Package ‘SparseM’
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Maintainer Roger Koenker <rkoenker@uiuc.edu>
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Imports graphics, stats, utils
Author Roger Koenker [cre, aut],
Pin Tian Ng [ctb] (Contributions to Sparse QR code),
Yousef Saad [ctb] (author of sparskit2),
Ben Shaby [ctb] (author of chol2csr)

Description Some basic linear algebra functionality for sparse matrices is
provided: including Cholesky decomposition and backsolving as well as
standard R subsetting and Kronecker products.

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character or NULL-class

Class "character or NULL"

Description
A virtual class needed by the "matrix.csc.hb" class

Objects from the Class
A virtual Class: No objects may be created from it.

Methods
No methods defined with class "character or NULL" in the signature.

lsq
Least Squares Problems in Surveying

Description
One of the four matrices from the least-squares solution of problems in surveying that were used by Michael Saunders and Chris Paige in the testing of LSQR

Usage
data(lsq)
Format

A list of class `matrix.csc.hb` or `matrix.ssc.hb` depending on how the coefficient matrix is stored with the following components:

- `ra` ra component of the csc or ssc format of the coefficient matrix, X.
- `ja` ja component of the csc or ssc format of the coefficient matrix, X.
- `ia` ia component of the csc or ssc format of the coefficient matrix, X.
- `rhs.ra` ra component of the right-hand-side, y, if stored in csc or ssc format; right-hand-side stored in dense vector or matrix otherwise.
- `rhs.ja` ja component of the right-hand-side, y, if stored in csc or ssc format; a null vector otherwise.
- `rhs.ia` ia component of the right-hand-side, y, if stored in csc or ssc format; a null vector otherwise.
- `xexact` vector of the exact solutions, b, if they exist; a null vector otherwise.
- `guess` vector of the initial guess of the solutions if they exist; a null vector otherwise.
- `dim` dimension of the coefficient matrix, X.
- `rhs.dim` dimension of the right-hand-side, y.
- `rhs.mode` storage mode of the right-hand-side; can be full storage or same format as the coefficient matrix.

References


See Also

`read.matrix.hb`

Examples

data(lsq)
class(lsq) # -> [1] "matrix.csc.hb"
model.matrix(lsq)->X
class(X) # -> "matrix.csr"
dim(X) # -> [1] 1850 712
y <- model.response(lsq) # extract the rhs
length(y) # [1] 1850
matrix.coo-class  Class "matrix.coo"

Description
A new class for sparse matrices stored in coordinate format

Objects from the Class
Objects can be created by calls of the form new("matrix.coo",...).

Slots
ra: Object of class numeric, a real array of nnz elements containing the non-zero elements of A.
ja: Object of class integer, an integer array of nnz elements containing the column indices of the elements stored in 'ra'.
ia: Object of class integer, an integer array of nnz elements containing the row indices of the elements stored in 'ra'.
dimension: Object of class integer, dimension of the matrix

Methods
as.matrix.csr signature(x = "matrix.coo"): ...
as.matrix signature(x = "matrix.coo"): ...
dim signature(x = "matrix.coo"): ...

See Also
matrix.csr-class

matrix.csc-class  Class "matrix.csc"

Description
A new class for sparse matrices stored in compressed sparse column format

Objects from the Class
Objects can be created by calls of the form new("matrix.csc",...).
Slots

ra: Object of class numeric, a real array of nnz elements containing the non-zero elements of A, stored in column order. Thus, if i<j, all elements of column i precede elements from column j. The order of elements within the column is immaterial.

ja: Object of class integer, an integer array of nnz elements containing the row indices of the elements stored in ‘ra’.

ia: Object of class integer, an integer array of n+1 elements containing pointers to the beginning of each column in the arrays ‘ra’ and ‘ja’. Thus ‘ia[i]’ indicates the position in the arrays ‘ra’ and ‘ja’ where the ith column begins. The last, (n+1)st, element of ‘ia’ indicates where the n+1 column would start, if it existed.

dimension: Object of class integer, dimension of the matrix

Methods

as.matrix.csr signature(x = "matrix.csc"): ...
as.matrix.ssc signature(x = "matrix.csc"): ...
as.matrix.ssr signature(x = "matrix.csc"): ...
as.matrix signature(x = "matrix.csc"): ...
chol signature(x = "matrix.csc"): ...
dim signature(x = "matrix.csc"): ...
t signature(x = "matrix.csc"): ...

See Also

matrix.csr-class

matrix.csc.hb-class

Class "matrix.csc.hb"

Description

A new class consists of the coefficient matrix and the right-hand-side of a linear system of equations, initial guess of the solution and the exact solutions if they exist stored in external files using the Harwell-Boeing format.

