# Package ‘car’

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Anova Tables for Various Statistical Models

Description

Calculates type-II or type-III analysis-of-variance tables for model objects produced by \texttt{lm}, \texttt{glm}, \texttt{multinom} (in the \texttt{nnet} package), \texttt{polr} (in the \texttt{MASS} package), \texttt{coxph} (in the \texttt{survival} package), \texttt{coxme} (in the \texttt{coxme} package), \texttt{svyglm} (in the \texttt{survey} package), \texttt{lmer} (in the \texttt{lme4} package), \texttt{lme} in the \texttt{nlme} package, and (by the default method) for most models with a linear predictor and asymptotically normal coefficients (see details below). For linear models, F-tests are calculated; for generalized linear models, likelihood-ratio chi-square, Wald chi-square, or F-tests are calculated; for multinomial logit and proportional-odds logit models, likelihood-ratio tests are calculated. Various test statistics are provided for multivariate linear models produced by \texttt{lm} or \texttt{manova}. Partial-likelihood-ratio tests or Wald tests are provided for Cox models. Wald chi-square tests are provided for fixed effects in linear and generalized linear mixed-effects models. Wald chi-square or F tests are provided in the default case.

Usage

\begin{verbatim}
Anova(mod, ...)  
Manova(mod, ...)  
\end{verbatim}

\begin{verbatim}
## S3 method for class 'lm'
Anova(mod, error, type=c("II","III", 2, 3),
  white.adjust=c(FALSE, TRUE, "hc3", "hc0", "hc1", "hc2", "hc4"),
  vcov.=NULL, singular.ok, ...)  

## S3 method for class 'aov'
Anova(mod, ...)  

## S3 method for class 'glm'
Anova(mod, type=c("II","III", 2, 3),
  test.statistic=c("LR", "Wald", "F"),
  error, error.estimate=c("pearson", "dispersion", "deviance"),
  singular.ok, ...)  

## S3 method for class 'multinom'
Anova(mod, type = c("II","III", 2, 3), ...)  

## S3 method for class 'polr'
Anova(mod, type = c("II","III", 2, 3), ...)

## S3 method for class 'mlm'
Anova(mod, type=c("II","III", 2, 3), SSPE, error.df,
  idata, idesign, icontrasts=c("contr.sum", "contr.poly"), imatrix,
  test.statistic=c("Pillai", "Wilks", "Hotelling-Lawley", "Roy"), ...)
\end{verbatim}
\texttt{Anova}?

\# S3 method for class 'manova'
\texttt{Anova(mod, \ldots)}

\# S3 method for class 'mlm'
\texttt{Manova(mod, \ldots)}

\# S3 method for class 'Anova.mlm'
\texttt{print(x, \ldots)}

\# S3 method for class 'Anova.mlm'
\texttt{summary(object, test.statistic, univariate=object$repeated,}
\quad \texttt{multivariate=TRUE, p.adjust.method, \ldots)}

\# S3 method for class 'summary.Anova.mlm'
\texttt{print(x, digits = getOption("digits"),}
\quad \texttt{SSP=TRUE, SSPE=SSP, \ldots)}

\# S3 method for class 'univaov'
\texttt{print(x, digits = max(getOption("digits") - 2L, 3L),}
\quad \texttt{style=c("wide", "long"),}
\quad \texttt{by=c("response", "term"),}
\quad \texttt{\ldots)}

\# S3 method for class 'univaov'
\texttt{as.data.frame(x, row.names, optional, by=c("response", "term"), \ldots)}

\# S3 method for class 'coxph'
\texttt{Anova(mod, type=c("II", "III", 2, 3),}
\quad \texttt{test.statistic=c("LR", "Wald"), \ldots)}

\# S3 method for class 'coxme'
\texttt{Anova(mod, type=c("II", "III", 2, 3),}
\quad \texttt{test.statistic=c("Wald", "LR"), \ldots)}

\# S3 method for class 'lme'
\texttt{Anova(mod, type=c("II", "III", 2, 3),}
\quad \texttt{vcov.=vcov(mod, complete=FALSE), singular.ok, \ldots)}

\# S3 method for class 'mer'
\texttt{Anova(mod, type=c("II", "III", 2, 3),}
\quad \texttt{test.statistic=c("Chisq", "F"), vcov.=vcov(mod, complete=FALSE), singular.ok, \ldots)}

\# S3 method for class 'merMod'
\texttt{Anova(mod, type=c("II", "III", 2, 3),}
\quad \texttt{test.statistic=c("Chisq", "F"), vcov.=vcov(mod, complete=FALSE), singular.ok, \ldots)}

\# S3 method for class 'svyglm'

Anova(mod, ...)

## S3 method for class 'rlm'
Anova(mod, ...)

## Default S3 method:
Anova(mod, type=c("II", "III", 2, 3),
test.statistic=c("Chisq", "F"), vcov.=vcov(mod, complete=FALSE),
singular.ok, ...)

Arguments

- **mod**: lm, aov, glm, multinom, polr mlm, coxph, coxme, lme, mer, merMod, svyglm, rlm, or other suitable model object.
- **error**: for a linear model, an lm model object from which the error sum of squares and degrees of freedom are to be calculated. For F-tests for a generalized linear model, a glm object from which the dispersion is to be estimated. If not specified, mod is used.
- **type**: type of test, "II", "III", 2, or 3. Roman numerals are equivalent to the corresponding Arabic numerals.
- **singular.ok**: defaults to TRUE for type-II tests, and FALSE for type-III tests where the tests for models with aliased coefficients will not be straightforwardly interpretable; if FALSE, a model with aliased coefficients produces an error.
- **test.statistic**: for a generalized linear model, whether to calculate "LR" (likelihood-ratio), "Wald", or "F" tests; for a Cox or Cox mixed-effects model, whether to calculate "LR" (partial-likelihood ratio) or "Wald" tests; in the default case or for linear mixed models fit by lmer, whether to calculate Wald "Chisq" or Kenward-Roger "F" tests with Satterthwaite degrees of freedom (warning: the KR F-tests can be very time-consuming). For a multivariate linear model, the multivariate test statistic to compute — one of "Pillai", "Wilks", "Hotelling-Lawley", or "Roy", with "Pillai" as the default. The summary method for Anova.mlm objects permits the specification of more than one multivariate test statistic, and the default is to report all four.
- **error.estimate**: for F-tests for a generalized linear model, base the dispersion estimate on the Pearson residuals ("pearson", the default); use the dispersion estimate in the model object ("dispersion"); or base the dispersion estimate on the residual deviance ("deviance"). For binomial or Poisson GLMs, where the dispersion is fixed to 1, setting error.estimate="dispersion" is changed to "pearson", with a warning.
- **white.adjust**: if not FALSE, the default, tests use a heteroscedasticity-corrected coefficient covariance matrix; the various values of the argument specify different corrections. See the documentation for hccm for details. If white.adjust=TRUE then the "hc3" correction is selected.
- **SSPE**: For Anova for a multivariate linear model, the error sum-of-squares-and-products matrix; if missing, will be computed from the residuals of the model; for the print method for the summary of an Anova of a multivariate linear model, whether or not to print the error SSP matrix (defaults to TRUE).
SSP

if TRUE (the default), print the sum-of-squares and cross-products matrix for the hypothesis and the response-transformation matrix.

error.df

The degrees of freedom for error; if missing, will be taken from the model.

idata

an optional data frame giving a factor or factors defining the intra-subject model for multivariate repeated-measures data. See Details for an explanation of the intra-subject design and for further explanation of the other arguments relating to intra-subject factors.

idesign

a one-sided model formula using the “data” in idata and specifying the intra-subject design.

icontrasts

names of contrast-generating functions to be applied by default to factors and ordered factors, respectively, in the within-subject “data”; the contrasts must produce an intra-subject model matrix in which different terms are orthogonal. The default is c("contr.sum","contr.poly").

imatrix

as an alternative to specifying idata, idesign, and (optionally) icontrasts, the model matrix for the within-subject design can be given directly in the form of list of named elements. Each element gives the columns of the within-subject model matrix for a term to be tested, and must have as many rows as there are responses; the columns of the within-subject model matrix for different terms must be mutually orthogonal.

x, object

object of class "Anova.mlm" to print or summarize.

multivariate, univariate

compute and print multivariate and univariate tests for a repeated-measures ANOVA or multivariate linear model; the default is TRUE for both for repeated measures and TRUE for multivariate for a multivariate linear model.

p.adjust.method

if given for a multivariate linear model when univariate tests are requested, the univariate tests are corrected for simultaneous inference by term; if specified, should be one of the methods recognized by p.adjust or TRUE, in which case the default (Holm) adjustment is used.

digits

minimum number of significant digits to print.

style

for printing univariate tests if requested for a multivariate linear model; one of "wide", the default, or "long".

by

if univariate tests are printed in "long" style, they can be ordered by "response", the default, or by "term".

row.names, optional

not used.

vcov.

in the default method, an optional coefficient-covariance matrix or function to compute a covariance matrix, computed by default by applying the generic vcov function to the model object. A similar argument may be supplied to the lm method, and the default (NULL) is to ignore the argument; if both vcov. and white.adjust are supplied to the lm method, the latter is used.

...  
do not use.
Details

The designations "type-II" and "type-III" are borrowed from SAS, but the definitions used here do not correspond precisely to those employed by SAS. Type-II tests are calculated according to the principle of marginality, testing each term after all others, except ignoring the term’s higher-order relatives; so-called type-III tests violate marginality, testing each term in the model after all of the others. This definition of Type-II tests corresponds to the tests produced by SAS for analysis-of-variance models, where all of the predictors are factors, but not more generally (i.e., when there are quantitative predictors). Be very careful in formulating the model for type-III tests, or the hypotheses tested will not make sense.

As implemented here, type-II Wald tests are a generalization of the linear hypotheses used to generate these tests in linear models.

For tests for linear models, multivariate linear models, and Wald tests for generalized linear models, Cox models, mixed-effects models, generalized linear models fit to survey data, and in the default case, Anova finds the test statistics without refitting the model. The svyglm method simply calls the default method and therefore can take the same arguments.

The standard R anova function calculates sequential ("type-I") tests. These rarely test interesting hypotheses in unbalanced designs.

A MANOVA for a multivariate linear model (i.e., an object of class "mlm" or "manova") can optionally include an intra-subject repeated-measures design. If the intra-subject design is absent (the default), the multivariate tests concern all of the response variables. To specify a repeated-measures design, a data frame is provided defining the repeated-measures factor or factors via idata, with default contrasts given by the icontrasts argument. An intra-subject model-matrix is generated from the formula specified by the idesign argument; columns of the model matrix corresponding to different terms in the intra-subject model must be orthogonal (as is insured by the default contrasts). Note that the contrasts given in icontrasts can be overridden by assigning specific contrasts to the factors in idata. As an alternative, the within-subjects model matrix can be specified directly via the imatrix argument. Manova is essentially a synonym for Anova for multivariate linear models.

If univariate tests are requested for the summary of a multivariate linear model, the object returned contains a univaov component of "univaov"; print and as.data.frame methods are provided for the "univaov" class.

For the default method to work, the model object must contain a standard terms element, and must respond to the vcov, coef, and model.matrix functions. If any of these requirements is missing, then it may be possible to supply it reasonably simply (e.g., by writing a missing vcov method for the class of the model object).

Value

An object of class "anova", or "Anova.mlm", which usually is printed. For objects of class "Anova.mlm", there is also a summary method, which provides much more detail than the print method about the MANOVA, including traditional mixed-model univariate F-tests with Greenhouse-Geisser and Huynh-Feldt corrections.

Warning

Be careful of type-III tests: For a traditional multifactor ANOVA model with interactions, for example, these tests will normally only be sensible when using contrasts that, for different terms, are
orthogonal in the row-basis of the model, such as those produced by `contr.sum`, `contr.poly`, or `contr.helmert`, but not by the default `contr.treatment`. In a model that contains factors, numeric covariates, and interactions, main-effect tests for factors will be for differences over the origin. In contrast (pun intended), type-II tests are invariant with respect to (full-rank) contrast coding. If you don’t understand this issue, then you probably shouldn’t use `Anova` for type-III tests.

Author(s)

John Fox <jfox@mcmaster.ca>; the code for the Mauchly test and Greenhouse-Geisser and Huynh-Feldt corrections for non-sphericity in repeated-measures ANOVA are adapted from the functions `stats::mauchly.test.SSD` and `stats::sphericity` by R Core; `summary.Anova.mlm` and `print.summary.Anova.mlm` incorporates code contributed by Gabriel Baud-Bovy.

References


See Also

`linearHypothesis`, `anova anova.lm`, `anova.glm`, `anova.mlm`, `anova.coxph`, `svyglm`.

