

Package ‘mvinfluence’

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Type Package

Title Influence Measures and Diagnostic Plots for Multivariate Linear Models

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Description Computes regression deletion diagnostics for multivariate linear models and provides some associated diagnostic plots. The diagnostic measures include hat-values (leverages), generalized Cook's distance, and generalized squared 'studentized' residuals. Several types of plots to detect influential observations are provided.

Depends car, heplots

Suggests

License GPL-2

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mvinfluence-package	<i>Influence Measures and Diagnostic Plots for Multivariate Linear Models</i>
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Description

This collection of functions is designed to compute regression deletion diagnostics for multivariate linear models following Barrett & Ling (1992). These are close analogs of standard methods for univariate and generalized linear models handled by the `influence.measures` in the stats package. These functions also extend plots of influence diagnostic measures such as those provided by `influencePlot` in the stats package.

In addition, the functions provide diagnostics for deletion of subsets of observations of size $m > 1$. This case is theoretically interesting because sometimes pairs ($m=2$) of influential observations can mask each other, sometimes they can have joint influence far exceeding their individual effects, as well as other interesting phenomena described by Lawrence (1995). Associated methods for the case $m > 1$ are still under development in this package.

Details

```
Package: mvinfluence
Type: Package
Version: 0.7
Date: 2013-9-06
License: GPL-2
```

The design goal for this package is that, as an extension of standard methods for univariate linear models, you should be able to fit a linear model with a multivariate response,

```
mymlm <- lm( cbind(y1, y2, y3) ~ x1 + x2 + x3, data=mydata)
```

and then get useful diagnostics and plots with

```
influence(mymlm)
hatvalues(mymlm)
influencePlot(mymlm, ...)
```

Author(s)

Michael Friendly

Maintainer: Michael Friendly <friendly@yorku.ca>

References

Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.

Barrett, B. E. (2003). Understanding Influence in Multivariate Regression. *Communications in Statistics – Theory and Methods*, **32**, 3, 667-680.

A. J. Lawrence (1995). Deletion Influence and Masking in Regression *Journal of the Royal Statistical Society. Series B (Methodological)* , Vol. **57**, No. 1, pp. 181-189.

See Also

[influence.measures](#), [influence.mlm](#), [influencePlot.mlm](#), ...

[Jdet](#), [Jtr](#) provide some theoretical description and definitions of influence measures in the Barrett & Ling framework.

Examples

```
# none here
```

Fertilizer

Fertilizer Data

Description

A small data set on the use of fertilizer (x) in relation to the amount of grain (y1) and straw (y2) produced.

Usage

```
data(Fertilizer)
```

Format

A data frame with 8 observations on the following 3 variables.

grain amount of grain produced

straw amount of straw produced

fertilizer amount of fertilizer applied

Details

The first observation is an obvious outlier and influential observation.

Source

Anderson, T. W. (1984). *An Introduction to Multivariate Statistical Analysis*, New York: Wiley, p. 369.

References

Hossain, A. and Naik, D. N. (1989). Detection of influential observations in multivariate regression. *Journal of Applied Statistics*, 16 (1), 25-37.

Examples

```
data(Fertilizer)

# simple plots
plot(Fertilizer, col=c('red', rep("blue",7)), cex=c(2,rep(1.2,7)), pch=as.character(1:8))
biplot(prcomp(Fertilizer))

#fit mlm
mod <- lm(cbind(grain, straw) ~ fertilizer, data=Fertilizer)
Anova(mod)

# influence plots (m=1)
influencePlot(mod)
influencePlot(mod, type='LR')
influencePlot(mod, type='stres')
```

infIndexPlot.mlm

Influence Index Plots for Multivariate Linear Models

Description

Provides index plots of some diagnostic measures for a multivariate linear model: Cook's distance, a generalized (squared) studentized residual, hat-values (leverages), and Mahalanobis squared distances of the residuals.