Objects from the Class

Objects can be created by calls of the form new("matrix.csc.hb", ...).
Slots

ra: Object of class numeric, ra component of the csc or ssc format of the coefficient matrix, X.
ja: Object of class integer, ja component of the csc or ssc format of the coefficient matrix, X.
ia: Object of class numeric, ia component of the csc or ssc format of the coefficient matrix, X.
rhs.ra: Object of class numeric, ra component of the right-hand-side, y, if stored in csc or ssc format; right-hand-side stored in dense vector or matrix otherwise.
guess: Object of class numeric or NULL vector of the initial guess of the solutions if they exist; a null vector otherwise.
xexact: Object of class numeric or NULL vector of the exact solutions, b, if they exist; a null vector otherwise.
dimension: Object of class integer, dimension of the coefficient matrix, X.
rhs.dim: Object of class integer, dimension of the right-hand-side, y.
rhs.mode: Object of class character or NULL storage mode of the right-hand-side; can be full storage or same format as the coefficient matrix.

Methods

model.matrix signature(object = "matrix.csc.hb"): ...
**Slots**

ra: Object of class numeric, a real array of nnz elements containing the non-zero elements of A, stored in row order. Thus, if i<j, all elements of row i precede elements from row j. The order of elements within the rows is immaterial.

ja: Object of class integer, an integer array of nnz elements containing the column indices of the elements stored in ‘ra’.

ia: Object of class integer, an integer array of n+1 elements containing pointers to the beginning of each row in the arrays ‘ra’ and ‘ja’. Thus ‘ia[i]’ indicates the position in the arrays ‘ra’ and ‘ja’ where the ith row begins. The last, (n+1)st, element of ‘ia’ indicates where the n+1 row would start, if it existed.

dimension: Object of class integer, dimension of the matrix

**Methods**

```r
%*% signature(x = "matrix.csr", y = "matrix.csr"): ...
%*% signature(x = "matrix.csr", y = "matrix"): ...
%*% signature(x = "matrix.csr", y = "numeric"): ...
%*% signature(x = "matrix", y = "matrix.csr"): ...
%*% signature(x = "numeric", y = "matrix.csr"): ...

as.matrix.csc signature(x = "matrix.csr"): ...
as.matrix.ssc signature(x = "matrix.csr"): ...
as.matrix.ssr signature(x = "matrix.csr"): ...
as.matrix.coo signature(x = "matrix.csr"): ...
as.matrix signature(x = "matrix.csr"): ...
chol signature(x = "matrix.csr"): ...
diag signature(x = "matrix.csr"): ...
diag<- signature(x = "matrix.csr"): ...
dim signature(x = "matrix.csr"): ...
image signature(x = "matrix.csr"): ...
solve signature(a = "matrix.csr"): ...
t signature(x = "matrix.csr"): ...
diff signature(x = "matrix.csr"): ...
```

**See Also**

matrix.csc-class
matrix.csr.chol-class  

Class "matrix.csr.chol"

Description
A class of objects returned from Ng and Peyton's (1993) block sparse Cholesky algorithm

Objects from the Class
Objects can be created by calls of the form `new("matrix.csr.chol",...)`.

Slots

- `nrow`: Object of class integer, number of rows in the linear system of equations
- `nnzlindx`: Object of class numeric, number of non-zero elements in lindx
- `nsuper`: Object of class integer, number of supernodes
- `lindx`: Object of class integer, vector of integer containing, in column major order, the row subscripts of the non-zero entries in the Cholesky factor in a compressed storage format
- `xlindx`: Object of class integer, vector of integer of pointers for lindx
- `nnzl`: Object of class numeric, number of non-zero entries, including the diagonal entries, of the Cholesky factor stored in lnz
- `lnz`: Object of class numeric, contains the entries of the Cholesky factor
- `log.det`: Object of class numeric, log determinant of the Cholesky factor
- `xlnz`: Object of class integer, column pointer for the Cholesky factor stored in lnz
- `invp`: Object of class integer, vector of integer of inverse permutation vector
- `perm`: Object of class integer, vector of integer of permutation vector
- `xsuper`: Object of class integer, array containing the supernode partitioning
- `det`: Object of class numeric, determinant of the Cholesky factor
- `ierr`: Object of class integer, error flag
- `time`: Object of class numeric execution time

Methods

- `backsolve` signature(r = "matrix.csr.chol"): ...
- `as.matrix.csr` signature(x = "matrix.csr.chol", upper.tri=TRUE): ...

See Also

- `chol`, `backsolve`
class "matrix.ssc"

Description

A new class for sparse matrices stored in symmetric sparse column format

Objects from the Class

Objects can be created by calls of the form new("matrix.ssc", ...).

Slots

ra: Object of class numeric, a real array of nnz elements containing the non-zero elements of the lower triangular part of A, stored in column order. Thus, if i<j, all elements of column i precede elements from column j. The order of elements within the column is immaterial.

ja: Object of class integer, an integer array of nnz elements containing the row indices of the elements stored in ‘ra’.

ia: Object of class integer, an integer array of n+1 elements containing pointers to the beginning of each column in the arrays ‘ra’ and ‘ja’. Thus ‘ia[i]’ indicates the position in the arrays ‘ra’ and ‘ja’ where the ith column begins. The last, (n+1)st, element of ‘ia’ indicates where the n+1 column would start, if it existed.

dimension: Object of class integer, dimension of the matrix

Methods

as.matrix.csc signature(x = "matrix.ssc"): ...

as.matrix.csr signature(x = "matrix.ssc"): ...

as.matrix.ssr signature(x = "matrix.ssc"): ...

as.matrix signature(x = "matrix.ssc"): ...

dim signature(x = "matrix.ssc"): ...