Examples

```r
## Two-Way Anova
mod <- lm(conformity ~ fcategory*partner.status, data=Moore,
          contrasts=list(fcategory=contr.sum, partner.status=contr.sum))
Anova(mod)
Anova(mod, type=3)  # note use of contr.sum in call to lm()

## One-Way MANOVA
## See ?Pottery for a description of the data set used in this example.
summary(Anova(lm(cbind(Al, Fe, Mg, Ca, Na) ~ Site, data=Pottery)))

## MANOVA for a randomized block design (example courtesy of Michael Friendly:
## See ?Soils for description of the data set)
soils.mod <- lm(cbind(pH,N,Dens,P,Ca,Mg,K,Na,Conduc) ~ Block + Contour*Depth,
                 data=Soils)
Manova(soils.mod)
summary(Anova(soils.mod), univariate=TRUE, multivariate=FALSE,
         p.adjust.method=TRUE)
```
## a multivariate linear model for repeated-measures data
## See ?OBrienKaiser for a description of the data set used in this example.

```r
phase <- factor(rep(c("pretest", "posttest", "followup"), c(5, 5, 5)),
   levels=c("pretest", "posttest", "followup"))
hour <- ordered(rep(1:5, 3))
idata <- data.frame(phase, hour)
idata

mod.ok <- lm(cbind(pre.1, pre.2, pre.3, pre.4, pre.5,
    post.1, post.2, post.3, post.4, post.5,
    fup.1, fup.2, fup.3, fup.4, fup.5) ~ treatment*gender,
   data=OBrienKaiser)
(av.ok <- Anova(mod.ok, idata=idata, idesign=~phase*hour))

summary(av.ok, multivariate=FALSE)
```

## A "doubly multivariate" design with two distinct repeated-measures variables
## (example courtesy of Michael Friendly)
## See ?WeightLoss for a description of the dataset.

```r
imatrix <- matrix(c(
  1,0,-1, 1, 0, 0,
  1,0, 0,-2, 0, 0,
  1,0, 1, 1, 0, 0,
  0,1, 0, 0,-1, 1,
  0,1, 0, 0, 0,-2,
  0,1, 0, 0, 1, 1), 6, 6, byrow=TRUE)
colnames(imatrix) <- c("WL", "SE", "WL.L", "WL.Q", "SE.L", "SE.Q")
rownames(imatrix) <- colnames(WeightLoss)[-1]
(imatrix <- list(measure=imatrix[,1:2], month=imatrix[,3:6]))
contrasts(WeightLoss$group) <- matrix(c(-2,1,1, 0,-1,1), ncol=2)
(wl.mod<-lm(cbind(wl1, wl2, wl3, se1, se2, se3)~group, data=WeightLoss))
Anova(wl.mod, imatrix=imatrix, test="Roy")
```

## mixed-effects models examples:

## Not run:
library(nlme)
example(lme)
Anova(fm2)

## End(Not run)

## Not run:
library(lme4)
example(glmer)
Anova(gm1)

## End(Not run)
**avPlots**

### Added-Variable Plots

**Description**

These functions construct added-variable, also called partial-regression, plots for linear and generalized linear models.

**Usage**

- `avPlots(model, terms=~., intercept=FALSE, layout=NULL, ask, main, ...)`
- `avp(...)`
- `avPlot(model, ...)`

```r
## S3 method for class 'lm'
avPlot(model, variable,
id=TRUE, col = carPalette()[1], col.lines = carPalette()[2],
xlab, ylab, pch = 1, lwd = 2,
main=paste("Added-Variable Plot:", variable),
grid=TRUE,
ellipse=FALSE,
    marginal.scale=FALSE, ...)

## S3 method for class 'glm'
avPlot(model, variable,
id=TRUE,
     col = carPalette()[1], col.lines = carPalette()[2],
xlab, ylab, pch = 1, lwd = 2, type=c("Wang", "Weisberg"),
main=paste("Added-Variable Plot:", variable), grid=TRUE,
ellipse=FALSE, ...)
```

**Arguments**

- `model` model object produced by `lm` or `glm`.
- `terms` A one-sided formula that specifies a subset of the predictors. One added-variable plot is drawn for each term. For example, the specification `terms = ~.-X3` would plot against all terms except for \(X_3\). If this argument is a quoted name of one of the terms, the added-variable plot is drawn for that term only.
- `intercept` Include the intercept in the plots; default is `FALSE`.
- `variable` A quoted string giving the name of a regressor in the model matrix for the horizontal axis.
- `layout` If set to a value like `c(1,1)` or `c(4,3)`, the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you...
will get a maximum of nine per page. If layout=NA, the function does not set the
layout and the user can use the par function to control the layout, for example
to have plots from two models in the same graphics window.

main
The title of the plot; if missing, one will be supplied.

ask
If TRUE, ask the user before drawing the next plot; if FALSE don’t ask.

id
controls point identification; if FALSE, no points are identified; can be a list
of named arguments to the showLabels function; TRUE, the default, is equivalent to
list(method=list(abs(residuals(model,type="pearson")),"x"),n=2,cex=1,col=carPalette()
which identifies the 2 points with the largest residuals and the 2 points with the
most extreme horizontal values (i.e., largest partial leverage).

col
color for points; the default is the second entry in the current car palette (see
carPalette and par).

col.lines
color for the fitted line.

pch
plotting character for points; default is 1 (a circle, see par).

lwd
line width; default is 2 (see par).

xlab
x-axis label. If omitted a label will be constructed.

ylab
y-axis label. If omitted a label will be constructed.

type
if "Wang" use the method of Wang (1985); if "Weisberg" use the method in the
Arc software associated with Cook and Weisberg (1999).

grid
If TRUE, the default, a light-gray background grid is put on the graph.

ellipse
controls plotting data-concentration ellipses. If FALSE (the default), no ellipses
are plotted. Can be a list of named values giving levels, a vector of one or
more bivariate-normal probability-contour levels at which to plot the ellipses;
and robust, a logical value deteremining whether to use the cov.trob function in
the MASS package to calculate the center and covariance matrix for the data
ellipses. TRUE is equivalent to list(levels=c(.5,.95),robust=TRUE).

marginal.scale
Consider an added-variable plot of Y versus X given Z. If this argument is FALSE
then the limits on the horizontal axis are determined by the range of the residuals
from the regression of X on Z and the limits on the vertical axis are determined
by the range of the residuals from the regressnio of Y on Z. If the argument
is TRUE, then the limits on the horizontal axis are determined by the range of
X minus it mean, and on the vertical axis by the range of Y minus its means;
adjustment is made if necessary to include outliers. This scaling allows visual-
zation of the correlations between Y and Z and between X and Z. For example,
if the X and Z are highly correlated, then the points will be concentrated on the
middle of the plot.

Details
The function intended for direct use is avPlots (for which avp is an abbreviation).

Value
These functions are used for their side effect id producing plots, but also invisibly return the coor-
dinates of the plotted points.
bcPower

Author(s)

John Fox <jfox@mcmaster.ca>, Sanford Weisberg <sandy@umn.edu>

References


See Also

residualPlots, crPlots, ceresPlots, link{dataEllipse}, showLabels, dataEllipse.

Examples

avPlots(lm(prestige ~ income + education + type, data=Duncan))

avPlots(glm(partic != "not.work" ~ hincome + children, 
              data=Womenlf, family=binomial), id=FALSE)

m1 <- lm(partic ~ tfr + menwage + womwage + debt + parttime, Bfox)
par(mfrow=c(1,3))
# marginal plot, ignoring other predictors:
with(Bfox, dataEllipse(womwage, partic, levels=0.5))
abline(lm(partic ~ womwage, Bfox), col="red", lwd=2)
# AV plot, adjusting for others:
avPlots(m1, ~ womwage, ellipse=list(levels=0.5))
# AV plot, adjusting and scaling as in marginal plot
avPlots(m1, ~ womwage, marginal.scale=TRUE, ellipse=list(levels=0.5))

bcPower

Box-Cox, Box-Cox with Negatives Allowed, Yeo-Johnson and Basic Power Transformations

Description

Transform the elements of a vector or columns of a matrix using, the Box-Cox, Box-Cox with negatives allowed, Yeo-Johnson, or simple power transformations.
Usage

bcPower(U, lambda, jacobian.adjusted=FALSE, gamma=NULL)

bcnPower(U, lambda, jacobian.adjusted=FALSE, gamma)

bcnPowerInverse(z, lambda, gamma)

yjPower(U, lambda, jacobian.adjusted=FALSE)

basicPower(U, lambda, gamma=NULL)

Arguments

U A vector, matrix or data.frame of values to be transformed
lambda Power transformation parameter with one element for each column of U, usually in the range from $-2$ to $2$.
jacobian.adjusted If TRUE, the transformation is normalized to have Jacobian equal to one. The default FALSE is almost always appropriate.
gamma For bcPower or basicPower, the transformation is of $U + \gamma$, where gamma is a positive number called a start that must be large enough so that $U + \gamma$ is strictly positive. For the bcnPower, Box-cox power with negatives allowed, see the details below.
z a numeric vector the result of a call to bcnPower with jacobian.adjusted=FALSE.

Details

The Box-Cox family of scaled power transformations equals $(x^\lambda - 1)/\lambda$ for $\lambda \neq 0$, and $\log(x)$ if $\lambda = 0$. The bcPower function computes the scaled power transformation of $x = U + \gamma$, where $\gamma$ is set by the user so $U + \gamma$ is strictly positive for these transformations to make sense.

The Box-Cox family with negatives allowed was proposed by Hawkins and Weisberg (2017). It is the Box-Cox power transformation of

$$z = 0.5(U + \sqrt{U^2 + \gamma^2})$$

where for this family $\gamma$ is either user selected or is estimated. gamma must be positive if $U$ includes negative values and non-negative otherwise, ensuring that $z$ is always positive. The bcnPower transformations behave similarly to the bcPower transformations, and introduce less bias than is introduced by setting the parameter $\gamma$ to be non-zero in the Box-Cox family.

The function bcnPowerInverse computes the inverse of the bcnPower function, so $U = \text{bcnPowerInverse}(\text{bcnPower}(U, \lambda, \gamma), \lambda, \gamma)$ is true for any permitted value of gamma and lam.

If family="yeo.johnson" then the Yeo-Johnson transformations are used. This is the Box-Cox transformation of $U + 1$ for nonnegative values, and of $|U| + 1$ with parameter $2 - \lambda$ for $U$ negative. The basic power transformation returns $U^\lambda$ if $\lambda$ is not 0, and $\log(\lambda)$ otherwise for $U$ strictly positive.

If jacobian.adjusted is TRUE, then the scaled transformations are divided by the Jacobian, which is a function of the geometric mean of $U$ for skewPower and yjPower and of $U + \gamma$ for
bcPower. With this adjustment, the Jacobian of the transformation is always equal to 1. Jacobian adjustment facilitates computing the Box-Cox estimates of the transformation parameters. Missing values are permitted, and return NA where ever U is equal to NA.

Value

Returns a vector or matrix of transformed values.

Author(s)

Sanford Weisberg, <sandy@umn.edu>

References


See Also

`powerTransform`, `testTransform`

Examples

```r
U <- c(NA, (-3:3))
## Not run: bcPower(U, 0) # produces an error as U has negative values
bcPower(U, 0, gamma=4)
bcPower(U, 0.5, jacobian.adjusted=TRUE, gamma=4)
bcnPower(U, 0, gamma=2)
basicPower(U, lambda = 0, gamma=4)
yjPower(U, 0)
V <- matrix(1:10, ncol=2)
bcPower(V, c(0, 2))
basicPower(V, c(0,1))
```

Boot

Bootstrapping for regression models

Description

This function provides a simple front-end to the boot function in the `boot` package that is tailored to bootstrapping based on regression models. Whereas boot is very general and therefore has many arguments, the Boot function has very few arguments.
Usage

Boot(object, f=coef, labels=names(f(object)), R=999,
    method=c("case", "residual"), ncores=1, ...)

## Default S3 method:
Boot(object, f=coef, labels=names(f(object)),
    R=999, method=c("case", "residual"), ncores=1,
    start = FALSE, ...)

## S3 method for class 'lm'
Boot(object, f=coef, labels=names(f(object)),
    R=999, method=c("case", "residual"), ncores=1, ...)

## S3 method for class 'glm'
Boot(object, f=coef, labels=names(f(object)),
    R=999, method=c("case", "residual"), ncores=1, ...)

## S3 method for class 'nls'
Boot(object, f=coef, labels=names(f(object)),
    R=999, method=c("case", "residual"), ncores=1, ...)

Arguments

object A regression object of class "lm", "glm" or "nls". The function may work with
other regression objects that support the update method and have a subset
argument. See discussion of the default method in the details below.

f A function whose one argument is the name of a regression object that will be
applied to the updated regression object to compute the statistics of interest.
The default is coef, to return regression coefficient estimates. For example, f
= function(obj) coef(obj)[1]/coef(obj)[2] will bootstrap the ratio of the
first and second coefficient estimates.

labels Provides labels for the statistics computed by f. Default labels are obtained from
a call to f, or generic labels if f does not return names.

R Number of bootstrap samples. The number of bootstrap samples actually com-
puted may be smaller than this value if either the fitting method is iterative and
fails to converge for some bootstrap samples, or if the rank of a fitted model is
different in a bootstrap replication than in the original data.

method The bootstrap method, either "case" for resampling cases or "residuals" for a
residual bootstrap. See the details below. The residual bootstrap is available
only for lm and nls objects and will return an error for glm objects.

... Arguments passed to the boot function, see boot.

start Should the estimates returned by f be passed as starting values for each bootstrap
iteration? Alternatively, start can be a numeric vector of starting values. The
default is to use the estimates from the last bootstrap iteration as starting values
for the next iteration.
ncores  A numeric argument that specifies the number of cores for parallel processing for unix systems. If less than or equal to 1, no parallel processing will be used. Note in a Windows platform will produce a warning and set this argument to 1.

Details

Boot uses a regression object and the choice of method, and creates a function that is passed as the statistic argument to the boot function in the boot package. The argument R is also passed to boot. If ncores is greater than 1, then the parallel and ncpus arguments to boot are set appropriately to use multiple cores, if available, on your computer. All other arguments to boot are kept at their default values unless you pass values for them.

The methods available for lm and nls objects are “case” and “residual”. The case bootstrap resamples from the joint distribution of the terms in the model and the response. The residual bootstrap fixes the fitted values from the original data, and creates bootstraps by adding a bootstrap sample of the residuals to the fitted values to get a bootstrap response. It is an implementation of Algorithm 6.3, page 271, of Davison and Hinkley (1997). For nls objects ordinary residuals are used in the resampling rather than the standardized residuals used in the lm method. The residual bootstrap for generalized linear models has several competing approaches, but none are without problems. If you want to do a residual bootstrap for a glm, you will need to write your own call to boot.

