corresponding 2-dimensional arrays described by the two trailing dimensions of \( b \) and \( A \). In other words, for a 10x4x2 array \( b \) and a 10x4x4 array \( A \), the resulting array \( x \) will contain the solutions for each of the 10 corresponding 4x2 arrays contained in \( b \) and 4x4 arrays contained in \( A \). Therefore, \( A \times x[n,..] = b[n,..], \) for \( 1 \leq n \leq 10 \).

\texttt{solpd} does not check to see that the matrix \( A \) is symmetric. \texttt{solpd} will look only at the upper half of the matrix including the principal diagonal.

If the \( A \) matrix is not positive definite:

\begin{align*}
\text{trap 1} & \quad \text{return scalar error code 30.} \\
\text{trap 0} & \quad \text{terminate with an error message.}
\end{align*}

One obvious use for this function is to solve for least squares coefficients. The effect of this function is thus similar to that of the \( / \) operator.

If \( X \) is a matrix of independent variables, and \( Y \) is a vector containing the dependent variable, then the following code will compute the least squares coefficients of the regression of \( Y \) on \( X \):

\[
b = \texttt{solpd}(X'Y,X'X);\]

**Example**

```matlab
n = 5;
format /lo 16,8;
```
```plaintext
A = randn(n,n);
A = A'A;
x = randn(n,1);
b = A*x;

x2 = solpd(b,A);

print " X solpd(b,A) Difference";
print x-x2~x-x2;
```

produces:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.32547881</td>
<td>0.32547881</td>
<td>-4.9960036e-16</td>
<td></td>
</tr>
<tr>
<td>1.5190182</td>
<td>1.5190182</td>
<td>-1.7763568e-15</td>
<td></td>
</tr>
<tr>
<td>0.88099266</td>
<td>0.88099266</td>
<td>1.5543122e-15</td>
<td></td>
</tr>
<tr>
<td>1.8192784</td>
<td>1.8192784</td>
<td>-2.2204460e-16</td>
<td></td>
</tr>
<tr>
<td>-0.060848175</td>
<td>-0.060848175</td>
<td>1.4710455e-15</td>
<td></td>
</tr>
</tbody>
</table>

**See Also**

chol, invpd, trap

**sortc, sortcc**

**Purpose**

Sorts a matrix of numeric or character data.

**Format**

```plaintext
y = sortc(x, c);
y = sortcc(x, c);
```
**Input**

\[ x \] \quad N\times K \text{ matrix.}

\[ c \] \quad \text{scalar specifying one column of } x \text{ to sort on.}

**Output**

\[ y \] \quad N\times K \text{ matrix equal to } x \text{ and sorted on the column } c.

**Remarks**

These functions will sort the rows of a matrix with respect to a specified column. That is, they will sort the elements of a column and will arrange all rows of the matrix in the same order as the sorted column.

\texttt{sortc} assumes that the column to sort on is numeric. \texttt{sortcc} assumes that the column to sort on contains character data.

The matrix may contain both character and numeric data, but the sort column must be all of one type. Missing values will sort as if their value is below -\infty.

The sort will be in ascending order. This function uses the Quicksort algorithm.

If you need to obtain the matrix sorted in descending order, you can use:

\[ \texttt{rev(sortc}(x, c)) \]

**Example**

\[ \texttt{let x[3,3] = 4 7 3} \]
The above example code produces, $y$ equal to:

\[
\begin{array}{ccc}
1 & 3 & 2 \\
3 & 4 & 8 \\
\end{array}
\]

\[
y = \text{sortc}(x, 1);
\]

**See Also**

`rev`

**sortd**

**Purpose**

Sorts a data file on disk with respect to a specified variable.

**Format**

\[
\text{sortd}(\text{infile}, \text{outfile}, \text{keyvar}, \text{keytyp});
\]

**Input**

- `infile` string, name of input file.
- `outfile` string, name of output file, must be different.
- `keyvar` string, name of key variable.
keytyp | scalar, type of key variable.
| 1 | numeric key, ascending order.
| 2 | character key, ascending order.
| -1 | numeric key, descending order.
| -2 | character key, descending order.

Remarks

The data set *infile* will be sorted on the variable *keyvar*, and will be placed in *outfile*.

If the inputs are null ("" or 0), the procedure will ask for them.

Source

sortd.src

See Also

sortme, sorte, sortcc, sorthc, sorthcc

sorthc, sorthcc

Purpose

Sorts a matrix of numeric or character data, or a string array.
**Format**

\[ y = \text{sorthc}(x, c); \]
\[ y = \text{sorthcc}(x, c); \]

**Input**

\[ x \quad \text{NxK matrix or string array.} \]
\[ c \quad \text{scalar specifying one column of } x \text{ to sort on.} \]

**Output**

\[ y \quad \text{NxK matrix or string array equal to } x \text{ and sorted on the column } c. \]

**Remarks**

These functions will sort the rows of a matrix or string array with respect to a specified column. That is, they will sort the elements of a column and will arrange all rows of the object in the same order as the sorted column.

\text{sorthc} assumes that the column to sort on is numeric. \text{sorthcc} assumes that the column to sort on contains character data.

If \( x \) is a matrix, it may contain both character and numeric data, but the sort column must be all of one type. Missing values will sort as if their value is below \(-\infty\).

The sort is in ascending order. This function uses the heap sort algorithm.

If you need to obtain the matrix sorted in descending order, you can use:

\[ \text{rev(sorthc}(x, c)) \]
Example

```plaintext
let x[3,3]= 4 7 3
   1 3 2
   3 4 8;

//Sort x based upon the values in the third column
y = sortc(x,3);
```

This produces y equal to:

```
1 3 2
4 7 3
3 4 8
```

See Also

`sortc`, `rev`

`sortind`, `sortindc`

Purpose

Returns the sorted index of x.

Format

```plaintext
ind = sortind(x);
ind = sortindc(x);
```
**Input**

\( x \)  
N\( x \)1 column vector.

**Output**

\( ind \)  
N\( x \)1 vector representing sorted index of \( x \).

**Remarks**

\( sortind \) assumes that \( x \) contains numeric data. \( sortindc \) assumes that \( x \) contains character data.

This function can be used to sort several matrices in the same way that some other reference matrix is sorted. To do this, create the index of the reference matrix, then use \texttt{submat} to rearrange the other matrices in the same way.

**Example**

```plaintext
//Create uniform random integers between 0 and 10
x = round(10*rndu(10, 1));

ind = sortind(x);
y = x[ind];
```

After running the above code:

```
    9.00
    8.00
    0.00
    4.00
    6.00
```

\( x \) =
sortmc

**Purpose**

Sorts a matrix on multiple columns.

**Format**

\[ y = \text{sortmc}(x, v); \]

**Input**

- \( x \) : NxK matrix to be sorted.
- \( v \) : Lx1 vector containing integers specifying the columns, in order, that are to be sorted. If an element is negative, that column will be interpreted as character data.
Output

\[ y \] \quad \text{NxK sorted matrix.}

Example

\emph{sortmc} keeps all rows together. After it sorts on the first specified column, it will continue to sort the rows of the matrix using the other specified columns ONLY when there is a tie in the first column. For example:

\begin{verbatim}
x = [ 9 2 5 6,
     3 6 1 9,
     3 7 4 1,
     1 2 8 9 ];

sl = sortc(x, 1);
sm = sortmc(x, 1|2);
\end{verbatim}

will return:

\begin{verbatim}
1 2 8 9

sl = 3 7 4 1
   3 6 1 9
   9 2 5 6

sm = 1 2 8 9
    3 6 1 9
    9 2 5 6
\end{verbatim}

In the output above, we see that the difference between \texttt{sl} and \texttt{sm} is that the second and third rows have been switched. This is because \emph{sortmc} first sorted the matrix based upon row one like \emph{sortc}. Then \emph{sortmc} sorted the rows in which the first
column was the same (in our example they are both threes), based upon the values in the second column.

**Source**

```
sortmc.src
```

**See Also**

```
sortd, sorte, sortcc, sorthe, sorthec
```

**sortr, sortrc**

**Purpose**

Sorts the columns of a matrix of numeric or character data, with respect to a specified row.

**Format**

```
y = sortr(x, r);
y = sortrc(x, r);
```

**Input**

```
x       NxK matrix.
r       scalar, row of x on which to sort.
```
Output

\[ y \quad \text{NxK matrix equal to } x \text{ and sorted on row } r. \]

Remarks

These functions sort the columns of a matrix with respect to a specified row. That is, they sort the elements of a row and arrange all rows of the matrix in the same order as the sorted column.

*sortr* assumes the row on which to sort is numeric. *sortrc* assumes that the row on which to sort contains character data.

The matrix may contain both character and numeric data, but the sort row must be all of one type. Missing values will sort as if their value is below -\( \infty \).

The sort will be in left to right ascending order. This function uses the Quicksort algorithm. If you need to obtain the matrix sorted left to right in descending order (i.e., ascending right to left), use:

\[
\text{rev}(\text{sortr}(x, r)')'
\]

Example

```plaintext
//Create a 5 x 3 matrix of random integers
//between 1 and 30
x = ceil(30*randu(5, 3));

//Sort the columns based upon the first row
y = sortr(x, 1);
```

Examine the variables after the code above. Notice that the columns remain the same, but their order has changed.
If we were to use the same $x$, but sort on the 5th row:

$$y_2 = \text{sortr}(x, 5);$$

We get the following result:

$$
\begin{array}{ccc}
21.000 & 10.000 & 18.000 \\
30.000 & 11.000 & 20.000 \\
\end{array}
\quad
\begin{array}{ccc}
y_2 = 23.000 & 10.000 & 7.000 \\
9.000 & 6.000 & 20.000 \\
4.000 & 7.000 & 30.000 \\
\end{array}
$$

**spBiconjGradSol**

**Purpose**

Attempts to solve the system of linear equations $Ax = b$ using the biconjugate gradient method where $A$ is a sparse matrix.
**Format**

\[ x = \text{spBiconjGradSol}(a, b, \epsilon, \text{maxit}); \]

**Input**

- **a**
  - NxN, sparse matrix.
- **b**
  - Nx1, dense vector.
- **epsilon**
  - Method tolerance: If \( \epsilon \) is set to 0, the default tolerance is set to \( 1e-6 \).
- **maxit**
  - Maximum number of iterations. If \( \text{maxit} \) is set to 0, the default setting is 300 iterations.

**Output**

- **x**
  - Nx1 dense vector.

**Example**

```plaintext
nz = [33.446, 82.641, -12.710, -25.062, 0.000,
     0.000, -26.386, 17.016, 21.576, -45.273,
     0.000, -42.331, -47.902, 0.000, 0.000,
     0.000, -26.517, -22.135, -76.827, 31.920,
     10.364, -29.843, -20.277, 0.000, 65.816];

b = [10.349,
     -3.117,
     4.240,
     0.013,
     2.115];
```
sparse matrix a;
a = densesosp(nz,0);

//Setting the third and fourth arguments to 0 employs the
//default tolerance and maxit settings
x = spBiconjGradSol(a,b,0,0);

//Solve the system of equations using the '/' operator for
//comparison
x2 = b/a;

The output from the above code:

\[
x = \begin{bmatrix}
0.135 \\
0.055 \\
-0.137 \\
0.018 \\
-0.006 \\
\end{bmatrix}
\]

\[
x2 = \begin{bmatrix}
0.135 \\
0.055 \\
-0.137 \\
0.018 \\
-0.006 \\
\end{bmatrix}
\]

Remarks

If convergence is not reached within the maximum number of iterations allowed, the
function will either terminate the program with an error message or return an error
code which can be tested for with the scalerr function. This depends on the trap
state as follows:
trap 1    return error code: 60
trap 0    terminate with error message: Unable to converge in
allowed number of iterations.

If matrix A is not well conditioned use the / operator to perform the solve. If the
matrix is symmetric, spConjGradSol will be approximately twice as fast as
spBiconjGradSol.

See Also

spConjGradSol

spChol

Purpose

Computes the LL' decomposition of a sparse matrix A.

Format

\[ l = \text{spChol}(a); \]

Input

\[ a \]    
N\text{xN}, symmetric, positive definite sparse matrix.

Output

\[ l \]    
N\text{xN} lower-triangular sparse matrix.
Example

sparse matrix A;
sparse matrix L;

//Create a small, simple positive-definite matrix
let x = { 9.53984224e+001 -5.84272701e+000 1.99970335e+001,
          -5.84272701e+000 1.09765831e+002 2.52038945e+000,
          1.99970335e+001 2.52038945e+000 4.71834812e+000
};

//Create the sparse matrix A from x, keeping all elements
A = denseToSp(x, 0);

//Create matrix factorization
L = spChol(A);

See Also

spLDL, spLU

Technical Notes

spChol implements functions from the TAUCS library: TAUCS Version 2.2.
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All Rights Reserved.
**spConjGradSol**

**Purpose**

Attempts to solve the system of linear equations $Ax = b$ using the conjugate gradient method where $A$ is a symmetric sparse matrix.

**Format**

```plaintext
x = spConjGradSol(a, b, epsilon, maxit);
```

**Input**

- $a$ : NxN, symmetric sparse matrix.
- $b$ : Nx1, dense vector.
- $epsilon$ : Method tolerance: If $epsilon$ is set to 0, the default tolerance is set to $1e-6$.
- $maxit$ : Maximum number of iterations. If $maxit$ is set to 0, the default setting is 300 iterations.

**Output**

- $x$ : Nx1 dense vector

**Example**

```plaintext
nz = { 0.000 2845.607 0.000 0.000 0.000,
      2845.607 10911.430 0.000 0.000 0.000,
      ...
      }
```
sparse matrix a;

//Set 'a' to be a sparse matrix with the same contents as 
//the dense matrix 'nz'
a = densesp(nz,0);

//Create our right-hand-side
b = { 10.349,
    -3.117,
    4.240,
    0.013,
    2.115 };

//Setting the third and fourth arguments to 0 employs the 
//default tolerance maxit settings
x = spConjGradSol(a,b,0,0);

newb = a*x;

The results from the above code are:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.01504075</td>
<td>0.00363683</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>0.00203504</td>
<td>-0.00033936</td>
<td>0.00084234</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.34900000</td>
<td>-3.11700000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>newb</td>
<td>4.24000000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

38-1427
Remarks

If convergence is not reached within the maximum number of iterations allowed, the function will either terminate the program with an error message or return an error code which can be tested for with the `scalerr` function. This depends on the trap state as follows:

- **trap 1**: return error code: 60
- **trap 0**: terminate with error message: Unable to converge in allowed number of iterations.

If matrix A is not symmetric or well conditioned use the `/` operator to perform the solve. For a nonsymmetric, but well conditioned matrix A, use `spBiconjGradSol`.

See Also

- `spBiconjGradSol`

`spCreate`

Purpose

Creates a sparse matrix from vectors of non-zero values, row indices, and column indices.

Format

\[ y = \text{spCreate}(r, c, \text{vals}, \text{rinds}, \text{cinds}); \]
Input

- $r$ scalar, rows of output matrix.
- $c$ scalar, columns of output matrix.
- $vals$ Nx1 vector, non-zero values.
- $rinds$ Nx1 vector, row indices of corresponding non-zero values.
- $cinds$ Nx1 vector, column indices of corresponding non-zero values.

Output

- $y$ $r \times c$ sparse matrix.

Remarks

Since sparse matrices are strongly typed in GAUSS, $y$ must be defined as a sparse matrix before the call to $spCreate$.

Example

```gauss
//Declare 'y' to be a sparse matrix
sparse matrix y;

//Create the non-zero values to place in the sparse matrix
vals = {1.7, 2.4, 3.2, 4.5};

//Set the row and column indices for the location in which
```
//to place each successive element of 'vals' into the new
//matrix
rinds = { 2, 5, 8, 13 };
cinds = { 4, 1, 9, 5 };

y = spCreate(15, 10, vals, rinds, cinds);

This example creates a 15x10 sparse matrix y, containing the following non-zero values:

<table>
<thead>
<tr>
<th>Non-zero value</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>(2,4)</td>
</tr>
<tr>
<td>2.4</td>
<td>(5,1)</td>
</tr>
<tr>
<td>3.2</td>
<td>(8,9)</td>
</tr>
<tr>
<td>4.5</td>
<td>(13,5)</td>
</tr>
</tbody>
</table>

See Also

packedToSp, denseToSp, spEye

spDenseSubmat

Purpose

Returns a dense submatrix of a sparse matrix.

Format

\[ y = \text{spDenseSubmat}(x, \ rinds, \ cinds); \]
**Input**

\[ x \quad \text{MxN sparse matrix.} \]
\[ rinds \quad \text{Kx1 vector, row indices.} \]
\[ cinds \quad \text{Lx1 vector, column indices.} \]

**Output**

\[ y \quad \text{KxL dense matrix, the intersection of } rinds \text{ and } cinds. \]

**Remarks**

If \( rinds \) or \( cinds \) are scalar zeros, all rows or columns will be returned.

**Example**

```plaintext
sparse matrix y;
x = { 0 0 0 10,
     0 2 0 0,
     0 0 0 0,
     5 0 0 0,
     0 0 0 3 };;

//Set 'y' to be a sparse matrix with the same values as 'x'
y = denseToSp(x,0);

//Extract a submatrix from 'y' with all rows of 'y' and
//columns 1, 3 and 4
d = spDenseSubmat(y,0,1|3|4);
```
Now $d$ is equal to:

$$
\begin{array}{ccc}
0 & 0 & 10 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
5 & 0 & 0 \\
0 & 0 & 3 \\
\end{array}
$$

**See Also**

spSubmat

**spDiagRvMat**

**Purpose**

Inserts submatrices along the diagonal of a sparse matrix.

**Format**

$$
y = \text{spDiagRvMat}(x, \text{inds}, \text{size}, a);
$$

**Input**

- $x$ MxN sparse matrix.
- $\text{inds}$ Kx2 vector or scalar 0, row and column indices into $x$ at which to place the corresponding submatrices in $a$.
- $\text{size}$ Kx2 vector or scalar 0, sizes of the corresponding submatrices in $a$.
- $a$ KxLxP array, containing the submatrices to insert into $x$. 

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Output

\[ y \] MxN sparse matrix, a copy of \( x \) containing the specified insertions.

Remarks

Each row of \( \text{inds} \) must contain the row and column indices, respectively, that form the starting point for the insertion of the corresponding submatrix in \( a \). If \( \text{inds} \) is a scalar 0, the starting point for the insertion of each submatrix will be one row and one column past the ending point of the previous insertion. The first insertion will begin at the [1,1] element.

Each row of \( \text{size} \) must contain the number of rows and columns in the corresponding submatrix in \( a \). This allows you to insert submatrices of different sizes \( L \times P \) by inserting them into the planes of an array that is \( K \times \text{MAX}(L) \times \text{MAX}(P) \) and padding the submatrices with zeros to \( \text{MAX}(L) \times \text{MAX}(P) \). For each plane in \( a \), \text{spDiagRvMat} extracts the submatrix \( a[i,1:size[i,1],1:size[i,2]] \) and inserts that into \( x \) at the location indicated by the corresponding row of \( \text{inds} \). If \( \text{size} \) is a scalar 0, then each \( L \times P \) plane of \( a \) is inserted into \( x \) as is.

Example

```c
declare sparse matrix x, y;

//Create a 10x10 sparse identity matrix
x = spEye(10);

sx1 = { 2 3, 5 8 };
sx2 = { 8 2 3 4, 7 9 5 6, 3 2 8 4 };
sx3 = { 4 7 2, 6 5 3 };
```
sx4 = { 9, 3 };

//Create a 4x3x4 dimensional array with every element set to 0
a = arrayinit(4|3|4,0);

//Set some of the array values
a[1,1:2,1:2] = sx1;
a[2,. ,.] = sx2;
a[3,1:2,1:3] = sx3;
a[4,1:2,1] = sx4;

The value of a is now:

<table>
<thead>
<tr>
<th>Plane [1,. ,]</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.0000000</td>
<td>3.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td></td>
<td>5.0000000</td>
<td>8.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td></td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [2,. ,]</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.0000000</td>
<td>2.0000000</td>
<td>3.0000000</td>
<td>4.0000000</td>
</tr>
<tr>
<td></td>
<td>7.0000000</td>
<td>9.0000000</td>
<td>5.0000000</td>
<td>6.0000000</td>
</tr>
<tr>
<td></td>
<td>3.0000000</td>
<td>2.0000000</td>
<td>8.0000000</td>
<td>4.0000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [3,. ,]</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.0000000</td>
<td>7.0000000</td>
<td>2.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td></td>
<td>6.0000000</td>
<td>5.0000000</td>
<td>3.0000000</td>
<td>0.0000000</td>
</tr>
<tr>
<td></td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plane [4,. ,]</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
<td>0.0000000</td>
</tr>
</tbody>
</table>
inds = 0;
siz = \{ 2 2, 3 4, 2 3, 2 1 \};

\[ y = \text{spDiagRvMat}(x, \text{inds}, \text{siz}, a); \]

The output, in variable \( y \), is:

\[
\begin{pmatrix}
2 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
5 & 8 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 8 & 2 & 3 & 4 & 0 & 0 & 0 & 0 \\
0 & 0 & 7 & 9 & 5 & 6 & 0 & 0 & 0 & 0 \\
0 & 0 & 3 & 2 & 8 & 4 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 4 & 7 & 2 & 0 \\
0 & 0 & 0 & 0 & 0 & 6 & 5 & 3 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 9 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 3 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix}
\]

**spEigv**

**Purpose**

Computes a specified number of eigenvalues and eigenvectors of a square, sparse matrix \( a \).

**Format**

\[
\{ \text{va}, \text{ve} \} = \text{spEigv}(a, \text{nev}, \text{which}, \text{tol}, \text{maxit}, \text{ncv});
\]
**Input**

- **a**
  - NxN square, sparse matrix.

- **nev**
  - Scalar, number of eigenvalues to compute.

- **which**
  - String, may be one of the following: "LM" largest magnitude, "LR" largest real, "LI" largest imaginary, "SR" smallest real, or "SI" smallest imaginary. Default input 0, sets which to "LM."

- **tol**
  - Scalar, tolerance for eigenvalues. Default input 0, sets tol to 1e-15.

- **maxit**
  - Scalar, maximum number of iterations. Default input 0, sets maxit to nev x (columns of a) x 100.

- **ncv**
  - Scalar, size of Arnoldi factorization. The minimum setting is the greater of nev+2 and 20. See Remarks on how to set ncv. Default input 0, sets ncv to 2x nev+1.

**Output**

- **va**
  - nevx1 dense vector containing the computed eigenvalues of input matrix a.

- **ve**
  - Nx nev dense matrix containing the corresponding eigenvectors of input matrix a.

**Example**

```
randseed 3456;
```
sparse matrix a;
x = 10*randn(5,5);
a = densetosp(x,4);

0.0000000 -4.4011007 10.445221 -5.1742289 -16.336474  
a = 0.0000000 -20.853017 7.6285434 0.0000000 -15.626397  
-12.637055 8.1227002 0.0000000 -8.7817892 0.0000000  
0.0000000 -7.8181517 15.326816 0.0000000 0.0000000

{ va, ve } = spEigv(a,2,0,0,0,0);
/* equivalent to call { va, ve } = spEigv(a,2,"LM",1e-15,2  
*5*100,5); */

va = 21.089832  
-3.4769986 + 20.141970i

ve = -0.92097057 0.29490584 - 0.38519280i  
-0.10091920 -0.18070330 - 0.38405816i  
0.061241324 0.24121182 - 0.56419722i  
0.36217049 0.017643612 + 0.26254313i  
0.081917964 -0.31466284 - 0.19936942i

Below we show that the first eigenvalue times the corresponding eigenvector (1)  
equals the input matrix times the first eigenvector (2).

(1) va[1]*ve[.,1] = (2) a*ve[.,1] =  
-19.423115  
-2.1283690  
1.2915693  
7.6381149  
1.7276361  
-19.423115  
-2.1283690  
1.2915693  
7.6381149  
1.7276361
Remarks

The ideal setting for input $ncv$ is problem dependent and cannot be easily predicted ahead of time. Increasing $ncv$ will increase the amount of memory used during computation. For a large, sparse matrix, $ncv$ should be small compared to the order of input matrix $a$. $spEigv$ is not thread-safe.

Technical Notes

$spEigv$ implements functions from the ARPACK library.

spEye

**Purpose**

Creates a sparse identity matrix.

**Format**

$$y = spEye(n);$$

**Input**

$n$ scalar, order of identity matrix.

**Output**

$y$ $n \times n$ sparse identity matrix.
Remarks

Since sparse matrices are strongly typed in GAUSS, $y$ must be defined as a sparse matrix before the call to `spEye`.

Example

```plaintext
//Declare 'y' a sparse matrix
sparse matrix y;

//Create 3x3 sparse identity matrix
y = spEye(3);
```

$y$ is now equal to:

```
1 0 1
0 1 0
0 0 1
```

See Also

`spCreate`, `spOnes`, `denseToSp`

spGetNZE

Purpose

Returns the non-zero values in a sparse matrix, as well as their corresponding row and column indices.
**Format**

\[
\begin{align*}
\{ \text{vals}, \text{rowinds}, \text{colinds} \} &= \text{spNumNZE}(x);
\end{align*}
\]

**Input**

\[x \quad \text{MxN sparse matrix.}\]

**Output**

- **vals**: Nx1 vector, non-zero values in \(x\).
- **rinds**: Nx1 vector, row indices of corresponding non-zero values.
- **cinds**: Nx1 vector, column indices of corresponding non-zero values.