See Also

matrix.csr-class
Class "matrix.ssc.hb"

Description

A new class consists of the coefficient matrix and the right-hand-side of a linear system of equations, initial guess of the solution and the exact solutions if they exist stored in external files using the Harwell-Boeing format.

Objects from the Class

Objects can be created by calls of the form new("matrix.ssc.hb",...).

Slots

- **ra**: Object of class numeric, ra component of the csc or ssc format of the coefficient matrix, X.
- **ja**: Object of class integer, ja component of the csc or ssc format of the coefficient matrix, X.
- **ia**: Object of class integer, ia component of the csc or ssc format of the coefficient matrix, X.
- **rhs.ra**: Object of class numeric, ra component of the right-hand-side, y, if stored in csc or ssc format; right-hand-side stored in dense vector or matrix otherwise.
- **guess**: Object of class numeric or NULL vector of the initial guess of the solutions if they exist; a null vector otherwise.
- **xexact**: Object of class numeric or NULL vector of the exact solutions, b, if they exist; a null vector otherwise.
- **dimension**: Object of class integer, dimension of the coefficient matrix, X.
- **rhs.dim**: Object of class integer, dimension of the right-hand-side, y.
- **rhs.mode**: Object of class character or NULL storage mode of the right-hand-side; can be full storage or same format as the coefficient matrix.

Extends

Class "matrix.csc.hb", directly.

Methods

- **model.matrix** signature(object = "matrix.ssc.hb"): ...
matrix.ssr-class

Class "matrix.ssr"

Description

A new class for sparse matrices stored in symmetric sparse row format

Objects from the Class

Objects can be created by calls of the form `new("matrix.ssr",...)`.

Slots

- `ra`: Object of class numeric, a real array of nnz elements containing the non-zero elements of the lower triangular part of A, stored in row order. Thus, if i<j, all elements of row i precede elements from row j. The order of elements within the rows is immaterial.

- `ja`: Object of class integer, an integer array of nnz elements containing the column indices of the elements stored in ‘ra’.

- `ia`: Object of class integer, an integer array of n+1 elements containing pointers to the beginning of each row in the arrays ‘ra’ and ‘ja’. Thus ‘ia[i]’ indicates the position in the arrays ‘ra’ and ‘ja’ where the ith row begins. The last, (n+1)st, element of ‘ia’ indicates where the n+1 row would start, if it existed.

- `dimension`: Object of class integer, dimension of the matrix

Methods

- `as.matrix.csc` signature(x = "matrix.ssr"): ...
- `as.matrix.csr` signature(x = "matrix.ssr"): ...
- `as.matrix.ssr` signature(x = "matrix.ssr"): ...
- `as.matrix` signature(x = "matrix.ssr"): ...
- `dim` signature(x = "matrix.ssr"): ...

See Also

matrix.csr-class
**mslm-class**

*Class “mslm”*

**Description**

A sparse extension of `lm`

**Objects from the Class**

Objects can be created by calls of the form `new("mslm",...)`.

**Slots**

- `coefficients`: Object of class numeric estimated coefficients
- `chol`: Object of class `matrix.csr.chol` generated by the function `chol`
- `residuals`: Object of class "numeric" residuals
- `fitted`: Object of class "numeric" fitted values

**Extends**

Class "lm", directly. Class "slm", directly. Class "oldClass", by class "lm".

**Methods**

- `coef` signature(object = "mslm"): ...
- `fitted` signature(object = "mslm"): ...
- `residuals` signature(object = "mslm"): ...
- `summary` signature(object = "mslm"): ...

**See Also**

`slm`

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**numeric or NULL-class**

*Class “numeric or NULL”*

**Description**

A virtual class needed by the "matrix.csc hb" class

**Objects from the Class**

A virtual Class: No objects may be created from it.

**Methods**

No methods defined with class "numeric or NULL" in the signature.
**slm**

Fit a linear regression model using sparse matrix algebra

**Description**

This is a function to illustrate the use of sparse linear algebra to solve a linear least squares problem using Cholesky decomposition. The syntax and output attempt to emulate `lm()` but may fail to do so fully satisfactorily. Ideally, this would eventually become a method for `lm`. The main obstacle to this step is that it would be necessary to have a model.matrix function that returned an object in sparse csr form. For the present, the objects represented in the formula must be in dense form. If the user wishes to specify fitting with a design matrix that is already in sparse form, then the lower level function `slm.fit()` should be used.