For the default object to work with other types of regression models, the model must have methods for the following generic functions: residuals(object,type="pearson") must return Pearson residuals; fitted(object) must return fitted values; hatvalues(object) should return the leverages, or perhaps the value 1 which will effectively ignore setting the hatvalues. In addition, the data argument should contain no missing values among the columns actually used in fitting the model, as the resampling may incorrectly attempt to include cases with missing values. For lm, glm and nls, missing values cause the return of an error message.

An attempt to fit using a bootstrap sample may fail. In a lm or glm fit, the bootstrap sample could have a different rank from the original fit. In an nls fit, convergence may not be obtained for some bootstraps. In either case, NA are returned for the value of the function f. The summary methods handle the NAs appropriately.

Fox and Weisberg (2017) cited below discusses this function and provides more examples.

Value

See boot for the returned value of the structure returned by this function.

Author(s)

Sanford Weisberg, <sandy@umn.edu>. Achim Zeileis added multicore support, and also fixed the default method to work for many more regression models.

References


See Also

Functions that work with boot objects from the boot package are boot.array.boot.ci.plot.boot and empinf. Additional functions in the car package are summary.boot, confint.boot, and hist.boot.

Examples

```r
m1 <- lm(Fertility ~ ., swiss)
betahat.boot <- Boot(m1, R=199) # 199 bootstrap samples--too small to be useful
summary(betahat.boot) # default summary
confint(betahat.boot)
hist(betahat.boot)
# Bootstrap for the estimated residual standard deviation:
sigmahat.boot <- Boot(m1, R=199, f=sigmaHat, labels="sigmaHat")
summary(sigmahat.boot)
confint(sigmahat.boot)
```

#### boxCox

Graph the profile log-likelihood for Box-Cox transformations in 1D, or in 2D with the bcnPower family.

Description

Computes and optionally plots profile log-likelihoods for the parameter of the Box-Cox power family, the Yeo-Johnson power family, or for either of the parameters in a bcnPower family. This is a slight generalization of the boxcox function in the MASS package that allows for families of transformations other than the Box-Cox power family. The boxCox2d function produces a contour plot of the two-dimensional likelihood profile for the bcnPower family.

Usage

```r
boxCox(object, ...)
```

## Default S3 method:

```r
boxCox(object,
    lambda = seq(-2, 2, 1/10), plotit = TRUE,
    interp = plotit, eps = 1/50,
    xlab=NULL, ylab=NULL,
    family="bcPower",
    param=c("lambda", "gamma"), gamma=NULL,
    grid=TRUE, ...)

## S3 method for class 'formula'
```
boxCox(object, lambda = seq(-2, 2, 1/10), plotit = TRUE, family = "bcPower", param = c("lambda", "gamma"), gamma = NULL, grid = TRUE, ...)

## S3 method for class 'lm'
boxCox(object, lambda = seq(-2, 2, 1/10), plotit = TRUE, ...)

boxCox2d(x, ksds = 4, levels = c(0.5, 0.95, 0.99, 0.999),
          main = "bcnPower Log-likelihood", grid=TRUE, ...)

Arguments

object a formula or fitted model object of class lm or aov.
lambda vector of values of \( \lambda \), with default (-2, 2) in steps of 0.1, where the profile log-likelihood will be evaluated.
plotit logical which controls whether the result should be plotted; default TRUE.
interp logical which controls whether spline interpolation is used. Default to TRUE if plotting with lambda of length less than 100.
eps Tolerance for lambda = 0; defaults to 0.02.
xlab defaults to "lambda" or "gamma".
ylab defaults to "log-Likelihood" or for bcnPower family to the appropriate label.
family Defaults to "bcPower" for the Box-Cox power family of transformations. If set to "yjPower" the Yeo-Johnson family, which permits negative responses, is used. If set to bcnPower the function gives the profile log-likelihood for the parameter selected via param.
param Relevant only to family="bcnPower", produces a profile log-likelihood for the parameter selected, maximizing over the remaining parameter.
gamma For use when the family="bcnPower", param="gamma". If this is a vector of positive values, then the profile log-likelihood for the location (or start) parameter in the bcnPower family is evaluated at these values of gamma. If gamma is NULL, then evaluation is done at 100 equally spaced points between \( \min(0.01, g_{\max} - 3 \times sd) \) and \( g_{\max} + 3 \times sd \), where \( g_{\max} \) is the maximum likelihood estimate of gamma, and sd is the sd of the response. See bcnPower for the definition of gamma.
grid If TRUE, the default, a light-gray background grid is put on the graph.
... additional arguments passed to the lm method with boxCox.formula or passed to contour with boxCox2d.
x An object created by a call to powerTransform using family="bcnPower".
ksds Contour plotting of the log-likelihood surface will cover plus of minus ksds standard deviations on each axis.
levels Contours will be drawn at the values of levels. For example, levels=c(.5,.99) would display two contours, at the 50% level and at the 99% level.
main Title for the contour plot
The **boxCox** function is an elaboration of the **boxcox** function in the **MASS** package. The first 7 arguments are the same as in boxcox, and if the argument `family="bcPower"` is used, the result is essentially identical to the function in **MASS**. Two additional families are the **yjPower** and **bcnPower** families that allow a few values of the response to be non-positive. The **bcnPower** family has two parameters: a power \(\lambda\) and a start or location parameter \(\gamma\), and the **boxCox** function can be used to obtain a profile log-likelihood for either parameter with \(\lambda\) as the default. Alternatively, the **boxCox2d** function can be used to get a contour plot of the profile log-likelihood.

**Value**

Both functions ae designed for their side effects of drawing a graph. The **boxCox** function returns a list of the lambda (or possibly, gamma) vector and the computed profile log-likelihood vector, invisibly if the result is plotted. If plotit=TRUE plots log-likelihood vs lambda and indicates a 95% confidence interval about the maximum observed value of lambda. If interp=TRUE, spline interpolation is used to give a smoother plot.

**Author(s)**

Sanford Weisberg, <sandy@umn.edu>

**References**


**See Also**

**boxcox**, **yjPower**, **bcPower**, **bcnPower**, **powerTransform**, **contour**

**Examples**

```r
with(trees, boxCox(Volume ~ log(Height) + log(Girth), data = trees,
    lambda = seq(-0.25, 0.25, length = 10)))

data("quine", package = "MASS")
with(quine, boxCox(Days ~ Eth*Sex*Age*Lrn, 
    lambda = seq(-0.05, 0.45, len = 20), family="yjPower"))
```
boxCoxVariable

**Description**

Computes a constructed variable for the Box-Cox transformation of the response variable in a linear model.

**Usage**

```r
boxCoxVariable(y)
```

**Arguments**

- `y` response variable.

**Details**

The constructed variable is defined as \( y[\log(y/\bar{y}) - 1] \), where \( \bar{y} \) is the geometric mean of \( y \).

The constructed variable is meant to be added to the right-hand-side of the linear model. The t-test for the coefficient of the constructed variable is an approximate score test for whether a transformation is required.

If \( b \) is the coefficient of the constructed variable, then an estimate of the normalizing power transformation based on the score statistic is \( 1 - b \). An added-variable plot for the constructed variable shows leverage and influence on the decision to transform \( y \).

**Value**

a numeric vector of the same length as \( y \).

**Author(s)**

John Fox <jfox@mcmaster.ca>

**References**


**See Also**

`boxcox`, `powerTransform`, `bcPower`
Examples

```r
mod <- lm(interlocks + 1 ~ assets, data=Ornstein)
mod.aux <- update(mod, . ~ . + boxCoxVariable(interlocks + 1))
summary(mod.aux)
# avPlots(mod.aux, "boxCoxVariable(interlocks + 1)"
```

---

**Boxplot**

**Boxplots With Point Identification**

**Description**

Boxplot is a wrapper for the standard R `boxplot` function, providing point identification, axis labels, and a formula interface for boxplots without a grouping variable.

**Usage**

```
Boxplot(y, ...)
```

  ## Default S3 method:
  Boxplot(y, g, id=TRUE, xlab, ylab, ...)

  ## S3 method for class 'formula'
  Boxplot(formula, data=NULL, subset, na.action=NULL, 
          id=TRUE, xlab, ylab, ...)

  ## S3 method for class 'list'
  Boxplot(y, xlab="", ylab="", ...)

  ## S3 method for class 'data.frame'
  Boxplot(y, id=TRUE, ...)

  ## S3 method for class 'matrix'
  Boxplot(y, ...)

**Arguments**

- **y**
  a numeric variable for which the boxplot is to be constructed; a list of numeric variables, each element of which will be treated as a group; a numeric data frame or a numeric matrix, each of whose columns will be treated as a group.

- **g**
  a grouping variable, usually a factor, for constructing parallel boxplots.

- **id**
  a list of named elements giving one or more specifications for labels of individual points ("outliers"): n, the maximum number of points to label (default 10); location, "lr" (left or right) of points or "avoid" to try to avoid overplotting; method, one of "y" (automatic, the default), "identify" (interactive), or "none"; col for labels (default is the first color in `carPalette()`); and cex size of labels (default is 1). Can be FALSE to suppress point identification or
boxTidwell

TRUE (the default) to use all defaults. This is similar to how showLabels handles point labels for other functions in the car package, except that the usual default is id=FALSE.

xlab, ylab  text labels for the horizontal and vertical axes; if missing, Boxplot will use the variable names, or, in the case of a list, data frame, or matrix, empty labels.

formula  a ‘model’ formula, of the form ~ y to produce a boxplot for the variable y, or of the form y ~ g, y ~ g1*g2*... or y ~ g1 + g2 + ... to produce parallel boxplots for y within levels of the grouping variable(s) g, etc., usually factors.

data, subset, na.action  as for statistical modeling functions (see, e.g., lm).

... further arguments, such as at, to be passed to boxplot.

Author(s)

John Fox <jfox@mcmaster.ca>, with a contribution from Steve Ellison to handle at argument (see boxplot).

References


See Also

boxplot

Examples

Boxplot(~income, data=Prestige, id=list(n=Inf)) # identify all outliers
Boxplot(income ~ type, data=Prestige)
Boxplot(income ~ type, data=Prestige, at=c(1, 3, 2))
Boxplot(k5 + k618 ~ lfp*wc, data=Mroz)
with(Prestige, Boxplot(income, id=list(labels=rownames(Prestige))))
with(Prestige, Boxplot(income, type, id=list(labels=rownames(Prestige))))
Boxplot(scale(Prestige[, 1:4]))

boxTidwell  Box-Tidwell Transformations

Description

Computes the Box-Tidwell power transformations of the predictors in a linear model.
Usage

```r
boxTidwell(y, ...)  

## S3 method for class 'formula'
boxTidwell(formula, other.x=NULL, data=NULL, subset,  
            na.action=getOption("na.action"), verbose=FALSE, tol=0.001,  
            max.iter=25, ...)  

## Default S3 method:
boxTidwell(y, x1, x2=NULL, max.iter=25, tol=0.001,  
           verbose=FALSE, ...)  

## S3 method for class 'boxTidwell'
print(x, digits=getOption("digits") - 2, ...)  
```

Arguments

- `formula`: two-sided formula, the right-hand-side of which gives the predictors to be transformed.
- `other.x`: one-sided formula giving the predictors that are not candidates for transformation, including (e.g.) factors.
- `data`: an optional data frame containing the variables in the model. By default the variables are taken from the environment from which `boxTidwell` is called.
- `subset`: an optional vector specifying a subset of observations to be used.
- `na.action`: a function that indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`.
- `verbose`: if TRUE a record of iterations is printed; default is FALSE.
- `tol`: if the maximum relative change in coefficients is less than `tol` then convergence is declared.
- `max.iter`: maximum number of iterations.
- `y`: response variable.
- `x1`: matrix of predictors to transform.
- `x2`: matrix of predictors that are not candidates for transformation.
- `...`: not for the user.
- `x`: `boxTidwell` object.
- `digits`: number of digits for rounding.

Details

The maximum-likelihood estimates of the transformation parameters are computed by Box and Tidwell’s (1962) method, which is usually more efficient than using a general nonlinear least-squares routine for this problem. Score tests for the transformations are also reported.

Value

an object of class `boxTidwell`, which is normally just printed.


**Author(s)**

John Fox <jfox@mcmaster.ca>

**References**


**Examples**

```r
boxTidwell(prestige ~ income + education, ~ type + poly(women, 2), data=Prestige)
```

---

**brief**  
*Print Abbreviated Output*

**Description**

Print data objects and statistical model summaries in abbreviated form.

**Usage**

```r
brief(object, ...)
```

```
## S3 method for class 'data.frame'
brief(object, rows = if (nr <= 10) c(nr, 0) else c(3, 2),
cols, head=FALSE, tail=FALSE, elided = TRUE,
classes = inherits(object, "data.frame"), ...)
## S3 method for class 'matrix'
brief(object, rows = if (nr <= 10) c(nr, 0) else c(3, 2), ...)
## S3 method for class 'numeric'
brief(object, rows = c(2, 1), elided = TRUE, ...)
## S3 method for class 'integer'
brief(object, rows = c(2, 1), elided = TRUE, ...)
## S3 method for class 'character'
brief(object, rows = c(2, 1), elided = TRUE, ...)
## S3 method for class 'factor'
brief(object, rows=c(2, 1), elided=TRUE, ...)
## S3 method for class 'list'
brief(object, rows = c(2, 1), elided = TRUE, ...)
## S3 method for class 'function'
brief(object, rows = c(5, 3), elided = TRUE, ...)
```
## S3 method for class 'lm'
brief(object, terms = ~ .,
       intercept=missing(terms), pvalues=FALSE,
       digits=3, horizontal=TRUE, vcov., ...)

## S3 method for class 'glm'
brief(object, terms = ~ .,
       intercept=missing(terms), pvalues=FALSE,
       digits=3, horizontal=TRUE, vcov., dispersion, exponentiate, ...)