**Example**

```plaintext
sparse matrix y;
x = \{ 0 0 0 10,
      0 2 0 0,
      0 0 0 0,
      5 0 0 0,
      0 0 0 3 \};

//Create sparse matrix from 'x'
y = denseToSp(x, 0);

//Get non-zero values, row indices and column indices
{ v, r, c } = spGetNZE(y);
```

\(v\), the non-zero values, is equal to:

38-1440
$r$, the row indices, is equal to:

```
1
2
4
5
```

c, the column indices, is equal to:

```
4
2
1
4
```

**See Also**

*spNumNZE*

**spline**

**Purpose**

Computes a two-dimensional interpolatory spline.

**Format**

```matlab
{ u, v, w } = spline(x, y, z, sigma, g);
```
**Input**

- **x** 1xK vector, x-abscissae (x-axis values).
- **y** Nx1 vector, y-abscissae (y-axis values).
- **z** KxN matrix, ordinates (z-axis values).
- **sigma** scalar, tension factor.
- **g** scalar, grid size factor.

**Output**

- **u** 1x(K*g) vector, x-abscissae, regularly spaced.
- **v** (N*g)x1 vector, y-abscissae, regularly spaced.
- **w** (K*g)x(N*g) matrix, interpolated ordinates.

**Remarks**

**sigma** contains the tension factor. This value indicates the curviness desired. If **sigma** is nearly zero (e.g., .001), the resulting surface is approximately the tensor product of cubic splines. If **sigma** is large (e.g., 50.0), the resulting surface is approximately bi-linear. If **sigma** equals zero, tensor products of cubic splines result. A standard value for **sigma** is approximately 1.

**g** is the grid size factor. It determines the fineness of the output grid. For **g** = 1, the output matrices are identical to the input matrices. For **g** = 2, the output grid is twice as fine as the input grid, i.e., **u** will have twice as many columns as **x**, **v** will have twice as many rows as **y**, and **w** will have twice as many rows and columns as **z**.
**Source**

spline.src

**spLDL**

**Purpose**

Computes the LDL decomposition of a symmetric sparse matrix A.

**Format**

```
{l, d} = spLDL(a);
```

**Input**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>N x N, symmetric sparse matrix.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>l</td>
<td>NxN lower-triangular sparse matrix.</td>
</tr>
<tr>
<td>d</td>
<td>NxN diagonal sparse matrix.</td>
</tr>
</tbody>
</table>

**Example**

```latex
declare sparse matrix a, l, d;
nz = { 142 13 56 57 0,
```
13 0 0 0 0,
56 0 94 47 0,
57 0 47 35 0,
0 0 0 0 0};

a = densetosp(nz,0);
{l, d} = spLDL(a);

**Remarks**

`spLDL` will not check to see if the input matrix is symmetric. The function looks only at the lower triangular portion of the input matrix.

**See Also**

`spLU`

**Technical Notes**

`spLDL` implements functions from the TAUCS library:

TAUCS Version 2.2 Copyright ©2003, by Sivan Toledo, Tel-Aviv University, stoledo@tau.ac.il. All Rights Reserved.

**spLU**

**Purpose**

Computes the LU decomposition of a sparse matrix A with partial pivoting.

**Format**

```
{l, u} = spLU(a);
```
Input

\[ a \] N x N, non-singular sparse matrix.

Output

\[ l \] N\times N "scrambled" lower-triangular sparse matrix. This is a lower triangular matrix that has been reordered based upon the row pivoting.

\[ u \] N\times N "scrambled" upper-triangular sparse matrix. This is an upper triangular matrix that has been reordered based upon column pivoting to preserve sparsity.

Example

```
declare sparse matrix a, l, u;

nz = {-5.974, 0, -13.37, 6.136, 0,
       0, 5.932, 7.712, 0, -6.549,
       0, -5.728, 0, 14.227, 0,
       0, -12.164, 9.916, 13.902, 6.182,
       13.425, 0, -12.654, -16.534, 0};

a = densetosp(nz,0);
{l, u} = spLU(a);
```
Remarks

If the input matrix or either of the factors L and U are singular, the function will either terminate the program with an error message or return an error code which can be tested for with the scalerr function. This depends on the trap state as follows:

- **trap 1**: return error code: 50
- **trap 0**: terminate with error message: Matrix singular

See Also

spLDL

Technical Notes

spLU implements functions from the SuperLU 4.0 library written by James W. Demmel, John R. Gilbert and Xiaoye S. Li.

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**spNumNZE**

Purpose

Returns the number of non-zero elements in a sparse matrix.

Format

\[ n = \text{spNumNZE}(x); \]
**Input**

\[ x \]  

MxN sparse matrix.

**Output**

\[ n \]  

scalar, the number of non-zero elements in \( x \).

**Example**

```plaintext
sparse matrix y;
x = { 0 0 0 10,
     0 2 0 0,
     0 0 0 0,
     5 0 0 0,
     0 0 0 3 };

y = denseToSp(x,0);
n = spNumNZE(y);
print "The number of nonzeros is" n;
```

4.00

**See Also**

spGetNZE
spOnes

Purpose

Generates a sparse matrix containing only ones and zeros

Format

\[ y = \text{spOnes}(r, c, rinds, cinds); \]

Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>scalar, rows of output matrix.</td>
</tr>
<tr>
<td>( c )</td>
<td>scalar, columns of output matrix.</td>
</tr>
<tr>
<td>( rinds )</td>
<td>Nx1 vector, row indices of ones.</td>
</tr>
<tr>
<td>( cinds )</td>
<td>Nx1 vector, column indices of ones.</td>
</tr>
</tbody>
</table>

Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>( r \times c ) sparse matrix of ones.</td>
</tr>
</tbody>
</table>

Remarks

Since sparse matrices are strongly typed in GAUSS, \( y \) must be defined as a sparse matrix before the call to \text{spOnes}. 

Example

```c
//declare sparse matrix
```
sparse matrix y;

//Set row indices and column indices
rinds = { 1, 3, 5 };
cinds = { 2, 1, 3 };

//Create a 5x4 sparse matrix with ones at the intersection
//of the 'rind' and 'cind'
y = spOnes(5,4,rinds,cinds);

The resulting y is equal to:

0 1 0 0
0 0 0 0
1 0 0 0
0 0 0 0
0 0 1 0
0 0 0 0
0 0 0 1

See Also
spCreate, spEye, spZeros, denseToSp

SpreadsheetReadM

Purpose

Reads and writes Excel files.

Format

xlsmat = SpreadsheetReadM(file, range, sheet);
**Input**

- **file** string, name of `.xls` file.
- **range** string, range to read or write; e.g., "a1:b20".
- **sheet** scalar, sheet number.

**Output**

- **xlsmat** matrix of numbers read from Excel.

**Portability**

Windows, Linux and Mac

**Remarks**

If the read functions fail, they will return a scalar error code which can be decoded with `scalerr`. If the write function fails, it returns a non-zero error number.

**See Also**

`scalerr`, `error`, `SpreadsheetReadSA`, `SpreadsheetWrite`

**SpreadsheetReadSA**

**Purpose**

Reads and writes Excel files.
**Format**

\[
xlssa = \text{SpreadsheetReadSA}(file, \text{range}, \text{sheet});
\]

**Input**

- `file`: string, name of .xls file.
- `range`: string, range to read or write; e.g., "a1:b20".
- `sheet`: scalar, sheet number.

**Output**

- `xlssa`: string array read from Excel.

**Portability**

Windows, Linux and Mac

**Remarks**

If the read functions fail, they will return a scalar error code which can be decoded with `scalerr`. If the write function fails, it returns a non-zero error number.

**See Also**

`scalerr`, `error`, `SpreadsheetReadM`, `SpreadsheetWrite`
## SpreadsheetWrite

### Purpose

Reads and writes Excel files.

### Format

\[
xlsret = \text{SpreadsheetWrite}(\text{data, file, range, sheet});
\]

### Input

- **data**: matrix, string or string array, data to write.
- **file**: string, name of .xls file.
- **range**: string, range to read or write; e.g., "a1:b20".
- **sheet**: scalar, sheet number.

### Output

- **xlsret**: success code, 0 if successful, else error code.

### Portability

Windows, Linux and Mac

### Remarks

If the read functions fail, they will return a scalar error code which can be decoded 38-1452.
with `scalerr`. If the write function fails, it returns a non-zero error number.

**See Also**

`scalerr`, `error`, `SpreadsheetReadM`, `SpreadsheetReadSA`

**spScale**

**Purpose**

Scales a sparse matrix.

**Format**

\[
\{ a, r, s \} = \text{spScale}(x);
\]

**Input**

\( x \)  
MxN sparse matrix.

**Output**

\( a \)  
MxN scaled sparse matrix.

\( r \)  
Mx1 vector, row scale factors.

\( s \)  
Nx1 vector, column scale factors.
Remarks

`spScale` scales the elements of the matrix by powers of 10 so that they are all within (-10,10).

Example

```
x = { 25  -12    0,  
       3    0   -11,  
       8  -100    0  };  

declare sparse matrix sm, smsc;  
sm = denseToSp(x,0);  

{ smsc, r, c } = spScale(sm);  
```

The results:

```
smsc =  
2.50 -0.12  0.00  
0.30  0.00 -0.11  
0.80 -1.00  0.00  

c =  
1.00  
0.10  
0.10  
r =  
0.10  
0.10  
0.10  
```
**spSubmat**

**Purpose**

Returns a sparse submatrix of a sparse matrix.

**Format**

\[ y = \text{spSubmat}(x, \text{rinds}, \text{cinds}); \]

**Input**

- \( x \) MxN sparse matrix.
- \( \text{rinds} \) Kx1 vector, row indices.
- \( \text{cinds} \) Lx1 vector, column indices.

**Output**

- \( s \) KxL sparse matrix, the intersection of \( \text{rinds} \) and \( \text{cinds} \).

**Remarks**

If \( \text{rinds} \) or \( \text{cinds} \) are scalar zeros, all rows or columns will be returned.

Since sparse matrices are strongly typed in **GAUSS**, \( y \) must be defined as a sparse matrix before the call to \( \text{spSubmat} \).
Example

```plaintext
sparse matrix y;
sparse matrix z;

x = { 0 0 0 10,
    0 2 0 0,
    0 0 0 0,
    5 0 0 0,
    0 0 0 3 };

y = denseToSparse(x,0);

//Extract all columns; rows 1, 3 and 4
z = sparseSubmat(y,1|3|4,0);

//Extract all values from 'z' into a dense matrix 'd'
d = denseSubmat(z,0,0);
```

Now \(d\) is equal to:

```
0.00 0.00 0.00 10.00
0.00 0.00 0.00 0.00
5.00 0.00 0.00 0.00
```

See Also

- `spDenseSubmat`

- `spToDense`

Purpose

Converts a sparse matrix to a dense matrix.
**Format**

\[ y = \text{spToDense}(x); \]

**Input**

\( x \) MxN sparse matrix.

**Output**

\( y \) MxN dense matrix.

**Remarks**

A dense matrix is just a normal format matrix.

**Example**

```matlab
sparse matrix y;

//Create a 4x4 sparse identity matrix
y = spEye(4);

//Create a dense matrix with the same values as 'y'
d = spToDense(y);
```

The dense matrix \( d \) is equal to:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 \\
\end{bmatrix}
\]
See Also

spDenseSubmat, denseToSp

spTrTDense

Purpose

Multiplies a sparse matrix transposed by a dense matrix.

Format

\[ y = \text{spTrTDense}(s, d); \]

Input

\( s \)  
NxM sparse matrix.

\( d \)  
NxL dense matrix.

Output

\( y \)  
MxL dense matrix, the result of \( s^\top d \).

Remarks

This may also be accomplished by the following code:
\[ y = s'*d; \]

However, \texttt{spTrT_dense} will be more efficient.

### See Also

\texttt{spTScalar}

### spTScalar

#### Purpose

Multiplies a sparse matrix by a scalar.

#### Format

\[ y = \texttt{spTScalar}(s, \text{scal}, \text{rinds}, \text{cinds}); \]

#### Input

- \( s \): NxM sparse matrix.
- \( \text{scal} \): scalar.
- \( \text{rinds} \): Kx1 vector of row indices.
- \( \text{cinds} \): Lx1 vector of column indices.
Output

\[ y \]  
KxL sparse matrix.

Remarks

Only the elements of \( s \) specified by \( rinds \) and \( cinds \) will be multiplied by \( scal \). All other elements will be unchanged in the result.

To select all rows or all columns, input a scalar 0 for \( rinds \) or \( cinds \).

Since sparse matrices are strongly typed in GAUSS, \( y \) must be defined as a sparse matrix before the call to \textit{spTScalar}.

Example

```
sparse matrix y;
x = { 3 0 2 1,
     0 4 0 0,
     5 0 0 3,
     0 1 2 0};

rinds = 0;
cinds = { 2,4 }; 

//Multiply all elements in the second and fourth column 
//by 'scal'
y = spTScalar(x,10,rinds,cinds);
d = spDenseSubmat(y,0,0);
```

The result, in \( d \) is:

```
3 0 2 1 
0 4 0 0 
```
See Also

spTrTDense

**spZeros**

**Purpose**

Creates a sparse matrix containing no non-zero values.

**Format**

\[ y = \text{spZeros}(r, c); \]

**Input**

- \( r \): scalar, rows of output matrix.
- \( c \): scalar, columns of output matrix.

**Output**

- \( y \): \( r \times c \) sparse matrix.
**Remarks**

Since sparse matrices are strongly typed in **GAUSS**, \( y \) must be defined as a sparse matrix before the call to `spZeros`.

**Example**

```gauss
sparse matrix y;

//Create a 4x3 sparse matrix with all elements set to 0
y = spZeros(4,3);

//Create a dense matrix with the same values as 'y'
d = spToDense(y);
```

The contents of \( d \) are equal to:

```
0 0 0
0 0 0
0 0 0
0 0 0
```

**See Also**

`spOnes`, `spEye`

**sqpSolve**

**Purpose**

Solves the nonlinear programming problem using a sequential quadratic programming method.
Format

\[
\{ x, f, lagr, retcode \} = \text{sqpSolve}(&fct, start);
\]

Input

&_fct

pointer to a procedure that computes the function to be minimized. This procedure must have one input argument, a vector of parameter values, and one output argument, the value of the function evaluated at the input vector of parameter values.

_start

Kx1 vector of start values.

Global Input

&_sqp_A

MxK matrix, linear equality constraint coefficients.

&_sqp_B

Mx1 vector, linear equality constraint constants.

These globals are used to specify linear equality constraints of the following type:

\[_sqp_A \times x = _sqp_B\]

where \(x\) is the Kx1 unknown parameter vector.

&_sqp_EqProc

scalar, pointer to a procedure that computes the nonlinear equality constraints. For example, the statement:

\[_sqp_EqProc = \&eqproc;\]

tells \text{sqpSolve} that nonlinear equality constraints are to be
placed on the parameters and where the procedure computing them is to be found. The procedure must have one input argument, the Kx1 vector of parameters, and one output argument, the Rx1 vector of computed constraints that are to be equal to zero. For example, suppose that you wish to place the following constraint:


The procedure for this is:

```
proc eqproc(p);
    retp(p[1]*p[2]-p[3]);
endp;
```

MxK matrix, linear inequality constraint coefficients.
Mx1 vector, linear inequality constraint constants.
These globals are used to specify linear inequality constraints of the following type:

\[ _\text{sqp}_C \times X \geq _\text{sqp}_D \]

where \( x \) is the Kx1 unknown parameter vector.

Scalar, pointer to a procedure that computes the nonlinear inequality constraints. For example the statement:

```
_\text{sqp}_\text{EqProc} = \&\text{ineqproc};
```

tells \text{sqpSolve} that nonlinear equality constraints are to be placed on the parameters and where the procedure computing them is to be found. The procedure must have one input argument, the Kx1 vector of parameters, and one output argument, the Rx1 vector of computed constraints that are to be
equal to zero. For example, suppose that you wish to place the following constraint:


The procedure for this is:

```plaintext
proc ineqproc(p);
    retp(p[1]*p[2]-p[3]);
endp;
```

**_sqp_Bounds_**

Kx2 matrix, bounds on parameters. The first column contains the lower bounds, and the second column the upper bounds. If the bounds for all the coefficients are the same, a 1x2 matrix may be used. Default is:

\[
\begin{bmatrix}
1 \times 10^{256} & 2 \times 10^{256}
\end{bmatrix}
\]

**_sqp_GradProc_**

scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. For example, the statement:

```plaintext
_sqp_GradProc = &gradproc;
```

tells **sqpSolve** that a gradient procedure exists and where to find it. The user-provided procedure has two input arguments, a Kx1 vector of parameter values and an NxP matrix of data. The procedure returns a single output argument, an NxK matrix of gradients of the log-likelihood function with respect to the parameters evaluated at the vector of parameter values.

Default = 0, i.e., no gradient procedure has been provided.

**_sqp_HessProc_**

scalar, pointer to a procedure that computes the Hessian, i.e.,
the matrix of second order partial derivatives of the function with respect to the parameters. For example, the instruction:

```c
_sqp_HessProc = &hessproc;
```

will tell `sqpSolve` that a procedure has been provided for the computation of the Hessian and where to find it. The procedure that is provided by the user must have two input arguments, a Px1 vector of parameter values and an NxK data matrix. The procedure returns a single output argument, the PxP symmetric matrix of second order derivatives of the function evaluated at the parameter values.

- `_sqp_MaxIters` scalar, maximum number of iterations. Default = 1e+5. Termination can be forced by pressing C on the keyboard.
- `_sqp_DirTol` scalar, convergence tolerance for gradient of estimated coefficients. Default = 1e-5. When this criterion has been satisfied, `sqpSolve` will exit the iterations.
- `_sqp_ParNames` Kx1 character vector, parameter names.
- `_sqp_PrintIters` scalar, if nonzero, prints iteration information. Default = 0. Can be toggled during iterations by pressing P on the keyboard.
- `_sqp_FeasibleTest` scalar, if nonzero, parameters are tested for feasibility before computing function in line search. If function is defined outside inequality boundaries, then this test can be turned off.
- `_sqp_RandRadius` scalar, if zero, no random search is attempted. If nonzero it is the radius of random search which is invoked whenever the usual line search fails. Default = .01.
- `__output` scalar, if nonzero, results are printed. Default = 0.
Output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Kx1 vector of parameters at minimum.</td>
</tr>
<tr>
<td>f</td>
<td>scalar, function evaluated at x.</td>
</tr>
<tr>
<td>lagr</td>
<td>vector, created using vput. Contains the Lagrangean for the constraints. They may be extracted with the vread command using the following strings:</td>
</tr>
<tr>
<td></td>
<td>&quot;lineq&quot; Lagrangeans of linear equality constraints,</td>
</tr>
<tr>
<td></td>
<td>&quot;nlineq&quot; Lagrangeans of nonlinear equality constraints</td>
</tr>
<tr>
<td></td>
<td>&quot;linineq&quot; Lagrangeans of linear inequality constraints</td>
</tr>
<tr>
<td></td>
<td>&quot;nlinineq&quot; Lagrangeans of nonlinear inequality constraints</td>
</tr>
<tr>
<td></td>
<td>&quot;bounds&quot; Lagrangeans of bounds</td>
</tr>
</tbody>
</table>

Whenever a constraint is active, its associated Lagrangean will be nonzero.

<table>
<thead>
<tr>
<th>retcode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>normal convergence</td>
</tr>
<tr>
<td>1</td>
<td>forced exit</td>
</tr>
<tr>
<td>2</td>
<td>maximum number of iterations exceeded</td>
</tr>
<tr>
<td>3</td>
<td>function calculation failed</td>
</tr>
<tr>
<td>4</td>
<td>gradient calculation failed</td>
</tr>
<tr>
<td>5</td>
<td>Hessian calculation failed</td>
</tr>
<tr>
<td>6</td>
<td>line search failed</td>
</tr>
<tr>
<td>7</td>
<td>error with constraints</td>
</tr>
</tbody>
</table>

**Remarks**

Pressing C on the keyboard will terminate iterations, and pressing P will toggle iteration output.

`sqpSolve` is recursive, that is, it can call itself with another function and set of global variables,

**Example**

```plaintext
//Reset all sqpSolve global variables
sqpSolveSet;

proc fct(x);
endp;

proc ineqp(x);
    retp(6*x[2] + 4*x[3] - x[1]**3 - 3);
endp;

proc eqp(x);
    retp(1-sumc(x));
endp;
```
```c
_sqp_Bounds = { 0 1e256 };
start = { .1, .7, .2 };
_sqp_IneqProc = &ineqp;
_sqp_EqProc = &eqp;

{ x,f,lagr,ret } = sqpSolve(&fct,start);
```

**Source**

sqpsolve.src

**sqpSolveMT**

**Purpose**

Solves the nonlinear programming problem.

**Include**

sqpsolvemt.sdf

**Format**

```c
out1 = sqpSolveMT(&fct, par1, data1, c1);
```
**Input**

&fct  
pointer to a procedure that computes the function to be minimized. This procedure must have two input arguments, an instance of structure of type PV and an instance of a structure of type DS, and one output argument, either a 1x1 scalar or an Nx1 vector of function values evaluated at the parameters stored in the PV instance using data stored in the DS instance.

par1  
an instance of structure of type PV. The par1 instance is passed to the user-provided procedure pointed to by &fct. par1 is constructed using the "pack" functions.

data1  
an array of instances of a DS structure. This array is passed to the user-provided pointed by &fct to be used in the objective function. sqpSolveMT does not look at this structure. Each instance contains the the following members which can be set in whatever way that is convenient for computing the objective function:

- data1[i].dataMatrix     NxK matrix, data matrix.
- data1[i].dataArray       NxKxL.. array, data array.
- data1[i].vnames          string array, variable names (optional).
- data1[i].dsname          string, data name (optional).
- data1[i].type            scalar, type of data (optional).

c1  
an instance of an sqpSolveMTControl structure. Normally an
instance is initialized by calling `sqpsolveMTControlCreate` and members of this instance can be set to other values by the user. For an instance named `c1`, the members are:

- **c1.A**: MxK matrix, linear equality constraint coefficients: $c1.A \cdot p = c1.B$ where $p$ is a vector of the parameters.

- **c1.B**: Mx1 vector, linear equality constraint constants: $c1.A \cdot p = c1.B$ where $p$ is a vector of the parameters.

- **c1.C**: MxK matrix, linear inequality constraint coefficients: $c1.C \cdot p \geq c1.D$ where $p$ is a vector of the parameters.

- **c1.D**: Mx1 vector, linear inequality constraint constants: $c1.C \cdot p \geq c1.D$ where $p$ is a vector of the parameters.

- **c1.eqProc**: scalar, pointer to a procedure that computes the nonlinear equality constraints. When such a procedure has been provided, it has one input argument, a structure of type SQPdata, and one output argument, a vector of computed equality constraints. For more details see Remarks below. Default = ., i.e., no equality procedure.

- **c1.weights**: vector, weights for objective function returning a vector. Default = 1.
<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c1.\text{ineqProc}$</td>
<td>scalar, pointer to a procedure that computes the nonlinear inequality constraints. When such a procedure has been provided, it has one input argument, a structure of type SQPdata, and one output argument, a vector of computed inequality constraints. For more details see Remarks below. Default = ., i.e., no inequality procedure.</td>
</tr>
<tr>
<td>$c1.\text{bounds}$</td>
<td>1x2 or Kx2 matrix, bounds on parameters. If 1x2 all parameters have same bounds. Default = -1e256 1e256.</td>
</tr>
<tr>
<td>$c1.\text{covType}$</td>
<td>scalar, if 2, QML covariance matrix, else if 0, no covariance matrix is computed, else ML covariance matrix is computed.</td>
</tr>
<tr>
<td>$c1.\text{gradProc}$</td>
<td>scalar, pointer to a procedure that computes the gradient of the function with respect to the parameters. Default = ., i.e., no gradient procedure has been provided.</td>
</tr>
<tr>
<td>$c1.\text{hessProc}$</td>
<td>scalar, pointer to a procedure that computes the Hessian, i.e., the matrix of second order partial derivatives of the function with respect to the parameters. Default = ., i.e., no Hessian procedure has been provided.</td>
</tr>
<tr>
<td>$c1.\text{maxIters}$</td>
<td>scalar, maximum number of iterations. Default = 1e+5.</td>
</tr>
<tr>
<td>$c1.\text{dirTol}$</td>
<td>scalar, convergence tolerance for gradient of estimated coefficients. Default = 1e-5.</td>
</tr>
</tbody>
</table>
When this criterion has been satisfied SQPSolve exits the iterations.

$c1.feasibleTest$ scalar, if nonzero, parameters are tested for feasibility before computing function in line search. If function is defined outside inequality boundaries, then this test can be turned off. Default $= 1$.

$c1.randRadius$ scalar, If zero, no random search is attempted. If nonzero, it is the radius of random search which is invoked whenever the usual line search fails. Default $= .01$.

$c1.output$ scalar, if nonzero, results are printed. Default $= 0$.

$c1.printIters$ scalar, if nonzero, prints iteration information. Default $= 0$.

Output

`out1` an instance of an `sqpSolveMTout` structure. For an instance named `out1`, the members are:

`out1x.par` an instance of structure of type PV containing the parameter estimates will be placed in the member matrix `out1.par`.

`out1.fct` scalar, function evaluated at x.

`out1.lagr` an instance of a SQPLagrange structure.
containing the Lagrangeans for the constraints. The members are:

<table>
<thead>
<tr>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>out1.lagr.lineq</code></td>
<td>Mx1 vector, Lagrangeans of linear equality constraints.</td>
</tr>
<tr>
<td><code>out1.lagr.nlineq</code></td>
<td>Nx1 vector, Lagrangeans of nonlinear equality constraints.</td>
</tr>
<tr>
<td><code>out1.lagr.linineq</code></td>
<td>Px1 vector, Lagrangeans of linear inequality constraints.</td>
</tr>
<tr>
<td><code>out1.lagr.nlinineq</code></td>
<td>Qx1 vector, Lagrangeans of nonlinear inequality constraints.</td>
</tr>
<tr>
<td><code>out1.lagr.bounds</code></td>
<td>Kx2 matrix, Lagrangeans of bounds.</td>
</tr>
</tbody>
</table>

Whenever a constraint is active, its associated Lagrangean will be nonzero. For any constraint that is inactive throughout the iterations as well as at convergence, the corresponding Lagrangean matrix will be set to a scalar missing value.