**Usage**

```r
slm(formula, data, weights, na.action, method = "csr", contrasts = NULL, ...)
```

**Arguments**

- `formula`: a formula object, with the response on the left of a `~` operator, and the terms, separated by `+` operators, on the right. As in `lm()`, the response variable in the formula can be matrix valued.

- `data`: a data.frame in which to interpret the variables named in the formula, or in the subset and the weights argument. If this is missing, then the variables in the formula should be on the search list. This may also be a single number to handle some special cases – see below for details.

- `weights`: vector of observation weights; if supplied, the algorithm fits to minimize the sum of the weights multiplied into the absolute residuals. The length of weights must be the same as the number of observations. The weights must be nonnegative and it is strongly recommended that they be strictly positive, since zero weights are ambiguous.

- `na.action`: a function to filter missing data. This is applied to the model.frame after any subset argument has been used. The default (with `na.fail`) is to create an error if any missing values are found. A possible alternative is `na.omit`, which deletes observations that contain one or more missing values.

- `method`: there is only one method based on Cholesky factorization

- `contrasts`: a list giving contrasts for some or all of the factors default = `NULL` appearing in the model formula. The elements of the list should have the same name as the variable and should be either a contrast matrix (specifically, any full-rank matrix with as many rows as there are levels in the factor), or else a function to compute such a matrix given the number of levels.

- `...`: additional arguments for the fitting routines
Value

A list of class slm consisting of:

- coefficients: estimated coefficients
- chol: cholesky object from fitting
- residuals: residuals
- fitted: fitted values
- terms: terms
- call: call

Author(s)

Roger Koenker

References

Koenker, R and Ng, P. (2002). SparseM: A Sparse Matrix Package for R, 
http://www.econ.uiuc.edu/~roger/research/home.html

See Also

slm.methods for methods summary, print, fitted, residuals and coef associated with class slm, and slm.fit for lower level fitting functions. The latter functions are of special interest if you would like to pass a sparse form of the design matrix directly to the fitting process.

Examples

data(lsq)
X <- model.matrix(lsq) #extract the design matrix
y <- model.response(lsq) # extract the rhs
X1 <- as.matrix(X)
slm.time <- system.time(slm(y~X1-1) -> slm.o) # pretty fast
lm.time <- system.time(lm(y~X1-1) -> lm.o) # very slow

cat("slm time =",slm.time,"\n")
cat("slm Results: Reported Coefficients Truncated to 5 ","\n")
sum.slm <- summary(slm.o)
sum.slm$coef <- sum.slm$coef[1:5,]
sum.slm

cat("lm time =",lm.time,"\n")
cat("lm Results: Reported Coefficients Truncated to 5 ","\n")
sum.lm <- summary(lm.o)
sum.lm$coef <- sum.lm$coef[1:5,]
sum.lm
slm-class

Class "slm"

Description
A sparse extension of lm

Objects from the Class
Objects can be created by calls of the form new("slm", ...).

Slots
- coefficients: Object of class numeric estimated coefficients
- chol: Object of class matrix.csr.chol generated by function chol
- residuals: Object of class "numeric" residuals
- fitted: Object of class "numeric" fitted values

Extends
Class "lm", directly. Class "oldClass", by class "lm".

Methods
- coef signature(object = "slm"): ...
- fitted signature(object = "slm"): ...
- residuals signature(object = "slm"): ...
- summary signature(object = "slm"): ...

See Also
- slm

slm.fit
Internal slm fitting functions

Description
Fitting functions for sparse linear model fitting.

Usage
- slm.fit(x, y, method, ...)
- slm.wfit(x, y, weights, ...)
- slm.fit.csr(x, y, ...)
Arguments

- x design matrix.
- y vector of response observations.
- method only csr is supported currently
- weights an optional vector of weights to be used in the fitting process. If specified, weighted least squares is used with weights ‘weights’ (that is, minimizing

\[ \sum w_i e_i^2 \]

The length of weights must be the same as the number of observations. The weights must be nonnegative and it is strongly recommended that they be strictly positive, since zero weights are ambiguous.

... additional arguments.

Details

slm.fit and slm.wfit call slm.fit.csr to do Cholesky decomposition and then backsolve to obtain the least squares estimated coefficients. These functions can be called directly if the user is willing to specify the design matrix in matrix.csr form. This is often advantageous in large problems to reduce memory requirements.

Value

A list of class slm consisting of:

- coef estimated coefficients
- chol cholesky object from fitting
- residuals residuals
- fitted fitted values
- df.residual degrees of freedom
- terms terms
- call call

... additional arguments.