Usage

```
## S3 method for class 'mlm'
infIndexPlot(model,
  infl = mlm.influence(model, do.coef = FALSE), FUN = det,
  vars = c("Cook", "Studentized", "hat", "DSQ"),
  main = paste("Diagnostic Plots for", deparse(substitute(model))),
  pch = 19,
  labels,
  id.method = "y", id.n = if (id.method[1] == "identify") Inf else 0,
  id.cex = 1, id.col = palette()[1], id.location = "lr",
  grid = TRUE, ...)
```

Arguments

model	A multivariate linear model object of class <code>mlm</code> .
infl	influence measure structure as returned by <code>mlm.influence</code>
FUN	For $m > 1$, the function to be applied to the H and Q matrices returning a scalar value. FUN=det and FUN=tr are possible choices, returning the $ H $ and $tr(H)$ respectively.
vars	All the quantities listed in this argument are plotted. Use "Cook" for generalized Cook's distances, "Studentized" for generalized Studentized residuals, "hat" for hat-values (or leverages), and DSQ for the squared Mahalanobis distances of the model residuals. Capitalization is optional. All may be abbreviated by the first one or more letters.
main	main title for graph
pch	Plotting character for points
id.method, labels, id.n, id.cex, id.col, id.location	Arguments for the labelling of points. The default is <code>id.n=0</code> for labeling no points. See <code>showLabels</code> for details of these arguments.
grid	If TRUE, the default, a light-gray background grid is put on the graph
...	Arguments passed to <code>plot</code>

Details

This function produces index plots of the various influence measures calculated by `influence.mlm`, and in addition, the measure based on the Mahalanobis squared distances of the residuals from the origin.

Value

None. Used for its side effect of producing a graph.

Author(s)

Michael Friendly; borrows code from `car::infIndexPlot`

References

- Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.
- Barrett, B. E. (2003). Understanding Influence in Multivariate Regression *Communications in Statistics - Theory and Methods*, **32**, 667-680.

See Also

[influencePlot](#), [Mahalanobis](#), [infIndexPlot](#),

Examples

```
# iris data
data(iris)
iris.mod <- lm(as.matrix(iris[,1:4]) ~ Species, data=iris)
infIndexPlot(iris.mod, col=iris$Species, id.n=3)

# Sake data
data(Sake, package="heplots")
Sake.mod <- lm(cbind(taste,smell) ~ ., data=Sake)
infIndexPlot(Sake.mod, id.n=3)

# Rohwer data
data(Rohwer, package="heplots")
Rohwer2 <- subset(Rohwer, subset=group==2)
rownames(Rohwer2)<- 1:nrow(Rohwer2)
rohwer.mlm <- lm(cbind(SAT, PPVT, Raven) ~ n + s + ns + na + ss, data=Rohwer2)
infIndexPlot(rohwer.mlm, id.n=3)
```

influence.measures *Regression Deletion Diagnostics for Multivariate Linear Models*

Description

The functions `cooks.distance.mlm` and `hatvalues.mlm` are designed as extractor functions for regression deletion diagnostics for multivariate linear models following Barrett & Ling (1992). These are close analogs of methods for univariate and generalized linear models handled by the [influence.measures](#) in the stats package.

In addition, the functions provide diagnostics for deletion of subsets of observations of size $m > 1$.

Usage

```
## S3 method for class 'mlm'
cooks.distance(model, infl = mlm.influence(model, do.coef = FALSE), ...)

## S3 method for class 'mlm'
hatvalues(model, m = 1, infl, ...)
```

Arguments

<code>model</code>	A <code>mlm</code> object, as returned by <code>lm</code> with a multivariate response
<code>do.coef</code>	logical. Should the coefficients be returned in the <code>inflmlm</code> object?
<code>m</code>	Size of the subsets for deletion diagnostics

infl1 An influence structure, of class inflmlm as returned by [mlm.influence](#)
 ... Other arguments, passed on

Value

When $m=1$, these functions return a vector, corresponding to the observations in the data set.

When $m>1$, they return a list of $m \times m$ matrices, corresponding to deletion of subsets of size m .

Author(s)

Michael Friendly

References

Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.

See Also

[influencePlot.mlm](#), ~~~

Examples

```
data(Rohwer, package="heplots")
Rohwer2 <- subset(Rohwer, subset=group==2)
rownames(Rohwer2)<- 1:nrow(Rohwer2)
Rohwer.mod <- lm(cbind(SAT, PPVT, Raven) ~ n+s+ns+na+ss, data=Rohwer2)

hatvalues(Rohwer.mod)
cooks.distance(Rohwer.mod)
```

influence.mlm

Regression Deletion Diagnostics for Multivariate Linear Models

Description

This collection of functions is designed to compute regression deletion diagnostics for multivariate linear models following Barrett & Ling (1992) that are close analogs of methods for univariate and generalized linear models handled by the [influence.measures](#) in the **stats** package.