`out1.retcode` return code:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>normal convergence.</td>
</tr>
<tr>
<td>1</td>
<td>forced exit.</td>
</tr>
<tr>
<td>2</td>
<td>maximum number of iterations exceeded.</td>
</tr>
</tbody>
</table>
Remarks

There is one required user-provided procedure, the one computing the objective function to be minimized, and four other optional functions, one each for computing the equality constraints, the inequality constraints, the gradient of the objective function, and the Hessian of the objective function.

All of these functions have one input argument that is an instance of a structure of type struct PV and a second argument that is an instance of a structure of type struct DS. On input to the call to sqpSolveMT, the first argument contains starting values for the parameters and the second argument any required data. The data are passed in a separate argument because the structure in the first argument will be copied as it is passed through procedure calls which would be very costly if it contained large data matrices. Since sqpSolveMT makes no changes to the second argument it will be passed by pointer thus saving time because its contents aren't copied.

Both of the structures of type PV are set up using the PV "pack" procedures, pvPack, pvPackm, pvPacks, and pvPacksm. These procedures allow for setting up a parameter vector in a variety of ways.

For example, we might have the following objective function for fitting a nonlinear curve to data:
proc Micherlitz(struct PV par1, struct DS data1);
    local p0,e,s2,x,y;
    p0 = pvUnpack(par1, "parameters");
    y = data1.dataMatrix[.,1];
    x = data1.dataMatrix[.,2];
    e = y - p0[1] - p0[2]*exp(-p0[3] * x);
    retp(e'*e);
endp;

In this example the dependent and independent variables are passed to the procedure as the first and second columns of a data matrix stored in a single DS structure. Alternatively these two columns of data can be entered into a vector of DS structures, one for each column of data:

proc Micherlitz(struct PV par1, struct DS data1);
    local p0,e,s2,x,y;
    p0 = pvUnpack(par1, "parameters");
    y = data1[1].dataMatrix;
    x = data1[2].dataMatrix;
    e = y - p0[1] - p0[2]*exp(-p0[3]*x);
    retp(e'*e);
endp;

The syntax is similar for the optional user-provided procedures. For example, to constrain the squared sum of the first two parameters to be greater than one in the above problem, provide the following procedure:

proc ineqConst(struct PV par1, struct DS data1);
    local p0;
    p0 = pvUnpack(p0, "parameters");
    retp( (p0[2]+p0[1])^2 - 1);
endp;
The following is a complete example for estimating the parameters of the Micherlitz equation in data with bounds constraints on the parameters and where an optional gradient procedure has been provided:

```c
#include sqpSolveMT.sdf
struct DS d0;
d0 = dsCreate;

y = 3.183 |
   3.059 |
   2.871 |
   2.622 |
   2.541 |
   2.184 |
   2.110 |
   2.075 |
   2.018 |
   1.903 |
   1.770 |
   1.762 |
   1.550;

x = seqa(1,1,13);
d0.dataMatrix = y~x;

//Declare control structure
struct sqpSolveMTControl c0;

//Initialize structure to default values
c0 = sqpSolveMTControlCreate;

//Constrain parameters to be positive
c0.bounds = 0~100;

struct PV par1;
```
par1 = pvCreate;
par1 = pvPack(par1,.92|2.62|.114, "parameters");
struct sqpSolveMTout out1;
out1 = sqpSolveMT(&Micherlitz,par1,d0,c0);

print " parameter estimates ";
print pvUnPack(out1.par, "parameters");

proc Micherlitz(struct PV par1, struct DS data1);
    local p0,e,s2,x,y;
p0 = pvUnpack(par1, "parameters");
y = data1.dataMatrix[.,1];
x = data1.dataMatrix[.,2];
e = y - p0[1] - p0[2]*exp(-p0[3] * x);
retp(e'*e);
endp;

proc grad(struct PV par1, struct DS data1);
    local p0,e,w,g,r,x,y;
p0 = pvUnpack(par1, "parameters");
y = data1.dataMatrix[.,1];
x = data1.dataMatrix[.,2];
g = zeros(3,1);
w = exp(-p0[3] * x);
e = y - p0[1] - p0[2]*w;
r = e'*w;
g[1] = -2*sumc(e);
g[2] = -2*r;
g[3] = 2*p0[1]*p0[2]*r;
retp(g);
endp;

Source
sqpsolvemt.src

38-1478
See Also

sqpSolveMTControlCreate, sqpSolveMTLagrangeCreate, CR-sqpSolveMToutCreate

sqpSolveMTControlCreate

Purpose

Creates an instance of a structure of type sqpSolveMTcontrol set to default values.

Include

sqpsolvemt.sdf

Format

\[ s = \text{sqpSolveMTControlCreate}(); \]

Output

\[ s \quad \text{instance of structure of type \text{sqpSolveMTControl}}. \]

Example

```
//Declare instance of structure
struct sqpSolveMTControl s;

//Initialize the structure to default values
```
$s = \texttt{sqpSolveMTControlCreate}();$

**Source**

sqpsolvemt.src

**See Also**

sqpSolve

### sqpSolveMTLagrangeCreate

**Purpose**

Creates an instance of a structure of type `sqpSolveMTLagrange` set to default values.

**Include**

sqpsolvemt.sdf

**Format**

$s = \texttt{sqpSolveMTLagrangeCreate}();$

**Output**

$s$ instance of structure of type `sqpSolveMTLagrange`. 
Example

```c
//Declare instance of structure
struct sqpSolveMTlagrange sla;

//Initialize the structure to default values
sla = sqpSolveMTlagrangeCreate();
```

Source

sqpsolvemt.src

See Also

sqpSolve

**sqpSolveMToutCreate**

Purpose

Creates an instance of a structure of type sqpSolveMTout set to default values.

Include

sqpsolvemt.sdf

Format

```c
s = sqpSolveMToutCreate();
```
Output

$s$ instance of structure of type sqpSolveMTout.

Example

```c
// Declare instance of structure
struct sqpSolveMTout out;

// Initialize the structure to default values
out = sqpSolveMToutCreate();
```

Source

sqpsolvemt.src

See Also

sqpSolve

sqpSolveSet

Purpose

Resets global variables used by sqpSolve to default values.

Format

```c
sqpSolveSet;
```
Source
sqpsolve.src

sqrt

Purpose
Computes the square root of every element in x.

Format
\[ y = \sqrt{x}; \]

Input
\( x \)  
NxK matrix or N-dimensional array.

Output
\( y \)  
NxK matrix or N-dimensional array, the square roots of each element of x.

Remarks
If x is negative, complex results are returned by default. You can turn the generation of complex numbers for negative inputs on or off in the GAUSS configuration file, and with the \texttt{sysstate} function, case 8. If you turn it off, \texttt{sqrt} will generate an error
for negative inputs.
If \( x \) is already complex, the complex number state does not matter; \texttt{sqrt} will compute a complex result.

**Example**

```plaintext
let x[2,2] = 1 2 3 4;
y = sqrt(x);
```

The output, in variable \( y \) is equal to:

- 1.00000000
- 1.41421356
- 1.73205081
- 2.00000000

**stdc**

**Purpose**

Computes the standard deviation of the elements in each column of a matrix.

**Format**

```plaintext
y = stdc(x);
```

**Input**

\( x \)  
NxK matrix.
Output

| y | Kx1 vector, the standard deviation of each column of x. |

Remarks

This function essentially computes:

\[ \sqrt{\frac{1}{(N-1) \sum c ((x - \text{mean}(x))^2)}} \]

Thus, the divisor is N-1 rather than N, where N is the number of elements being summed. To convert to the alternate definition, multiply by

\[ \sqrt{\frac{(N-1)}{N}} \]

Example

```plaintext
//Set the rng seed so that the random numbers produced will
//be repeatable
rndseed 94243524;

//Create a vector of random normal numbers
y = randn(8100,1);

//Compute the standard deviation of the column vector 'y'
std = stdc(y);
```

The standard deviation, in variable `std`, is equal to:

1.00183907
See Also

meanc

stdsc

Purpose

Computes the standard deviation of the elements in each column of a matrix.

Format

\[ y = \text{stdsc}(x); \]

Input

\( x \) \quad N \times K \text{ matrix.}

Output

\( y \) \quad K \times 1 \text{ vector, the standard deviation of each column of } x.

Remarks

This function essentially computes:

\[
\sqrt{\frac{1}{N} \sum \left( (x - \text{meanc}(x))' \right)^2}
\]

Thus, the divisor is N rather than N-1, where N is the number of elements being summed. See \texttt{stdc} for the alternate definition.
Example

//Create 3 columns of random normal numbers
y = rndn(8100,3);

//Calculate the standard deviation of each column
std = stdsc(y);

The return, in variable std is equal to:

1.00095980
0.99488832
1.00201375

See Also

stdc, stds, meanc

stocv

Purpose

Converts a string to a character vector.

Format

\[ v = \text{stocv}(s); \]

Input

\( s \)  
string, to be converted to character vector.
Output

\[ v \]
N×1 character vector, contains the contents of \( s \).

Remarks

\texttt{stocv} breaks \( s \) up into a vector of 8-character length matrix elements. Note that the character information in the vector is not guaranteed to be null-terminated.

Example

\begin{verbatim}
\texttt{s = "Now is the time for all good men";}\\
\texttt{v = stocv(s);}\\
\end{verbatim}

\begin{verbatim}
"Now is t"\\
"the time "\\
\texttt{v =} "for all "\\
"good men"
\end{verbatim}

See Also

\texttt{cvtos, vget, vlist, vput, vread}

\textbf{stof}

Purpose

Converts a string to floating point.
**Format**

\[ y = \text{stof}(x); \]

**Input**

\( x \)  
string or NxK matrix containing character elements to be converted.

**Output**

\( y \)  
matrix, the floating point equivalents of the ASCII numbers in \( x \).

**Remarks**

If \( x \) is a string containing "1 2 3", then \text{stof} will return a 3x1 matrix containing the numbers 1, 2 and 3.

If \( x \) is a null string, \text{stof} will return a 0.

This uses the same input conversion routine as \text{loadm} and \text{let}. It will convert character elements and missing values. \text{stof} also converts complex numbers in the same manner as \text{let}.

**See Also**

\text{ftos}, \text{ftocv}, \text{chrs}
stop

**Purpose**

Stops a program and returns to the command prompt. Does not close files.

**Format**

```
stop;
```

**Remarks**

This command has the same effect as **end**, except it does not close files or the auxiliary output.

It is not necessary to put a **stop** or an **end** statement at the end of a program. If neither is found, an implicit **stop** is executed.

**See Also**

**end**, **new**, **system**

strcombine

**Purpose**

Converts an NxE string array to an Nx1 string vector by combining each element in a column separated by a user-defined delimiter string.

**Format**

```
y = strcombine(sa, delim, qchar);
```
**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sa</strong></td>
<td>NxM string array.</td>
</tr>
<tr>
<td><strong>delim</strong></td>
<td>1x1, 1xM, or Mx1 delimiter string.</td>
</tr>
<tr>
<td><strong>qchar</strong></td>
<td>scalar, 2x1, or 1x2 string vector containing quote characters as required:</td>
</tr>
<tr>
<td></td>
<td>scalar: Use this character as quote character.</td>
</tr>
<tr>
<td></td>
<td>If this is 0, no quotes are added.</td>
</tr>
<tr>
<td></td>
<td>2x1 or 1x2 string vector: Contains left and right quote characters.</td>
</tr>
</tbody>
</table>

**Output**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>y</strong></td>
<td>Nx1 string vector result.</td>
</tr>
</tbody>
</table>

**Example**

```plaintext
//Create strings with directory names
projDir = "myProject";
homeDir = "C:"
 gaussDir = "gauss"

//Horizontally concatenate the 2 strings into a 1 x 3 string //array
projDir = homeDir$~gaussDir$~projDir;

//Reshape projDir from a 1 x 3 string array into a 2 x 3
```
//string array
projDir = reshape(projDir, 2, 3);

//Create 2 x 1 string array with the names of the final directory, using vertical concatenation. Then add them onto the end of projDir
endDir = "data"|"src";
projDir = projDir~endDir;

//Convert the 2 x 4 string array into a 2 x 1 array with each column combined and separated by backslashes
projDir = strcombine(projDir, "\", 0);
print projDir;

The above example will give the following output:

projDir = C:\gauss\myProject\data\C:\gauss\myProject\src\n
Source
strfns.src

See Also
satostrC

strindx

Purpose

Finds the index of one string within another string.
Format

\[ y = \text{strindx}(\text{where}, \text{what}, \text{start}); \]

Input

- **where**: string or scalar, the data to be searched.
- **what**: string or scalar, the substring to be searched for in `where`.
- **start**: scalar, the starting point of the search in `where` for an occurrence of `what`. The index of the first character in a string is 1.

Output

- **y**: scalar containing the index of the first occurrence of `what`, within `where`, which is greater than or equal to `start`. If no occurrence is found, it will be 0.

Remarks

An example of the use of this function is the location of a name within a string of names:

```plaintext
z = "nameagepaysex";
x = "pay";
y = strindx(z, x, 1);
```

The above code will set `y` equal to:
8.00

This function is used with `strsect` for extracting substrings.

**See Also**

`strindx`, `strlen`, `strsect`, `strput`

---

### strlen

**Purpose**

Returns the length of a string.

**Format**

\[ y = strlen(x); \]

**Input**

\[ x \]

string, NxK matrix of character data, or NxK string array.

**Output**

\[ y \]

scalar containing the exact length of the string \( x \), or NxK matrix or string array containing the lengths of the elements in \( x \).
Remarks

The null character (ASCII 0) is a legal character within strings and so embedded nulls will be counted in the length of strings. The final terminating null byte is not counted, though.

For character matrices, the length is computed by counting the characters (maximum of 8) up to the first null in each element of the matrix. The null character, therefore, is not a valid character in matrices containing character data and is not counted in the lengths of the elements of those matrices.

Example

```c
x1 = "How long?";
x2 = "Classification";
len1 = strlen(x1);
len2 = strlen(x2);
```

After running the code above:

```c
len1 = 9
len2 = 14
```

See Also

strsect, strindx, strrindx
**strput**

**Purpose**

Lays a substring over a string.

**Format**

\[
y = \text{strput}(\text{substr}, \text{str}, \text{off});
\]

**Input**

- \textit{substr} string, the substring to be laid over the other string.
- \textit{str} string, the string to receive the substring.
- \textit{off} scalar, the offset in \textit{str} to place \textit{substr}. The offset of the first byte is 1.

**Output**

- \textit{y} string, the new string.

**Example**

```c
str = "max";
sub = "imum";
loc = 4;
y = \text{strput}(\text{sub}, \text{str}, \text{loc});
print y;
```

produces:

```
38-1496
```
Source

strput.src

strrindx

Purpose

Finds the index of one string within another string. Searches from the end of the string to the beginning.

Format

\[ y = \text{strrindx}(\text{where}, \text{what}, \text{start}); \]

Input

- **where**: string or scalar, the data to be searched.
- **what**: string or scalar, the substring to be searched for in *where*.
- **start**: scalar, the starting point of the search in *where* for an occurrence of *what*. *where* will be searched from this point backward for *what*. 
Output

$Y$ scalar containing the index of the last occurrence of $what$, within $where$, which is less than or equal to $start$. If no occurrence is found, it will be 0.

Remarks

A negative value for $start$ causes the search to begin at the end of the string. An example of the use of $strrindx$ is extracting a file name from a complete path specification:

```c
path = "/gauss/src/ols.src";
p = "/";
p = strrindx(path,p,-1);
if p:
    name = strsect(path,p+1,strlen(path)-p);
else:
    name = "";
endif;
```

The above code makes the following assignments:

- $pos = 11$
- $name = ols.src$

See Also

$strindx$, $strlen$, $strsect$, $strput$
**strsect**

**Purpose**

Extracts a substring of a string.

**Format**

\[ y = \text{strsect}(str, \text{start}, \text{len}); \]

**Input**

- **str**: string or scalar from which the segment is to be obtained.
- **start**: scalar, the index of the substring in `str`. The index of the first character is 1.
- **len**: scalar, the length of the substring.

**Output**

- **y**: string, the extracted substring, or a null string if `start` is greater than the length of `str`.

**Remarks**

If there are not enough characters in a string for the defined substring to be extracted, then a short string or a null string will be returned.

If `str` is a matrix containing character data, it must be scalar.
Example

```
strng = "This is an example string.";
y = strsect(strng,12,7);
```

The above code assigns the variable `y` to be:

```
example
```

See Also

strlen, strindx, strrindx

strsplit

Purpose

Splits an N\times1 string vector into an N\times K string array of the individual tokens.

Format

```
sa = strsplit(sv);
```

Input

```
sv
```

N\times1 string array.

Output

```
sa
```

N\times K string array.
Remarks

Each row of \( sv \) must contain the same number of tokens. The following characters are considered delimiters between tokens:

- space ASCII 32
- tab ASCII 9
- comma ASCII 44
- newline ASCII 10
- carriage return ASCII 13

Tokens containing delimiters must be enclosed in single or double quotes or parentheses. Tokens enclosed in single or double quotes will NOT retain the quotes upon translation. Tokens enclosed in parentheses WILL retain the parentheses after translation. Parentheses cannot be nested.

Example

//Create a 2x1 string array
let string sv = {
    "kingdom phylum class",
    "order family genus"  
};

//Split 'sv' into a string array in which each token is an element in a new string array
sa = strsplit(sv);

//Print the [1,1] element of 'sa' followed by the [1,2], [1,3], [2,1]...
for i(1, 2, 1);
    for j(1, 3, 1);
The above code sets \texttt{sa} to be equal to:

\begin{verbatim}
"kingdom" "phylum" "class" "order" "family" "genus"
\end{verbatim}

and produces the output:

\begin{verbatim}
kingdom
phylum
class
order
family
genus
\end{verbatim}

Elements that contain spaces may be grouped with single tics, like this:

\begin{verbatim}
let string ss = { "classification 'scientific
taxonomy'" }; 
ss2 = strsplit(ss);

print "ss2[1] = " ss2[1];
print "ss2[2] = " ss2[2];
\end{verbatim}

In this program, 'scientific taxonomy' is kept as one token, and thus the output from the above code is:

\begin{verbatim}
ss2[1] = classification
ss2[2] = scientific taxonomy
\end{verbatim}

\textbf{See Also}

\texttt{strsplitPad}
strsplitPad

Purpose

Splits a string vector into a string array of the individual tokens. Pads on the right with null strings.

Format

\[ sa = \text{strsplitPad}(sv, \ cols); \]

Input

- \( sv \)  
  Nx1 string array.
- \( cols \)  
  scalar, number of columns of output string array.

Output

- \( sa \)  
  Nx \( cols \) string array.

Remarks

Rows containing more than \( cols \) tokens are truncated and rows containing fewer than \( cols \) tokens are padded on the right with null strings. The following characters are considered delimiters between tokens:

- \text{space}  
  ASCII 32
- \text{tab}  
  ASCII 9
Tokens containing delimiters must be enclosed in single or double quotes or parentheses. Tokens enclosed in single or double quotes will NOT retain the quotes upon translation. Tokens enclosed in parentheses WILL retain the parentheses after translation. Parentheses cannot be nested.

Example

```plaintext
let string sv = {
    "alpha beta gamma",
    "delta, epsilon, zeta, eta",
    "theta iota kappa"
};

sa = strsplitPad(sv, 4);
```

After the code above, `sa` will be equal to:

```
"alpha""beta""gamma""""delta""epsilon""zeta""eta""theta""iota""kappa"
```

See Also

`strsplit`
**strtodt**

**Purpose**

Converts a string array of dates to a matrix in DT scalar format.

**Format**

\[ x = \text{strtodt}(sa, \ fmt); \]

**Input**

- \( sa \): NxK string array containing dates.
- \( fmt \): string containing date/time format characters.

**Output**

- \( x \): NxK matrix of dates in DT scalar format.

**Remarks**

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number:

\[ 20120921223505 \]

represents 22:35:05 or 10:35:05 PM on September 21, 2012.

The following formats are supported:
### YYYY
Four digit year

### YR
Last two digits of year

### MO
Number of month, 01-12

### DD
Day of month, 01-31

### HH
Hour of day, 00-23

### MI
Minute of hour, 00-59

### SS
Second of minute, 00-59

#### Example

```r
x = strtod("2012-07-12 10:18:32", "YYYY-MO-DD HH:MI:SS");
print x;
```

produces:

```
20120712101832.0
```

```r
x = strtod("2012-07-12 10:18:32", "YYYY-MO-DD");
print x;
```

produces:

```
20120712000000.0
```

```r
x = strtod("10:18:32", "HH:MI:SS");
print x;
```

produces:

```
101832.0
```
\[ x = \text{strtodt}("05-28-10", "MO-DD-YR"); \]
\[ \text{print } x; \]

produces:

\[ 20100528000000.0 \]

**See Also**

`dttostr`, `dttoutc`, `utctodt`

**strtof**

**Purpose**

Converts a string array to a numeric matrix.

**Format**

\[ x = \text{strtof}(sa); \]

**Input**

\[ sa \]

NxK string array containing numeric data.

**Output**

\[ x \]

NxK matrix.
Remarks

Elements with more than one numerical character separated by a delimiter such as a comma or a space will be interpreted as complex data. For example, the string:

```
"1.2 1.9"
```

will be converted into the number:

```
1.2 + 1.9i
```

Parentheses surrounding the numerical elements in the string will be ignored as will be a following $i$. The following strings will be interpreted as the same by `strtof`.

```
"(2.31 4.72)""2.31 4.73""2.31,4.73i"
```

Example

```
//Create a string array
string sa = { "1.1""2.2""3.3", "4.4""5.5""6.6" };
num = strtof(sa);
```

After the code above, $num$ is a numeric matrix with the following values:

```
1.100 2.200 3.300
4.400 5.500 6.600
```

See Also

`strtofplxx`, `ftostrC`
**strtofcplx**

**Purpose**

Converts a string array to a complex numeric matrix.

**Format**

\[ x = \text{strtofcplx}(sa); \]

**Input**

\[ sa \quad \text{NxK string array containing numeric data.} \]

**Output**

\[ x \quad \text{NxK complex matrix.} \]

**Remarks**

`strtofcplx` supports both real and complex data. It is slower than `strtof` for real matrices. `strtofcmlx` requires the presence of the real part. The imaginary part can be absent.

**See Also**

`strtof`, `ftostrC`
**strtriml**

**Purpose**

Strips all whitespace characters from the left side of each element in a string array.

**Format**

\[ y = \text{strtriml}(sa); \]

**Input**

\[ sa \quad \text{NxM string array.} \]

**Output**

\[ y \quad \text{NxM string array.} \]

**Source**

strfns.src

**See Also**

strtrim, strtrunc, strtruncl, strtruncpad, strtruncr
# strtrimr

## Purpose

Strips all whitespace characters from the right side of each element in a string array.

## Format

\[
y = \text{strtrimr}(sa);
\]

## Input

- **sa**: NxM string array.

## Output

- **y**: NxM string array.

## Source

strfns.src

## See Also

strtriml, strtrunc, strtrunc1, strtruncpad, strtruncr
**strtrunc**

**Purpose**

Truncates all elements of a string array to not longer than the specified number of characters.

**Format**

\[ y = \text{strtrunc}(sa, \text{ maxlen}); \]

**Input**

- \( sa \) : NxK string array.
- \( \text{ maxlen} \) : 1xK or 1x1 matrix, maximum length.

**Output**

- \( y \) : NxK string array result.

**Example**

```plaintext
string s = { "best", "linear", "unbiased", "estimator" }
ss = strtrunc(s, 6);
```

After the code above, the variables \( s \) and \( ss \) are equal to:

- best
- linear
\[ s = \text{unbiased estimator} \]
\[
\text{best linear} \\
ss = \text{unbiased estimator}
\]

**See Also**

`strtriml`, `strtrimr`, `strtrunc`, `strtruncpad`, `strtruncr`

**strtrunc**

**Purpose**

Truncates the left side of all elements of a string array by a user-specified number of characters.

**Format**

\[ y = \text{strtrunc}(sa, ntrunc); \]

**Input**

- `sa`  
  - NxM, Nx1, 1xM, or 1x1 string array.
- `ntrunc`  
  - NxM, Nx1, 1xM, or 1x1 matrix containing the number of characters to strip.
Output

\[
\begin{align*}
y & \quad \text{string array result.}
\end{align*}
\]

Source

strfns.src

See Also

strtriml, strtrimr, strtrunc, strtruncpad, strtruncr

strtruncpad

Purpose

Truncates all elements of a string array to the specified number of characters, adding spaces on the end as needed to achieve the exact length.

Format

\[
y = \text{strtruncpad}(sa, maxlen);
\]

Input

\[
\begin{align*}
sa & \quad \text{N}xK \text{ string array.} \\
maxlen & \quad \text{1}xK \text{ or 1x1 matrix, maximum length.}
\end{align*}
\]
### Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>NxK string array result.</td>
</tr>
</tbody>
</table>

### See Also

strtriml, strtrimr, strtrunc, strtruncl, strtruncr

### strtruncr

#### Purpose

Truncates the right side of all elements of a string array by a user-specified number of characters.