## S3 method for class 'multinom'
brief(object, terms = ~ .,
       intercept=missing(terms), pvalues=FALSE,
       digits=3, horizontal=TRUE, exponentiate=TRUE, ...)

## S3 method for class 'polr'
brief(object, terms = ~ .,
       intercept, pvalues=FALSE,
       digits=3, horizontal=TRUE, exponentiate=TRUE, ...)

## Default S3 method:
brief(object, terms = ~ .,
       intercept=missing(terms), pvalues=FALSE,
       digits=3, horizontal=TRUE, ...)

### Arguments

- **object**: a data or model object to abbreviate.
- **rows**: for a matrix or data frame, a 2-element integer vector with the number of rows to print at the beginning and end of the display; for a vector or factor, the number of lines of output to show at the beginning and end; for a list, the number of elements to show at the beginning and end; for a function, the number of lines to show at the beginning and end.
- **cols**: for a matrix or data frame, a 2-element integer vector with the number of columns to print at the beginning (i.e., left) and end (right) of the display.
- **head, tail**: alternatives to the rows argument; if TRUE, print the first or last 6 rows; can also be the number of the first or last few rows to print; only one of heads and tails should be specified; ignored if FALSE (the default).
- **elided**: controls whether to report the number of elided elements, rows, or columns; default is TRUE.
- **classes**: show the class of each column of a data frame at the top of the column; the classes are shown in single-character abbreviated form—e.g., [f] for a factor, [i] for an integer variable, [n] for a numeric variable, [c] for a character variable.
- **terms**: a one-sided formula giving the terms to summarize; the default is ~ .—i.e., to summarize all terms in the model.
intercept  whether or not to include the intercept; the default is TRUE unless the terms argument is given, in which case the default is FALSE; ignored for polr models.

pvalues    include the p-value for each coefficient in the table; default is FALSE.

exponentiate for a "glm" or "glmerMod" model using the log or logit link, or a "polr" or "multinom" model, show exponentiated coefficient estimates and confidence bounds.

digits     significant digits for printing.

horizontal if TRUE (the default), orient the summary produced by brief horizontally, which typically saves space.

dispersion see summary.glm

vcov.      either a matrix giving the estimated covariance matrix of the estimates, or a function that when called with object as an argument returns an estimated covariance matrix of the estimates. The default vcov. = vcov(object, complete=FALSE) uses the usual estimated covariance matrix with NA for any row and column with aliased regressors. Other choices include the functions documented at hccm, and a bootstrap estimate vcov. = vcov(Boot(object)); see the documentation for Boot. For the glm method, if the vcov. or dispersion argument is specified, then Wald-based confidence limits are computed; otherwise the reported confidence limits are computed by profiling the likelihood. NOTES: (1) The dispersion and vcov. arguments may not both be specified. (2) Setting vcov. = vcov returns an error if the model includes aliased terms; use vcov. = vcov(object, complete=FALSE). (3) The hccm method will generally return a matrix of full rank even if the model has aliased terms. Similarly vcov. = vcov(Boot(object)) may return a full rank matrix, or it will a matrix with NA corresponding to aliased regressors if same regressors are aliased in every bootstrap sample.

arguments to pass down.

Value

Invisibly returns object for a data object, or summary for a model object.

Note

The method brief.matrix calls brief.data.frame.

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

S
Examples

```r
brief(rnorm(100))
brief(Duncan)
brief(OBrienKaiser, elided=TRUE)
brief(matrix(1:500, 10, 50))
brief(lm)

mod.prestige <- lm(prestige ~ education + income + type, Prestige)
brief(mod.prestige, pvalues=TRUE)
brief(mod.prestige, - type)
mod.mroz <- glm(lfp ~ ., data=Mroz, family=binomial)
brief(mod.mroz)
```

---

car-defunct  Defunct Functions in the car Package

description

These functions are were deprecated in 2009 and are now defunct.

Usage

```r
av.plot(...)
av.plots(...)
box.cox(...)
bc(...)
box.cox.powers(...)
box.cox.var(...)
box.tidwell(...)
cookd(...)
confidence.ellipse(...)
ceres.plot(...)
ceres.plots(...)
cr.plot(...)
cr.plots(...)
data.ellipse(...)
durbin.watson(...)
levene.test(...)
leverage.plot(...)
leverage.plots(...)
linear.hypothesis(...)
ncv.test(...)
outlier.test(...)
qq.plot(...)
skewPower(...)
spread.level.plot(...)
```
Arguments

... pass arguments down.

Details

av.plot and av.plots are replaced by avPlot and avPlots functions.
box.cox and bc are now replaced by bcPower.
box.cox.powers is replaced by powerTransform.
box.cox.var is replaced by boxCoxVariable.
box.tidwell is replaced by boxTidwell.
cookd is replaced by cooks.distance in the stats package.
confidence.ellipse is replaced by confidenceEllipse.
ceres.plot and ceres.plots are now replaced by the ceresPlot and ceresPlots functions.
cr.plot and cr.plots are now replaced by the crPlot and crPlots functions.
data.ellipse is replaced by dataEllipse.
durbin.watson is replaced by durbinWatsonTest.
levene.test is replaced by leveneTest function.
leverage.plot and leverage.plots are now replaced by the leveragePlot and leveragePlots functions.
linear.hypothesis is replaced by the linearHypothesis function.
cncv.test is replaced by ncvTest.
outlier.test is replaced by outlierTest.
qq.plot is replaced by qqPlot.
skewPower is replaced by bcnPower.
spread.level.plot is replaced by spreadLevelPlot.

---

car-deprecated  Deprecated Functions in the car Package

Description

These functions are provided for compatibility with older versions of the car package only, and may be removed eventually. Commands that worked in versions of the car package prior to version 3.0-0 will not necessarily work in version 3.0-0 and beyond, or may not work in the same manner.

Usage

bootCase(...)  
nextBoot(...)
Arguments

... arguments to pass to methods.

Details

These functions are replaced by `Boot`.

See Also

See Also `Boot`

carHexsticker

View the Official Hex Sticker for the car Package

Description

These objects (currently only the `.carEnv environment) are exported for technical reasons and are not for direct use.

Author(s)

John Fox <jfox@mcmaster.ca>

carHexsticker

View the Official Hex Sticker for the car Package

Description

Open the official hex sticker for the car package in your browser

Usage

`carHexsticker()`

Value

Used for its side effect of opening the hex sticker for the car package in your browser.

Author(s)

John Fox <jfox@mcmaster.ca>

Examples

```r
## Not run:
carHexsticker()
## End(Not run)
```
carPalette

Set or Retrieve car Package Color Palette

Description

This function is used to set or retrieve colors to be used in car package graphics functions.

Usage

carPalette(palette)

Arguments

palette if missing, returns the colors that will be used in car graphics; if present, the colors to be used in graphics will be set. The palette argument may also be one of "car" or "default" to use the default car palette (defined below), "R" to use the default R palette, or "colorblind" to use a colorblind-friendly palette (from https://jfly.uni-koeln.de/color/).

Details

This function sets or returns the value of options(carPalette=pallete) that will be use in car graphics functions to determine colors. The default is c("black","blue","magenta","cyan","orange","gray","green3") which is nearly a permutation of the colors returned by the standard palette function that mini-
mizes the use of red and green in the same graph, and that substitutes orange for the often hard to see yellow.

Value

Invisibly returns the previous value of the car palette.

Author(s)

Sanford Weisberg and John Fox

References


See Also

palette, colors
Examples

```r
# Standard color palette
palette()
# car standard color palette
carPalette()
# set colors to all black
carPalette(rep("black", 8))
# Use a custom color palette with 12 distinct colors
carPalette(sample(colors(distinct=TRUE), 12))
# restore default
carPalette("default")
```

---

carWeb  Access to the R Companion to Applied Regression Website

Description

This function will access the website for An R Companion to Applied Regression, or setup files or data.

Usage

```
carWeb(page = c("webpage", "errata", "taskviews"), script, data, setup)
```

Arguments

- **page**: A character string indicating what page to open. The default "webpage" will open the main web page, "errata" displays the errata sheet for the book, "taskviews" fetches and displays a list of available task views from CRAN.
- **script**: The quoted name of a chapter in An R Companion to Applied Regression, like "chap-1", "chap-2", up to "chap-10". All the R commands used in that chapter will be displayed in your browser, where you can save them as a text file.
- **data**: The quoted name of a data file in An R Companion to Applied Regression, like "Duncan.txt" or "Prestige.txt". The file will be opened in your web browser. You do not need to specify the extension .txt.
- **setup**: If TRUE this command will download a number of files to your computer that are discussed in Fox and Weisberg (2019), beginning in Chapter 1.

Value

Either displays a web page or a PDF document or downloads files to your working directory.

Author(s)

Sanford Weisberg, based on the function UsingR in the UsingR package by John Verzani
ceresPlots

References


Examples

```r
## Not run:
carWeb()
carWeb(setup=TRUE)

## End(Not run)
```

ceresPlots Ceres Plots

Description

These functions draw Ceres plots for linear and generalized linear models.

Usage

```r
ceresPlots(model, terms = ~., layout = NULL, ask, main, 
...)

ceresPlot(model, ...) 

## S3 method for class 'lm'
ceresPlot(model, variable, id=FALSE, 
line=TRUE, smooth=TRUE, col=carPalette()[1], col.lines=carPalette()[-1], 
xlab, ylab, pch=1, lwd=2, grid=TRUE, ...)

## S3 method for class 'glm'
ceresPlot(model, ...) 
```

Arguments

- `model` model object produced by `lm` or `glm`.
- `terms` A one-sided formula that specifies a subset of the regressors. One component-plus-residual plot is drawn for each term. The default `~.` is to plot against all numeric predictors. For example, the specification `terms = ~ . -X3` would plot against all predictors except for `X3`. Factors and nonstandard predictors such as B-splines are skipped. If this argument is a quoted name of one of the regressors, the component-plus-residual plot is drawn for that predictor only.
- `layout` If set to a value like `c(1,1)` or `c(4,3)`, the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If `layout=NA`, the function does not set the
layout and the user can use the `par` function to control the layout, for example to have plots from two models in the same graphics window.

`ask`  If `TRUE`, ask the user before drawing the next plot; if `FALSE`, the default, don’t ask. This is relevant only if not all the graphs can be drawn in one window.

`main`  Overall title for any array of ceres plots; if missing a default is provided.

...  `ceresPlots` passes these arguments to `ceresPlot`. `ceresPlot` passes them to `plot`.

`variable`  A quoted string giving the name of a variable for the horizontal axis.

`id`  controls point identification; if `FALSE` (the default), no points are identified; can be a list of named arguments to the `showLabels` function; `TRUE` is equivalent to `list(method=list(abs(residuals(model,type="pearson")),"x"),n=2,cex=1,col=carPalette()[1],location="lr")`, which identifies the 2 points with the largest residuals and the 2 points with the most extreme horizontal (X) values.

`line`  `TRUE` to plot least-squares line.

`smooth`  specifies the smoother to be used along with its arguments; if `FALSE`, no smoother is shown; can be a list giving the smoother function and its named arguments; `TRUE`, the default, is equivalent to `list(smooth=loessLine)` for the smoothers supplied by the `car` package and their arguments. Ceres plots do not support variance smooths.

`col`  color for points; the default is the first entry in the current `car` palette (see `carPalette` and `par`).

`col.lines`  a list of at least two colors. The first color is used for the ls line and the second color is used for the fitted lowess line. To use the same color for both, use, for example, `col.lines=c("red","red")`

`xlab,ylab`  labels for the x and y axes, respectively. If not set appropriate labels are created by the function.

`pch`  plotting character for points; default is 1 (a circle, see `par`).

`lwd`  line width; default is 2 (see `par`).

`grid`  If `TRUE`, the default, a light-gray background grid is put on the graph

**Details**

Ceres plots are a generalization of component+residual (partial residual) plots that are less prone to leakage of nonlinearity among the predictors.

The function intended for direct use is `ceresPlots`.

The model cannot contain interactions, but can contain factors. Factors may be present in the model, but Ceres plots cannot be drawn for them.

**Value**

`NULL`. These functions are used for their side effect: producing plots.

**Author(s)**

John Fox `<jfox@mcmaster.ca>`
compareCoefs

References


See Also

*crPlots, avPlots, showLabels*

Examples

```r
ceresPlots(lm(prestige~income+education+type, data=Prestige), terms=~.-type)
```

---

**Description**

This function extracts estimates of regression parameters and their standard errors from one or more models and prints them in a table.

**Usage**

```r
compareCoefs(..., se = TRUE, zvals = FALSE, pvals = FALSE, vcov.,
  print = TRUE, digits = 3)
```

**Arguments**

- `...` One or more regression-model objects. These may be of class `lm`, `glm`, `nls`, or any other regression method for which the functions `coef` and `vcov` return appropriate values, or if the object inherits from the `mer` class created by the `lme4` package or `lme` in the `nlme` package.
- `se` If TRUE, the default, show standard errors as well as estimates.
- `zvals` If TRUE (the default is FALSE), print Wald statistics, the ratio of each coefficient to its standard error.
- `pvals` If codeTRUE (the default is FALSE), print two-sided p-values from the standard normal distribution corresponding to the Wald statistics.
- `vcov.` an optional argument, specifying a function to be applied to all of the models, returning a coefficient covariance matrix for each, or a list with one element for each model, with each element either containing a function to be applied to the corresponding model or a coefficient covariance matrix for that model. If omitted, vcov is applied to each model.
- `print` If TRUE, the default, the results are printed in a nice format using `printCoefmat`. If FALSE, the results are returned as a matrix.
- `digits` Passed to the `printCoefmat` function for printing the result.
Contrasts

Value

This function is mainly used for its side-effect of printing the result. It also invisibly returns a matrix of estimates, standard errors, Wald statistics, and p-values.