In addition, the functions provide diagnostics for deletion of subsets of observations of size $m>1$.

Usage

```
## S3 method for class 'mlm'
influence(model, do.coef = TRUE, m = 1, ...)

## S3 method for class 'inflmlm'
as.data.frame(x, ..., FUN = det, funnames = TRUE)

## S3 method for class 'inflmlm'
print(x, digits = max(3, getOption("digits") - 4), FUN = det, ...)
```

Arguments

model	An mlm object, as returned by <code>lm</code>
do.coef	logical. Should the coefficients be returned in the inflmlm object?
m	Size of the subsets for deletion diagnostics
x	An inflmlm object, as returned by <code>mlm.influence</code>
FUN	For $m > 1$, the function to be applied to the H and Q matrices returning a scalar value. FUN=det and FUN=tr are possible choices, returning the $ H $ and $tr(H)$ respectively.
funnames	logical. Should the FUN name be prepended to the statistics when creating a data frame?
...	Other arguments passed to methods
digits	Number of digits for the print method

Details

`influence.mlm` is a simple wrapper for the computational function, `mlm.influence` designed to provide an S3 method for class "mlm" objects.

There are still infelicities in the methods for the $m > 1$ case in the current implementation. In particular, for $m > 1$, you must call `influence.mlm` directly, rather than using the S3 generic `influence()`.

Value

`influence.mlm` returns an S3 object of class `inflmlm`, a list with the following components

m	Deletion subset size
H	Hat values, H_I . If $m=1$, a vector of diagonal entries of the 'hat' matrix. Otherwise, a list of $m \times m$ matrices corresponding to the subsets.
Q	Residuals, Q_I .
CookD	Cook's distance values
L	Leverage components
R	Residual components

subsets	Indices of the observations in the subsets of size m
labels	Observation labels
call	Model call for the mlm object
Beta	Deletion regression coefficients– included if do.coef=TRUE

Author(s)

Michael Friendly

References

Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.

See Also

[influencePlot.mlm](#), [mlm.influence](#)

Examples

```
# Rohwer data
Rohwer2 <- subset(Rohwer, subset=group==2)
rownames(Rohwer2) <- 1:nrow(Rohwer2)
Rohwer.mod <- lm(cbind(SAT, PPVT, Raven) ~ n+s+ns+na+ss, data=Rohwer2)

# m=1 diagnostics
influence(Rohwer.mod)

# try an m=2 case
res2 <- influence.mlm(Rohwer.mod, m=2, do.coef=FALSE)
res2.df <- as.data.frame(res2)
head(res2.df)
scatterplotMatrix(log(res2.df))

influencePlot(Rohwer.mod, id.n=4, type="cookd")

# Sake data
Sake.mod <- lm(cbind(taste,smell) ~ ., data=Sake)
influence(Sake.mod)
influencePlot(Sake.mod, id.n=3, type="cookd")
```

influencePlot.mlm *Influence Plots for Multivariate Linear Models*

Description

This function creates various types of “bubble” plots of influence measures with the areas of the circles representing the observations proportional to Cook’s distances.

type=“stres” plots squared (internally) Studentized residuals against hat values; type=“cookd” plots Cook’s distance against hat values; type=“LR” plots residual components against leverage components, with the property that contours of constant Cook’s distance fall on diagonal lines with slope = -1.

Usage

```
## S3 method for class 'mlm'
influencePlot(model, scale = 12, type=c("stres", "LR", "cookd"),
  infl = mlm.influence(model, do.coef = FALSE), FUN = det,
  fill = TRUE, fill.col = "red", fill.alpha.max = 0.5,
  labels,
  id.method = "noteworthy", id.n = if (id.method[1] == "identify") Inf else 0,
  id.cex = 1, id.col = palette()[1],
  ref.col = "gray", ref.lty = 2, ref.lab = TRUE, ...)
```