#### Format

$$ y = \text{strtruncr}(sa, \ ntrunc); $$

#### Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$sa$</td>
<td>NxM, Nx1, 1xM, or 1x1 string array.</td>
</tr>
<tr>
<td>$ntrunc$</td>
<td>NxM, Nx1, 1xM, or 1x1 matrix containing the number of characters to strip.</td>
</tr>
</tbody>
</table>

#### Output

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>String array result.</td>
</tr>
</tbody>
</table>
Source
strfnsrc

See Also
strtriml, strtrimr, strtrunc, strtruncr, strtruncpad

submat

Purpose
Extracts a submatrix of a matrix, with the appropriate rows and columns
given by the elements of vectors.

Format
\[ y = \text{submat}(x, r, c); \]

Input
\[ x \quad \text{NxK matrix.} \]
\[ r \quad \text{LxM matrix of row indices.} \]
\[ c \quad \text{PxQ matrix of column indices.} \]

Output
\[ y \quad \text{(L*M)x(P*Q) submatrix of } x, \text{ } y \text{ may be larger than } x. \]
**Remarks**

If $r = 0$, then all rows of $x$ will be used. If $c = 0$, then all columns of $x$ will be used.

**Example**

```plaintext
//Create 12x1 vector with consecutive numbers
x = seqa(1, 1, 12);

//Reshape the 12x1 vector into a 3x4 matrix
x = reshape(x, 3, 4);

v1 = 1 3;
v2 = 2 4;

//Extract sub-matrices
y = submat(x,v1,v2);
z = submat(x,0,v2);
```

After the code above, the matrix values are:

```
x  = 1 2 3 4
     5 6 7 8
      9 10 11 12

y  = 2 4
     10 12

z  = 2 4
     6 8
     10 12
```
subscat

Purpose

Changes the values in a vector depending on the category a particular element falls in.

Format

\[ y = \text{subscat}(x, v, s); \]

Input

- \( x \) \hspace{1cm} Nx1 vector.
- \( v \) \hspace{1cm} Px1 numeric vector, containing breakpoints specifying the ranges within which substitution is to be made. This MUST be sorted in ascending order.

  \( v \) can contain a missing value as a separate category if the missing value is the first element in \( v \).

  If \( v \) is a scalar, all matches must be exact for a substitution to be made.
- \( s \) \hspace{1cm} Px1 vector, containing values to be substituted.

See Also
diag, vec, reshape
Output

\[ y \]

Nx1 vector, with the elements in \( s \) substituted for the original elements of \( x \) according to which of the regions the elements of \( x \) fall into:

\[
\begin{align*}
x \leq v[1] & \rightarrow s[1] \\
& \cdots \\
v[p - 1] < x \leq v[p] & \rightarrow s[p] \\
x > v[p] & \rightarrow \text{the original value of } x
\end{align*}
\]

If missing is not a category specified in \( v \), missings in \( x \) are passed through without change.

Example

```plaintext
//Create an additive sequence from 1-10
x = seqa(1, 1, 10);

//Set the breakpoints which indicate where to apply the
//substitution such that elements 1-4 in 'x' will be set to
//the first value of 'sub', the 5th and 6th values will be
//set to the second element of 'sub' and the 7th-10th
//elements will be set to the third element of 'sub'
bp = { 4, 6, 10 };

//The substitution values
sub = { 3.14, 6.28, 9.42 };

y = subscat(x, bp, sub);
```

The above code assigns the following values:
substitute

**Purpose**
Substitutes new values for old values in a matrix, depending on the outcome of a logical expression.

**Format**

\[ y = \text{substitute}(x, e, v); \]

**Input**

- \( x \) : NxK matrix containing the data to be changed.
- \( e \) : LxM matrix, ExE conformable with \( x \) containing 1's and 0's.
- \( v \) : PxQ matrix, ExE conformable with \( x \) and \( e \), containing the values to be substituted for the original values of \( x \) when the corresponding element of \( e \) is 1.
Output

\[ y = \text{max}(N,L,P) \text{ by } \text{max}(K,M,Q) \text{ matrix.} \]

Remarks

The \( e \) matrix is usually the result of an expression or set of expressions using dot conditional and boolean operators.

Example

```plaintext
//Create a matrix with character elements for the
//first column
x = { Y 55 30,
      N 57 18,
      Y 24 3,
      N 63 38,
      Y 55 32,
      N 37 11 };

//Create a rows(x) by 1 vector with a '1' for each row
//that:
// 1) The first element is a Y
// 2) The second element is greater than or equal to 55
// 3) The third element is greater than or equal to 30
//If the row does not meet ALL of these conditions a 0 will
//be returned.
e = x[.,1] .*"Y" .and x[.,2] .>= 55 .and x[.,3] .>= 30;

//Substitute an 'R' for the first element in every row that
//meets the conditions specified in the assignment to 'e'
x[.,1] = substitute(x[.,1],e, "R");
```
The vector $e$ is equal to:

```
1
0
0
0
1
0
```

Here is what $x$ looks like after substitution:

```
R 55 30
N 57 18
Y 24  3
N 63 38
R 55 32
N 37 11
```

**Source**
datatran.src

**See Also**
code, recode

**subvec**

**Purpose**

Extracts an $N \times 1$ vector of elements from an $N \times K$ matrix.
**Format**

\[ y = \text{subvec}(x, c_i); \]

**Input**

- \( x \) \quad \text{NxK matrix.}
- \( c_i \) \quad \text{Nx1 vector of column indices.}

**Output**

- \( y \) \quad \text{Nx1 vector containing the elements in } x \text{ indicated by } c_i.

**Remarks**

Each element of \( y \) is from the corresponding row of \( x \) and the column set by the corresponding row of \( c_i \). In other words, \( y[i] = x[i, c_i[i]] \).

**Example**

```plaintext
//Create an additive sequence from 1-12, i.e. 1, 2, 3,...12
x = seqa(1, 1, 12);

//Reshape the sequential vector 'x' into a 4x3 matrix
x = reshape(x, 4, 3);

//The column indices (one per row of 'x') indicating which
//values to extract from 'x'
ci = { 2, 3, 1, 3 };
```
//Extract subvector from 'x' and assign it to 'y'
\[ y = \text{subvec}(x, ci); \]

After the above code, \( x \) and \( y \) are equal to:

\[
\begin{array}{ccc}
1 & 2 & 3 \\
4 & 5 & 6 \\
7 & 8 & 9 \\
10 & 11 & 12 \\
\end{array}
\]

\[
\begin{array}{c}
2 \\
6 \\
7 \\
12 \\
\end{array}
\]

\textbf{sumc}

\textbf{Purpose}

Computes the sum of each column of a matrix or the sum across the second-fastest moving dimension of an L-dimensional array.

\textbf{Format}

\[ y = \text{sumc}(x); \]

\textbf{Input}

\( x \) \quad \text{NxK matrix or L-dimensional array where the last two dimensions are NxK.}
Output

$y$  Kx1 vector or L-dimensional array where the last two dimensions are Kx1.

Example

```
//Create a 12x1 vector containing an additive sequence
//counting by twos, from 0-22, i.e. 2, 4, 6, 8...22
x = seqa(0,2,12);

//Reshape the 12x1 vector 'x' into a 3x4 matrix
x = reshape(x,3,4));

//Sum the columns
y = sumc(x);
```

After the above code, the variables $x$ and $y$ are equal to:

```
x =  
0 2 4 6
 8 10 12 14
16 18 20 22

y =  
24
30
36
42
```

```
//Create an additive sequence from 1-24 and reshape it into a 2x3x4 array
a = reshape(seqa(1,1,24),2|3|4);

//Sum the columns across the second fastest moving
```
//dimension
z = sumc(a);

a is a 2x3x4 array such that:

Plane [1,.,.]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>2.000000</td>
<td>3.000000</td>
<td>4.000000</td>
</tr>
<tr>
<td>5.000000</td>
<td>6.000000</td>
<td>7.000000</td>
<td>8.000000</td>
</tr>
<tr>
<td>9.000000</td>
<td>10.000000</td>
<td>11.000000</td>
<td>12.000000</td>
</tr>
</tbody>
</table>

Plane [2,.,.]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13.000000</td>
<td>14.000000</td>
<td>15.000000</td>
<td>16.000000</td>
</tr>
<tr>
<td>17.000000</td>
<td>18.000000</td>
<td>19.000000</td>
<td>20.000000</td>
</tr>
<tr>
<td>21.000000</td>
<td>22.000000</td>
<td>23.000000</td>
<td>24.000000</td>
</tr>
</tbody>
</table>

Variable z is a 2x4x1 array equal to:

Plane [1,.,.]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plane [2,.,.]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>51.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57.000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60.000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Also

cumsumc, meanc, stdc
**sumr**

**Purpose**

Computes the sum of each row of a matrix or the sum of the fastest moving dimension of an L-dimensional array.

**Format**

\[ y = \text{sumr}(x); \]

**Input**

\( x \)

N\(x\)K matrix or L-dimensional array where the last two dimensions are N\(x\)K.

**Output**

\( y \)

N\(x\)l vector or L-dimensional array where the last two dimensions are N\(x\)l.

**Example**

```plaintext
//Create an additive sequence from 1-12 and reshape it into
//a 3x4 matrix
x = reshape(seqa(1,1,12),3,4);

//Sum the rows
y = sumr(x);
```
After the above code, the variables \( x \) and \( y \) will be:

\[
\begin{array}{cccc}
1 & 2 & 3 & 4 \\
5 & 6 & 7 & 8 \\
9 & 10 & 11 & 12 \\
\end{array}
\begin{array}{c}
10 \\
26 \\
42 \\
\end{array}
\]

//Reshape an additive sequence from 1-24 into a 2x3x4 dimensional array
a = \texttt{areshape(seqa(1,1,24),2|3|4)};
\texttt{z = sumr(a);}

\( a \) is a 2x3x4 array such that:

\[
\begin{array}{cccc}
1.000000 & 2.000000 & 3.000000 & 4.000000 \\
5.000000 & 6.000000 & 7.000000 & 8.000000 \\
9.000000 & 10.000000 & 11.000000 & 12.000000 \\
\end{array}
\begin{array}{cccc}
13.000000 & 14.000000 & 15.000000 & 16.000000 \\
17.000000 & 18.000000 & 19.000000 & 20.000000 \\
21.000000 & 22.000000 & 23.000000 & 24.000000 \\
\end{array}
\]

The variable \( z \) is equal to:

\[
\begin{array}{c}
10.000000 \\
26.000000 \\
42.000000 \\
\end{array}
\]

38-1528
Plane [2,..]
  58.000000
  74.000000
  90.000000

See Also
sumc

surface

Purpose
Graphs a 3-D surface. NOTE: This function is for use with the deprecated PQG graphics. Use plotSurface instead.

Library
pgraph

Format

\texttt{surface(x, y, z);}\

Input
\begin{itemize}
  \item \texttt{x} \quad 1xK vector, the X axis data.
  \item \texttt{y} \quad Nx1 vector, the Y axis data.
\end{itemize}
\( z \)  
\( N \times K \) matrix, the matrix of height data to be plotted.

**Global Input**

\( _{psurf} \)  
2x1 vector, controls 3-D surface characteristics.  

[1] if 1, show hidden lines. Default 0.  

[2] color for base (default 7). The base is an outline of the X-Y plane with a line connecting each corner to the surface. If 0, no base is drawn.

\( _{pticout} \)  
scalar, if 0 (default), tick marks point inward, if 1, tick marks point outward.

\( _{pzclr} \)  
Z level color control.  

There are 3 ways to set colors for the Z levels of a surface graph.

1. To specify a single color for the entire surface plot, set the color control variable to a scalar value 1-15. For example:

\[
_{pzclr} = 15;
\]

2. To specify multiple colors distributed evenly over the entire Z range, set the color control variable to a vector containing the desired colors only. **GAUSS** will automatically calculate the required corresponding Z values for you. The following example will produce a three color surface plot, the Z ranges being lowest=blue, middle=light blue,
3. To specify multiple colors distributed over selected ranges, the Z ranges as well as the colors must be manually input by the user. The following example assumes -0.2 to be the minimum value in the \( z \) matrix:

```c
_pzclr = { -0.2 1, /* z >= -0.2 blue */
           0.0 10,
           /* z >= 0.0 light blue */
           0.2 15 };
           /* z >= 0.2 white */
```

Since a Z level is required for each selected color, the user must be responsible to compute the minimum value of the \( z \) matrix as the first Z range element. This may be most easily accomplished by setting the _pzclr matrix as shown above (the first element being an arbitrary value), then resetting the first element to the minimum \( z \) value as follows:

```c
_pzclr = { 0.0 1, 0.0 10, 0.2 15 };
_pzclr[1,1] = minc(minc(z));
```

See **PQG Graphics Colors**, Section 1, for the list of available colors.
Remarks

\texttt{surface} uses only the minimum and maximum of the X axis data in generating the graph and tick marks.

Source

\texttt{psurface.src}

See Also

\texttt{volume, view}

svd

Purpose

Computes the singular values of a matrix.

Format

\[ s = \texttt{svd}(x); \]

Input

\[ x \quad \text{NxP matrix whose singular values are to be computed.} \]

Output

\[ s \quad \text{Mx1 vector, where } M = \texttt{min}(N,P), \text{ containing} \]

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the singular values of $x$ arranged in descending order.

Global Input

$_{svderr}$ scalar, if not all of the singular values can be computed, $_{svderr}$ will be nonzero. The singular values in $s[_{svderr}+1], \ldots s[M]$ will be correct.

Remarks

Error handling is controlled with the low bit of the trap flag.

| trap 0 | set $_{svderr}$ and terminate with message |
| trap 1 | set $_{svderr}$ and continue execution |

Example

```plaintext
//Create a 5x5 random normal matrix
x = rndn(5,5);

//Calculate the singular values of matrix 'x'
y = svd(x);
```

Source

svd.src
See Also

svd2, svds

svd1

Purpose

Computes the singular value decomposition of a matrix so that: \( x = u \cdot s \cdot v' \).

Format

\[
\{ u, s, v \} = \text{svd1}(x);
\]

Input

\( x \)  
NxP matrix whose singular values are to be computed.

Output

\( u \)  
Nxn matrix, the left singular vectors of \( x \).

\( s \)  
NxP diagonal matrix, containing the singular values of \( x \)  
arranged in descending order on the principal diagonal.

\( v \)  
PnP matrix, the right singular vectors of \( x \).

Global Output

\(_{\text{svderr}}\)  
scalar, if all of the singular values are correct, \(_{\text{svderr}}\) is 0. 
If not all of the singular values can be computed, \(_{\text{svderr}}\) is 38-1534.
set and the diagonal elements of \( s \) with indices greater than \(_\text{svderr}\) are correct.

**Remarks**

Error handling is controlled with the low bit of the trap flag.

<table>
<thead>
<tr>
<th>Trap</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>set _\text{svderr} and terminate with message</td>
</tr>
<tr>
<td>1</td>
<td>set _\text{svderr} and continue execution</td>
</tr>
</tbody>
</table>

**Example**

```plaintext
//Create 10x10 random normal matrix
x = \text{rndn}(10,10);

//Perform matrix decomposition
\{ u, s, v \} = \text{svd1}(x);

newx = u*s*v';

//Calculate the largest difference between 'x' and 'newx'
maxdiff = \text{maxc(maxc(abs(newx - x)))};
```

**Source**

`svd.scr`

**See Also**

`svd`, `svd2`, `svdsv`
svd2

Purpose

Computes the singular value decomposition of a matrix so that: $x = u * s * v'$ (compact $u$).

Format

$\{ u, s, v \} = \text{svd2}(x)$;

Input

$x$  
NxP matrix whose singular values are to be computed.

Output

$u$  
NxN or NxP matrix, the left singular vectors of $x$. If $N > P$, then $u$ will be NxP, containing only the $P$ left singular vectors of $x$.

$s$  
NxP or PxP diagonal matrix, containing the singular values of $x$ arranged in descending order on the principal diagonal. If $N > P$, then $s$ will be PxP.

$v$  
PxP matrix, the right singular vectors of $x$.

Global Output

$_{\text{svderr}}$ scalar, if all of the singular values are correct, $_{\text{svderr}}$ is 0. If not all of the singular values can be computed, $_{\text{svderr}}$ is 38-1536.
set and the diagonal elements of \( s \) with indices greater than \( \_svderr \) are correct.

## Remarks

Error handling is controlled with the low bit of the trap flag.

<table>
<thead>
<tr>
<th>Trap</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trap 0</td>
<td>set ( _svderr ) and terminate with message</td>
</tr>
<tr>
<td>Trap 1</td>
<td>set ( _svderr ) and continue execution</td>
</tr>
</tbody>
</table>

## Source

svd.src

## See Also

svd, svdl, svdcusv

## svdcusv

**Purpose**

Computes the singular value decomposition of \( x \) so that: \( x = u * s * v' \) (compact \( u \)).

**Format**

\[
\{ \, u, \, s, \, v \} = \text{svdcusv}(x);
\]
**Input**

\( x \)  
NxP matrix or K-dimensional array where the last two dimensions are NxP, whose singular values are to be computed.

**Output**

\( u \)  
NxN or NxP matrix or K-dimensional array where the last two dimensions are NxN or NxP, the left singular vectors of \( x \). If \( N > P \), \( u \) is NxP, containing only the P left singular vectors of \( x \).

\( s \)  
NxP or PxP diagonal matrix or K-dimensional array where the last two dimensions describe NxP or PxP diagonal arrays, the singular values of \( x \) arranged in descending order on the principal diagonal. If \( N > P \), \( s \) is PxP.

\( v \)  
PxP matrix or K-dimensional array where the last two dimensions are PxP, the right singular vectors of \( x \).

**Remarks**

If \( x \) is an array, the resulting arrays \( u \), \( s \) and \( v \) will contain their respective results for each of the corresponding 2-dimensional arrays described by the two trailing dimensions of \( x \). In other words, for a 10x4x5 array \( x \), \( u \) will be a 10x4x4 array containing the left singular vectors of each of the 10 corresponding 4x5 arrays contained in \( x \). \( s \) will be a 10x4x5 array and \( v \) will be a 10x5x5 array both containing their respective results for each of the 10 corresponding 4x5 arrays contained in \( x \).
If not all of the singular values can be computed, $s[1,1]$ is set to a scalar error code. Use scalerr to convert this to an integer. The diagonal elements of $s$ with indices greater than scalerr($s[1,1]$) are correct. If scalerr($s[1,1]$) returns a 0, all of the singular values have been computed.

**See Also**

svd2, svds, svdusv

**svds**

**Purpose**

Computes the singular values of $x$.

**Format**

$$s = \text{svds}(x);$$

**Input**

$x$

Nxp matrix or K-dimensional array where the last two dimensions are Nxp, whose singular values are to be computed.

**Output**

$s$

Min(N,P)x1 vector or K-dimensional array where the last two dimensions are min(N,P)x1, the singular values of $x$
arranged in descending order.

**Remarks**

If \( x \) is an array, the result will be an array containing the singular values of each of the 2-dimensional arrays described by the two trailing dimensions of \( x \). In other words, for a 10x4x5 array \( x \), \( s \) will be a 10x4x1 array containing the singular values of each of the 10 4x5 arrays contained in \( x \).

If not all of the singular values can be computed, \( s[1] \) is set to a scalar error code. Use `scalerr` to convert this to an integer. The elements of \( s \) with indices greater than `scalerr(s[1])` are correct. If `scalerr(s[1])` returns a 0, all of the singular values have been computed.

**See Also**

`svd`, `svdcusv`, `svdusv`

**svdusv**

**Purpose**

Computes the singular value decomposition of \( x \) so that: \( x = u \ast s \ast v' \).

**Format**

\[
\{ u, s, v \} = \text{svdusv}(x);
\]

**Input**

\( x \)  
N\( x \)P matrix or \( K \)-dimensional array where the last two
dimensions are NxP, whose singular values are to be computed.

Output

\[
\begin{align*}
  u & : \text{NxD matrix or K-dimensional array where the last two dimensions are NxD, the left singular vectors of } x. \\
  s & : \text{NxD diagonal matrix or K-dimensional array where the last two dimensions describe NxD diagonal arrays, the singular values of } x \text{ arranged in descending order on the principal diagonal.} \\
  v & : \text{PxD matrix or K-dimensional array where the last two dimensions are PxD, the right singular vectors of } x.
\end{align*}
\]

Remarks

If \( x \) is an array, the resulting arrays \( u, s \) and \( v \) will contain their respective results for each of the corresponding 2-dimensional arrays described by the two trailing dimensions of \( x \). In other words, for a 10x4x5 array \( x \), \( u \) will be a 10x4x4 array containing the left singular vectors of each of the 10 corresponding 4x5 arrays contained in \( x \). \( s \) will be a 10x4x5 array and \( v \) will be a 10x5x5 array both containing their respective results for each of the 10 corresponding 4x5 arrays contained in \( x \).

If not all of the singular values can be computed, \( s[1,1] \) is set to a scalar error code. Use \texttt{scalerr} to convert this to an integer. The diagonal elements of \( s \) with indices greater than \texttt{scalerr}(\( s[1,1] \)) are correct. If \texttt{scalerr}(\( s[1,1] \)) returns a 0, all of the singular values have been computed.
See Also

svd1, svdcusv, svds

sysstate

Purpose

Gets or sets general system parameters.

Format

\{ \text{rets...} \} = \text{sysstate}(\text{case}, y);

Remarks

The available cases are as follows:

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Version Information</strong> Returns the current GAUSS version information in an 8-element numeric vector.</td>
</tr>
<tr>
<td>2-7</td>
<td><strong>GAUSS System Paths</strong> Gets or sets GAUSS system path.</td>
</tr>
<tr>
<td>8</td>
<td><strong>Complex Number Toggle</strong> Controls automatic generation of complex numbers in \text{sqrt}, \text{ln}, and \text{log} for negative arguments.</td>
</tr>
<tr>
<td>9</td>
<td><strong>Complex Trailing Character</strong> Gets or sets trailing character for the imaginary part of a complex number.</td>
</tr>
<tr>
<td>10</td>
<td><strong>Printer Width</strong> Gets or sets \text{lprint} width.</td>
</tr>
<tr>
<td>11</td>
<td><strong>Auxiliary Output Width</strong> Gets or sets the auxiliary output width.</td>
</tr>
<tr>
<td>13</td>
<td><strong>LU Tolerance</strong> Gets or sets singularity tolerance for LU</td>
</tr>
</tbody>
</table>
Case 14 Cholesky Tolerance Gets or sets singularity tolerance for Cholesky decomposition in current thread.

Case 15 Screen State Gets or sets window state as controlled by screen command.

Case 18 Auxiliary Output Gets auxiliary output parameters.

Case 19 Get/Set Format Gets or sets format parameters.

Case 21 Imaginary Tolerance Gets or sets imaginary tolerance in current thread.

Case 22 Source Path Gets or sets the path the compiler will search for source files.

Case 24 Dynamic Library Directory Gets or sets the path for the default dynamic library directory.

Case 25 Temporary File Path Gets or sets the path GAUSS will use for temporary files.

Case 26 Interface Mode Returns the current interface mode.

Case 28 Random Number Generator Parameters Gets or sets parameters used by the random number generation commands.

Case 30 Base Year Toggle Specifies whether year value returned by date is to include base year (1900) or not.

Case 32 Global LU Tolerance Gets or sets global singularity tolerance for LU decomposition.

Case 33 Global Cholesky Tolerance Gets or sets global singularity tolerance for Cholesky decomposition.

Case 34 Global Imaginary Tolerance Gets or sets global imaginary tolerance.

Case 1: Version Information
Purpose

Returns the current GAUSS version information in an 8-element numeric vector.

Format

\[ vi = \text{sysstate}(1,0); \]

Output

\( vi \)

8x1 numeric vector containing version information:

[8] Always 0.

\( vi[4] \) indicates the type of machine on which GAUSS is running:

1 Intel x86
2 Sun SPARC
Cases 2-7: GAUSS System Paths

**Purpose**

Gets or sets GAUSS system path.

**Format**

\[
\text{oldpath} = \text{sysstate}(\text{case, path});
\]

**Input**

- **case**
  - scalar 2-7, path to set.
  - 2 .exe file location.
  - 3 loadexe path.
4 save path.
5 load, loadm path.
6 loadf, loadp path.
7 loads path.

path scalar 0 to get path, or string containing the new path.

Output

oldpath string, original path.

Remarks

If path is of type matrix, the path will be returned but not modified.

Case 8: Complex Number Toggle

Purpose

Controls automatic generation of complex numbers in sqrt, ln and log for negative arguments.

Format

oldstate = sysstate(8, state);

Input

state scalar, 1, 0, or -1
Output

\( \text{oldstate} \) scalar, the original state.

Remarks

If \( state = 1 \), \( \log \), \( \ln \), and \( \sqrt{ } \) will return complex numbers for negative arguments. If \( state = 0 \), the program will terminate with an error message when negative numbers are passed to \( \log \), \( \ln \), and \( \sqrt{ } \). If \( state = -1 \), the current state is returned and left unchanged. The default state is 1.

Case 9: Complex Trailing Character

Purpose

Gets or sets trailing character for the imaginary part of a complex number.

Format

\[
\text{oldtrail} = \text{sysstate}(9, \text{trail});
\]

Input

\( trail \) scalar 0 to get character, or string containing the new trailing character.

Output

\( \text{oldtrail} \) string, the original trailing character.
Remarks

The default character is "i".

Case 10: Printer Width

Purpose

Gets or sets lprint width.

Format

\[ oldwidth = \text{sysstate}(10, \ width); \]

Input

\[ width \quad \text{scalar, new printer width.} \]

Output

\[ oldwidth \quad \text{scalar, the current original width.} \]

Remarks

If \( width \) is 0, the printer width will not be changed.