Author(s)

John Fox <jfox@mcmaster.ca>

References


Examples

```r
mod1 <- lm(prestige ~ income + education, data=Duncan)
mod2 <- update(mod1, subset=-c(6,16))
mod3 <- update(mod1, . - . + type)
mod4 <- update(mod1, . - . + I(income + education)) # aliased coef.
compareCoefs(mod1)
compareCoefs(mod1, mod2, mod4)
compareCoefs(mod1, mod2, mod3, zvals=TRUE, pvals=TRUE)
compareCoefs(mod1, mod2, se=FALSE)
compareCoefs(mod1, mod1, vcov.=list(vcov, hccm))
```

Contrasts

<table>
<thead>
<tr>
<th>Functions to Construct Contrasts</th>
</tr>
</thead>
</table>

Description

These are substitutes for similarly named functions in the `stats` package (note the uppercase letter starting the second word in each function name). The only difference is that the contrast functions from the `car` package produce easier-to-read names for the contrasts when they are used in statistical models.

The functions and this documentation are adapted from the `stats` package.

Usage

```r
contr.Treatment(n, base = 1, contrasts = TRUE)
contr.Sum(n, contrasts = TRUE)
contr.Helmert(n, contrasts = TRUE)
```

Arguments

- `n` a vector of levels for a factor, or the number of levels.
- `base` an integer specifying which level is considered the baseline level. Ignored if contrasts is FALSE.
- `contrasts` a logical indicating whether contrasts should be computed.
Details

These functions are used for creating contrast matrices for use in fitting analysis of variance and regression models. The columns of the resulting matrices contain contrasts which can be used for coding a factor with \( n \) levels. The returned value contains the computed contrasts. If the argument \( \text{contrasts} \) is \( \text{FALSE} \) then a square matrix is returned.

Several aspects of these contrast functions are controlled by options set via the \texttt{options} command:

\begin{itemize}
\item \texttt{decorate.contrasts} This option should be set to a 2-element character vector containing the prefix and suffix characters to surround contrast names. If the option is not set, then \( c("[","]") \) is used. For example, setting \texttt{options(decorate.contrasts=c(".-","."))} produces contrast names that are separated from factor names by a period. Setting \texttt{options(decorate.contrasts=c("",""))} reproduces the behaviour of the \( R \) base contrast functions.
\item \texttt{decorate.contr.Treatment} A character string to be appended to contrast names to signify treatment contrasts; if the option is unset, then "T." is used.
\item \texttt{decorate.contr.Sum} Similar to the above, with default "S."
\item \texttt{decorate.contr.Helmert} Similar to the above, with default "H."
\item \texttt{contr.Sum.show.levels} Logical value: if \( \text{TRUE} \) (the default if unset), then level names are used for contrasts; if \( \text{FALSE} \), then numbers are used, as in \texttt{contr.sum} in the \texttt{base} package.
\end{itemize}

Note that there is no replacement for \texttt{contr.poly} in the \texttt{base} package (which produces orthogonal-polynomial contrasts) since this function already constructs easy-to-read contrast names.

Value

A matrix with \( n \) rows and \( k \) columns, with \( k = n - 1 \) if \( \text{contrasts} \) is \( \text{TRUE} \) and \( k = n \) if \( \text{contrasts} \) is \( \text{FALSE} \).

Author(s)

John Fox \(<\text{jfox@mcmaster.ca}>\)

References


See Also

\texttt{contr.treatment, contr.sum, contr.helmert, contr.poly}

Examples

\begin{verbatim}
# contr.Treatment vs. contr.treatment in the base package:

lm(prestige ~ (income + education)*type, data=Prestige,
   contrasts=list(type="contr.Treatment"))

## Call:
## lm(formula = prestige ~ (income + education) * type, data = Prestige,
##     contrasts = list(type = "contr.Treatment"))
\end{verbatim}
## Coefficients:
## (Intercept) income education
## 2.275753 0.003522 1.713275
## 15.351896 -33.536652 -0.002903
## -0.002072 1.387809 4.290875

```r
lm(prestige ~ (income + education)*type, data=Prestige,
   contrasts=list(type="contr.treatment"))
```

## Call:
## `lm(formula = prestige ~ (income + education) * type, data = Prestige,
##    contrasts = list(type = "contr.treatment"))`

## Coefficients:
## (Intercept) income education
## 2.275753 0.003522 1.713275
## typeprof typewc income:typeprof
## 15.351896 -33.536652 -0.002903
## income:typewc education:typeprof education:typewc
## -0.002072 1.387809 4.290875

---

**crPlots**

Component+Residual (Partial Residual) Plots

### Description

These functions construct component+residual plots, also called partial-residual plots, for linear and generalized linear models.

### Usage

```r
crPlots(model, terms = ~., layout = NULL, ask, main, ...
crp(...)
crPlot(model, ...)```

**S3 method for class 'lm'**

```r
crPlot(model, variable, id=FALSE,
   order=1, line=TRUE, smooth=TRUE,
   col=carPalette()[1], col.lines=carPalette()[-1],
   xlab, ylab, pch=1, lwd=2, grid=TRUE, ...)
```
Arguments

- **model**: model object produced by `lm` or `glm`.
- **terms**: A one-sided formula that specifies a subset of the regressors. One component-plus-residual plot is drawn for each regressor. The default `~` is to plot against all numeric regressors. For example, the specification `terms = ~ . -X3` would plot against all regressors except for `X3`, while `terms = ~ log(X4)` would give the plot for the predictor `X4` that is represented in the model by `log(X4)`. If this argument is a quoted name of one of the predictors, the component-plus-residual plot is drawn for that predictor only.
- **layout**: If set to a value like `c(1,1)` or `c(4,3)`, the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If `layout=NA`, the function does not set the layout and the user can use the `par` function to control the layout, for example to have plots from two models in the same graphics window.
- **ask**: If `TRUE`, ask the user before drawing the next plot; if `FALSE`, the default, don’t ask. This is relevant only if not all the graphs can be drawn in one window.
- **main**: The title of the plot; if missing, one will be supplied.
- **...**: `crPlots` passes these arguments to `crPlot`. `crPlot` passes them to `plot`.
- **variable**: A quoted string giving the name of a variable for the horizontal axis.
- **id**: controls point identification; if `FALSE` (the default), no points are identified; can be a list of named arguments to the `showLabels` function; `TRUE` is equivalent to `list(method=list(abs(residuals(model,type="pearson")),"x"),n=2,cex=1,col=carPalette()[1],location="lr")`, which identifies the 2 points with the largest residuals and the 2 points with the most extreme horizontal (X) values.
- **order**: order of polynomial regression performed for predictor to be plotted; default 1.
- **line**: `TRUE` to plot least-squares line.
- **smooth**: specifies the smoother to be used along with its arguments; if `FALSE`, no smoother is shown; can be a list giving the smoother function and its named arguments; `TRUE`, the default, is equivalent to `list(smother=loessLine)`. See `ScatterplotSmoothers` for the smoothers supplied by the `car` package and their arguments.
- **col**: color for points; the default is the first entry in the current `car` palette (see `carPalette` and `par`).
- **col.lines**: a list of at least two colors. The first color is used for the ls line and the second color is used for the fitted lowess line. To use the same color for both, use, for example, `col.lines=c("red", "red")`.
- **xlab, ylab**: labels for the x and y axes, respectively. If not set appropriate labels are created by the function.
- **pch**: plotting character for points; default is 1 (a circle, see `par`).
- **lwd**: line width; default is 2 (see `par`).
- **grid**: If `TRUE`, the default, a light-gray background grid is put on the graph.
Details

The function intended for direct use is `crPlots`, for which `crp` is an abbreviation.

The model cannot contain interactions, but can contain factors. Parallel boxplots of the partial residuals are drawn for the levels of a factor.

Value

NULL. These functions are used for their side effect of producing plots.

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

ceresPlots, avPlots

Examples

```r
crPlots(m<-lm(prestige ~ income + education, data=Prestige))

crPlots(m, terms=~ . - education) # get only one plot

crPlots(lm(prestige ~ log2(income) + education + poly(women,2), data=Prestige))

crPlots(glm(partic != "not.work" ~ hincome + children, 
data=Women1f, family=binomial), smooth=list(span=0.75))
```

deltaMethod

Estimate and Standard Error of a Nonlinear Function of Estimated Regression Coefficients

Description

deltaMethod is a generic function that uses the delta method to get a first-order approximate standard error for a nonlinear function of a vector of random variables with known or estimated covariance matrix.
Usage

deltaMethod(object, ...)  

## Default S3 method:  
deltaMethod(object, g., vcov., func=g., constants, level=0.95,  
  rhs, ..., envir=parent.frame())  
## S3 method for class 'lm'  
deltaMethod(object, g., vcov.=vcov(object, complete=FALSE),  
  parameterNames=names(coef(object)), ..., envir=parent.frame())  
## S3 method for class 'nls'  
deltaMethod(object, g., vcov.=vcov(object, complete=FALSE), ..., envir=parent.frame())  
## S3 method for class 'multinom'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE),  
  parameterNames = if (is.matrix(coef(object)))  
  colnames(coef(object)) else names(coef(object)), ..., envir=parent.frame())  
## S3 method for class 'survreg'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE), ..., envir=parent.frame())  
## S3 method for class 'coxph'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE),  
  parameterNames = names(coef(object)), ..., envir=parent.frame())  
## S3 method for class 'mer'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE),  
  parameterNames = names(fixef(object)), ..., envir=parent.frame())  
## S3 method for class 'merMod'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE),  
  parameterNames = names(fixef(object)), ..., envir=parent.frame())  
## S3 method for class 'lme'  
deltaMethod(object, g., vcov. = vcov(object, complete=FALSE),  
  parameterNames = names(fixef(object)), ..., envir=parent.frame())  
## S3 method for class 'lmList'  
deltaMethod(object, g., ..., envir=parent.frame())

Arguments

object  
For the default method, object is either (1) a vector of p named elements, so  
names(object) returns a list of p character strings that are the names of the elements of object; or (2) a model object for which there are coef and vcov methods, and for which the named coefficient vector returned by coef is asymptotically normally distributed with asymptotic covariance matrix returned by vcov. For the other methods, object is a regression object for which coef(object) or fixef(object) returns a vector of parameter estimates.

g.  
A quoted string that is the function of the parameter estimates to be evaluated; see the details below.
**deltaMethod**

vcov.  
The (estimated) covariance matrix of the coefficient estimates. For the default method, this argument is required. For all other methods, this argument must either provide the estimated covariance matrix or a function that when applied to object returns a covariance matrix. The default is to use the function vcov.

func  
A quoted string used to annotate output. The default of func = g. is usually appropriate.

parameterNames  
A character vector of length p that gives the names of the parameters in the same order as they appear in the vector of estimates. This argument will be useful if some of the names in the vector of estimates include special characters, like I(x2^2), or x1:x2 that will confuse the numerical differentiation function. See details below.

constants  
This argument is a named vector whose elements are constants that are used in the f argument. It isn’t generally necessary to specify this argument but it may be convenient to do so.

level  
level for confidence interval, default 0.95.

rhs  
hypothesized value for the specified function of parameters; if absent no hypothesis test is performed.

...  
Used to pass arguments to the generic method.

eenv  
Environment in which g. is evaluated; not normally specified by the user.

**Details**

Suppose x is a random vector of length p that is at least approximately normally distributed with mean β and estimated covariance matrix C. Then any function g(β) of β, is estimated by g(x), which is in large samples normally distributed with mean g(β) and estimated variance $h^T Ch$, where h is the first derivative of g(β) with respect to β evaluated at x. This function returns both g(x) and its standard error, the square root of the estimated variance.

The default method requires that you provide x in the argument object, C in the argument vcov., and a text expression in argument g. that when evaluated gives the function g. The call names(object) must return the names of the elements of x that are used in the expression g. .

Since the delta method is often applied to functions of regression parameter estimates, the argument object may be the name of a regression object from which the estimates and their estimated variance matrix can be extracted. In most regression models, estimates are returned by the coef(object) and the variance matrix from vcov(object). You can provide an alternative function for computing the sample variance matrix, for example to use a sandwich estimator.

For mixed models using lme4 or nlme, the coefficient estimates are returned by the fixef function, while for multinom, lmList and nlsList coefficient estimates are returned by coef as a matrix.

Methods for these models are provided to get the correct estimates and variance matrix.

The argument g. must be a quoted character string that gives the function of interest. For example, if you set m2 <- lm(Y ~ X1 + X2 + x1:X2), then deltaMethod(m2, ”X1/X2”) applies the delta method to the ratio of the coefficient estimates for X1 and X2. The argument g. can consist of constants and names associated with the elements of the vector of coefficient estimates.

In some cases the names may include characters such as the colon : used in interactions, or mathematical symbols like + or - signs that would confuse the function that computes numerical derivatives, and for this case you can replace the names of the estimates with the parameterNames argument. For example, the ratio of the X2 main effect to the interaction term could be computed using...
deltaMethod(m2, "b1/b3", parameterNames=c("b0", "b1", "b2", "b3"). The name "(Intercept)" used for the intercept in linear and generalized linear models is an exception, and it will be correctly interpreted by deltaMethod. Another option is to use back-ticks to quote nonstandard R names, as in deltaMethod(m2, "X1/X1:X2").

For multinom objects, the coef function returns a matrix of coefficients, with each row giving the estimates for comparisons of one category to the baseline. The deltaMethod function applies the delta method to each row of this matrix. Similarly, for lmList and nlsList objects, the delta method is computed for each element of the list of models fit.

For nonlinear regression objects produced by the nls function, the call coef(object) returns the estimated coefficient vectors with names corresponding to parameter names. For example, m2 <- nls(y ~ theta/(1 + gamma * x), start = list(theta=2, gamma=3)) will have parameters named c("theta", "gamma"). In many other familiar regression models, such as those produced by lm and glm, the names of the coefficient estimates are the corresponding regressor names, not parameter names.

For mixed-effects models fit with lmer and glmer from the lme4 package or lme and nlme from the nlme package, only fixed-effect coefficients are considered.

For regression models for which methods are not provided, you can extract the named vector of coefficient estimates and and estimate of its covariance matrix and then apply the default deltaMethod function.

Note: Earlier versions of deltaMethod included an argument parameterPrefix that implemented the same functionality as the parameterNames argument, but which caused several problems that were not easily fixed without the change in syntax.

Value

An object of class "deltaMethod", inheriting from "data.frame", for which a print method is provided. The object contains columns named Estimate for the estimate, SE for its standard error, and columns for confidence limits and possibly a hypothesis test. The value of g. is given as a row label.

Author(s)

Sanford Weisberg, <sandy@umn.edu>, John Fox <jfox@mcmaster.ca>, and Pavel Krivitsky.

References


See Also

First derivatives of g. are computed using symbolic differentiation by the function D.
Examples