Author(s)

Roger Koenker

References

Koenker, R and Ng, P. (2002). SparseM: A Sparse Matrix Package for R, 
http://www.econ.uiuc.edu/~roger/research/home.html

See Also

slm
Examples

data(lsq)
X <- model.matrix(lsq) # extract the design matrix
y <- model.response(lsq) # extract the rhs
class(X) # -> "matrix.csr"
class(y) # -> NULL
slm.fit(X,y)->slm.fit.o # this is much more efficient in memory usage than slm()
slm(y-as.matrix(X)-1) -> slm.o # this requires X to be transformed into dense mode
cat("Difference between \texttt{slm.fit} and \texttt{slm} estimated coefficients =",
sum(abs(slm.fit.o$coef-slm.o$coef)),"n")

slm.methods

Methods for slm objects

Description

Summarize, print, and extract objects from slm objects.

Usage

## S3 method for class 'slm'
summary(object, correlation, ...)
## S3 method for class 'mslm'
summary(object, ...)
## S3 method for class 'slm'
print(x, digits, ...)
## S3 method for class 'summary.slm'
print(x, digits, symbolic.cor, signif.stars, ...)
## S3 method for class 'slm'
fitted(object, ...)
## S3 method for class 'slm'
residuals(object, ...)
## S3 method for class 'slm'
coef(object, ...)
## S3 method for class 'slm'
extractAIC(fit, scale = 0, k = 2, ...)
## S3 method for class 'slm'
deviance(object, ...)

Arguments

object, x, fit object of class slm.
digits minimum number of significant digits to be used for most numbers.
scale optional numeric specifying the scale parameter of the model, see 'scale' in 'step'. Currently only used in the "lm" method, where 'scale' specifies the estimate of the error variance, and 'scale = 0' indicates that it is to be estimated by maximum likelihood.
k numeric specifying the "weight" of the equivalent degrees of freedom ("edf") part in the AIC formula.

symbolic.cor logical; if TRUE, the correlation of coefficients will be printed. The default is FALSE

signif.stars logical; if TRUE, P-values are additionally encoded visually as "significance stars" in order to help scanning of long coefficient tables. It defaults to the 'show.signif.stars' slot of 'options'.

correlation logical; if TRUE, the correlation matrix of the estimated parameters is returned and printed.

... additional arguments passed to methods.

Value

print.slm and print.summary.slm return invisibly. fitted.slm, residuals.slm, and coef.slm return the corresponding components of the slm object. extractAIC.slm and deviance.slm return the AIC and deviance values of the fitted object.

Author(s)

Roger Koenker

References


See Also

slm

Examples

data(lsq)
X <- model.matrix(lsq) # extract the design matrix
y <- model.response(lsq) # extract the rhs
X1 <- as.matrix(X)
slm.time <- system.time(slm(y~X1-1) -> slm.o) # pretty fast
cat("slm time =",slm.time,"\n")
cat("slm Results: Reported Coefficients Truncated to 5 ","\n")
sum.slm <- summary(slm.o)
sum.slm$coef <- sum.slm$coef[1:5,]
sum.slm
fitted(slm.o)[1:10]
residuals(slm.o)[1:10]
coef(slm.o)[1:10]
Description

Read, and extract components of data in Harwell-Boeing sparse matrix format.

Usage

read.matrix.hb(file)
model.matrix(object, ...)
model.response(data, type)

Arguments

file           file name to read from or
data, object    an object of either 'matrix.csc.hb' or 'matrix.ssc.hb' class
type           One of ""any", "numeric", "double". Using the either of latter two coerces the result to have storage mode "double"
...            additional arguments to model.matrix

Details

Sparse coefficient matrices in the Harwell-Boeing format are stored in 80-column records. Each file begins with a multiple line header block followed by two, three or four data blocks. The header block contains summary information on the storage formats and storage requirements. The data blocks contain information of the sparse coefficient matrix and data for the right-hand-side of the linear system of equations, initial guess of the solution and the exact solutions if they exist. The function model.matrix extracts the X matrix component. The function model.response extracts the y vector (or matrix). The function model.guess extracts the guess vector. The function model.xexact extracts the xexact vector. This function is written in R replacing a prior implementation based on iohb.c which had memory fault difficulties. The function write.matrix.hb has been purged; users wishing to write matrices in Harwell-Boeing format are advised to convert SparseM matrices to Matrix classes and use writeHB from the Matrix package. Contributions of code to facilitate this conversion would be appreciated!

Value

The function read.matrix.hb returns a list of class matrix.csc.hb or matrix.ssc.hb depending on how the coefficient matrix is stored in the file.

ra            ra component of the csc or ssc format of the coefficient matrix, X.
ja            ja component of the csc or ssc format of the coefficient matrix, X.
ia            ia component of the csc or ssc format of the coefficient matrix, X.
rhs.ra        ra component of the right-hand-side, y, if stored in csc or ssc format; right-hand-side stored in dense vector or matrix otherwise.
rhs.ja  ja component of the right-hand-side, y, if stored in csc or ssc format; a null vector otherwise.
rhs.ia  ia component of the right-hand-side, y, if stored in csc or ssc format; a null vector otherwise.
xexact  vector of the exact solutions, b, if they exist; a null vector otherwise.
guess  vector of the initial guess of the solutions if they exist; a null vector otherwise.
dimension  dimension of the coefficient matrix, X.
rhs.dim  dimension of the right-hand-side, y.
rhs.mode  storage mode of the right-hand-side; can be full storage or same format as the coefficient matrix, for the moment the only allowed mode is "F" for full, or dense mode.