Arguments

model	An mlm object, as returned by lm with a multivariate response.
scale	a factor to adjust the radii of the circles, in relation to $\sqrt{\text{CookD}}$
type	Type of plot: one of c(“stres”, “cookd”, “LR”)
infl	influence measure structure as returned by mlm.influence
FUN	For $m > 1$, the function to be applied to the H and Q matrices returning a scalar value. FUN=det and FUN=tr are possible choices, returning the $ H $ and $\text{tr}(H)$ respectively.
labels, id.method, id.n, id.cex, id.col	settings for labelling points; see <code>link{showLabels}</code> for details. To omit point labelling, set <code>id.n=0</code> , the default. The default <code>id.method=“noteworthy”</code> is used in this function to indicate setting labels for points with large Studentized residuals, hat-values or Cook’s distances. See Details below. Set <code>id.method=“identify”</code> for interactive point identification.
fill, fill.col, fill.alpha.max	fill: logical, specifying whether the circles should be filled. When fill=TRUE, fill.col gives the base fill color to which transparency specified by fill.alpha.max is applied.
ref.col, ref.lty, ref.lab	arguments for reference lines. Incompletely implemented in this version
...	other arguments passed down

Details

The `id.method="noteworthy"` setting also requires setting `id.n>0` to have any effect. Using `id.method="noteworthy"`, and `id.n>0`, the number of points labeled is the union of the largest `id.n` values on each of L, R, and CookD.

Value

If points are identified, returns a data frame with the hat values, Studentized residuals and Cook's distance of the identified points. If no points are identified, nothing is returned. This function is primarily used for its side-effect of drawing a plot.

Author(s)

Michael Friendly

References

Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.

McCulloch, C. E. & Meeter, D. (1983). Discussion of "Outliers..." by R. J. Beckman and R. D. Cook. *Technometrics*, 25, 152-155

See Also

[mlm.influence](#), [lrPlot](#)
[influencePlot](#) in the car package

Examples

```
data(Rohwer, package="heplots")
Rohwer2 <- subset(Rohwer, subset=group==2)
Rohwer.mod <- lm(cbind(SAT, PPVT, Raven) ~ n+s+ns+na+ss, data=Rohwer2)

influencePlot(Rohwer.mod, id.n=4, type="stres")
influencePlot(Rohwer.mod, id.n=4, type="LR")
influencePlot(Rohwer.mod, id.n=4, type="cookd")

# Sake data
data(Sake, package="heplots")
Sake.mod <- lm(cbind(taste,smell) ~ ., data=Sake)
influencePlot(Sake.mod, id.n=3, type="stres")
influencePlot(Sake.mod, id.n=3, type="LR")
influencePlot(Sake.mod, id.n=3, type="cookd")

# Adopted data
data(Adopted, package="heplots")
Adopted.mod <- lm(cbind(Age2IQ, Age4IQ, Age8IQ, Age13IQ) ~ AMED + BMIQ, data=Adopted)
influencePlot(Adopted.mod, id.n=3)
influencePlot(Adopted.mod, id.n=3, type="LR", ylim=c(-4,-1.5))
```

Description

These functions implement the general classes of influence measures for multivariate regression models defined in Barrett and Ling (1992), Eqn 2.3, 2.4, as shown in their Table 1.

They are defined in terms of the submatrices for a deleted index subset I

$$H_I = X_I(X^T X)^{-1} X_I$$

$$Q_I = E_I(E^T E)^{-1} E_I$$

corresponding to the hat and residual matrices in univariate models.

For subset size $m = 1$ these evaluate to scalar equivalents of hat values and studentized residuals.

For subset size $m > 1$ these are $m \times m$ matrices and functions in the J^{det} class use $|H_I|$ and $|Q_I|$, while those in the J^{tr} class use $tr(H_I)$ and $tr(Q_I)$.

The functions COOKD, COVRATIO, and DFFITS implement some of the standard influence measures in these terms for the general cases of multivariate linear models and deletion of subsets of size $m > 1$, but they are only included here for experimental purposes.