```r
m1 <- lm(time ~ t1 + t2, data = Transact)
deltaMethod(m1, "b1/b2", parameterNames= paste("b", 0:2, sep=""))
deltaMethod(m1, "t1/t2", rhs=1) # use names of preds. rather than coefs.
deltaMethod(m1, "t1/t2", vcov=hccm) # use hccm function to est. vars.
deltaMethod(m1, "1/(Intercept)"
# The next example invokes the default method by extracting the
# vector of estimates and covariance matrix explicitly
deltaMethod(coef(m1), "t1/t2", vcov.=vcov(m1))
```

---

**densityPlot**

### Description

densityPlot constructs and graphs nonparametric density estimates, possibly conditioned on a factor, using the standard R `density` function or by default `adaptiveKernel`, which computes an adaptive kernel density estimate. `depan` provides the Epanechnikov kernel and `dbiwt` provides the biweight kernel.

### Usage

```r
densityPlot(x, ...)
```

#### Default S3 method:
```r
densityPlot(x, g, method=c("adaptive", "kernel"),
  bw=if (method == "adaptive") bw.nrd0 else "SJ", adjust=1,
  kernel, xlim, ylim,
  normalize=FALSE, xlab=deparse(substitute(x)), ylab="Density", main="",
  col=carPalette(), lty=seq_along(col), lwd=2, grid=TRUE,
  legend=TRUE, show.bw=FALSE, rug=TRUE, ...)
```

#### S3 method for class 'formula'
```r
densityPlot(formula, data=NULL, subset,
  na.action=NULL, xlab, ylab, main="", legend=TRUE, ...)
```

```r
adaptiveKernel(x, kernel=dnorm, bw=bw.nrd0, adjust=1.0, n=500,
  from, to, cut=3, na.rm=TRUE)
```

```r
depan(x)
```

```r
dbiwt(x)
```

### Arguments

- **x**: a numeric variable, the density of which is estimated; for `depan` and `dbiwt`, the argument of the kernel function.
- **g**: an optional factor to divide the data.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>formula</td>
<td>R model formula, of the form ~ variable to estimate the unconditional density of variable, or variable ~ factor to estimate the density of variable within each level of factor.</td>
</tr>
<tr>
<td>data</td>
<td>Optional data frame containing the data.</td>
</tr>
<tr>
<td>subset</td>
<td>Optional vector defining a subset of the data.</td>
</tr>
<tr>
<td>na.action</td>
<td>Function to handle missing values; defaults to value of the R na.action option, initially set to na.omit.</td>
</tr>
<tr>
<td>method</td>
<td>Either &quot;adaptive&quot; (the default) for an adaptive-kernel estimate or &quot;kernel&quot; for a fixed-bandwidth kernel estimate.</td>
</tr>
<tr>
<td>bw</td>
<td>Geometric mean bandwidth for the adaptive-kernel or bandwidth of the kernel density estimate(s). Must be a numerical value or a function to compute the bandwidth (default bw.nrd0) for the adaptive kernel estimate; for the kernel estimate, may be the quoted name of a rule to compute the bandwidth, or a numeric value. If plotting by groups, bw may be a vector of values, one for each group. See density and bw.SJ for details of the kernel estimator.</td>
</tr>
<tr>
<td>adjust</td>
<td>Multiplicative adjustment factor for the bandwidth; the default, 1, indicates no adjustment; if plotting by groups, adjust may be a vector of adjustment factors, one for each group. The default bandwidth-selection rule tends to give a value that's too large if the distribution is asymmetric or has multiple modes; try setting adjust &lt; 1, particularly for the adaptive-kernel estimator.</td>
</tr>
<tr>
<td>kernel</td>
<td>For densityPlot this is the name of the kernel function for the kernel estimator (the default is &quot;gaussian&quot;, see density); or a kernel function for the adaptive-kernel estimator (the default is dnorm, producing the Gaussian kernel). For adaptiveKernel this is a kernel function, defaulting to dnorm, which is the Gaussian kernel (standard-normal density).</td>
</tr>
<tr>
<td>xlim, ylim</td>
<td>Axis limits; if missing, determined from the range of x-values at which the densities are estimated and the estimated densities.</td>
</tr>
<tr>
<td>normalize</td>
<td>If TRUE (the default is FALSE), the estimated densities are rescaled to integrate approximately to 1; particularly useful if the density is estimated over a restricted domain, as when from or to are specified.</td>
</tr>
<tr>
<td>xlab</td>
<td>Label for the horizontal-axis; defaults to the name of the variable x.</td>
</tr>
<tr>
<td>ylab</td>
<td>Label for the vertical axis; defaults to &quot;Density&quot;.</td>
</tr>
<tr>
<td>main</td>
<td>Plot title; default is empty.</td>
</tr>
<tr>
<td>col</td>
<td>Vector of colors for the density estimate(s); defaults to the color carPalette.</td>
</tr>
<tr>
<td>lty</td>
<td>Vector of line types for the density estimate(s); defaults to the successive integers, starting at 1.</td>
</tr>
<tr>
<td>lwd</td>
<td>Line width for the density estimate(s); defaults to 2.</td>
</tr>
<tr>
<td>grid</td>
<td>If TRUE (the default), grid lines are drawn on the plot.</td>
</tr>
<tr>
<td>legend</td>
<td>A list of up to two named elements: location, for the legend when densities are plotted for several groups, defaults to &quot;upppright&quot; (see legend); and title of the legend, which defaults to the name of the grouping factor. If TRUE, the default, the default values are used; if FALSE, the legend is suppressed.</td>
</tr>
<tr>
<td>n</td>
<td>Number of equally spaced points at which the adaptive-kernel estimator is evaluated; the default is 500.</td>
</tr>
</tbody>
</table>
from, to, cut

the range over which the density estimate is computed; the default, if missing, is \(\min(x) - \text{cut} \times \text{bw}, \max(x) + \text{cut} \times \text{bw}\).

na.rm

remove missing values from \(x\) in computing the adaptive-kernel estimate? The default is TRUE.

show.bw

if TRUE, show the bandwidth(s) in the horizontal-axis label or (for multiple groups) the legend; the default is FALSE.

rug

if TRUE (the default), draw a rug plot (one-dimensional scatterplot) at the bottom of the density estimate.

... arguments to be passed down.

Details

If you use a different kernel function than the default \dnorm\ that has a standard deviation different from 1 along with an automatic rule like the default function \bw.nrd0\, you can attach an attribute to the kernel function named "scale" that gives its standard deviation. This is true for the two supplied kernels, \depan\ and \dbiwt\.

Value

densityPlot invisibly returns the "density" object computed (or list of "density" objects) and draws a graph. adaptiveKernel returns an object of class "density" (see \density\).

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

density, bw.SJ, plot.density

Examples

densityPlot(~ income, show.bw=TRUE, method="kernel", data=Prestige)
densityPlot(~ income, show.bw=TRUE, data=Prestige)
densityPlot(~ income, from=0, normalize=TRUE, show.bw=TRUE, data=Prestige)

densityPlot(income ~ type, data=Prestige)
densityPlot(~ income, show.bw=TRUE, method="kernel", data=Prestige)
densityPlot(~ income, show.bw=TRUE, data=Prestige)
densityPlot(~ income, from=0, normalize=TRUE, show.bw=TRUE, data=Prestige)

densityPlot(income ~ type, kernel=depan, data=Prestige)
dfbetaPlots

\[ \text{densityPlot(income ~ type, kernel=depan, legend=list(location="top"), data=Prestige)} \]

\[ \text{plot(adaptiveKernel(UN$infantMortality, from=0, adjust=0.75), col="magenta")} \]
\[ \text{lines(density(na.omit(UN$infantMortality), from=0, adjust=0.75), col="blue")} \]
\[ \text{rug(UN$infantMortality, col="cyan")} \]
\[ \text{legend("topright", col=c("magenta", "blue"), lty=1, legend=c("adaptive kernel", "kernel"), inset=0.02)} \]

\[ \text{plot(adaptiveKernel(UN$infantMortality, from=0, adjust=0.75), col="magenta")} \]
\[ \text{lines(density(na.omit(UN$infantMortality), from=0, adjust=0.75), col="blue")} \]
\[ \text{rug(UN$infantMortality, col="cyan")} \]
\[ \text{legend("topright", col=c("magenta", "blue"), lty=1, legend=c("adaptive kernel", "kernel"), inset=0.02)} \]

---

**dfbetaPlots**

**dfbeta and dfbetas Index Plots**

**Description**

These functions display index plots of dfbeta (effect on coefficients of deleting each observation in turn) and dfbetas (effect on coefficients of deleting each observation in turn, standardized by a deleted estimate of the coefficient standard error). In the plot of dfbeta, horizontal lines are drawn at 0 and +/- one standard error; in the plot of dfbetas, horizontal lines are drawn and 0 and +/- 1.

**Usage**

\[ \text{dfbetaPlots(model, ...)} \]
\[ \text{dfbetasPlots(model, ...)} \]

## S3 method for class 'lm'
\[ \text{dfbetaPlots(model, terms=~., intercept=FALSE, layout=NULL, ask, main, xlab, ylab, labels=rownames(dfbeta), id.method="y", id.n=if(id.method[1]=="identify") Inf else 0, id.cex=1, id.col=carPalette()[1], id.location="lr", col=carPalette()[1], grid=TRUE, ...)} \]

## S3 method for class 'lm'
\[ \text{dfbetasPlots(model, terms=~., intercept=FALSE, layout=NULL, ask, main, xlab, ylab, labels=rownames(dfbeta), id.method="y", id.n=if(id.method[1]=="identify") Inf else 0, id.cex=1, id.col=carPalette()[1], id.location="lr", col=carPalette()[1], grid=TRUE, ...)} \]
Arguments

- **model**: model object produced by `lm` or `glm`.
- **terms**: A one-sided formula that specifies a subset of the terms in the model. One dfbeta or dfbetas plot is drawn for each regressor. The default `~.` is to plot against all terms in the model with the exception of an intercept. For example, the specification `terms = ~.-X3` would plot against all terms except for `X3`. If this argument is a quoted name of one of the terms, the index plot is drawn for that term only.
- **intercept**: Include the intercept in the plots; default is `FALSE`.
- **layout**: If set to a value like `c(1,1)` or `c(4,3)`, the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If `layout=NA`, the function does not set the layout and the user can use the `par` function to control the layout, for example, to have plots from two models in the same graphics window.
- **main**: The title of the graph; if missing, one will be supplied.
- **xlab**: Horizontal axis label; defaults to "Index".
- **ylab**: Vertical axis label; defaults to coefficient name.
- **ask**: If TRUE, ask the user before drawing the next plot; if FALSE, the default, don’t ask.
- ... optional additional arguments to be passed to `plot`, `points`, and `showLabels`.
- **id.method**, **labels**, **id.n**, **id.cex**, **id.col**, **id.location**: Arguments for the labelling of points. The default is `id.n=0` for labeling no points. See `showLabels` for details of these arguments.
- **col**: color for points; defaults to the first entry in the color `carPalette`.
- **grid**: If TRUE, the default, a light-gray background grid is put on the graph

Value

NULL. These functions are used for their side effect: producing plots.

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

dfbeta, dfbetas
Examples

dfbetaPlots(lm(prestige ~ income + education + type, data=Duncan))

dfbetasPlots(glm(partic != "not.work" ~ hincome + children, 
data=Womenlf, family=binomial))

durbinWatsonTest

---

**durbinWatsonTest**

*Durbin-Watson Test for Autocorrelated Errors*

Description

Computes residual autocorrelations and generalized Durbin-Watson statistics and their bootstrapped p-values. `dwt` is an abbreviation for `durbinWatsonTest`.

Usage

durbinWatsonTest(model, ...)

dwt(...)

```
## S3 method for class 'lm'
durbinWatsonTest(model, max.lag=1, simulate=TRUE, reps=1000, 
                 method=c("resample","normal"),
                 alternative=c("two.sided", "positive", "negative"), ...)