The function model.matrix returns the X matrix of class matrix.csr. The function model.response returns the y vector (or matrix). The function model.guess returns the guess vector (or matrix). The function model.xexact returns the xexact vector (or matrix).

Author(s)
Pin Ng

References

See Also
slm for sparse version of lm
SparseM.ops for operators on class matrix.csr
SparseM.solve for linear equation solving for class matrix.csr
SparseM.image for image plotting of class matrix.csr
SparseM.ontology for coercion of class matrix.csr

Examples

```r
Xy <- read.matrix.hb(system.file("extdata","lsq.rra",package = "SparseM"))
class(Xy) # -> [1] "matrix.csc hb"
X <- model.matrix(Xy)->X
class(X) # -> "matrix.csr"
dim(X) # -> [1] 1850 712
y <- model.response(Xy) # extract the rhs
length(y) # [1] 1850
Xy <- read.matrix.hb(system.file("extdata","rua_32_ax.rua",package = "SparseM"))
X <- model.matrix(Xy)
y <- model.response(Xy) # extract the rhs
g <- model.guess(Xy) # extract the guess
a <- model.xexact(Xy) # extract the xexact
fit <- solve(t(X) %*% X, t(X) %*% y) # compare solution with xexact solution
```
SparseM.image 

**Image Plot for Sparse Matrices**

**Description**
Display the pattern of non-zero entries of a matrix of class `matrix.csr`.

**Usage**
```r
## S4 method for signature 'matrix.csr'
image(x, col=c("white","gray"),
    xlab="column", ylab="row", ...)
```

**Arguments**
- `x` a matrix of class `matrix.csr`.
- `col` a list of colors such as that generated by `rainbow`. Defaults to `c("white","gray")`
- `xlab,ylab` each a character string giving the labels for the x and y axis.
- `...` additional arguments.

**Details**
The pattern of the non-zero entries of a sparse matrix is displayed. By default nonzero entries of the matrix appear as gray blocks and zero entries as white background.

**References**

**See Also**
`SparseM.ops`, `SparseM.solve`, `SparseM.ontology`

**Examples**
```r
a <- rnorm(20*5)
A <- matrix(a,20,5)
A[row(A)>col(A)+4|row(A)<col(A)+3] <- 0
b <- rnorm(20*5)
B <- matrix(b,20,5)
B[row(A)>col(A)+2|row(A)<col(A)+2] <- 0
image(as.matrix.csr(A)%*%as.matrix.csr(t(B)))
```
Description

This group of functions evaluates and coerces changes in class structure.

Usage

```r
## S3 method for class 'matrix.csr'
as(x, nrow = 1, ncol = 1, eps = .Machine$double.eps, ...)
## S3 method for class 'matrix.csc'
as(x, nrow = 1, ncol = 1, eps = .Machine$double.eps, ...)
## S3 method for class 'matrix.ssr'
as(x, nrow = 1, ncol = 1, eps = .Machine$double.eps, ...)
## S3 method for class 'matrix.ssc'
as(x, nrow = 1, ncol = 1, eps = .Machine$double.eps, ...)
## S3 method for class 'matrix.csr'
is(x, ...)
## S3 method for class 'matrix.csc'
is(x, ...)
## S3 method for class 'matrix.ssr'
is(x, ...)
## S3 method for class 'matrix.ssc'
is(x, ...)
```

Arguments

- `x` is a matrix, or vector object, of either dense or sparse form
- `nrow` number of rows of matrix
- `ncol` number of columns of matrix
- `eps` A tolerance parameter: elements of x such that abs(x) < eps set to zero. This argument is only relevant when coercing matrices from dense to sparse form. Defaults to eps = .Machine$double.eps
- `...` other arguments

Details

The function `matrix.csc` acts like `matrix` to coerce a vector object to a sparse matrix object of class `matrix.csr`. This aspect of the code is in the process of conversion from S3 to S4 classes. For the most part the S3 syntax prevails. An exception is the code to coerce vectors to diagonal matrix form which uses `as(v,"matrix.diag.csr")`. The generic functions `as.matrix.xxx` coerce a matrix `x` into a matrix of storage class `matrix.xxx`. The argument matrix `x` may be of conventional dense form, or of any of the four supported classes: `matrix.csr,matrix.csc,matrix.ssr,matrix.ssc`. The generic functions `is.matrix.xxx` evaluate whether the argument is of class `matrix.xxx`. The function `as.matrix` transforms a matrix of any sparse class into conventional dense form. The
primary storage class for sparse matrices is the compressed sparse row matrix.csr class. An \( n \) by \( m \) matrix \( A \) with real elements \( a_{ij} \), stored in matrix.csr format consists of three arrays:

- \( ra \): a real array of \( nnz \) elements containing the non-zero elements of \( A \), stored in row order. Thus, if \( i<j \), all elements of row \( i \) precede elements from row \( j \). The order of elements within the rows is immaterial.
- \( ja \): an integer array of \( nnz \) elements containing the column indices of the elements stored in \( ra \).
- \( ia \): an integer array of \( n+1 \) elements containing pointers to the beginning of each row in the arrays \( ra \) and \( ja \). Thus \( ia[i] \) indicates the position in the arrays \( ra \) and \( ja \) where the \( i \)th row begins. The last, \( (n+1) \)st, element of \( ia \) indicates where the \( n+1 \) row would start, if it existed.