Usage

Jdet(H, Q, a, b, f)

Jtr(H, Q, a, b, f)

COOKD(H, Q, n, p, r, m)

COVRATIO(H, Q, n, p, r, m)

DFFITS(H, Q, n, p, r, m)

Arguments

H	a scalar or $m \times m$ matrix giving the hat values for subset I
Q	a scalar or $m \times m$ matrix giving the residual values for subset I
a	the a parameter for the J^{det} and J^{tr} classes
b	the b parameter for the J^{det} and J^{tr} classes
f	scaling factor for the J^{det} and J^{tr} classes
n	sample size
p	number of predictor variables
r	number of response variables
m	deletion subset size

Details

These functions are purely experimental and not intended to be used directly. However, they may be useful to define other influence measures than are currently implemented here.

Value

The scalar result of the computation.

Author(s)

Michael Friendly

References

Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.

lrPlot

Regression LR Influence Plot

Description

This function creates a “bubble” plot of functions, $R = \log(\text{Studentized residuals}^2)$ by $L = \log(H/p*(1-H))$ of the hat values, with the areas of the circles representing the observations proportional to Cook’s distances.

This plot, suggested by McCulloch & Meeter (1983) has the attractive property that contours of equal Cook’s distance are diagonal lines with slope = -1. Various reference lines are drawn on the plot corresponding to twice and three times the average hat value, a “large” squared studentized residual and contours of Cook’s distance.

Usage

```
lrPlot(model, ...)
```

```
## S3 method for class 'lm'
lrPlot(model, scale = 12,
xlab = "log Leverage factor [log H/p*(1-H)]",
ylab = "log (Studentized Residual^2)",
xlim = NULL, ylim,
labels,
id.method = "noteworthy",
id.n = if (id.method[1] == "identify") Inf else 0,
id.cex = 1, id.col = palette()[1],
ref = c("h", "v", "d", "c"), ref.col = "gray",
ref.lty = 2, ref.lab = TRUE,
...)
```

Arguments

<code>model</code>	a linear or generalized-linear model.
<code>scale</code>	a factor to adjust the radii of the circles, in relation to $\sqrt{\text{CookD}}$
<code>xlab, ylab</code>	axis labels.
<code>xlim, ylim</code>	Limits for x and y axes. In the space of (L, R) very small residuals typically extend the y axis enough to swamp the large residuals, so the default for <code>ylim</code> is set to a range of 6 log units starting at the maximum value.
<code>labels, id.method, id.n, id.cex, id.col</code>	settings for labelling points; see <code>link{showLabels}</code> for details. To omit point labelling, set <code>id.n=0</code> , the default. The default <code>id.method="noteworthy"</code> is used in this function to indicate setting labels for points with large Studentized residuals, hat-values or Cook's distances. See Details below. Set <code>id.method="identify"</code> for interactive point identification.
<code>ref</code>	Options to draw reference lines, any one or more of <code>c("h", "v", "d", "c")</code> . "h" and "v" draw horizontal and vertical reference lines at noteworthy values of R and L respectively. "d" draws equally spaced diagonal reference lines for contours of equal CookD. "c" draws diagonal reference lines corresponding to approximate 0.95 and 0.99 contours of CookD.
<code>ref.col, ref.lty</code>	Color and line type for reference lines. Reference lines for "c" %in% ref are handled separately.
<code>ref.lab</code>	A logical, indicating whether the reference lines should be labeled.
<code>...</code>	arguments to pass to the plot and points functions.

Details

The `id.method="noteworthy"` setting also requires setting `id.n>0` to have any effect. Using `id.method="noteworthy"`, and `id.n>0`, the number of points labeled is the union of the largest `id.n` values on each of L, R, and CookD.

Value

If points are identified, returns a data frame with the hat values, Studentized residuals and Cook's distance of the identified points. If no points are identified, nothing is returned. This function is primarily used for its side-effect of drawing a plot.

Author(s)

Michael Friendly

References

- A. J. Lawrence (1995). Deletion Influence and Masking in Regression *Journal of the Royal Statistical Society. Series B (Methodological)*, Vol. 57, No. 1, pp. 181-189.
- McCulloch, C. E. & Meeter, D. (1983). Discussion of "Outliers..." by R. J. Beckman and R. D. Cook. *Technometrics*, 25, 152-155.