Case 11: Auxiliary Output Width

Purpose

Gets or sets the auxiliary output width.
**Format**

```plaintext
oldwidth = sysstate(11, width);
```

**Input**

- **width**: scalar, new output width.

**Output**

- **oldwidth**: scalar, the original output width.

**Remarks**

If `width` is 0 then the output width will not be changed.

This may also be set with the `outwidth` command.

**See Also**

- `outwidth`

**Case 13: LU Tolerance**

**Purpose**

Gets or sets singularity tolerance for LU decomposition in current thread.

**Format**

```plaintext
oldtol = sysstate(13, tol);
```
**Input**

\( tol \)  
scalar, new tolerance.

**Output**

\( oldtol \)  
scalar, the original tolerance.

**Remarks**

The tolerance must be \( \geq 0 \). If \( tol \) is negative, the tolerance is returned and left unchanged.

This tolerance is thread-safe. It must be set in the same thread in which it is to be referenced. To set the global singularity tolerance for LU decomposition, use case 32.

**See Also**

croutp, inv

Case 14: Cholesky Tolerance

**Purpose**

Gets or sets singularity tolerance for Cholesky decomposition in current thread.

**Format**

\[ oldtol = \text{sysstate}(14, \ tol); \]
**Input**

\[ tol \] scalar, new tolerance.

**Output**

\[ oldtol \] scalar, the original tolerance.

**Remarks**

The tolerance must be \( \geq 0 \). If \( tol \) is negative, the tolerance is returned and left unchanged.

This tolerance is thread-safe. It must be set in the same thread in which it is to be referenced. To set the global singularity tolerance for Cholesky decomposition, use case 33.

This affects the following functions:

- \( \text{solpd} \)
- \( \text{invpd} \) for matrices \( \leq 12 \times 12 \)

**See Also**

- \( \text{chol} \), \( \text{invpd} \), \( \text{solpd} \)

**Case 15: Screen State**

**Purpose**

Gets or sets window state as controlled by \( \text{screen} \) command.
Format

\[ \text{oldstate} = \text{sysstate}(15, \text{state}); \]

Input

\( \text{state} \) scalar, new window state.

Output

\( \text{oldstate} \) scalar, the original window state.

Remarks

If \( \text{state} = 1 \), window output is turned on. If \( \text{state} = 0 \), window output is turned off. If \( \text{state} = -1 \), the state is returned unchanged.

See Also

screen

Case 18: Auxiliary Output

Purpose

Gets auxiliary output parameters.

Format

\[ \{ \text{state, name} \} = \text{sysstate}(18,0); \]
Output

<table>
<thead>
<tr>
<th>state</th>
<th>scalar, auxiliary output state, 1 - on, 0 - off.</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>string, auxiliary output filename.</td>
</tr>
</tbody>
</table>

See Also

output

Case 19: Get/Set Format

Purpose

Gets or sets format parameters.

Format

```plaintext
oldfmt = sysstate(19, fmt);
```

Input

<table>
<thead>
<tr>
<th>fmt</th>
<th>scalar or 11x1 column vector containing the new format parameters. Usually this will have come from a previous <code>sysstate(19,0)</code> call. See Output for description of matrix.</th>
</tr>
</thead>
</table>

Output

<table>
<thead>
<tr>
<th>oldfmt</th>
<th>11x1 vector containing the current format parameters. The</th>
</tr>
</thead>
</table>
characters in quotes are components of the format string that gets passed through to the C library `printf` function:

[1] format conversion type:
   - 0: string format ("s")
   - 1: compact format ("g").
   - 2: auto format ("#g").
   - 3: scientific format ("e").
   - 4: decimal format ("f").
   - 5: compact format, upper case ("G").
   - 6: auto format, upper case ("#G").
   - 7: scientific format, upper case ("E").

[2] justification:
   - 0: right justification.
   - 1: left justification ("-").

[3] sign:
   - 0: sign used only for negative numbers.
   - 1: sign always used ("+").

[4] leading zero:
   - 0: no leading zero.
   - 1: leading zero ("0").
[5] trailing character:

0  no trailing character.
1  trailing space (" ").
2  trailing comma (”,“).
3  trailing tab ("\t").

[6] row delimiter:

0  no row delimiter.
1  one newline between rows ("\n").
2  two newlines between rows ("\n\n").
3  print "Row 1, Row 2, ..." before each row ("\nRow \%u\n", where "\%u" is the row number).

[7] carriage line feed position:

0  newline row delimiters positioned before rows.
1  newline row delimiters positioned after rows.


0  newline row delimiters occur between rows of a matrix only if that matrix has more than one row.
newline row delimiters occur between rows of a matrix, regardless of number of rows.

- field width.
- precision.
- formatted flag.

<table>
<thead>
<tr>
<th>0</th>
<th>formatting disabled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>formatting enabled.</td>
</tr>
</tbody>
</table>

**Remarks**

If `fmt` is scalar 0, then the format parameters will be left unchanged.

See the `format` and `print` commands for more information on the formatting parameters.

**See Also**

`format`, `print`

**Case 21: Imaginary Tolerance**

**Purpose**

Gets or sets imaginary tolerance in current thread.

**Format**

`oldtol = sysstate(21, tol);`
**Input**

(tol) scalar, the new tolerance.

**Output**

(oldtol) scalar, the original tolerance.

**Remarks**

The imaginary tolerance is used to test whether the imaginary part of a complex matrix can be treated as zero or not. Functions that are not defined for complex matrices check the imaginary part to see if it can be ignored. The default tolerance is 2.23e-16, or machine epsilon.

If tol<0, the current tolerance is returned.

This tolerance is thread-safe. It must be set in the same thread in which it is to be referenced. To set the global imaginary tolerance, use case 34.

**See Also**

hasimag

**Case 22: Source Path**

**Purpose**

Gets or sets the path the compiler will search for source files.
Format

\[ \text{oldpath} = \text{sysstate}(22, \ path); \]

Input

\( \text{path} \) scalar 0 to get path, or string containing the new path.

Output

\( \text{oldpath} \) string, original path.

Remarks

If \( \text{path} \) is a matrix, the current source path is returned.

This resets the \( \text{src\_path} \) configuration variable. \( \text{src\_path} \) is initially defined in the \texttt{GAUSS} configuration file, \texttt{gauss.cfg}.

\( \text{path} \) can list a sequence of directories, separated by semicolons.

Resetting \( \text{src\_path} \) affects the path used for subsequent \texttt{run} and \texttt{compile} statements.

Case 24: Dynamic Library Directory

Purpose

Gets or sets the path for the default dynamic library directory.

Format

\[ \text{oldpath} = \text{sysstate}(24, \ path); \]
**Input**

\[ path \]

scalar 0 to get path, or string containing the new path.

**Output**

\[ oldpath \]

string, original path.

**Remarks**

If \( path \) is a matrix, the current path is returned.

\( path \) should list a single directory, not a sequence of directories.

Changing the dynamic library path does not affect the state of any DLL's currently linked to GAUSS. Rather, it determines the directory that will be searched the next time \texttt{dlibrary} is called.

**UNIX**

Changing the path has no effect on GAUSS's default DLL, \texttt{libgauss.so}. \texttt{libgauss.so} must always be located in the GAUSSHOME directory.

**Windows**

Changing the path has no effect on GAUSS's default DLL, \texttt{gauss.dll}. \texttt{gauss.dll} must always be located in the GAUSSHOME directory.

**See Also**

\texttt{dlibrary}, \texttt{dllcall}

Case 25: Temporary File Path
**Purpose**

Gets or sets the path GAUSS will use for temporary files.

**Format**

\[ oldpath = \text{sysstate}(25, \ path); \]

**Input**

\[ path \]

scalar 0 to get path, or string containing the new path.

**Output**

\[ oldpath \]

string, original path.

**Remarks**

If \[ path \] is of type matrix, the path will be returned but not modified.

**Case 26: Interface Mode**

**Purpose**

Returns the current interface mode.

**Format**

\[ mode = \text{sysstate}(26,0); \]
**Output**

<table>
<thead>
<tr>
<th>mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>non-X mode</td>
</tr>
<tr>
<td>1</td>
<td>terminal (-v) mode</td>
</tr>
<tr>
<td>2</td>
<td>X Windows mode</td>
</tr>
</tbody>
</table>

**Remarks**

A mode of 0 indicates that you're running a non-X version of **GAUSS**; i.e., a version that has no X Windows capabilities. A mode of 1 indicates that you're running an X Windows version of **GAUSS**, but in terminal mode; i.e., you started **GAUSS** with the -v flag. A mode of 2 indicates that you're running **GAUSS** in X Windows mode.

**Case 28: Random Number Generator Parameters**

**Purpose**

- Gets or sets the random number generator (RNG) parameters.

**Format**

```plaintext
oldprms = sysstate(28, prms);
```

**Input**

<table>
<thead>
<tr>
<th>prms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scalar 0</td>
<td>to get parameters, or 3x1 matrix of new parameters.</td>
</tr>
<tr>
<td>[1] seed</td>
<td>0&lt;seed&lt;2³²</td>
</tr>
</tbody>
</table>
multiplier, 0<mult<2^{32}

constant, 0<=const<2^{32}

Output

oldprms 3x1 vector, the original parameters.

Remarks

If prms is a scalar 0, the current parameters will be returned without being changed.

The modulus of the RNG cannot be changed; it is fixed at 2^{32}.

See Also

rndcon, rndmult, rndseed, rndn, rndu

Case 30: Base Year Toggle

Purpose

Specifies whether year value returned by date is to include base year (1900) or not.

Format

oldstate = sysstate(30, state);
**Input**

`state`  
scalar, 1, 0, or missing value.

**Output**

`oldstate`  
scalar, the original state.

**Remarks**

Internally, `date` acquires the number of years since 1900. `sysstate` case 30 specifies whether `date` should add the base year to that value or not. If `state = 1`, `date` adds 1900, returning a fully-qualified 4-digit year.

If `state = 0`, `date` returns the number of years since 1900. If `state` is a missing value, the current state is returned. The default state is 1.

**Case 32: Global LU Tolerance**

**Purpose**

Gets or sets global singularity tolerance for LU decomposition.

**Format**

```
oldtol = sysstate(32, tol);
```

**Input**

`tol`  
scalar, new tolerance.
Output

\[ oldtol \] scalar, the original tolerance.

Remarks

The tolerance must be \( \geq 0 \). If \( tol \) is negative, the tolerance is returned and left unchanged.

This is a global tolerance and therefore not thread-safe. To set the singularity tolerance for LU decomposition in the current thread, use case 13.

See Also

croutp, inv

Case 33: Global Cholesky Tolerance

Purpose

Gets or sets global singularity tolerance for Cholesky decomposition.

Format

\[ oldtol = \text{sysstate}(33, \ tol); \]

Input

\[ tol \] scalar, new tolerance.
Output

\[ \text{oldtol} \quad \text{scalar, the original tolerance.} \]

Remarks

The tolerance must be \( \geq 0 \). If \( tol \) is negative, the tolerance is returned and left unchanged.

This is a global tolerance and therefore not thread-safe. To set the singularity tolerance for Cholesky decomposition in the current thread, use case 14.

This affects the following functions:

- \text{solpd}
- \text{invpd} for matrices \( \leq 12x12 \)

See Also

\text{chol, invpd, solpd}

Case 34: Global Imaginary Tolerance

Purpose

Gets or sets the global imaginary tolerance.

Format

\[ \text{oldtol} = \text{sysstate}(34, \text{tol}); \]
**Input**

* tol * scalar, the new tolerance.

**Output**

* oldtol * scalar, the original tolerance.

**Remarks**

The imaginary tolerance is used to test whether the imaginary part of a complex matrix can be treated as zero or not. Functions that are not defined for complex matrices check the imaginary part to see if it can be ignored. The default tolerance is 2.23e-16, or machine epsilon.

If * tol*<0, the current tolerance is returned.

This is a global tolerance and therefore not thread-safe. To set the imaginary tolerance in the current thread, use case 21.

**See Also**

* hasimag
* system

**Purpose**

Quits GAUSS and returns to the operating system.
Format

```
  system;
  system  c;
```

Input

```
c
```
scalar, an optional exit code that can be recovered by the program that invoked GAUSS. The default is 0. Valid arguments are 0-255.

Remarks

The `system` command always returns an exit code to the operating system or invoking program. If you don't supply one, it returns 0. This is usually interpreted as indicating success.

See Also

`exec`
Purpose
Tabs the cursor to a specified text column.

Format

```
  tab(col);
  print  expr1  expr2  tab(col1)  expr3  tab(col2)  expr4 ...
```

Input

```
col  
```
scalar, the column position to tab to.

Remarks

```
col specifies an absolute column position. If col is not an integer, it will be truncated.

tab can be called alone or embedded in a print statement. You cannot embed it within a parenthesized expression in a print statement, though. For example:

```
  print  (tab(20)  c + d * e);
```

will not give the results you expect. If you have to use parenthesized expressions, write it like this instead:

```
  print  (tab(20)  c + d * e);
```
\textbf{Purpose}  
Returns the tangent of its argument.

\textbf{Format}  
\[ y = \tan(x); \]

\textbf{Input}  
\( x \) \quad \text{NxK matrix or N-dimensional array.}

\textbf{Output}  
\( y \) \quad \text{NxK matrix or N-dimensional array.}

\textbf{Remarks}  
For real matrices, \( x \) should contain angles measured in radians.  
To convert degrees to radians, multiply the degrees by \( \pi/180 \).

\textbf{Example}  
//Create an additive sequence 0.1, 0.2, 0.3...0.9
\[ x = \text{seqa}(0.1, 0.1, 9); \]
\[ y = \tan(x); \]

The above code produces:

\[
\begin{align*}
0.1003346 \\
0.2027100 \\
0.3093362 \\
0.4227932 \\
y = 0.5463024 \\
0.6841368 \\
0.8422883 \\
1.0296386 \\
1.2601582
\end{align*}
\]

See Also

atan, pi

tanh

Purpose

Computes the hyperbolic tangent.

Format

\[ y = \text{tanh}(x); \]
## Input

$x$  
N×K matrix or N-dimensional array.

## Output

$y$  
N×K matrix or N-dimensional array containing the hyperbolic tangents of the elements of $x$.

## Example

```plaintext
//Create a sequence starting at -0.5 and increasing by 0.25, i.e. -0.5, -0.25, 0, 0.25...1
x = seqa(-0.5, 0.25, 7);
x = x * pi;
y = tanh(x);
```

After the above code, $y$ is equal to:

-0.46211716
-0.24491866
0.00000000
0.24491866
0.46211716
0.63514895
0.76159416

## Source

trig.src
tempname

Purpose

Creates a temporary file with a unique name.

Format

\[ tname = \text{tempname}(path, \ pre, \ suf); \]

Input

- \( path \): string, path where the file will reside.
- \( pre \): string, a prefix to begin the file name with.
- \( suf \): string, a suffix to end the file name with.

Output

- \( tname \): string, unique temporary file name of the form \( path/preXXXXnnnnn{suf} \), where XXXX are 4 letters, and nnnnn is the process id of the calling process.

Remarks

Any or all of the inputs may be a null string or 0. If \( path \) is not specified, the current working directory is used.

If unable to create a unique file name of the form requested, \text{tempname} returns a null string.
WARNING: GAUSS does not remove temporary files created by `tempname`. It is left to the user to remove them when they are no longer needed.

ThreadBegin

Purpose

Marks the beginning of a multi-line block of code to be executed as a thread.

Format

```
ThreadBegin;
```

Example

```
ThreadBegin;
m = n*p;
n = calcA(m);
ThreadEnd;
```

Notice that the writer-must-isolate rule (see Multi-Threaded Programming in GAUSS, Chapter 1) does not apply within the bounds of the 
`ThreadBegin/ThreadEnd` pair, as there is no risk of simultaneous access to a symbol. The rule only applies between the threads in a given set (and their children).

See `ThreadJoin` for an example of a fully-defined thread set.

See Also

`ThreadEnd`, `ThreadJoin`, `ThreadStat`
**ThreadEnd**

**Purpose**

Marks the end of a multi-line block of code to be executed as a thread.

**Format**

```
ThreadEnd;
```

**Example**

```
ThreadBegin;
  m = n*p;
  n = calcA(m);
ThreadEnd;
```

Notice that the **writer-must-isolate** rule (see *Multi-Threaded Programming in GAUSS*, Chapter 1) does not apply within the bounds of the `ThreadBegin/ThreadEnd` pair, as there is no risk of simultaneous access to a symbol. The rule only applies between the threads in a given set (and their children).

See **ThreadJoin** for an example of a fully-defined thread set.

**See Also**

`ThreadBegin`, `ThreadJoin`, `ThreadStat`

**ThreadJoin**

**Purpose**

Completes the definition of a set of threads to be executed simultaneously.
Format

```
ThreadJoin;
```

Remarks

Each thread in the set must adhere to the **writer-must-isolate** rule (see Multi-
Threaded Programming in GAUSS, Chapter 1). Because the threads in a set execute
simultaneously, there is no way of knowing in one thread the current "state" of a
symbol in another, and thus no way of safely or meaningfully accessing it.

Example

```
ThreadBegin;       //Thread 1--isolates y,z
    y = x'x;
    z = y'y;
ThreadEnd;
ThreadBegin;       //Thread 2--isolates q,r
    q = r'r;
    r = q'q;
ThreadEnd;
ThreadStat n = m'm; //Thread 3--isolates n
ThreadStat p = o'o; //Thread 4--isolates p
ThreadJoin;       //Joins threads 1-4
b = z + r + n'p;   //y,z,q,r,n,p available again,
                   // can be read and written
```

Note how threads 1-4 isolate the various symbols they assign to--no other thread
references the written symbols at all. Once the threads are joined, however, the
symbols are again available for use, and can be both read and assigned to.

See Also

`ThreadBegin`, `ThreadEnd`, `ThreadStat`
**ThreadStat**

**Purpose**

Marks a single line of code to be executed as a thread.

**Format**

```
ThreadStat statement;
```

**Example**

```
ThreadStat m = n*p;
```

See **ThreadJoin** for an example of a fully-defined thread set.

**See Also**

**ThreadBegin, ThreadEnd, ThreadJoin**

---

**time**

**Purpose**

Returns the current system time.

**Format**

```
y = time;
```
**Output**

| y | 4x1 numeric vector, the current time in the order: hours, minutes, seconds, and hundredths of a second. |

**Example**

```matlab
define time;

print time;
```

| 7.000000 |
| 31.000000 |
| 46.000000 |
| 33.000000 |

**See Also**

date, datestr, datestring, datestrymd, hsec, timestr

timedt

**Purpose**

Returns system date and time in DT scalar format.

**Format**

```matlab
dt = timedt;
```

**Output**

| dt | scalar, system date and time in DT scalar format. |
Remarks

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number:

```
20100306071511
```

represents:

```
07:15:11 or 7:15:11 AM on March 6, 2010.
```

Source
time.src

See Also
todaydt, timeutc, ddate

timestr

Purpose

Formats a time in a vector to a string.

Format

```
ts = timestr(t);
```

Input

```
t
```

4x1 vector from the time function, or a zero. If the input is
0, the `time` function will be called to return the current system time.

**Output**

| ts | 8 character string containing current time in the format: hr:mn:sc |

**Example**

```plaintext
    t = { 7, 31, 46, 33 };
    ts = timestr(t);
    print ts;
```

produces:

```
    7:31:46
```

**Source**

time.src

**See Also**

date, datestr, datestring, datestrymd, ethsec, etstr, time

timeutc

**Purpose**

Returns the number of seconds since January 1, 1970 Greenwich Mean Time.
**Format**

```
tc = timeutc;
```

**Output**

```
tc     scalar, number of seconds since January 1, 1970 Greenwich Mean Time.
```

**Example**

```c
//Retrieve seconds since January 1, 1970 GMT
tc = timeutc;

//Convert to a date time vector
utv = utctodtv(tc);
```

After the code above, \textit{tc} and \textit{utv} are equal to:

```
tc = 1340080112

utv = 2012 06 18 21 28 32 1 169
```

**See Also**

dtvnormal, utctodtv
**title**

**Purpose**
Sets the title for the graph. NOTE: This function is for the deprecated PQG graphics. Use `plotSetTitle` instead.

**Library**
pgraph

**Format**

```
title(str);
```

**Input**

*str* string, the title to display above the graph.

**Remarks**

Up to three lines of title may be produced by embedding a line feed character ("\L") in the title string.

**Example**

```
title("First title line\LSecond title line\L"\n"Third title line");
```

Fonts may be specified in the title string. For instructions on using fonts, see Selecting Fonts, Section 1.0.1.
Source
pgraph.src

See Also
xlabel, ylabel, fonts

tkf2eps

Purpose
Converts a .tkf file to an Encapsulated PostScript file. NOTE: This function is deprecated and does not work for the new .plot graphics files. Use plotSave to convert .plot files to EPS format.

Library
pgraph

Format

\[ ret = tkf2eps(tekfile, epsfile); \]

Input

\begin{itemize}
  \item \texttt{tekfile} \hspace{1em} string, name of .tkf file.
  \item \texttt{epsfile} \hspace{1em} string, name of Encapsulated PostScript file.
\end{itemize}
Output

$\text{ret} \quad \text{scalar, 0 if successful}$

Remarks

The conversion is done using the global parameters in `peps.dec`. You can modify these globally by editing the `.dec` file, or locally by setting them in your program before calling `tkf2eps`.

See the header of the output Encapsulated PostScript file and a PostScript manual if you want to modify these parameters.

tkf2ps

Purpose

Converts a `.tkf` file to a PostScript file. NOTE: This function is deprecated and does not work for the new `.plot` graphics files. Use `plotSave` to convert `.plot` files to PS format.

Library

pgraph

Format

\[
\text{ret} = \text{tkf2ps}(\text{tekfile, psfile});
\]
**Input**

<table>
<thead>
<tr>
<th>string</th>
<th>name of .tkf file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>tekfile</td>
<td>string, name of PostScript file.</td>
</tr>
<tr>
<td>psfile</td>
<td></td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>scalar</th>
<th>0 if successful.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ret</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks**

The conversion is done using the global parameters in `peps.dec`. You can modify these globally by editing the `.dec` file, or locally by setting them in your program before calling `tkf2ps`.

See the header of the output PostScript file and a PostScript manual if you want to modify these parameters.

**tocart**

**Purpose**

Converts from polar to Cartesian coordinates.

**Format**

\[ xy = \text{tocart}(r, \theta); \]
**Input**

- \( r \)  
  \( \text{N} \times \text{K} \) real matrix, radius.
- \( \theta \)  
  \( \text{L} \times \text{M} \) real matrix, \( \text{E} \times \text{E} \) conformable with \( r \), angle in radians.

**Output**

- \( xy \)  
  \( \text{max}(\text{N}, \text{L}) \) by \( \text{max}(\text{K}, \text{M}) \) complex matrix containing the \( x \) coordinate in the real part and the \( y \) coordinate in the imaginary part.

**Source**

**todaydt**

**Purpose**

Returns system date in DT scalar format. The time returned is always midnight (00:00:00), the beginning of the returned day.

**Format**

```
dt = todaydt();
```

**Output**

- \( dt \)  
  scalar, system date in DT scalar format.
Remarks

The DT scalar format is a double precision representation of the date and time. In the DT scalar format, the number:

```
20130906130525
```

represents 13:05:25 or 1:05:25 PM on September 6, 2013.

Example

`todaydt` can be used with the function `dttostr` to print the current date as a string:

```
//Get today's date in dt scalar format
dt = todaydt();

//Convert the dtscalar to a desired format
dt_str = dttostr(dt, "MO/DD/YYYY");

//Combining strings with the '+' operator
print "Today is " + dt_str;
```

returns:

```
Today is 10/22/2013
```

Source

time.src

See Also

dttostr, timedt, timeutc, dtdate
toeplitz

**Purpose**

Creates a Toeplitz matrix from a column vector.

**Format**

\[ t = \text{toeplitz}(x); \]

**Input**

- \( x \)  
  Kx1 vector.

**Output**

- \( t \)  
  KxK Toeplitz matrix.

**Example**

```c
//Create the sequence 1, 2, 3, 4, 5 and assign it to 'x'
x = seqa(1,1,5);

//Create a diagonal-constant or Toeplitz matrix
y = toeplitz(x);
```

After the code above, \( y \) is equal to:

```
1 2 3 4 5
2 1 2 3 4
3 2 1 2 3
```
## Source

toeplitz.src

## token

### Purpose

Extracts the leading token from a string.

### Format

```
{token, str_left} = token(str);
```

### Input

- **str**
  
  string, the string to parse.

### Output

- **token**
  
  string, the first token in `str`.
- **str_left**
  
  string, `str` minus `token`.

### Remarks

`str` can be delimited with commas or spaces.
The advantage of token over parse is that parse is limited to tokens of 8 characters or less; token can extract tokens of any length.

**Example**

**Example 1**

```plaintext
title = "Australia exports";
{ country, str_left } = token(title);
print country;
print str_left;
```

returns:

```
Australia
exports
```

**Example 2**

Here is a keyword that uses token to parse its string parameter:

```plaintext
//Create a keyword called 'add' that takes the input
//'s' and executes all of the code from the 'keyword
//add(s)' line until the 'endp' statement each time
//it is called
keyword add(s);
    local tok,sum;
    sum = 0;

    //Continue loop until 's' equals an empty string
do until s $== ""

