Package 'mvinfluence'

May 17, 2018

Type Package

Title Influence Measures and Diagnostic Plots for Multivariate Linear Models

Version 0.8-3

Date 2018-05-16

Author Michael Friendly

Maintainer Michael Friendly <friendly@yorku.ca>

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

LazyData TRUE

License GPL-2

URL https://github.com/friendly/mvinfluence

BugReports https://github.com/friendly/mvinfluence/issues

NeedsCompilation no

Repository CRAN

Date/Publication 2018-05-17 17:01:07 UTC

R topics documented:

`mvinfluence-package` *Influence Measures and Diagnostic Plots for Multivariate Linear Models*

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

The DESCRIPTION file:

Package:	mvinfluence
Type:	Package
Title:	Influence Measures and Diagnostic Plots for Multivariate Linear Models
Version:	0.8-3
Date:	2018-05-16
Author:	Michael Friendly
Maintainer:	Michael Friendly <friendly@yorku.ca>
Description:	Computes regression deletion diagnostics for multivariate linear models and provides some associated diagnos
Depends:	car, heplots
Suggests:	
LazyData:	TRUE
License:	GPL-2
URL:	https://github.com/friendly/mvinfluence
BugReports:	https://github.com/friendly/mvinfluence/issues
Packaged:	2012-03-18 21:51:10 UTC; Michael

Index of help topics:

```
Fertilizer              Fertilizer Data
Jdet                    General Classes of Influence Measures
cooks.distance.mlm      Regression Deletion Diagnostics for
                        Multivariate Linear Models
infIndexPlot.mlm        Influence Index Plots for Multivariate Linear
                        Models
influence.mlm           Regression Deletion Diagnostics for
                        Multivariate Linear Models
influencePlot.mlm       Influence Plots for Multivariate Linear Models
lrPlot                  Regression LR Influence Plot
mlm.influence           Calculate Regression Deletion Diagnostics for
                        Multivariate Linear Models
mpower                  General Matrix Power
mvinfluence-package     Influence Measures and Diagnostic Plots for
                        Multivariate Linear Models
tr                      Matrix trace
```

~~ An overview of how to use the package, including the most important ~~ ~~ functions ~~ 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 `mlm` .
`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 $tr(H)$ 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 labeling of points. The default is id.n=0 for labeling no points. See showLabels for details of these arguments.
grid	If TRUE, the default, a light-gray background grid is put on the graph
...	Arguments passed to plot

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.mlm, 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

`model`	A `mlm` object, as returned by `lm` with a multivariate response
`do.coef`	logical. Should the coefficients be returned in the `inflmlm` object?
`m`	Size of the subsets for deletion diagnostics
`infl`	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 lm
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 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 $tr(H)$ 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(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 $tr(H)$ respectively.
labels, id.method, id.n, id.cex, id.col	settings for labelling points; see link{showLabels} for details. To omit point labelling, set id.n=0, the default. The default id.method="noteworthy" 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 id.method="identify" 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.

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

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))
```

Jfuns *General Classes of Influence Measures*

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(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

`model`	a linear or generalized-linear model.
`scale`	a factor to adjust the radii of the circles, in relation to `sqrt(CookD)`
`xlab, ylab`	axis labels.
`xlim, ylim`	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 `ylim` is set to a range of 6 log units starting at the maximum value.

`labels, id.method, id.n, id.cex, id.col`
: settings for labeling points; see `link{showLabels}` for details. To omit point labeling, set `id.n=0`, the default. The default `id.method="noteworthy"` 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 `id.method="identify"` for interactive point identification.

`ref`
: Options to draw reference lines, any one or more of `c("h", "v", "d", "c")`. `"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.

`ref.col, ref.lty`
: Color and line type for reference lines. Reference lines for `"c" %in% ref` are handled separately.

`ref.lab`
: A logical, indicating whether the reference lines should be labeled.

`...`
: 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.mlm`

`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` *Calculate Regression Deletion Diagnostics for Multivariate Linear Models*

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 `lm`
`do.coef`	logical. Should the coefficients be returned in the `inflmlm` 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 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.

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` *Matrix trace*

Description

Calculates the trace of a matrix

Usage

```
tr(M)
```

Arguments

`M`	a matrix

Value

returns the sum of the diagonal elements

Author(s)

Michael Friendly

Examples

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

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