See Also[influencePlot](#)[influencePlot](#) in the car package for other methods**Examples**

```
# artificial example from Lawrence (1995)
x <- c( 0, 0, 7, 7, 8, 8, 9, 9, 10, 10, 11, 11, 18, 18 )
y <- c( 0, 6, 6, 7, 6, 7, 6, 7, 6, 7, 6, 7, 7, 18 )
DF <- data.frame(x,y, row.names=LETTERS[1:length(x)])
DF

with(DF, {
plot(x,y, pch=16, cex=1.3)
abline(lm(y~x), col="red", lwd=2)
NB <- c(1,2,13,14)
text(x[NB],y[NB], LETTERS[NB], pos=c(4,4,2,2))
}
)

mod <- lm(y~x, data=DF)
# standard influence plot from car
influencePlot(mod, id.n=4)

# lrPlot version
lrPlot(mod, id.n=4)

library(car)
dmod <- lm(prestige ~ income + education, data = Duncan)
influencePlot(dmod, id.n=3)
lrPlot(dmod, id.n=3)
```

mlm.influence	<i>Calculate Regression Deletion Diagnostics for Multivariate Linear Models</i>
---------------	---

Description

mlm.influence is the main computational function in this package. It is usually not called directly, but rather via its alias, [influence.mlm](#), the S3 method for a mlm object.

Usage

```
mlm.influence(model, do.coef = TRUE, m = 1, ...)
```

Arguments

model	An mlm object, as returned by <code>lm</code>
do.coef	logical. Should the coefficients be returned in the <code>inflmlm</code> object?
m	Size of the subsets for deletion diagnostics
...	Further arguments passed to other methods

Details

The computations and methods for the $m=1$ case are straight-forward, as are the computations for the $m>1$ case. Associated methods for $m>1$ are still under development.

Value

`mlm.influence` returns an S3 object of class `inflmlm`, a list with the following components

m	Deletion subset size
H	Hat values, H_I . If $m=1$, a vector of diagonal entries of the ‘hat’ matrix. Otherwise, a list of $m \times m$ matrices corresponding to the subsets.
Q	Residuals, Q_I .
CookD	Cook’s distance values
L	Leverage components
R	Residual components
subsets	Indices of the observations in the subsets of size m
labels	Observation labels
call	Model call for the mlm object
Beta	Deletion regression coefficients– included if <code>do.coef=TRUE</code>

Author(s)

Michael Friendly

References

- Barrett, B. E. and Ling, R. F. (1992). General Classes of Influence Measures for Multivariate Regression. *Journal of the American Statistical Association*, **87**(417), 184-191.
- Barrett, B. E. (2003). Understanding Influence in Multivariate Regression. *Communications in Statistics – Theory and Methods*, **32**, 3, 667-680.

See Also

[influencePlot.mlm](#), ~~~

Examples

```
Rohwer2 <- subset(Rohwer, subset=group==2)
rownames(Rohwer2)<- 1:nrow(Rohwer2)
Rohwer.mod <- lm(cbind(SAT, PPVT, Raven) ~ n+s+ns+na+ss, data=Rohwer2)
Rohwer.mod
influence(Rohwer.mod)

# Sake data
Sake.mod <- lm(cbind(taste,smell) ~ ., data=Sake)
influence(Sake.mod)
```

mpower

General Matrix Power

Description

Calculates the n -th power of a square matrix, where n can be a positive or negative integer or a fractional power.

Usage

```
mpower(A, n)
```

Arguments

A	A square matrix. Must also be symmetric for non-integer powers.
n	matrix power

Details

If $n < 0$, the method is applied to A^{-1} . When n is an integer, the function uses the Russian peasant method, or repeated squaring for efficiency. Otherwise, it uses the spectral decomposition of A , requiring a symmetric matrix.

Value

Returns the matrix A^n

Author(s)

Michael Friendly

See Also

Packages `corpcor` and `expm` define similar functions.

Examples

```
M <- matrix(sample(1:9), 3,3)
mpower(M,2)
mpower(M,4)

# make a symmetric matrix
MM <- crossprod(M)
mpower(MM, -1)
Mhalf <- mpower(MM, 1/2)
all.equal(MM, Mhalf %*% Mhalf)
```

tr	<i>Matrix trace</i>
----	---------------------

Description

Calculates the trace of a matrix

Usage

```
tr(M)
```

Arguments

M a matrix

Value

returns the sum of the diagonal elements

Author(s)

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Examples

```
M <- matrix(sample(1:9), 3,3)
tr(M)
```

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