The compressed sparse column class matrix.csc is defined in an analogous way, as are the matrix.ssrr, symmetric sparse row, and matrix.sssc, symmetric sparse column classes.

**Note**

`as.matrix.ssrr` and `as.matrix.sssc` should ONLY be used with symmetric matrices.

`as.matrix.csr(x)`, when \( x \) is an object of class matrix.csr.chol (that is, an object returned by a call to \( \text{chol}(a) \) when \( a \) is an object of class matrix.csr or matrix.csc), by default returns an upper triangular matrix, which is not consistent with the result of \( \text{chol} \) in the base package. To get an lower triangular matrix, use either `as.matrix.csr(x, upper.tri = FALSE)` or `t(as.matrix.csr(x))`.

**References**


**See Also**

SparseM hb for handling Harwell-Boeing sparse matrices.

**Examples**

```r
n1 <- 10
p <- 5
a <- rnorm(n1*p)
a[abs(a)<0.5] <- 0
A <- matrix(a,n1,p)
B <- t(A)%*%A
A.csr <- as.matrix.csr(A)
A.csc <- as.matrix.csc(A)
B.ssr <- as.matrix.ssrr(B)
B.ssc <- as.matrix.sssc(B)
is.matrix.csr(A.csr) # -> TRUE
is.matrix.csc(A.csc) # -> TRUE
is.matrix.ssrr(B.ssr) # -> TRUE
is.matrix.sssc(B.ssc) # -> TRUE
as.matrix(A.csr)
```
as.matrix(A.csc)
as.matrix(B.ssr)
as.matrix(B.ssc)
as.matrix.csr(rep(0,9),3,3) #sparse matrix of all zeros
as(4,"matrix.diag.csr") #identity matrix of dimension 4

---

**SparseM.ops**

**Basic Linear Algebra for Sparse Matrices**

**Description**

Basic linear algebra operations for sparse matrices of class `matrix.csr`.

**Arguments**

- `x`: matrix of class `matrix.csr`.
- `y`: matrix of class `matrix.csr` or a dense matrix or vector.
- `value`: replacement values.
- `i`, `j`: vectors of elements to extract or replace.
- `nrow`: optional number of rows for the result.
- `lag`: an integer indicating which lag to use.
- `differences`: an integer indicating the order of the difference.

**Details**

Linear algebra operations for matrices of class `matrix.csr` are designed to behave exactly as for regular matrices. In particular, matrix multiplication, kronecker product, addition, subtraction and various logical operations should work as with the conventional dense form of matrix storage, as does indexing, `rbind`, `cbind`, and diagonal assignment and extraction. The method `diag` may be used to extract the diagonal of a `matrix.csr` object, to create a sparse diagonal see `SparseM.ontology`.

The function `determinant` computes the (log) determinant, of the argument, returning a "det" object as the base function. This is preferred over using the function `det()` which is a simple wrapper for `determinant()`. Using `det()` in the following way is somewhat deprecated:

```
det() # computes the determinant of the argument matrix. If the matrix is of class `matrix.csr` then it must be symmetric, or an error will be returned. If the matrix is of class `matrix.csr.chol` then the determinant of the Cholesky factor is returned, ie the product of the diagonal elements.
```

The function `norm` is used to check for symmetry by computing the maximum of the elements of the difference between the matrix and its transpose. Optionally, this sup norm can be replaced by the Hilbert-Schmidt norm, or the l1 norm.

**References**

Koenker, R and Ng, P. (2002). SparseM: A Sparse Matrix Package for R,  
See Also

slm for sparse linear model fitting. SparseM.ontology for coercion and other class relations involving the sparse matrix classes.

Examples

```r
n1 <- 10
n2 <- 10
p <- 6
y <- rnorm(n1)
a <- rnorm(n1*p)
a[abs(a) < 0.5] <- 0
A <- matrix(a, n1, p)
A.csr <- as.matrix.csr(A)
b <- rnorm(n2*p)
b[abs(b) < 1.0] <- 0
B <- matrix(b, n2, p)
B.csr <- as.matrix.csr(B)

# matrix transposition and multiplication
A.csr %*% t(B.csr)

# kronecker product - via kronecker() methods:
A.csr %x% matrix(1:4, 2, 2)
```

Description

chol performs a Cholesky decomposition of a symmetric positive definite sparse matrix x of class matrix.csr.
backsolve performs a triangular back-fitting to compute the solutions of a system of linear equations in one step.
backsolve and forwardsolve can also split the functionality of backsolve into two steps.
solve combines chol and backsolve and will compute the inverse of a matrix if the right-hand-side is missing.