## Default S3 method:
durbinWatsonTest(model, max.lag=1, ...)

## S3 method for class 'durbinWatsonTest'
print(x, ...)
```

Arguments

- `model` a linear-model object, or a vector of residuals from a linear model.
- `max.lag` maximum lag to which to compute residual autocorrelations and Durbin-Watson statistics.
- `simulate` if `TRUE` p-values will be estimated by bootstrapping.
- `reps` number of bootstrap replications.
- `method` bootstrap method: "resample" to resample from the observed residuals; "normal" to sample normally distributed errors with 0 mean and standard deviation equal to the standard error of the regression.
- `alternative` sign of autocorrelation in alternative hypothesis; specify only if `max.lag = 1`; if `max.lag > 1`, then alternative is taken to be "two.sided".
- `...` arguments to be passed down.
- `x` `durbinWatsonTest` object.
Ellipses

Value

Returns an object of type "durbinWatsonTest".

Note

p-values are available only from the lm method.

Author(s)

John Fox <jfox@mcmaster.ca>

References


Examples

durbinWatsonTest(lm(fconvict ~ tfr + partic + degrees + mconvict, data=Hartnagel))

Ellipses, Data Ellipses, and Confidence Ellipses

Description

These functions draw ellipses, including data ellipses, and confidence ellipses for linear, generalized linear, and possibly other models.

Usage

ellipse(center, shape, radius, log="", center.pch=19, center.cex=1.5, segments=51, draw=TRUE, add=draw, xlab="", ylab="", col=carPalette()[2], lwd=2, fill=FALSE, fill.alpha=0.3, grid=TRUE, ...)
dataEllipse(x, y, groups, group.labels=group.levels, ellipse.label, weights, log="", levels=c(0.5, 0.95), center.pch=19, center.cex=1.5, draw=TRUE, plot.points=draw, add=!plot.points, segments=51, robust=FALSE, xlab=deparse(substitute(x)), ylab=deparse(substitute(y)), col=if (missing(groups)) carPalette()[1:2] else carPalette()[1:length(group.levels)], pch=if (missing(groups)) 1 else seq(group.levels), lwd=2, fill=FALSE, fill.alpha=0.3, grid=TRUE, id=FALSE, ...)

confidenceEllipse(model, ...)

## S3 method for class 'lm'
confidenceEllipse(model, which.coef, vcov.=vcov, L, levels=0.95, Scheffe=FALSE, dfn, center.pch=19, center.cex=1.5, segments=51, xlab, ylab,
Ellipses

col=carPalette()[2], lwd=2, fill=FALSE, fill.alpha=0.3, draw=TRUE, add=!draw, ...)

## S3 method for class 'glm'
confidenceEllipsoid(model, chisq, ...)

## Default S3 method:
confidenceEllipsoid(model, which.coef, vcov.=vcov,
L, levels=0.95, Scheffe=FALSE, dfn,
center.pch=19, center.cex=1.5, segments=51, xlab, ylab,
col=carPalette()[2], lwd=2, fill=FALSE, fill.alpha=0.3, draw=TRUE, add=!draw, ...)

Arguments

center 2-element vector with coordinates of center of ellipse.
shape $2 \times 2$ shape (or covariance) matrix.
radius radius of circle generating the ellipse.
log when an ellipse is to be added to an existing plot, indicates whether computa-
tions were on logged values and to be plotted on logged axes: “x” if the x-axis
is logged, “y” if the y-axis is logged, and “xy” or “yx” if both axes are logged.
The default is “”, indicating that neither axis is logged.
center.pch character for plotting ellipse center; if FALSE or NULL the center point isn’t plotted.
center.cex relative size of character for plotting ellipse center.
segments number of line-segments used to draw ellipse.
draw if TRUE produce graphical output; if FALSE, only invisibly return coordinates of
ellipse(s).
add if TRUE add ellipse(s) to current plot.
xlab label for horizontal axis.
ylab label for vertical axis.
x a numeric vector, or (if y is missing) a 2-column numeric matrix.
y a numeric vector, of the same length as x.
groups optional: a factor to divide the data into groups; a separate ellipse will be plotted
for each group (level of the factor).
group.labels labels to be plotted for the groups; by default, the levels of the groups factor.
ellipse.label a label for the ellipse(s) or a vector of labels; if several ellipses are drawn and
just one label is given, then that label will be repeated. The default is not to label
the ellipses.
weights a numeric vector of weights, of the same length as x and y to be used by cov.wt
or cov.trob in computing a weighted covariance matrix; if absent, weights of
1 are used.
plot.points if FALSE data ellipses are drawn, but points are not plotted.
levels draw elliptical contours at these (normal) probability or confidence levels.
robust
if TRUE use the cov.trob function in the MASS package to calculate the center and covariance matrix for the data ellipse.

model
a model object produced by lm or glm.

which.coef
2-element vector giving indices of coefficients to plot; if missing, the first two coefficients (disregarding the regression constant) will be selected.

vcov.
a coefficient-covariance matrix or a function (such as hccm) to compute the coefficient-covariance matrix from model; the default is the vcov function.

L
As an alternative to selecting coefficients to plot, a transformation matrix can be specified to compute two linear combinations of the coefficients; if the L matrix is given, it takes precedence over the which.coef argument. L should have two rows and as many columns as there are coefficients. It can be given directly as a numeric matrix, or specified by a pair of character-valued expressions, in the same manner as for the link{linearHypothesis} function, but with no right-hand side.

Scheffe
if TRUE scale the ellipse so that its projections onto the axes give Scheffe confidence intervals for the coefficients.

dfn
“numerator” degrees of freedom (or just degrees of freedom for a GLM) for drawing the confidence ellipse. Defaults to the number of coefficients in the model (disregarding the constant) if Scheffe is TRUE, or to 2 otherwise; selecting dfn = 1 will draw the “confidence-interval generating” ellipse, with projections on the axes corresponding to individual confidence intervals with the stated level of coverage.

chisq
if TRUE, the confidence ellipse for the coefficients in a generalized linear model are based on the chisquare statistic, if FALSE on the $F$-statistic. This corresponds to using the default and linear-model methods respectively.

col
color for lines and ellipse center; the default is the second entry in the current car palette (see carPalette and par). For dataEllipse, two colors can be given, in which case the first is for plotted points and the second for lines and the ellipse center; if ellipses are plotted for groups, then this is a vector of colors for the groups.

pch
for dataEllipse this is the plotting character (default, symbol 1, a hollow circle) to use for the points; if ellipses are plotted by groups, then this a vector of plotting characters, with consecutive symbols starting with 1 as the default.

lwd
line width; default is 2 (see par).

fill
fill the ellipse with translucent color col (default, FALSE)?

fill.alpha
transparency of fill (default = 0.3).

... other plotting parameters to be passed to plot and line.

id
controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method="mahal",n=2,cex=1,col=carPalette()[1],location="lr") (with the default col actually dependent on the number of groups), which identifies the 2 points with the largest Mahalanobis distances from the center of the data.

grid
If TRUE, the default, a light-gray background grid is put on the graph
Ellipses

Details

The ellipse is computed by suitably transforming a unit circle.

dataEllipse superimposes the normal-probability contours over a scatterplot of the data.

Value

These functions are mainly used for their side effect of producing plots. For greater flexibility (e.g., adding plot annotations), however, ellipse returns invisibly the (x, y) coordinates of the calculated ellipse. dataEllipse and confidenceEllipse return invisibly the coordinates of one or more ellipses, in the latter instance a list named by levels.

Author(s)

Georges Monette, John Fox <jfox@mcmaster.ca>, and Michael Friendly.

References


See Also

cov.trob, cov.wt, linearHypothesis.

Examples

dataEllipse(Duncan$income, Duncan$education, levels=0.1*1:9,
     ellipse.label=0.1*1:9, lty=2, fill=TRUE, fill.alpha=0.1)

certaintyEllipse(lm(prestige~income+education, data=Duncan), Scheffe=TRUE)

confidenceEllipse(lm(prestige~income+education, data=Duncan), vcov.=hccm)

confidenceEllipse(lm(prestige~income+education, data=Duncan),
    L=c("income + education", "income - education"))

wts <- rep(1, nrow(Duncan))
wts[c(6, 16)] <- 0 # delete Minister, Conductor

with(Duncan, {
    dataEllipse(income, prestige, levels=0.68)
dataEllipse(income, prestige, levels=0.68, robust=TRUE, plot.points=FALSE, col="green3")
dataEllipse(income, prestige, weights=wts, levels=0.68, plot.points=FALSE, col="brown")
dataEllipse(income, prestige, weights=wts, robust=TRUE, levels=0.68, plot.points=FALSE, col="blue")
})
with(Prestige, dataEllipse(income, education, type, 
  id=list(n=2, labels=rownames(Prestige)), pch=15:17, 
  xlim=c(0, 25000), center.pch="+", 
  group.labels=c("Blue Collar", "Professional", "White Collar"), 
  ylim=c(5, 20), level=.95, fill=TRUE, fill.alpha=0.1))

Export

Export a data frame to disk in one of many formats

Description

Uses the export function in the rio package to export a file to disk. This function adds an argument for converting row.names to a column in the resulting file.

Usage

Export(x, file, format, ..., keep.row.names)

Arguments

x A data frame or matrix to be written to a file.
file A character string naming a file. If the file name has an extension, such as .xlsx, the extension is used to infer the type of file to be exported. See export for the file types supported.
format see export.
... Additional arguments; see export.
keep.row.names If set to TRUE, then the data frame’s row.names are appended to the left of the data frame with the name "id". If set to quoted character string, the row.names are added using the character string as its name. If set to FALSE row.names are lost.

Details

This is a convenience function in the car package for exporting (writing) a data frame to a file in a wide variety of formats including csv, Microsoft Excel. It optionally allows converting the row.names for the data frame to a column before writing. It then calls export in the rio package. That function in turn uses many other packages and functions for writing the function to a file.

Value

The name of the output file as a character string (invisibly).

Author(s)

Sanford Weisberg <sandy@umn.edu>
References


See Also

export, Import

Examples

Export(Duncan, "Duncan.csv", keep.row.names="occupation")
Duncan2 <- Import("Duncan.csv") # Automatically restores row.names
identical(Duncan, Duncan2)
# cleanup
unlink("Duncan.csv")

---

hccm

Heteroscedasticity-Corrected Covariance Matrices

Description

Calculates heteroscedasticity-corrected covariance matrices linear models fit by least squares or weighted least squares. These are also called “White-corrected” or “White-Huber” covariance matrices.

Usage

hccm(model, ...)

## S3 method for class 'lm'
hccm(model, type=c("hc3", "hc0", "hc1", "hc2", "hc4"),
     singular.ok=TRUE, ...)

## Default S3 method:
hccm(model, ...)

Arguments

model a unweighted or weighted linear model, produced by lm.

type one of "hc0", "hc1", "hc2", "hc3", or "hc4"; the first of these gives the classic White correction. The "hc1", "hc2", and "hc3" corrections are described in Long and Ervin (2000); "hc4" is described in Cribari-Neto (2004).
singular.ok if FALSE (the default is TRUE), a model with aliased coefficients produces an error; otherwise, the aliased coefficients are ignored in the coefficient covariance matrix that's returned.

... arguments to pass to hccm.lm.
Details

The original White-corrected coefficient covariance matrix ("hc0") for an unweighted model is

\[ V(b) = (X'X)^{-1}X'diag(e_i^2)X(X'X)^{-1} \]

where \( e_i^2 \) are the squared residuals, and \( X \) is the model matrix. The other methods represent adjustments to this formula. If there are weights, these are incorporated in the corrected covariance matrix.

The function \texttt{hccm.default} simply catches non-\texttt{lm} objects.

Value

The heteroscedasticity-corrected covariance matrix for the model.

Author(s)

John Fox <jfox@mcmaster.ca>

References


Examples

```r
options(digits=4)
mod<-lm(interlocks~assets+nation, data=Ornstein)
vcov(mod)
## (Intercept) assets nationOTH nationUK nationUS
## (Intercept) 1.079e+00 -1.588e-05 -1.037e+00 -1.057e+00 -1.032e+00
## assets -1.588e-05 1.642e-09 1.155e-05 1.362e-05 1.109e-05
## nationOTH -1.037e+00 1.155e-05 7.019e+00 1.021e+00 1.003e+00
## nationUK -1.057e+00 1.362e-05 1.021e+00 7.405e+00 1.017e+00
## nationUS -1.032e+00 1.109e-05 1.003e+00 1.017e+00 2.128e+00
hccm(mod)
## (Intercept) assets nationOTH nationUK nationUS
## (Intercept) 1.664e+00 -3.957e-05 -1.569e+00 -1.611e+00 -1.572e+00
## assets -3.957e-05 6.752e-09 2.275e-05 3.051e-05 2.231e-05
## nationOTH -1.569e+00 2.275e-05 8.289e+00 1.539e+00 1.520e+00
## nationUK -1.611e+00 3.051e-05 1.539e+00 4.476e+00 1.543e+00
## nationUS -1.572e+00 2.231e-05 1.520e+00 1.543e+00 1.946e+00
```
hist.boot

Methods Functions to Support boot Objects

Description

The Boot function in the car package uses the boot function from the boot package to do a straightforward case or residual bootstrap for many regression objects. These are method functions for standard generics to summarize the results of the bootstrap. Other tools for this purpose are available in the boot package.

Usage