        //Remove the first token from 's' and return
        //it in 'tok'
        { tok, s } = token(s);
```

//Convert the string in 'tok' to a floating
//point number and add it to 'sum'
    sum = sum + stof(tok);
    endo;

//Set the formatting for print statements to
//create 1 space between numbers and
//to print 2 digits after the decimal point
    format /rd 1,2;
    print "Sum is: " sum;
    endp;

If you type:

//Since it is a 'keyword' and not a 'proc', 'add'
//will take everything between 'add' and the
//semi-colon as a string input and refer to it
//internally as the 's' variable
    add 1 2 3 4 5 6;

add will respond:

    Sum is: 15.00

Source
token.src

See Also
parse
**topolar**

**Purpose**

Converts from Cartesian to polar coordinates.

**Format**

\[
\{ r, \ theta \} = \text{topolar}(xy);
\]

**Input**

\[ xy \]

NxK complex matrix containing the \( x \) coordinate in the real part and the \( y \) coordinate in the imaginary part.

**Output**

\[ r \]

NxK real matrix, radius.

\[ theta \]

NxK real matrix, angle in radians.

**Source**

coord.src

---

**trace**

**Purpose**

Allows the user to trace program execution for debugging purposes.
Format

```
trace new;
trace new, mask;
```

Input

- `new` scalar, new value for trace flag.
- `mask` scalar, optional mask to allow leaving some bits of the trace flag unchanged.

Remarks

The `trace` command has no effect unless you are running your program under GAUSS's source level debugger. Setting the `trace` flag will not generate any debugging output during normal execution of a program.

The argument is converted to a binary integer with the following meanings:

<table>
<thead>
<tr>
<th>bit</th>
<th>decimal</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ones</td>
<td>1</td>
<td>trace calls/returns</td>
</tr>
<tr>
<td>twos</td>
<td>2</td>
<td>trace line numbers</td>
</tr>
<tr>
<td>fours</td>
<td>4</td>
<td>unused</td>
</tr>
<tr>
<td>eights</td>
<td>8</td>
<td>output to window</td>
</tr>
<tr>
<td>sixteens</td>
<td>16</td>
<td>output to print</td>
</tr>
<tr>
<td>thirty-twos</td>
<td>32</td>
<td>output to auxiliary output</td>
</tr>
<tr>
<td>sixty-fours</td>
<td>64</td>
<td>output to error log</td>
</tr>
</tbody>
</table>
You must set one or more of the output bits to get any output from `trace`. If you set `trace` to 2, you'll be doing a line number trace of your program, but the output will not be displayed anywhere.

The `trace` output as a program executes will be as follows:

```
(+GRAD)  calling function or procedure `GRAD'
(-GRAD)  returning from `GRAD'
[47]     executing line 47
```

Note that the line number trace will only produce output if the program was compiled with line number records.

To set a single bit use two arguments:

```
trace 16,16;  turn on output to printer
trace 0,16;   turn off output to printer
```

**Example**

```
trace 1+8;  //trace fn/proc calls/returns to standard
           //output
trace 2+8;  //trace line numbers to standard output
trace 1+2+8;  //trace line numbers and fn/proc calls/
               //returns to standard output
trace 1+16;  //trace fn/proc calls/returns to printer
trace 2+16;  //trace line numbers to printer
trace 1+2+16;  //trace line numbers and fn/proc calls/
               //returns to printer
```

**See Also**

`lineson`
trap

Purpose

Sets the trap flag to enable or disable trapping of numerical errors.

Format

```
trap new;
trap new, mask;
```

Input

- `new`  
  scalar, new trap value.
- `mask`  
  scalar, optional mask to allow leaving some bits of the trap flag unchanged.

Remarks

The trap flag is examined by some functions to control error handling. There are 16 bits in the trap flag, but most GAUSS functions will examine only the lowest order bit:

```
trap 1;       turn trapping on
trap 0;       turn trapping off
```

If we extend the use of the trap flag, we will use the lower order bits of the trap flag. It would be wise for you to use the highest 8 bits of the trap flag if you create some sort of user-defined trap mechanism for use in your programs. (See the function trapchk for detailed instructions on testing the state of the trap flag; see error for generating user-defined error codes.)
To set only one bit and leave the others unchanged, use two arguments:

```
trap 1,1;  set the ones bit
trap 0,1;  clear the ones bit
```

**Example**

```
proc(0) = printinv(x);
    local oldval,y;
    oldval = trapchk(1);
    trap 1,1;
    y = inv(x);
    trap oldval,1;
    if scalerr(y);
        errorlog "WARNING: x is singular";
    else;
        print "y" y;
    endif;
endp;
```

In this example the result of `inv` is trapped in case `x` is singular. The trap state is reset to the original value after the call to `inv`.

Calling `printinv` as follows:

```
x = eye(3);
printinv(x);
```

produces:

```
y =
    1.0000000 0.0000000 0.0000000
    0.0000000 1.0000000 0.0000000
    0.0000000 0.0000000 1.0000000
```
while

\[
\begin{align*}
  x &= \text{ones}(3, 3); \\
  \text{printinv}(x);
\end{align*}
\]

produces:

WARNING: x is singular

See Also

scalerr, trapchk, error

trapchk

Purpose

Tests the value of the trap flag.

Format

\[ y = \text{trapchk}(m); \]

Input

\[ m \quad \text{scalar mask value.} \]

Output

\[ y \quad \text{scalar which is the result of the bitwise logical AND of the trap flag and the mask value.} \]
Remarks

To check the various bits in the trap flag, add the decimal values for the bits you wish to check according to the chart below and pass the sum in as the argument to the trapchk function:

<table>
<thead>
<tr>
<th>bit</th>
<th>decimal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>128</td>
</tr>
<tr>
<td>8</td>
<td>256</td>
</tr>
<tr>
<td>9</td>
<td>512</td>
</tr>
<tr>
<td>10</td>
<td>1024</td>
</tr>
<tr>
<td>11</td>
<td>2048</td>
</tr>
<tr>
<td>12</td>
<td>4096</td>
</tr>
<tr>
<td>13</td>
<td>8192</td>
</tr>
<tr>
<td>14</td>
<td>16384</td>
</tr>
<tr>
<td>15</td>
<td>32768</td>
</tr>
</tbody>
</table>

If you want to test if either bit 0 or bit 8 is set, then pass an argument of 1+256 or 257 to trapchk. The following table demonstrates values that will be returned for:

\[ y = \text{trapchk}(257); \]
<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>value of bit 0 in trap flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>256</td>
<td>257</td>
</tr>
</tbody>
</table>

value of bit 8 in trap flag

**GAUSS** functions that test the trap flag currently test only bits 0 and 1.

**See Also**

*scalerr*, *trap*, *error*

**trigamma**

**Purpose**

Computes trigamma function.

**Format**

\[ y = \text{trigamma}(x); \]

**Input**

\[ x \]

MxN matrix or N-dimensional array.

**Output**

\[ y \]

MxN matrix or N-dimensional array, trigamma.
Remarks

The trigamma function is the second derivative of the log of the gamma function with respect to its argument.

trimr

Purpose

Trims rows from the top and/or bottom of a matrix.

Format

\[ y = \text{trimr}(x, t, b); \]

Input

- \( x \): NxK matrix from which rows are to be trimmed.
- \( t \): scalar containing the number of rows which are to be removed from the top of \( x \).
- \( b \): scalar containing the number of rows which are to be removed from the bottom of \( x \).

Output

- \( y \): RxK matrix where \( R=N-(t+b) \), containing the rows left after the trim.
Remarks
If either \( t \) or \( b \) is zero, then no rows will be trimmed from that end of the matrix.

Example

```plaintext
//Create a 5x3 matrix of random uniform numbers
x = rndu(5,3);

//Remove the top 2 rows of x and the bottom row
y = trimr(x,2,1);
```

If \( x \) is equal to:

```plaintext
0.780 0.922 0.864
0.151 0.687 0.947
0.271 0.014 0.060
0.054 0.084 0.526
0.880 0.278 0.199
```

then \( y \) will equal:

```plaintext
0.271 0.014 0.060
0.054 0.084 0.526
```

See Also
- submat
- rotater
- shiftr

trunc

Purpose
Converts numbers to integers by truncating the fractional portion.
**Format**

\[ y = \text{trunc}(x); \]

**Input**

\[ x \quad \text{NxK matrix or N-dimensional array.} \]

**Output**

\[ y \quad \text{NxK matrix or N-dimensional array containing the truncated elements of } x. \]

**Example**

\[
\begin{align*}
x &= 100 \ast \text{rndn}(2,2); \\
y &= \text{trunc}(x);
\end{align*}
\]

If \( x \) equals:

\[
\begin{pmatrix}
-153.373 & -1.972 \\
109.412 & 127.732
\end{pmatrix}
\]

then, \( y \) will equal:

\[
\begin{pmatrix}
-153.000 & -1.000 \\
109.000 & 127.000
\end{pmatrix}
\]

**See Also**

`ceil`, `floor`, `round`
type

Purpose

Returns the symbol table type of its argument.

Format

\[ t = \text{type}(x); \]

Input

\[ x \]  local or global symbol, can be an expression.

Output

\[ t \]  scalar, argument type.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>matrix</td>
</tr>
<tr>
<td>13</td>
<td>string</td>
</tr>
<tr>
<td>15</td>
<td>string array</td>
</tr>
<tr>
<td>17</td>
<td>structure</td>
</tr>
<tr>
<td>21</td>
<td>array</td>
</tr>
<tr>
<td>23</td>
<td>structure pointer</td>
</tr>
<tr>
<td>23</td>
<td>sparse matrix</td>
</tr>
</tbody>
</table>
Remarks

type returns the type of a single symbol. The related function typcv will take a character vector of symbol names and return a vector of either their types or the missing value code for any that are undefined. type works for the symbol types listed above; typcv works for user-defined procedures, keywords and functions as well. type works for global or local symbols; typcv works only for global symbols.

Example

```gauss
k = { "CHARS" };
print k;
if type(k) == 6;
    k = "" $+ k; /* force matrix to string */
endif;

//The '$' in front of 'k' tells GAUSS to interpret it as character data
print $k;
```

produces:

```
CHARS
```

See Also

typcv, typef

typcv

Purpose

Returns the symbol table type of objects whose names are given as a string or as elements of a character vector or string array.
Format

\[ y = \text{typecv}(x); \]

Input

\( x \)
string, or \( N \times 1 \) character vector or string array which contains the names of variables whose type is to be determined.

Output

\( y \)
scalar or \( N \times 1 \) vector containing the types of the respective symbols in \( x \).

Remarks

The values returned by \texttt{typecv} for the various variable types are as follows:

- 5 keyword (\texttt{keyword})
- 6 matrix (numeric, character, or mixed)
- 8 procedure (\texttt{proc})
- 9 function (\texttt{fn})
- 13 string
- 15 string array
- 17 structure
- 21 array
- 23 structure pointer
**typecv** will return the **GAUSS** missing value code if the symbol is not found, so it may be used to determine if a symbol is defined or not.

### Example

```gauss
xvar = sqrt(5);
yvar = "betahat";
fn area(r) = pi*r*r;
let names = xvar yvar area;
y = typecv(names);
```

This code assigns the following to `y`:

```gauss
  6  //6 for type matrix
  13 //13 for string
  9  //9 for function
```

### See Also

[type, typef, varput, varget]

### typef

#### Purpose

Returns the type of data (the number of bytes per element) in a **GAUSS** data set.

#### Format

```gauss
y = typef(fp);
```
**Input**

$fp$  
scalar, file handle of an open file.

**Output**

$y$  
scalar, type of data in GAUSS data set.

**Remarks**

If $fp$ is a valid GAUSS file handle, then $y$ will be set to the type of the data in the file as follows:

- 2: 2-byte signed integer
- 4: 4-byte IEEE floating point
- 8: 8-byte IEEE floating point

**Example**

```gauss
//Assign a variable to represent each of our file names
infile = "dat1";
outfile = "dat2";

//Open the file "dat1" for reading.
//Note: The ^ before 'infile' tells GAUSS to use the value
//of the string variable 'infile' (which is 'dat1' in this
//case) rather than name of the variable.
open fin = ^infile;

//Get the names of the variables that are saved in the
//dataset
```
names = `getname`(infile);

//Create a new data set file using the same variable names
//as 'dat1', with 1 column per data element and using the
//same size data, i.e. the number of bytes per element, as
//the data in 'dat1'
create fout = `outfile` with ^names, 0, typef(fin);

In this example, a file dat2.dat is created which has the same variables and
variable type as the input file, dat1.dat. `typef` is used to return the type of the
input file data for the create statement.

**See Also**

colsf, rowsf
union

Purpose

Returns the union of two vectors with duplicates removed.

Format

\[ y = \text{union}(v1, \ v2, \ flag); \]

Input

- \( v1 \): Nx1 vector.
- \( v2 \): Mx1 vector.
- \( flag \): scalar, 1 if numeric data, 0 if character.

Output

- \( y \): Lx1 vector containing all unique values that are in \( v1 \) and \( v2 \), sorted in ascending order.

Remarks

The combined elements of \( v1 \) and \( v2 \) must fit into a single vector.
**Example**

```gauss
//Create two column vectors with character data
let v1 = mary jane linda john;
let v2 = mary sally;

x = \textbf{union}(v1,v2,0);

//The '$' in front of 'x' tells GAUSS to print 'x' as
//character data
print $x;
```

The above code will produce the following results:

- JANE
- JOHN
- LINDA
- MARY
- SALLY

**unionsa**

**Purpose**

Returns the union of two string vectors with duplicates removed.

**Format**

```gauss
y = \textbf{unionsa}(sv1, sv2);
```
### Input

- sv1: Nx1 or 1xN string vector.
- sv2: Mx1 or 1xM string vector.

### Output

- y: Lx1 vector containing all unique values that are in sv1 and sv2, sorted in ascending order.

### Example

```c
string sv1 = { "mary", "jane", "linda", "john" };
string sv2 = { "mary", "sally" };
y = unionsa(sv1,sv2);
print y;
```

The above code produces the following output:

```
   jane
   john
   linda
   mary
   sally
```

### Source

unionsa.src

### See Also

union
### uniqindx

#### Purpose

Computes the sorted index of \( x \), leaving out duplicate elements.

#### Format

\[
index = \text{uniqindx}(x, \ flag);
\]

#### Input

<table>
<thead>
<tr>
<th>( x )</th>
<th>Nx1 or 1xN vector.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( flag )</td>
<td>scalar, 1 if numeric data, 0 if character.</td>
</tr>
</tbody>
</table>

#### Output

| \( index \)      | Mx1 vector, indices corresponding to the elements of \( x \) sorted in ascending order with duplicates removed. |

#### Remarks

Among sets of duplicates it is unpredictable which elements will be indexed.

#### Example

```plaintext
let x = 5 4 4 3 3 2 1;

//Create a sorted index of all the unique elements in 'x'
```
ind = \texttt{uniqindx}(x,1);

//Use the index 'ind' to return all of the unique elements
//of 'x' in ascending order
y = x[ind];

After running the above code, \texttt{ind} and \texttt{y} are equal to:

\begin{tabular}{cc}
7.0000000 & 1.0000000 \\
6.0000000 & 2.0000000 \\
4.0000000 & 3.0000000 \\
3.0000000 & 4.0000000 \\
1.0000000 & 5.0000000 \\
\end{tabular}

\textbf{See Also}

\texttt{unique}, \texttt{uniqindxsa}

\textbf{uniqindxsa}

\textbf{Purpose}

Computes the sorted index of a string vector, omitting duplicate elements.

\textbf{Format}

\[ \texttt{ind} = \texttt{uniqindxsa}(sv); \]

\textbf{Input}

\texttt{sv} \quad \text{Nx1 or 1xN string vector.}
Output

\[ ind \quad \text{Mx1 vector, indices corresponding to the elements of } \, sv \]
\[ \text{sorted in ascending order with duplicates removed.} \]

Remarks

Among sets of duplicates it is unpredictable which elements will be indexed.

Example

```c
string sv = {"mary", "linda", "linda", "jane", "jane", "cindy", "betty"};
ind = uniqindxs(a)(sv);
y = sv[ind];
```

The above code assigns the variables \( ind \) and \( y \) as follows:

<table>
<thead>
<tr>
<th>ind</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>betty</td>
</tr>
<tr>
<td>6</td>
<td>cindy</td>
</tr>
<tr>
<td>4</td>
<td>jane</td>
</tr>
<tr>
<td>2</td>
<td>linda</td>
</tr>
<tr>
<td>1</td>
<td>mary</td>
</tr>
</tbody>
</table>

Source

uniquesa.src

See Also

unique, uniques, uniqindx
unique

Purpose
Sorts and removes duplicate elements from a vector.

Format
\[ y = \text{unique}(x, \ \text{flag}); \]

Input
- \( x \) N\times1 or 1\times N \) vector.
- \( \text{flag} \) scalar, 1 if numeric data, 0 if character.

Output
- \( y \) M\times1 vector, sorted \( x \) with the duplicates removed.

Example
//Create a column vector with duplicate elements
let eventYear = 1632 2012 1709 1812 1709 1989 1830 1875 191
2 1912 1924 1960;

//Sort 'eventYear' as numeric data and remove any duplicate elements
years = \text{unique}(eventYear,1);
After the code above, the variables `eventYear` and `years` are assigned as follows:

<table>
<thead>
<tr>
<th>eventYear</th>
<th>year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1632</td>
<td>1632</td>
</tr>
<tr>
<td>2012</td>
<td>1632</td>
</tr>
<tr>
<td>1709</td>
<td>1709</td>
</tr>
<tr>
<td>1812</td>
<td>1812</td>
</tr>
<tr>
<td>1709</td>
<td>1830</td>
</tr>
</tbody>
</table>

80 543

See Also

`uniquesa`, `uniqindx`

uniquesa

Purpose

Removes duplicate elements from a string vector.

Format

\[ y = \text{uniquesa}(sv); \]

Input

\( sv \)  
N×1 or 1×N string vector.
Output

\[ y \text{ sorted Mx1 string vector containing all unique elements found in } sv. \]

Example

```c
//Create a 8x1 string array
string comTrades = { "corn", "gold", "soybeans", "silver", "coffee", "oil", "silver", "soybeans" };

//Return an alphabetized string array containing the unique elements from 'comTrades'
commodity = uniquesa(comTrades);
```

After the code above, the variables `comTrades` and `commodity` will be equal to:

- `comTrades`: corn, gold, soybeans
- `commodity`: coffee, corn, soybeans

Remarks

It is important to note that the return from `uniquesa` will always be a column vector, even if the input string array is a row vector.
Source
uniquesa.src

See Also
unique, uniqindxsa, uniqindx

upmat, upmat1

Purpose
Returns the upper portion of a matrix. upmat returns the main diagonal and every element above. upmat1 is the same except it replaces the main diagonal with ones.

Format
\[
\begin{align*}
u &= \text{upmat}(x); \\
u &= \text{upmat1}(x);
\end{align*}
\]

Input
\[
\begin{align*}
x & \quad \text{NxK matrix.}
\end{align*}
\]

Output
\[
\begin{align*}
u & \quad \text{NxK matrix containing the upper elements of } x. \text{ The lower elements are replaced with zeros. upmat returns the main diagonal intact. upmat1 replaces the main diagonal with ones.}
\end{align*}
\]
Example

\[
x = \begin{bmatrix}
7 & 2 & -1 \\
2 & 3 & -2 \\
4 & -2 & 8
\end{bmatrix};
\]

\[
u = \text{upmat}(x);
\]

\[
u1 = \text{upmat1}(x);
\]

The resulting matrices are:

\[
\begin{bmatrix}
7 & 2 & -1 \\
2 & 3 & -2 \\
4 & -2 & 8
\end{bmatrix}
\]

\[
u = \begin{bmatrix}
0 & 3 & -2 \\
0 & 8 & 0
\end{bmatrix}
\]

\[
u1 = \begin{bmatrix}
0 & 1 & -2 \\
0 & 0 & 1
\end{bmatrix}
\]

Source
diag.src

See Also
lowmat, lowmat1, diag, diagrv, crout

upper

Purpose

Converts a string, matrix of character data, or string array to uppercase.

Format

\[
y = \text{upper}(x);
\]
Input

\( \mathbf{x} \)  
string, or NxK matrix, or string array containing the character data to be converted to uppercase.

Output

\( \mathbf{y} \)  
string, or NxK matrix, or string array containing the uppercase equivalent of the data in \( \mathbf{x} \).

Remarks

If \( \mathbf{x} \) is a numeric matrix, \( \mathbf{y} \) will contain garbage. No error message will be generated since GAUSS does not distinguish between numeric and character data in matrices.

Example

```gauss
//Create a lowercase string
\texttt{x} = "uppercase";

//Convert the string to upper case
\texttt{y} = upper(\texttt{x});

//Adding the '$' tells GAUSS to treat the data as character data
print \$\texttt{y};
```

This code produces:

UPPERCASE
See Also

lower

use

Purpose

Loads a compiled file at the beginning of the compilation of a source program.

Format

usetname;

Input

fname

literal or ^string, the name of a compiled file created using the compile or the saveall command.

Remarks

The use command can be used ONCE at the TOP of a program to load in a compiled file which the rest of the program will be added to. In other words, if xy.e had the following lines:

```
library pgraph;
externalproc xy;
x = seqa(0.1,0.1,100);
```

it could be compiled to xy.gc. Then the following program could be run:

38-1620
use xy;
    \textit{xy}(x, \sin(x));

which would be equivalent to:

\begin{verbatim}
new;
library pgraph;
x = \textit{seqa}(0.1,0.1,100);
\textit{xy}(x, \sin(x));
\end{verbatim}

The \textit{use} command can be used at the top of files that are to be compiled with the \textit{compile} command. This can greatly shorten compile time for a set of closely related programs. For example:

\begin{verbatim}
library pgraph;
externalproc xy,logx,logy,loglog,hist;
saveall pgraph;
\end{verbatim}

This would create a file called \texttt{pgraph.gcg} containing all the procedures, strings and matrices needed to run PQG programs. Other programs could be compiled very quickly with the following statement at the top of each:

\begin{verbatim}
use pgraph;
\end{verbatim}

or the same statement could be executed once, for instance from the command prompt, to instantly load all the procedures for PQG.

When the compiled file is loaded with \textit{use}, all previous symbols and procedures are deleted before the program is loaded. It is therefore unnecessary to execute a \textit{new} before \textit{use}'ing a compiled file.

\textit{use} can appear only ONCE at the TOP of a program.

\section*{See Also}

\texttt{compile, run, saveall}
**utctodt**

**Purpose**

Converts UTC scalar format to DT scalar format.

**Format**

\[ dt = \text{utctodt}(utc); \]

**Input**

- **utc**
  - Nx1 vector, UTC scalar format.

**Output**

- **dt**
  - Nx1 vector, DT scalar format.

**Remarks**

A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time. In DT scalar format, 08:35:52 on June 11, 2005 is 20050611083552.

**Example**

```python
  tc = 1346290409;
  print "tc = " tc;
  dt = utctodt(tc);
  print "dt = " dt;
```

produces:

38-1622
Source
time.src

See Also
dtvnormal, timeutc, utctodtv, dttodtv, dtvtodt, dtoutc, dttodt, strtodt, dttostr

utctodtv

Purpose

Converts UTC scalar format to DTV vector format.

Format

\[ dtv = \text{utctodtv}(utc); \]

Input

\( utc \)  
Nx1 vector, UTC scalar format.

Output

\( dtv \)  
Nx8 matrix, DTV vector format.
Remarks

A UTC scalar gives the number of seconds since or before January 1, 1970 Greenwich Mean Time.

Each row of \textit{dtv}, in DTV vector format, contains:

- \([N, 1]\) Year, four digit integer.
- \([N, 2]\) Month in Year, 1-12.
- \([N, 4]\) Hours since midnight, 0-23.
- \([N, 5]\) Minutes, 0-59.
- \([N, 6]\) Seconds, 0-59.
- \([N, 7]\) Day of week, 0-6, 0=Sunday.
- \([N, 8]\) Days since Jan 1 of current year, 0-365.

Example

```c
//Set 'tc' equal to the number of seconds since January 1, 1970
tc = timeutc;
print "tc = " tc;

dtv = utctodtv(tc);
print "dtv = " dtv;
```

produces:

```
tc = 1340315529
dtv = 2012 6 21 14 52 9 4 172
```
See Also
dtvnormal, timeutc, utctodt, dttdtv, dttutc, dttodt, dtvtoutc, strtodt, dttostr

utrisol

Purpose

Computes the solution of $Ux = b$ where $U$ is an upper triangular matrix.

Format

$x = utrisol(b, U);$  

Input

$b$ 
PxK matrix.

$U$ 
PxP upper triangular matrix.

Output

$x$ 
PxK matrix, solution of $Ux = b$.

Remarks

utrisol applies a back solve to $Ux = b$ to solve for $x$. If $b$ has more than one column, each column is solved for separately, i.e., utrisol applies a back solve to $U * x[:,i] = b[:,i]$. 
vals

Purpose

Converts a string into a matrix of its ASCII values.

Format

\[ y = \text{vals}(s); \]

Input

\[ s \quad \text{string of length N where } N > 0. \]

Output

\[ y \quad \text{Nx1 matrix containing the ASCII values of the characters in the string } s. \]

Remarks

If the string is null, the function will fail and an error message will be given.
Example

//Initialize 'k' so it will be 0 for the first iteration of //the 'do while' loop
k = 0;

//Prompt the user for input
print "Continue Program? [Y/N]";

//Continually check for keyboard input and exit the loop on //keyboard input
do while (k == 0);
    k = key;
enddo;

//Follow a different code branch depending upon which key //the user entered
if k == vals("Y") or k == vals("y");
    print "You chose to continue";
else;
    print "Exiting program now";
endif;

In this example the key function is used to read keyboard input. When key returns a nonzero value, meaning a key has been pressed, the ASCII value it returns is tested to see if it is an uppercase or lowercase 'Y'. If it is, the program will follow the first branch and print:

You chose to continue

otherwise, it will follow the second branch and print:

Exiting program now
See Also

chrs, flos, stof

\textbf{varCovM, varCovX}

\textbf{Purpose}

Computes the population variance-covariance matrix.

\textbf{Format}

\begin{verbatim}
vc = varCovM(mm);
vc = varCovX(x);
\end{verbatim}

\textbf{Input}

\begin{itemize}
\item \textit{mm} \hspace{1cm} KxK moment ($x'x$) matrix. A constant term MUST have been the first variable when the moment matrix was computed.
\item \textit{x} \hspace{1cm} NxK matrix of data.
\end{itemize}

\textbf{Output}

\begin{itemize}
\item \textit{vc} \hspace{1cm} KxK variance-covariance matrix.
Example