Usage

```r
chol(x, ...)
## S4 method for signature 'matrix.csr.chol'
backsolve(r, x, k = NULL, upper.tri = NULL,
        transpose = NULL, twice = TRUE, ...)
forwardsolve(l, x, k = ncol(l), upper.tri = FALSE, transpose = FALSE)
solve(a, b, ...)
```
Arguments

- **a**: symmetric positive definite matrix of class `matrix.csr`.
- **r**: object of class `matrix.csr.chol` returned by the function `chol`.
- **l**: object of class `matrix.csr.chol` returned by the function `chol`.
- **x, b**: vector (regular matrix) of right-hand-side(s) of a system of linear equations.
- **k**: inherited from the generic; not used here.
- **upper.tri**: inherited from the generic; not used here.
- **transpose**: inherited from the generic; not used here.
- **twice**: Logical flag: If true backsolve solves twice, see below.
- **...**: further arguments passed to or from other methods.

Details

`chol` performs a Cholesky decomposition of a symmetric positive definite sparse matrix `a` of class `matrix.csr` using the block sparse Cholesky algorithm of Ng and Peyton (1993). The structure of the resulting `matrix.csr.chol` object is relatively complicated. If necessary it can be coerced back to a `matrix.csr` object as usual with `as.matrix.csr`. `backsolve` does triangular back-fitting to compute the solutions of a system of linear equations. For systems of linear equations that only vary on the right-hand-side, the result from `chol` can be reused. Contrary to the behavior of `backsolve` in base R, the default behavior of `backsolve(C, b)` when `C` is a `matrix.csr.chol` object is to produce a solution to the system $Ax = b$ where `C <- chol(A)`, see the example section. When the flag `twice` is `FALSE` then `backsolve` solves the system $Cx = b$, up to a permutation – see the comments below. The command `solve` combines `chol` and `backsolve`, and will compute the inverse of a matrix if the right-hand-side is missing. The determinant of the Cholesky factor is returned providing a means to efficiently compute the determinant of sparse positive definite symmetric matrices.

There are several integer storage parameters that are set by default in the call to the Cholesky factorization, these can be overridden in any of the above functions and will be passed by the usual "dots" mechanism. The necessity to do this is usually apparent from error messages like: Error in local(X...) increase tmpmax. For example, one can use, `solve(A, b, tmpmax = 100*nrow(A))`. The current default for `tmpmax` is `50*nrow(A)`. Some experimentation may be needed to select appropriate values, since they are highly problem dependent. See the code of `chol()` for further details on the current defaults.

Note

Because the sparse Cholesky algorithm re-orders the positive definite sparse matrix `A`, the value of `x <- backsolve(C, b)` does not equal the solution to the triangular system $Cx = b$, but is instead the solution to the system $CPx = Pb$ for some permutation matrix $P$ (and analogously for $x <- forwardsolve(C, b)$). However, a little algebra easily shows that `backsolve(C, forwardsolve(C, b), twice = FALSE)` is the solution to the equation $Ax = b$. Finally, if `C <- chol(A)` for some sparse covariance matrix `A`, and `z` is a conformable standard normal vector, then the product `y <- as.matrix.csr(C) %*% z` is normal with covariance matrix `A` irrespective of the permutation of the Cholesky factor.
References


See Also

slm for sparse version of lm

Examples

data(lsq)
class(lsq) # -> [1] "matrix.csc.hb"
model.matrix(lsq)->design.o
class(design.o) # -> "matrix.csr"
dim(design.o) # -> [1] 1850 712
y <- model.response(lsq) # extract the rhs
length(y) # [1] 1850

t(design.o) %*% design.o -> XpX
t(design.o) %*% y -> Xpy
chol(XpX) -> chol.o

b1 <- backsolve(chol.o,Xpy) # least squares solutions in two steps
b2 <- solve(XpX,Xpy) # least squares estimates in one step
b3 <- backsolve(chol.o, forwardsolve(chol.o, Xpy),
                twice = FALSE) # in three steps
# checking that these three are indeed equal:
stopifnot(all.equal(b1, b2), all.equal(b2, b3))

summary.mslm-class

Class "summary.mslm"
summary.slm-class  
Class "summary.slm"

Description
Sparse version of summary.lm

Objects from the Class
A virtual Class: No objects may be created from it.

Methods
  print  signature(x = "summary.slm"): ...

triogramX  
A Design Matrix for a Triogram Problem

Description
This is a design matrix arising from a bivariate smoothing problem using penalized triogram fitting. It is used in the SparseM vignette to illustrate the use of the sparse matrix image function.

Usage
  data(triogramX)

Format
A 375 by 100 matrix stored in compressed sparse row format

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