```plaintext
//Set rndseed for repeatable random numbers
rndseed 7234242;

//Create three randomly generated independent variables
x = rndn(500, 3);

//Create the population variance-covariance matrix from data matrix 'x'
var_x = varCovX(x);
```

After the code above, `var_x` will be equal to:

```
1.0941806  0.0040829  -0.0024871
0.0040829  1.0606611  0.0493555
-0.0024871  0.0493555  0.8729622
```

where the diagonal elements in the matrix represent the population variance of the each column, while the off-diagonal elements represent the population covariance between the data columns.

The population variance can also be calculated using the moment matrix, \( x'x \) and the GAUSS function `varCovM`. A constant term must be included in the data matrix \( x \) when computing the moment equation. Consider the following data matrix \( x1 \), consisting of the original data matrix \( x \) and a column of ones:

```plaintext
//Set rndseed so 'rndn' will return the same numbers as above
rndseed 7234242;

//Note: the ~ operator performs horizontal concatenation
x1 = ones(500,1)~rndn(500,3);
```
//Create moment matrix
x2 = x1'x1;

//Calculate variance-covariance matrix using the moment matrix
var_xm = varCovM(x2);

After the code above, var_xm will be equal to:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0941806</td>
<td>0.0040829</td>
<td>-0.0024871</td>
</tr>
<tr>
<td>0.0040829</td>
<td>1.0606611</td>
<td>0.0493555</td>
</tr>
<tr>
<td>-0.0024871</td>
<td>0.0493555</td>
<td>0.8729622</td>
</tr>
</tbody>
</table>

**Remarks**

The variance covariance matrix is that of the population data matrix. It is computed as the moment matrix of deviations about the mean divided by the number of observations N. For a sample covariance matrix which uses N - 1 rather than N see varCovMS or varCovXS.

**Source**

corrs.src

**See Also**

momentd, corrms, corrxs

**varCovMS, varCovXS**

**Purpose**

Computes a sample variance-covariance matrix.
**Format**

\[
vc = \text{varCovMS}(mm);
vc = \text{varCovXS}(x);
\]

**Input**

<table>
<thead>
<tr>
<th>mm</th>
<th>KxK moment ((x'x)) matrix. A constant term MUST have been the first variable when the moment matrix was computed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>NxK matrix of data.</td>
</tr>
</tbody>
</table>

**Output**

| \(vc\) | KxK variance-covariance matrix.                                                                                                  |

**Example**

```plaintext
//Set rndseed for repeatable random numbers
rndseed 7234242;

//Create three randomly generated independent variables
x = rndn(500, 3);

//Create the sample variance-covariance matrix from data matrix 'x'
var_x = varCovXS(x);
```

After the code above, \(var_x\) will be equal to:
where the diagonal elements in the matrix represent the sample variance of the each column, while the off-diagonal elements represent the sample covariance between the data columns.

The sample variance can also be calculated using the moment matrix, \(x'x\) and the GAUSS function \texttt{varCovMS}. A constant term must be included in the data matrix \(x\) when computing the moment equation. Consider the following data matrix \(x1\), consisting of the original data matrix \(x\) and a column of ones:

```gauss
//Set rndseed so 'rndn' will return the same numbers as above
rndseed 7234242;

//Note: the ~ operator performs horizontal concatenation
x1 = ones(500,1)~rndn(500,3);

//Create moment matrix
x2 = x1'x1;

//Calculate variance-covariance matrix using the moment matrix
var_xm = varCovMS(x2);
```

After the code above, \(var_xm\) will be equal to:

\[
\begin{pmatrix}
1.0963733 & 0.0040911 & -0.0024921 \\
0.0040911 & 1.0627867 & 0.0494544 \\
-0.0024921 & 0.0494544 & 0.8747116
\end{pmatrix}
\]
**Remarks**

The variance covariance matrix is that of the sample data matrix. It is computed as the moment matrix of deviations about the mean divided by the number of observations minus one, \( N - 1 \). For a population covariance matrix which uses \( N \) rather than \( N - 1 \) see `varCovM` or `varCovX`.

**Source**

corrs.src

**See Also**

`momentd`, `corrms`, `corrxs`

**varget**

**Purpose**

Accesses a global variable whose name is given as a string argument.

**Format**

\[
y = \text{varget}(s);
\]

**Input**

\( s \) string containing the name of the global symbol you wish to access.
Output

| y | contents of the variable whose name is in s. |

Remarks

This function searches the global symbol table for the symbol whose name is in s and returns the contents of the variable if it exists. If the symbol does not exist, the function will terminate with an Undefined symbol error message. If you want to check to see if a variable exists before using this function, use typecv.

Example

```plaintext
alpha = 1;
beta = 2;
letter = "alpha";

//Check to see if a variable named alpha exists
if typecv(letter) == miss(0,0);
    print letter " does NOT exist";
else;
    //Assign the value of the variable named alpha to 'tmp'
    tmp = varget(letter);
    print "the value of " letter " is: " tmp;
endif;
```

The code above produces the following output:

the value of alpha is: 1
**vargetl**

**Purpose**

Accesses a local variable whose name is given as a string argument.

**Format**

\[ y = \text{vargetl}(s); \]

**Input**

\( s \) string containing the name of the local symbol you wish to access.

**Output**

\( y \) contents of the variable whose name is in \( s \).

**Remarks**

This function searches the local symbol list for the symbol whose name is in \( s \) and returns the contents of the variable if it exists. If the symbol does not exist, the function will terminate with an Undefined symbol error message.

**Example**

```plaintext
proc rndNormEx( r, c, loc, std, ptVar);
    local rnd1, rnd2, rnd3;
```
//Create random normal numbers with mean 0 and standard
//deviation 1
rnd1 = rndn(r, c);

//Change the mean to 'loc'
rnd2 = rnd1 + loc;

//Change the standard deviation to 'std'
rnd3 = std * rnd2;

//Set the contents of tmp to be equal to the contents of
//the local variable with the same name as the string
//passed in as 'ptVar'
tmp = vargetl(ptVar);

print ptVar " is equal to: " tmp;

retp(rnd3);
endp;

//Set the rng seed for repeatable results
rndseed 54223423;

//Passing in the final variable as the string rnd1, will
//cause the proc rndNormEx to print the contents of rnd1
r = rndNormEx( 2, 2, 0, 3, "rnd1");

The code above will produce the following output:

          rnd1 is equal to:
    0.5240627925408163  1.4904799236486497  -1.1716182730350617  -0.0519353312479753

See Also

varputl
varmall

**Purpose**

Computes log-likelihood of a Vector ARMA model.

**Format**

\[ ll = \text{varmall}(w, \phi, \theta, v_c); \]

**Input**

- \( w \) \( \text{NxK matrix, time series.} \)
- \( \phi \) \( (K*P)xK \text{ matrix, AR coefficient matrices.} \)
- \( \theta \) \( (K*Q)xK \text{ matrix, MA coefficient matrices.} \)
- \( v_c \) \( \text{KxK matrix, covariance matrix.} \)

**Output**

- \( ll \) \( \text{scalar, log-likelihood. If the calculation fails \( ll \) is set to missing value with error code:} \)
  - \( \text{Error Code} \)
  - \( \text{Reason for Failure} \)
  - \( 1 \) \( M < 1 \)
  - \( 2 \) \( N < 1 \)
  - \( 3 \) \( P < 0 \)
4  Q < 0
5  P = 0 and Q = 0
7  floating point work space too small
8  integer work space too small
9  vc is not positive definite
10  AR parameters too close to stationarity boundary
11  model not stationary
12  model not invertible
13  I+M'H'HM not positive definite

**Remarks**

`vardall` is adapted from code developed by Jose Alberto Mauricio of the Universidad Complutense de Madrid. It was published as Algorithm AS311 in Applied Statistics. Also described in "Exact Maximum Likelihood Estimation of Stationary Vector ARMA Models," JASA, 90:282-264.

**varmares**

**Purpose**

Computes residuals of a Vector ARMA model.

**Format**

```
res = varmares(w, phi, theta);
```
### Input

<table>
<thead>
<tr>
<th>$w$</th>
<th>NxK matrix, time series.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>(K*P)xK matrix, AR coefficient matrices.</td>
</tr>
<tr>
<td>$\theta$</td>
<td>(K*Q)xK matrix, MA coefficient matrices.</td>
</tr>
</tbody>
</table>

### Output

<table>
<thead>
<tr>
<th>$res$</th>
<th>NxK matrix, residuals. If the calculation fails $res$ is set to missing value with error code:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Reason for Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$M &lt; 1$</td>
</tr>
<tr>
<td>2</td>
<td>$N &lt; 1$</td>
</tr>
<tr>
<td>3</td>
<td>$P &lt; 0$</td>
</tr>
<tr>
<td>4</td>
<td>$Q &lt; 0$</td>
</tr>
<tr>
<td>5</td>
<td>$P = 0$ and $Q = 0$</td>
</tr>
<tr>
<td>7</td>
<td>floating point work space too small</td>
</tr>
<tr>
<td>8</td>
<td>integer work space too small</td>
</tr>
<tr>
<td>10</td>
<td>AR parameters too close to stationarity boundary</td>
</tr>
<tr>
<td>11</td>
<td>model not stationary</td>
</tr>
<tr>
<td>12</td>
<td>model not invertible</td>
</tr>
<tr>
<td>13</td>
<td>I+M'H'HM not positive definite</td>
</tr>
</tbody>
</table>
**Remarks**

`varmares` is adapted from code developed by Jose Alberto Mauricio of the Universidad Complutense de Madrid. It was published as Algorithm AS311 in Applied Statistics. Also described in "Exact Maximum Likelihood Estimation of Stationary Vector ARMA Models," JASA, 90:282-264.

**varput**

**Purpose**

Allows a matrix, array, string, or string array to be assigned to a global symbol whose name is given as a string argument.

**Format**

\[ y = \text{varput}(x, \ n); \]

**Input**

- \( x \) matrix, array, string, or string array which is to be assigned to the target variable.
- \( n \) string containing the name of the global symbol which will be the target variable.

**Output**

- \( y \) scalar, 1 if the operation is successful and 0 if the operation fails.
Remarks

$x$ and $n$ may be global or local. The variable, whose name is in $n$, that $x$ is assigned to is always a global.

If the function fails, it will be because the global symbol table is full.

This function is useful for returning values generated in local variables within a procedure to the global symbol table.

Example

```plaintext
source = rndn(2,2);
targname = "target";

if not varput(source, targname);
    print "Symbol table full";
    end;
endif;
```

See Also

`varget`, `typecv`

varputl

Purpose

Allows a matrix, array, string, or string array to be assigned to a local symbol given as a string argument.
Format

\[ y = \text{varputl}(x, \ n); \]

Input

- **x**: matrix, array, string, or string array which is to be assigned to the target variable.
- **n**: string containing the name of the local symbol which will be the target variable.

Output

- **y**: scalar, 1 if the operation is successful and 0 if the operation fails.

Remarks

\( x \) and \( n \) may be global or local. The variable, whose name is in \( n \), that \( x \) is assigned to is always a local.

Example

```
proc myProc(x);
   local a,b,c,d,e,vars,putvar;
   a=1;b=2;c=3;d=5;e=7;
   vars = { a b c d e };
   putvar = 0;
   //Keep looping until the user enters a letter
```
// a-e or A-E
do while putvar $/= vars;
   // Two semi-colons at the end of a print statement,
   // prevents a 'new line' from being printed
   print "Assign x (" $vars "): ";
   putvar = upper(cons);
   print;
end;

// Assign the variable whose letter/name was entered by
// the user to be the value passed into 'myProc'
call varputl(x, putvar);
retp(a+b*c-d/e);
endp;

// Format printing of numbers to allow 2 spaces between them
// and 1 digit after the decimal place
format /rds 2,1;

z = myProc(17);
print " z is " z;

produces (Note: this program will ask for user input at the GAUSS command prompt):

Assign x ( A B C D E ): a

z is 22.3

See Also
vargetl
vartypef

**Purpose**

Returns a vector of ones and zeros that indicate whether variables in a data set are character or numeric.

**Format**

\[ y = \text{vartypef}(f); \]

**Input**

\( f \)  
file handle of an open file.

**Output**

\( y \)  
\( N \times 1 \) vector of ones and zeros, 1 if variable is numeric, 0 if character.

**Remarks**

This function should be used in place of older functions that are based on the case of the variable names. You should also use the v96 data set format.
vc, vcx

**Purpose**

Computes an unbiased estimate a variance-covariance matrix.

NOTE: **vc** and **vcx** have been replaced with functions **varCovXS** and **varCovMS** whose descriptions use more standard statistical nomenclature. **vcx** and **vc** will continue to be available for backwards compatibility.

**Format**

\[
\begin{align*}
vc &= \text{vc}m(m); \\
vc &= \text{vc}x(x);
\end{align*}
\]

**Input**

\- \text{m} \quad \text{KxK moment} (x'x) \text{ matrix. A constant term MUST have been the first variable when the moment matrix was computed.}

\- \text{x} \quad \text{NxK matrix of data.}

**Output**

\- \text{vc} \quad \text{KxK variance-covariance matrix.}

**Remarks**

The variance-covariance matrix is computed as an unbiased estimator of the population variance-covariance. It is computed as the moment matrix of deviations about the mean divided by the number of observations minus one, \( N - 1 \). For an
observed variance-covariance matrix which uses \( N \) rather than \( N - 1 \) see \texttt{vcms} or \texttt{vcxs}.

**Source**

corr.src

**See Also**

\texttt{momentd}

**vcms, vcxs**

**Purpose**

Computes the observed variance-covariance matrix.

NOTE: \texttt{vcms} and \texttt{vcxs} have been replaced with functions \texttt{varCovX} and \texttt{varCovM} whose descriptions use more standard statistical nomenclature. \texttt{vcxs} and \texttt{vcms} will continue to be available for backwards compatibility.

**Format**

\[
vc = \texttt{vcms}(m);
\]
\[
vc = \texttt{vcxs}(x);
\]

**Input**

\[
m \quad \text{KxK moment (} x'x \text{) matrix. A constant term MUST have been the first variable when the moment matrix was computed.}
\]
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>N x K matrix of data.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v_c$</td>
<td>K x K variance-covariance matrix.</td>
</tr>
</tbody>
</table>

**Remarks**

The variance-covariance matrix is that of the input data matrix. It is computed as the moment matrix of deviations about the mean divided by the number of observations $N$. For an unbiased estimator covariance matrix which uses $N - 1$ rather than $N$ see $v_{cm}$ or $v_{cx}$. 

**Source**

corr.src

**See Also**

momentd, corrms, corrxs

**vec, vecr**

**Purpose**

Creates a column vector by appending the columns/rows of a matrix to each other.
Format

\[ yc = \text{vec}(x); \]
\[ yr = \text{vecr}(x); \]

Input

\( x \)  
NxK matrix.

Output

\( yc \)  
(N*K)x1 vector, the columns of \( x \) appended to each other.

\( yr \)  
(N*K)x1 vector, the rows of \( x \) appended to each other and the result transposed.

Remarks

\text{vecr} is much faster.

Example

\[ x = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}; \]
\[ yc = \text{vec}(x); \]
\[ yr = \text{vecr}(x); \]

The code above assigns the variables \( yc \) and \( yr \):

\[
\begin{array}{cc}
1 & 1 \\
yc = 3 & yr = 2 \\
\end{array}
\]
**vech**

**Purpose**

Vectorizes a symmetric matrix by retaining only the lower triangular portion of the matrix.

**Format**

\[ v = \text{vech}(x); \]

**Input**

\( x \)  

NxN symmetric matrix.

**Output**

\( v \)  

\((N*(N+1)/2)x1\) vector, the lower triangular portion of the matrix \( x \).

**Remarks**

As you can see from the example below, \texttt{vech} will not check to see if \( x \) is symmetric. It just packs the lower triangular portion of the matrix into a column vector in row-wise order.
Example

//Add a 3x1 column vector containing 10, 20, 30 to a 1x3 //row vector containing 1, 2, 3, to create a 3x3 matrix
x = seqa(10,10,3) + seqa(1,1,3)';

//Turn the lower triangular portion of 'x' into a column //vector in 'v'
v = vech(x);

//Expand the vector 'v' into a symmetric matrix in 'sx'
sx = xpnd(v);

After the code above:

```
   11 12 13
   21  1 1  1
  x =  2 1 2 2 3
  v =  2 2 3 1 1
     3 1 3 2 3
     3 2
     3

sx = xpnd(v);
```

See Also

xpnd

vector (dataloop)

Purpose

Specifies the creation of a new variable within a data loop.
**Format**

```
vector # numvar = numeric_expression;
vector $ charvar = character_expression;
```

**Remarks**

A numeric_expression is any valid expression returning a numeric value. A character_expression is any valid expression returning a character value. If neither '§' nor '#' is specified, '#' is assumed.

vector is used in place of make when the expression returns a scalar rather than a vector. vector forces the result of such an expression to a vector of the correct length. vector could actually be used anywhere that make is used, but would generate slower code for expressions that already return vectors.

Any variables referenced must already exist, either as elements of the source data set, as extern's, or as the result of a previous make, vector, or code statement.

**Example**

```
vector const = 1;
```

**See Also**

make (dataloop)

vget

**Purpose**

Extracts a matrix or string from a data buffer constructed with vput.
Format

\[ \{ x, \ dbufnew \} = \text{vget}(dbuf, \ name); \]

Input

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbuf</td>
<td>Nx1 vector, a data buffer containing various strings and matrices.</td>
</tr>
<tr>
<td>name</td>
<td>string, the name of the string or matrix to extract from dbuf.</td>
</tr>
</tbody>
</table>

Output

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>LxM matrix or string, the item extracted from dbuf.</td>
</tr>
<tr>
<td>dbufnew</td>
<td>Kx1 vector, the remainder of dbuf after x has been extracted.</td>
</tr>
</tbody>
</table>

Source

pack.src

See Also

vlist, vput, vread
**view**

**Purpose**
Sets the position of the observer in workbox units for 3-D plots. NOTE: This function is for the deprecated PQG graphics.

**Library**
pgraph

**Format**

\[ \text{view}(x, y, z); \]

**Input**

- **x** scalar, the X position in workbox units.
- **y** scalar, the Y position in workbox units.
- **z** scalar, the Z position in workbox units.

**Remarks**

The size of the workbox is set with \texttt{volume}. The viewer MUST be outside of the workbox. The closer the position of the observer, the more perspective distortion there will be. If \( x = y = z \), the projection will be isometric.

If \texttt{view} is not called, a default position will be calculated.

Use \texttt{viewxyz} to locate the observer in plot coordinates.
**Source**
pgraph.src

**See Also**
volume, viewxyz

**viewxyz**

**Purpose**

To set the position of the observer in plot coordinates for 3-D plots. NOTE: This function is for the deprecated PQG graphics.

**Library**
pgraph

**Format**

\[
\text{viewxyz}(x, y, z);
\]

**Input**

\[
\begin{align*}
x & \quad \text{scalar, the X position in plot coordinates.} \\
y & \quad \text{scalar, the Y position in plot coordinates.} \\
z & \quad \text{scalar, the Z position in plot coordinates.}
\end{align*}
\]
Remarks

The viewer MUST be outside of the workbox. The closer the observer, the more perspective distortion there will be.

If `viewxyz` is not called, a default position will be calculated.

Use `view` to locate the observer in workbox units.

Source

`pgraph.src`

See Also

`volume`, `view`

vlist

Purpose

Lists the contents of a data buffer constructed with `vput`.

Format

```
vlist(dbuf);
```

Input

| `dbuf` | Nx1 vector, a data buffer containing various strings and matrices. |
Remarks

vlist lists the names of all the strings and matrices stored in dbuf.

Source

vpack.src

See Also

vget, vput, vread

vnamecv

Purpose

Returns the names of the elements of a data buffer constructed with vput.

Format

\[ cv = \textit{vnamecv}(dbuf); \]

Input

dbuf

Nx1 vector, a data buffer containing various strings and matrices.

Output

cv

Kx1 character vector containing the names of the elements of dbuf.
See Also

vget, vput, vread, vtypecv

volume

Purpose

Sets the length, width, and height ratios of the 3-D workbox. NOTE: This function is for the deprecated PQG graphics.

Library

pgraph

Format

volume(x, y, z);

Input

x scalar, the X length of the 3-D workbox.
y scalar, the Y length of the 3-D workbox.
z scalar, the Z length of the 3-D workbox.

Remarks

The ratio between these values is what is important. If volume is not called, a default workbox will be calculated.
**Source**

pgraph.src

**See Also**

view

**vput**

**Purpose**

Inserts a matrix or string into a data buffer.

**Format**

\[ dbufnew = \text{vput}(dbuf, x, xname); \]

**Input**

- **dbuf**
  - Nx1 vector, a data buffer containing various strings and matrices. If \( dbuf \) is a scalar 0, a new data buffer will be created.

- **x**
  - LxM matrix or string, item to be inserted into \( dbuf \).

- **xname**
  - string, the name of \( x \), will be inserted with \( x \) into \( dbuf \).

**Output**

- **dbufnew**
  - Kx1 vector, the data buffer after \( x \) and \( xname \) have been inserted.
Remarks

If \( dbuf \) already contains \( x \), the new value of \( x \) will replace the old one.

Source

vpack.src

See Also

vget, vlist, vread

vread

Purpose

Reads a string or matrix from a data buffer constructed with \texttt{vput}.

Format

\[
x = \texttt{vread}(dbuf, \ xname);
\]

Input

- \textit{dbuf} \quad Nx1 vector, a data buffer containing various strings and matrices.
- \textit{xname} \quad string, the name of the matrix or string to read from \textit{dbuf}. 

**Output**

\[ x \] LxM matrix or string, the item read from \( dbuf \).

**Remarks**

\texttt{vread}, unlike \texttt{vget}, does not change the contents of \( dbuf \). Reading \( x \) from \( dbuf \) does not remove it from \( dbuf \).

**Source**

vpack.src

**See Also**

\texttt{vget, vlist, vput}

**vtypecv**

**Purpose**

Returns the types of the elements of a data buffer constructed with \texttt{vput}.

**Format**

\[ cv = \texttt{vtypecv}(dbuf); \]

**Input**

<table>
<thead>
<tr>
<th>( dbuf )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nx1 vector, a data buffer containing various strings and matrices.</td>
</tr>
</tbody>
</table>
Output

$c v$ Kx1 character vector containing the types of the elements of $dbuf$.

See Also

$vget, vput, vread, vnamecv$
wait, waitc

**Purpose**

Waits until any key is pressed.

**Format**

```
wait;
waitc;
```

**Remarks**

If you are working in terminal mode, these commands do not "see" any keystrokes until ENTER is pressed. **waitc** clears any pending keystrokes before waiting until another key is pressed.

**Source**

`wait.src, waitc.src`

**See Also**

`pause`
**walkindex**

**Purpose**

Walks the index of an array forward or backward through a specified dimension.

**Format**

\[ ni = \text{walkindex}(i, o, \text{dim}); \]

**Input**

- \( i \) : Mx1 vector of indices into an array, where \( M \leq N \).
- \( o \) : Nx1 vector of orders of an N-dimensional array.
- \( \text{dim} \) : scalar [1-to-M], index into the vector of indices \( i \), corresponding to the dimension to walk through, positive to walk the index forward, or negative to walk backward.

**Output**

- \( ni \) : Mx1 vector of indices, the new index.

**Remarks**

**walkindex** will return a scalar error code if the index cannot walk further in the specified dimension and direction.
Example

```
orders = (3,4,5,6,7);

//Create a 3x4x5x6x7 dimensional array with each element
//equal to 1
a = arrayinit(orders,1);

ind = { 2,3,3 };
ind = walkindex(ind,orders,-2);
```

```
2
ind = 2
3
```

This example decrements the second value of the index vector `ind`.

```
ind = walkindex(ind,orders,3);
```

```
2
ind = 2
4
```

Using the `orders` from the example above and the `ind` that was returned, this example increments the third value of the index vector `ind`.

See Also

`nextindex`, `previousindex`, `loopnextindex`
# window

## Purpose

Partitions the window into tiled regions (graphic panels) of equal size. **NOTE:** This function is for the deprecated PQG graphics.

## Library

pgraph

## Format

```
window(row, col, typ);
```

## Input

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>scalar, number of rows of graphic panels.</td>
</tr>
<tr>
<td>col</td>
<td>scalar, number of columns of graphic panels.</td>
</tr>
<tr>
<td>typ</td>
<td>scalar, graphic panel attribute type. If 1, the graphic panels will be transparent, if 0, the graphic panels will be nontransparent (blanked).</td>
</tr>
</tbody>
</table>

## Remarks

The graphic panels will be numbered from 1 to \((row) \times (col)\) starting from the left topmost graphic panel and moving right.

See `makewind` for creating graphic panels of a specific size and position. (For more information, see *Graphic Panels*, Section 1.1.)
Source
pwindow.src

See Also
dendwind, begwind, setwind, nextwind, getwind, makewind

writer

Purpose

Writes a matrix to a GAUSS data set.

Format

\[ y = \text{writer}(fh, x); \]

Input

\begin{align*}
fh & \quad \text{handle of the file that data is to be written to.} \\
x & \quad \text{NxK matrix.}
\end{align*}

Output

\begin{align*}
y & \quad \text{scalar specifying the number of rows of data actually written to the data set.}
\end{align*}
Remarks

The file must have been opened with create, open for append, or open for update.

The data in $x$ will be written to the data set whose handle is $fh$ starting at the current pointer position in the file. The pointer position in the file will be updated, so the next call to writer will put the next block of data after the first block. (See open and create for the initial pointer positions in the file for reading and writing.)

$x$ must have the same number of columns as the data set. colsf returns the number of columns in a data set.

writer returns the number of rows actually written to the data set. If $y$ does not equal rows($x$), the disk is probably full.

If the data set is not double precision, the data will be rounded as it is written out.

If the data contain character elements, the file must be double precision or the character information will be lost.

If the file being written to is the 2-byte integer data type, then missing values will be written out as -32768. These will not automatically be converted to missings on input. They can be converted with the miss function:

\[ x = \text{miss}(x, -32768); \]

Trying to write complex data to a data set that was originally created to store real data will cause a program to abort with an error message. (See create for details on creating a complex data set.)

Example

```plaintext
create fp = data with x, 10, 8;
if fp == -1;
```
errorlog "Can't create output file";
end;
endif;

c = 0;
do until c >= 10000;
y = rdn(100,10);
k = writer(fp,y);

if k /= rows(y);
   errorlog "Disk Full";
   fp = close(fp);
endif;
endo;
c = c+k;
endo;

fp = close(fp);

In this example, a 10000x10 data set of Normal random numbers is written to a data set called data.dat. The variable names are X01 - X10.

See Also
open, close, create, readr, saved, seekr
**xlabel**

**Purpose**

Sets a label for the X axis. NOTE: This function is for use with the deprecated PQG graphics, use `plotSetXLabel` for equivalent functionality.

**Library**

pgraph

**Format**

```plaintext
xlabel(str);
```

**Input**

| str       | string, the label for the X axis. |

**Source**

pgraph.src

**See Also**

title, ylabel, zlabel
# xlsGetSheetCount

## Purpose

 Gets the number of sheets in an Excel® spreadsheet.

## Format

```
nsheets = xlsGetSheetCount(file);
```

## Input

| file | string, name of .xls or .xlsx file. |

## Output

| nsheets | scalar, sheet count or an error code. |

## Portability

Windows, Linux and Mac

## Remarks

If `xlsGetSheetCount` fails, it will either terminate with an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the lowest order bit of the trap flag.

- `trap 0`: Print error message and terminate program.
- `trap 1`: Return scalar error code 10.
**Example**

**Example 1**

If you had an Excel file named *myfile.xlsx* in the directory *C:\mydata*, then you could determine the number of sheets in the file with the following code:

```plaintext
nsheets = xlsGetSheetCount("C:\\mydata\\myfile.xlsx");
```

**Example 2**

If you do not want your program to terminate in the case of an error in this function, you can set the `trap` state as in the example below.

```plaintext
fname = "C:\\mydata\\myfile.xlsx";

// Turn on trap
trap 1;

nsheets = xlsGetSheetCount(fname);

// Check to see if xlsGetSheetCount returned an error code
if scalmiss(nsheets);
    // Code to execute in error case here
endif;
```

**See Also**

`xlsGetSheetSize`, `xlsGetSheetTypes`, `xlsMakeRange`
**xlsGetSheetSize**

**Purpose**

Gets the size (rows and columns) of a specified sheet in an Excel® spreadsheet.

**Format**

\[
\{ \text{rows}, \text{cols} \} = \text{xlsGetSheetSize}(\text{file}, \text{sheet});
\]

**Input**

- **file**
  - string, name of .xls or .xlsx file.
- **sheet**
  - scalar, sheet index (1-based).

**Output**

- **rows**
  - scalar, number of rows.
- **cols**
  - scalar, number of columns.

**Portability**

Windows, Linux and Mac

**Remarks**

If `xlsGetSheetSize` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the
state of the trap flag.

- **trap 0** Print error message and terminate program.
- **trap 1** Return scalar error code 10.

If a scalar error code is returned, both return values will be set with the error code.

**Example**

**Example 1**

If you had an Excel file named *myfile.xlsx* in the directory `C:\mydata`, then you could determine the number of rows and columns in the first sheet of this file with the following code:

```c
sheetNum = 1;
{ r, c } = xlsGetSheetSize("C:\mydata\myfile.xlsx", sheetNum);
```

**Example 2**

If you do not want your program to terminate in the case of an error in this function, you can set the trap state as in the example below.

```c
sheetNum = 1;

// Retain the old trap value so it can be reset to its
// previous state
oldtrap = trapchk(1);

// Set trap
trap 1;

{ r, c } = xlsGetSheetSize("C:\mydata\myfile.xlsx","
```
See Also
xlsGetSheetCount, xlsGetSheetTypes, xlsMakeRange

xlsGetSheetTypes

Purpose

Gets the cell format types of a row in an Excel® spreadsheet.

Format

\[
\text{nsheets} = \text{xlsGetSheetTypes}(\text{file}, \text{sheet}, \text{row});
\]

Input

- **file**: string, name of .xls or .xlsx file.
- **sheet**: scalar, sheet index (1-based).
- **row**: scalar, the row of cells to be scanned.
Output

**types**

1xK vector of predefined data types representing the format of each cell in the specified row.

The possible types are:

0 Text
1 Numeric
2 Date

Portability

Windows, Linux and Mac

Example

For example, let us suppose that a file named *myfile.xlsx* exists in the directory \C:\mydata. Let us further suppose that the 'A1' element is a string and the 'B1:C1' elements are numbers. The first row has no other elements. Then the code:

```plaintext
fname = "C:\mydata\myfile.xlsx";
sheetNum = 1;
rowNum = 1;
cTypes = xlsGetSheetTypes(fname, sheetNum, rowNum);

//Do not print any values after the decimal point
format /rd 6,0
print cTypes;
```

would produce the following output:

```
0 1 1
```
Remarks

K is the number of columns found in the spreadsheet.

If `xlsGetSheetTypes` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the state of the `trap` flag.

- `trap 0` : Print error message and terminate program.
- `trap 1` : Return scalar error code 10.

See Also

`xlsGetSheetCount`, `xlsGetSheetSize`, `xlsMakeRange`

**xlsMakeRange**

**Purpose**

Builds an Excel® range string from a row/column pair.

**Format**

```plaintext
range = xlsMakeRange(row, col);
```

**Input**

- `row` : scalar or 2x1 vector.
- `col` : scalar or 2x1 vector.
Output

range string, an Excel®-formatted range specifier.

Portability

Available on Windows, Linux and Mac.

Remarks

If row is a 2x1 vector, it is interpreted as follows

\[
\begin{align*}
row[1] & \quad \text{starting row} \\
row[2] & \quad \text{ending row}
\end{align*}
\]

If col is a 2x1 vector, it is interpreted as follows:

\[
\begin{align*}
col[1] & \quad \text{starting column} \\
col[2] & \quad \text{ending column}
\end{align*}
\]

If xlsMakeRange fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with scalerr, depending on the state of the trap flag.

\[
\begin{align*}
\text{trap 0} & \quad \text{Print error message and terminate program.} \\
\text{trap 1} & \quad \text{Return scalar error code 10.}
\end{align*}
\]

Example

```c
//Scalar inputs
r = 3;
```
c = 6;
range = xlsMakeRange(r, c);
print range;

produces:
F3

//2x1 vector inputs
r = { 2, 37 };
c = { 3, 19 };
range = xlsMakeRange(r, c);
print range;

produces:
C2:S37

See Also
xlsGetSheetCount, xlsGetSheetSize, xlsGetSheetTypes

xlsReadM

Purpose

Reads from an Excel® spreadsheet into a GAUSS matrix.

Format

\[ mat = \text{xlsReadM}(file, range, sheet, vls); \]
**Input**

- **file**
  - string, name of .xls or .xlsx file.
- **range**
  - string, range to read, e.g. `a2:b20`, or the starting point of the read, e.g. `a2`.
- **sheet**
  - scalar, sheet number.
- **vls**
  - null string or 9x1 matrix, specifies the conversion of Excel® empty cells and special types into **GAUSS** (see Remarks). A null string results in all empty cells and special types being converted to **GAUSS** missing values.

**Output**

- **mat**
  - matrix or a scalar error code.

**Portability**

**Windows, Linux and Mac**

The `vls` input is currently ignored on Mac and Linux. Missing values will be returned for all cells that are empty or contain errors.

**Example**

For example, let us suppose that a file named `myfile.xlsx` exists in the directory `C:\mydata`. Let us further suppose that the 'A2:B10' elements contain a 9x2 matrix that we would like to read into **GAUSS**. Then the code:

```gauss
fname = "C:\mydata\myfile.xlsx";
range = "A2:B10";
```
sheetNum = 1;
rowNum = 1;
vls = "";
newMat = xlsReadM(fname, range, sheetNum, vls);

will read in the values in the specified range and assign them to newMat.

Remarks

If range is a null string, then by default the read will begin at cell a1.

The \texttt{vls} argument lets users control the import of Excel® empty cells and special types, according to the following table:

<table>
<thead>
<tr>
<th>Row Number</th>
<th>Excel® Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>empty cell</td>
</tr>
<tr>
<td>2</td>
<td>#N/A</td>
</tr>
<tr>
<td>3</td>
<td>#VALUE!</td>
</tr>
<tr>
<td>4</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>5</td>
<td>#NAME?</td>
</tr>
<tr>
<td>6</td>
<td>#REF!</td>
</tr>
<tr>
<td>7</td>
<td>#NUM!</td>
</tr>
<tr>
<td>8</td>
<td>#NULL!</td>
</tr>
<tr>
<td>9</td>
<td>#ERR</td>
</tr>
</tbody>
</table>

Use the following to convert all occurrences of #DIV/0! to 9999.99, and all other empty cells and special types to \texttt{GAUSS} missing values:

\begin{verbatim}
vls = reshape("", 9,1);
vls[4] = "Division by Zero";
\end{verbatim}
If `xlsReadM` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the state of the `trap` flag.

- **trap 0** Print error message and terminate program.
- **trap 1** Return scalar error code 10.

See Also

`xlsReadSA`, `xlsWrite`, `xlsWriteM`, `xlsWriteSA`, `xlsGetSheetCount`, `xlsGetSheetSize`, `xlsGetSheetTypes`, `xlsMakeRange`

**xlsReadSA**

**Purpose**

Reads from an Excel® spreadsheet into a GAUSS string array or string.

**Format**

```gauss
s = xlsReadSA(file, range, sheet, vls);
```

**Input**

- **file** string, name of .xls or .xlsx file.
- **range** string, range to read, e.g. `a2:b20` or the starting point of the read, e.g. `a2`.
- **sheet** scalar, sheet number.
**vls**

null string or 9x1 string array, specifies the conversion of Excel® empty cells and special types into **GAUSS** (see Remarks). A null string results in all empty cells and special types being converted to null strings.

**Output**

**s**

string array or string or a scalar error code.

**Portability**

**Windows, Linux and Mac**

The **vls** input is currently ignored on Mac and Linux. Missing values will be returned for all cells that are empty or contain errors.

**Remarks**

If **range** is a null string, then by default the read will begin at cell **a1**.

The **vls** argument lets users control the import of Excel® empty cells and special types, according to the following table:

<table>
<thead>
<tr>
<th>Row Number</th>
<th>Excel® Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>empty cell</td>
</tr>
<tr>
<td>2</td>
<td>#N/A</td>
</tr>
<tr>
<td>3</td>
<td>#VALUE!</td>
</tr>
<tr>
<td>4</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>5</td>
<td>#NAME?</td>
</tr>
<tr>
<td>6</td>
<td>#REF!</td>
</tr>
</tbody>
</table>
Use the following to convert all occurrences of #DIV/0! to "Division by Zero", and all other empty cells and special types to null strings:

```matlab
vls = reshape("", 9, 1);
vls[4] = "Division by Zero";
```

If `xlsReadSA` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the state of the `trap` flag.

- `trap 0` Print error message and terminate program.
- `trap 1` Return scalar error code 10.

**See Also**

`xlsReadM`, `xlsWrite`, `xlsWriteM`, `xlsWriteSA`, `xlsGetSheetCount`, `xlsGetSheetSize`, `xlsGetSheetTypes`, `xlsMakeRange`

**xlsWrite**

**Purpose**

Writes a GAUSS matrix, string, or string array to an Excel® spreadsheet.

**Format**

```matlab
ret = xlsWrite(data, file, range, sheet, vls);
```
**Input**

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>matrix, string, or string array.</td>
</tr>
<tr>
<td>file</td>
<td>string, name of .xls or .xlsx file.</td>
</tr>
<tr>
<td>range</td>
<td>string, the starting point of the write, e.g. a2.</td>
</tr>
<tr>
<td>sheet</td>
<td>scalar, sheet number.</td>
</tr>
<tr>
<td>vls</td>
<td>null string or 9x1 matrix or string array, specifies the conversion of GAUSS values or characters into Excel® empty cells and special types (see Remarks). A null string results in all GAUSS missing values and null strings being converted to empty cells.</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ret</td>
<td>scalar, 0 if success or a scalar error code.</td>
</tr>
</tbody>
</table>

**Portability**

**Windows, Linux and Mac**

The vls input is currently ignored on Mac and Linux. Missing values will be returned for all cells that are empty or contain errors.

**Remarks**

The vls argument lets users control the export to Excel® empty cells and special types, according to the following table:

<table>
<thead>
<tr>
<th>Row Number</th>
<th>Excel® Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>38-1684</td>
<td></td>
</tr>
</tbody>
</table>
Use the following to convert all occurrences of 9999.99 to #DIV/0! in Excel® and convert all GAUSS missing values to empty cells in Excel®:

```plaintext
vls = reshape(error(0),9,1);
```

If `xlsWrite` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scaler`, depending on the state of the `trap` flag.

- **trap 0** Print error message and terminate program.
- **trap 1** Return scalar error code 10.

**See Also**

`xlsReadSA`, `xlsReadM`, `xlsWriteM`, `xlsWriteSA`, `xlsGetSheetCount`, `xlsGetSheetSize`, `xlsGetSheetTypes`, `xlsMakeRange`
**xlsWriteM**

**Purpose**

Writes a GAUSS matrix to an Excel® spreadsheet.

**Format**

```
ret = xlsWriteM(data, file, range, sheet, vls);
```

**Input**

- `data` matrix.
- `file` string, name of .xls or .xlsx file.
- `range` string, the starting point of the write, e.g. a2.
- `sheet` scalar, sheet number.
- `vls` null string or 9x1 matrix, specifies the conversion of GAUSS values into Excel® empty cells and special types (see Remarks). A null string results in all GAUSS missing values being converted to empty cells.

**Output**

- `ret` scalar, 0 if success or a scalar error code.

**Portability**

Windows, Linux and Mac
The *vls* input is currently ignored on Mac and Linux. Missing values will be returned for all cells that are empty or contain errors.

**Remarks**

The *vls* argument lets users control the export to Excel® empty cells and special types, according to the following table:

<table>
<thead>
<tr>
<th>Row Number</th>
<th>Excel® Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>empty cell</td>
</tr>
<tr>
<td>2</td>
<td>#N/A</td>
</tr>
<tr>
<td>3</td>
<td>#VALUE!</td>
</tr>
<tr>
<td>4</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>5</td>
<td>#NAME?</td>
</tr>
<tr>
<td>6</td>
<td>#REF!</td>
</tr>
<tr>
<td>7</td>
<td>#NUM!</td>
</tr>
<tr>
<td>8</td>
<td>#NULL!</td>
</tr>
<tr>
<td>9</td>
<td>#ERR</td>
</tr>
</tbody>
</table>

Use the following to convert all occurrences of 9999.99 to #DIV/0! in Excel® and convert all *GAUSS* missing values to empty cells in Excel®:

```plaintext
vls = reshape(error(0), 9, 1);
```

If *xlsWriteM* fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with *scalerr*, depending on the state of the *trap* flag.

**trap 0**  
Print error message and terminate program.

**trap 1**  
Return scalar error code 10.
See Also

xlsReadSA, xlsReadM, xlsWrite, xlsWriteSA, xlsGetSheetCount, xlsGetSheetSize, xlsGetSheetTypes, xlsMakeRange

xlsWriteSA

Purpose

Writes a GAUSS string or string array to an Excel® spreadsheet.

Format

\[ ret = \text{xlsWriteSA}(\text{data}, \text{file}, \text{range}, \text{sheet}, \text{vls}) ; \]

Input

\begin{itemize}
  \item \textit{data} \quad \text{string or string array.}
  \item \textit{file} \quad \text{string, name of .xls file.}
  \item \textit{range} \quad \text{string, the starting point of the write, e.g. a2.}
  \item \textit{sheet} \quad \text{scalar, sheet number.}
  \item \textit{vls} \quad \text{null string or 9x1 string array, specifies the conversion of GAUSS characters into Excel® empty cells and special types (see Remarks). A null string results in all null strings being converted to empty cells.}
\end{itemize}
Output

\( ret \) scalar, 0 if success or a scalar error code.

Portability

Windows, Linux and Mac

The \( vls \) input is currently ignored on Mac and Linux. Missing values will be returned for all cells that are empty or contain errors.

Remarks

The \( vls \) argument lets users control the export to Excel® empty cells and special types, according to the following table:

<table>
<thead>
<tr>
<th>Row Number</th>
<th>Excel® Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>empty cell</td>
</tr>
<tr>
<td>2</td>
<td>#N/A</td>
</tr>
<tr>
<td>3</td>
<td>#VALUE!</td>
</tr>
<tr>
<td>4</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>5</td>
<td>#NAME?</td>
</tr>
<tr>
<td>6</td>
<td>#REF!</td>
</tr>
<tr>
<td>7</td>
<td>#NUM!</td>
</tr>
<tr>
<td>8</td>
<td>#NULL!</td>
</tr>
<tr>
<td>9</td>
<td>#ERR</td>
</tr>
</tbody>
</table>

Use the following to convert all occurrences of "Division by Zero" to #DIV/0!, and all null strings to empty cells:
vls = reshape("", 9, 1);
vls[4] = "Division by Zero";

If `xlsWriteSA` fails, it will either terminate and print an error message or return a scalar error code, which can be decoded with `scalerr`, depending on the state of the `trap` flag.

- **trap 0**: Print error message and terminate program.
- **trap 1**: Return scalar error code 10.

### See Also

`xlsReadM`, `xlsWrite`, `xlsWriteM`, `xlsReadSA`, `xlsGetSheetCount`, `xlsGetSheetSize`, `xlsGetSheetTypes`, `xlsMakeRange`  

### xpnd

#### Purpose

Expands a column vector into a symmetric matrix.

#### Format

\[ x = \text{xpnd}(v); \]

#### Input

- **v** 
  
  Kx1 vector, to be expanded into a symmetric matrix.
Output

$X$ MxM matrix, the results of taking $v$ and filling in a symmetric matrix with its elements.

\[
M = \left( -1 + \sqrt{1 + 8 \times K} \right) / 2
\]

Remarks

If $v$ does not contain the right number of elements, (that is, if $\sqrt{1 + 8 \times K}$ is not integral), then an error message is generated.

This function is particularly useful for hard-coding symmetric matrices, because only about half of the matrix needs to be entered.

Example

```c
x = { 1,
     2, 3,
     4, 5, 6,
     7, 8, 9, 10 };

y = xpnd(x);
```

After the code above, the variables $x$ and $y$ are equal to:

```
1 2 4 7
2 3 5 8
4 5 6 9
5 7 8 10
```
See Also
vech

xtics

Purpose
Sets and fixes scaling, axes numbering and tick marks for the X axis. NOTE: This function is for the deprecated PQG graphics.

Library
pgraph

Format

xtics(min, max, step, minordiv);

Input

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>min</td>
<td>scalar, the minimum value.</td>
</tr>
<tr>
<td>max</td>
<td>scalar, the maximum value.</td>
</tr>
<tr>
<td>step</td>
<td>scalar, the value between major tick marks.</td>
</tr>
<tr>
<td>minordiv</td>
<td>scalar, the number of minor subdivisions.</td>
</tr>
</tbody>
</table>
**Remarks**

This routine fixes the scaling for all subsequent graphs until `graphset` is called. This gives you direct control over the axes endpoints and tick marks. If `xtics` is called after a call to `scale`, it will override `scale`.

X and Y axes numbering may be reversed for `xy`, `logx`, `logy`, and `loglog` graphs. This may be accomplished by using a negative step value in the `xtics` and `ytics` functions.

**Source**

pscale.src

**See Also**

scale, ytics, ztics

**xy**

**Purpose**

Graphs X vs. Y using Cartesian coordinates. NOTE: This function is for the deprecated PQG graphics.

**Library**

pgraph

**Format**

`xy(x, y);`
**Input**

- **x**: Nx1 or NxM matrix. Each column contains the X values for a particular line.
- **y**: Nx1 or NxM matrix. Each column contains the Y values for a particular line.

**Remarks**

Missing values are ignored when plotting symbols. If missing values are encountered while plotting a curve, the curve will end and a new curve will begin plotting at the next non-missing value.

**Source**

pxy.src

**See Also**

*xyz, logx, logy, loglog*

**xyz**

**Purpose**

Graphs X vs. Y vs. Z using Cartesian coordinates. NOTE: This function is for the deprecated PQG graphics.

**Library**

pgraph
**Format**

\[ \text{xyz}(x, y, z); \]

**Input**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>(\text{Nx1 or NxK matrix. Each column contains the X values for a particular line.})</td>
</tr>
<tr>
<td>(y)</td>
<td>(\text{Nx1 or NxK matrix. Each column contains the Y values for a particular line.})</td>
</tr>
<tr>
<td>(z)</td>
<td>(\text{Nx1 or NxK matrix. Each column contains the Z values for a particular line.})</td>
</tr>
</tbody>
</table>

**Remarks**

Missing values are ignored when plotting symbols. If missing values are encountered while plotting a curve, the curve will end and a new curve will begin plotting at the next non-missing value.

**Source**

pxyz.src
**ylabel**

**Purpose**
Sets a label for the Y axis. NOTE: This function is for the deprecated PQG graphics.

**Library**

pgraph

**Format**

ylabel(str);

**Input**

str  
string, the label for the Y axis.

**Source**

pgraph.src

**See Also**

title, xlabel, zlabel
ytic

Purpose

Sets and fixes scaling, axes numbering and tick marks for the Y axis. NOTE: This function is for the deprecated PQG graphics.

Library

pgraph

Format

ytic(min, max, step, minordiv);

Input

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>min</td>
<td>scalar, the minimum value.</td>
</tr>
<tr>
<td>max</td>
<td>scalar, the maximum value.</td>
</tr>
<tr>
<td>step</td>
<td>scalar, the value between major tick marks.</td>
</tr>
<tr>
<td>minordiv</td>
<td>scalar, the number of minor subdivisions.</td>
</tr>
</tbody>
</table>

Remarks

This routine fixes the scaling for all subsequent graphs until graphset is called. This gives you direct control over the axes endpoints and tick marks. If ytics is called after a call to scale, it will override scale.
X and Y axes numbering may be reversed for \texttt{xy}, \texttt{logx}, \texttt{logy} and \texttt{loglog} graphs. This may be accomplished by using a negative step value in the \texttt{xtics} and \texttt{ytics} functions.

**Source**

\texttt{pscale.src}

**See Also**

\texttt{scale, xtics, ztics}
zeros

**Purpose**

Creates a matrix of zeros.

**Format**

\[ y = \text{zeros}(r, c); \]

**Input**

- \( r \) scalar, the number of rows.
- \( c \) scalar, the number of columns.

**Output**

- \( y \) \( r \times c \) matrix of zeros.

**Remarks**

This is faster than \texttt{ones}.

Noninteger arguments will be truncated to an integer.
Example

```matlab
y = zeros(3,2);
print y;
```

The code above produces the following output:

```
0.000  0.000
0.000  0.000
0.000  0.000
```

See Also

`ones`, `eye`

**zeta**

**Purpose**

Computes the Riemann Zeta function.

**Format**

```matlab
f = zeta(z);
```

**Input**

```
z     NxK matrix;  z may be complex.
```
Output

\[ f \] \quad \text{NxK matrix.}

Remarks

Euler MacLaurin series.

References

1. Jon Breslaw, 2009

zlabel

Purpose

Sets a label for the Z axis. NOTE: This function is for the deprecated PQG graphics.

Library

pgraph

Format

\[ \text{zlabel}(str); \]

Input

\[ str \] \quad \text{string, the label for the Z axis.}
Source
pgraph.src

See Also
title, xlabel, ylabel

ztics

Purpose
Sets and fixes scaling, axes numbering and tick marks for the Z axis. NOTE: This function is for the deprecated PQG graphics.

Library
pgraph

Format
ztics(min, max, step, minordiv);

Input

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>min</td>
<td>scalar, the minimum value.</td>
</tr>
<tr>
<td>max</td>
<td>scalar, the maximum value.</td>
</tr>
<tr>
<td>step</td>
<td>scalar, the value between major tick marks.</td>
</tr>
<tr>
<td>minordiv</td>
<td>scalar, the number of minor subdivisions. If this function is used with contour, contour labels will be placed every</td>
</tr>
</tbody>
</table>
minordiv levels. If 0, there will be no labels.

Remarks

This routine fixes the scaling for all subsequent graphs until graphset is called. This gives you direct control over the axes endpoints and tick marks. If ztics is called after a call to scale3d, it will override scale3d.

Source

pscale.src

See Also

scale3d, xtics, ytics, contour
39 Obsolete Commands

The following commands will no longer be supported and therefore should not be used when creating new programs.

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