```r
## S3 method for class 'boot'
hist(x, parm, layout = NULL, ask, main = "", freq = FALSE,
estPoint = TRUE, point.col = carPalette()[1], point.lty = 2, point.lwd = 2,
estDensity = !freq, den.col = carPalette()[2], den.lty = 1, den.lwd = 2,
estNormal = !freq, nor.col = carPalette()[3], nor.lty = 2, nor.lwd = 2,
ci = c("bca", "none", "perc", "norm"), level = 0.95,
legend = c("top", "none", "separate"), box = TRUE, ...)
## S3 method for class 'boot'
summary(object, parm, high.moments = FALSE, extremes = FALSE, ...)
## S3 method for class 'boot'
confint(object, parm, level = 0.95, type = c("bca", "norm",
"basic", "perc"), ...)
## S3 method for class 'boot'
Confint(object, parm, level = 0.95, type = c("bca", "norm",
"basic", "perc"), ...)
## S3 method for class 'boot'
v cov(object, ...)
```

Arguments

- `x, object` An object created by a call to boot in the boot package, or to Boot in the car package of class "boot".
- `parm` A vector of numbers or coefficient names giving the coefficients for which a histogram or confidence interval is desired. If numbers are used, 1 corresponds to the intercept, if any. The default is all coefficients.
- `layout` If set to a value like c(1,1) or c(4,3), the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If layout=NA, the function does not set the layout and the user can use the par function to control the layout, for example to have plots from two models in the same graphics window.
If \texttt{TRUE}, ask the user before drawing the next plot; if \texttt{FALSE}, don’t ask.

Main title for the graphs. The default is \texttt{main=“”} for no title.

The default for the generic \texttt{hist} function is \texttt{freq=TRUE} to give a frequency histogram. The default for \texttt{hist.boot} is \texttt{freq=FALSE} to give a density histogram. A density estimate and/or a fitted normal density can be added to the graph if \texttt{freq=FALSE} but not if \texttt{freq=TRUE}.

If \texttt{estPoint=TRUE}, the default, a vertical line is drawn on the histogram at the value of the point estimate computed from the complete data. The remaining three optional arguments set the color, line type and line width of the line that is drawn.

If \texttt{estDensity=TRUE} and \texttt{freq=FALSE}, the default, a kernel density estimate is drawn on the plot with a call to the density function with no additional arguments. The remaining three optional arguments set the color, line type and line width of the lines that are drawn.

If \texttt{estNormal=TRUE} and \texttt{freq=FALSE}, the default, a normal density with mean and sd computed from the data is drawn on the plot. The remaining three optional arguments set the color, line type and line width of the lines that are drawn.

A confidence interval based on the bootstrap will be added to the histogram using the BCa method if \texttt{ci=“bca”} the percentile method if \texttt{ci=“perc”}, or the normal method if \texttt{ci=“norm”}. No interval is drawn if \texttt{ci=“none”}. The default is \texttt{“bca”}. The interval is indicated by a thick horizontal line at \texttt{y=0}. For some bootstraps the BCa method is unavailable, in which case a warning is issued and \texttt{ci=“perc”} is substituted. If you wish to see all the options at once, see \texttt{boot.ci}.

The normal method is computed as the (estimate from the original data) minus the bootstrap bias plus or minus the standard deviation of the bootstrap replicates times the appropriate quantile of the standard normal distribution.

A legend can be added to the (array of) histograms. The value \texttt{“top”} puts at the top-left of the plots. The value \texttt{“separate”} puts the legend in its own graph following all the histograms. The value \texttt{“none”} suppresses the legend.

Add a box around each histogram.

Additional arguments passed to \texttt{hist}; for other methods this is included for compatibility with the generic method. For example, the argument \texttt{border=par()$bg} in \texttt{hist} will draw the histogram transparently, leaving only the density estimates. With the \texttt{vcov} function, the additional arguments are passed to \texttt{cov}. See the Value section, below.

Should the skewness and kurtosis be included in the summary? Default is \texttt{FALSE}.

Should the minimum, maximum and range be included in the summary? Default is \texttt{FALSE}.

Confidence level, a number between 0 and 1. In \texttt{confint}, \texttt{level} can be a vector; for example \texttt{level=c(.50, .90, .95)} will return the following estimated quantiles: \texttt{c(.025, .05, .25, .75, .95, .975)}.
type

Selects the confidence interval type. The types implemented are the "percentile" method, which uses the function quantile to return the appropriate quantiles for the confidence limit specified, the default bca which uses the bias-corrected and accelerated method presented by Efron and Tibshirani (1993, Chapter 14). For the other types, see the documentation for boot.

Value

hist is used for the side-effect of drawing an array of histograms of each column of the first argument. summary returns a matrix of summary statistics for each of the columns in the bootstrap object. The confint method returns confidence intervals. Confint appends the estimates based on the original fitted model to the left of the confidence intervals.

The vcov returns the sample covariance of the bootstrap sample estimates. If any of the bootstrap replications returned an NA value, then vcov will return a matrix of NAs. You can compute the covariance of the complete cases by adding the argument use="complete.obs" to the call to vcov; see cov.

Author(s)

Sanford Weisberg, <sandy@umn.edu>

References


See Also

See Also Boot, hist, density, Fox and Weisberg (2017), cited above

Examples

m1 <- lm(Fertility ~ ., swiss)
betahat.boot <- Boot(m1, R=99) # 99 bootstrap samples--too small to be useful
summary(betahat.boot) # default summary
confint(betahat.boot)
hist(betahat.boot)
Import data from many file formats

Description

Use the `import` function from the `rio` package to read a data.frame from a variety of file types. The `Import` function includes 3 additional arguments adding row names and for converting character and logical variables to factors.

Usage

```
Import(file, format, ..., row.names=TRUE,
       stringsAsFactors = default.stringsAsFactors())
```

Arguments

- `file`: A character string naming a file, URL, or single-file .zip or .tar archive. See the details below. If the file name has an extention like .xlsx or .csv then the type of file is inferred from the extension.
- `format`: If an extension is not present in the file name or it is wrong, the file format can be set with this argument; see `import`.
- `...`: Additional arguments passed to `import`.
- `row.names`: If TRUE, the default, the left-most character variable that has all unique elements is removed from the data frame and set to be `row.names`. To match `import`, set `row.names=FALSE`.
- `stringsAsFactors`: If TRUE, then character variables that do not have all unique elements are converted to factors. The default is determined by the value of `options("stringsAsFactors")` whose "factory fresh" default is equal to TRUE. To get the default behavior of the `import` function, set `stringsAsFactors=FALSE`.

Details

This function always calls the `import` function to read a data frame from a file. Many type of file are supported. The `Import` function allows the user to set `row.names`, and automatically convert character and logical variables to factors, but only if the format of the file is one of "txt","csv","xlsx","xls","ods". Many more details are given at the man page for `import`.

Value

A data frame. See `import` for more details

Author(s)

Sanford Weisberg <sandy@umn.edu>
See Also

import, Export

Examples

head(Duncan, 3) # first three rows
Export(Duncan, "Duncan.csv", keep.row.names="occupation")
Duncan2 <- Import("Duncan.csv") # Automatically restores row.names and factors
head(Duncan2, 3) # first three rows
identical(Duncan, Duncan2)
# cleanup
unlink("Duncan.csv")

infIndexPlot Influence Index Plot

Description

Provides index plots of influence and related diagnostics for a regression model.

Usage

infIndexPlot(model, ...)

influenceIndexPlot(model, ...)

## S3 method for class 'lm'
inIndexPlot(model, vars=c("Cook", "Studentized", "Bonf", "hat"),
id=TRUE, grid=TRUE, main="Diagnostic Plots", ...)

## S3 method for class 'influence.merMod'
inIndexPlot(model,
vars = c("dfbeta", "dfbetas", "var.cov.comps",
"cookd"), id = TRUE, grid = TRUE, main = "Diagnostic Plots", ...)

## S3 method for class 'influence.lme'
inIndexPlot(model,
vars = c("dfbeta", "dfbetas", "var.cov.comps",
"cookd"), id = TRUE, grid = TRUE, main = "Diagnostic Plots", ...)

Arguments

model A regression object of class lm, glm, or lmerMod, or an influence object for a lmer, glmer, or lme object (see influence.mixed.models). The lmerMod method calls the "lm" method and can take the same arguments.

vars All the quantities listed in this argument are plotted. Use "Cook" for Cook's distances, "Studentized" for Studentized residuals, "Bonf" for Bonferroni p-values for an outlier test, and and "hat" for hat-values (or leverages) for a linear
These functions compute deletion influence diagnostics for linear mixed-effects models fit by `lmer` in the `lme4` package and `lme` in the `nlme` package and for generalized linear mixed-effects models fit by `glmer` in the `lme4` package. The main functions are methods for the `influence` generic function. Other functions are provided for computing `dfbeta`, `dfbetas`, `cooks.distance`, and influence on variance-covariance components based on the objects computed by `influence.merMod` and `influence.lme`.

**Value**

Used for its side effect of producing a graph. Produces index plots of diagnostic quantities.

**Author(s)**

Sanford Weisberg <sandy@umn.edu> and John Fox

**References**


**See Also**

`cooks.distance`, `rstudent`, `outlierTest`, `hatvalues`, `influence.mixed.models`.

**Examples**

```r
influenceIndexPlot(lm(prestige ~ income + education + type, Duncan))
```

---

**Description**

These functions compute deletion influence diagnostics for linear mixed-effects models fit by `lmer` in the `lme4` package and `lme` in the `nlme` package and for generalized linear mixed-effects models fit by `glmer` in the `lme4` package. The main functions are methods for the `influence` generic function. Other functions are provided for computing `dfbeta`, `dfbetas`, `cooks.distance`, and influence on variance-covariance components based on the objects computed by `influence.merMod` and `influence.lme`.
Usage

```r
## S3 method for class 'merMod'
influence(model, groups, data, maxfun=1000, ncores=1, ...)
## S3 method for class 'lme'
influence(model, groups, data, ncores=1, ...)

## S3 method for class 'influence.merMod'
cooks.distance(model, ...)
## S3 method for class 'influence.lme'
cooks.distance(model, ...)
## S3 method for class 'influence.merMod'
dfbeta(model, which = c("fixed", "var.cov"), ...)
## S3 method for class 'influence.lme'
dfbeta(model, which = c("fixed", "var.cov"), ...)
## S3 method for class 'influence.merMod'
dfbetas(model, ...)
## S3 method for class 'influence.lme'
dfbetas(model, ...)
```

Arguments

- **model**: in the case of `influence.merMod` or `influence.lme`, a model of class "merMod" or "lme"; in the case of `cooks.distance`, `dfbeta`, or `dfbetas`, an object returned by `influence.merMod` or `influence.lme`.
- **groups**: a character vector containing the name of a grouping factor or names of grouping factors; if more than one name is supplied, then groups are defined by all combinations of levels of the grouping factors that appear in the data. If omitted, then each individual row of the data matrix is treated as a "group" to be deleted in turn.
- **data**: an optional data frame with the data to which `model` was fit; `influence.merMod` can usually reconstruct the data, and `influence.lme` can access the data unless `keep.data=FALSE` was specified in the call to `lme`, so it's usually unnecessary to supply the data argument.
- **maxfun**: The maximum number of function evaluations (for `influence.merMod`) to perform after deleting each group; the defaults are large enough so that the iterations will typically continue to convergence. Setting to `maxfun=20` for an `lmer` model or `100` for a `glmer` model will typically produce a faster reasonable approximation. An even smaller value can be used if interest is only in influence on the fixed effects.
- **ncores**: number of cores for parallel computation of diagnostics; if 1 (the default), the computation isn't parallelized; if Inf, all of the available physical cores (not necessarily logical cores — see `detectCores`) on the computer will be used.
- **which**: if "fixed.effects" (the default), return influence on the fixed effects; if "var.cov", return influence on the variance-covariance components.
- **...**: ignored.
Details

influence.merMod and influence.lme start with the estimated variance-covariance components from model and then refit the model omitting each group in turn, not necessarily iterating to completion. For example, maxfun=20 takes up to 20 function evaluations step away from the ML or REML solution for the full data, which usually provides decent approximations to the fully iterated estimates.

The other functions are methods for the dfbeta, dfbetas, and cooks.distance generics, to be applied to the "influence.merMod" or "influence.lme" object produced by the influence function; the dfbeta methods can also return influence on the variance-covariance components.

Value

influence.merMod and influence.lme return objects of class "influence.merMod" and "influence.lme" respectively, each of which contains the following elements:

"fixed.effects" the estimated fixed effects for the model.
"fixed.effects[-groups]" a matrix with columns corresponding to the fixed-effects coefficients and rows corresponding to groups, giving the estimated fixed effects with each group deleted in turn; groups is formed from the name(s) of the grouping factor(s).
"var.cov.comps" the estimated variance-covariance parameters for the model.
"var.cov.comps[-groups]" a matrix with the estimated covariance parameters (in columns) with each group deleted in turn.
"vcov" The estimated covariance matrix of the fixed-effects coefficients.
"vcov[-groups]" a list each of whose elements is the estimated covariance matrix of the fixed-effects coefficients with one group deleted.
"groups" a character vector giving the names of the grouping factors.
"deleted" the possibly composite grouping factor, each of whose elements is deleted in turn.
"converged" for influence.merMod, a logical vector indicating whether the computation converged for each group.
"function.evals" for influence.merMod, a vector of the number of function evaluations performed for each group.

For plotting "influence.merMod" and "influence.lme" objects, see infIndexPlot.

Author(s)

J. Fox <jfox@mcmaster.ca>

References


See Also

lmer, glmer, lme, infIndexPlot.
Examples

```r
if (require("lme4")){
  print(fm1 <- lmer(Reaction ~ Days + (Days | Subject),
                   sleepstudy)) # from ?lmer
  infIndexPlot(influence(fm1, "Subject"))
}
if (require("lme4")){
  gml <- glmer(cbind(incidence, size - incidence) ~ period + (1 | herd),
                data = cbpp, family = binomial)
  infIndexPlot(influence(gml, "herd", maxfun=100))
  gml.11 <- update(gml, subset = herd != 11) # check deleting herd 11
  compareCoefs(gml, gml.11)
}
```

### influencePlot

**Regression Influence Plot**

**Description**

This function creates a “bubble” plot of Studentized residuals versus hat values, with the areas of the circles representing the observations proportional to the value Cook’s distance. Vertical reference lines are drawn at twice and three times the average hat value, horizontal reference lines at -2, 0, and 2 on the Studentized-residual scale.

**Usage**

```r
influencePlot(model, ...)
```

```r
## S3 method for class 'lm'
influencePlot(model, scale=10,
             xlab="Hat-Values", ylab="Studentized Residuals", id=TRUE, ...)
```

```r
## S3 method for class 'lmerMod'
influencePlot(model, ...)
```

**Arguments**

- `model` a linear, generalized-linear, or linear mixed model; the "lmerMod" method calls the "lm" method and can take the same arguments.
- `scale` a factor to adjust the size of the circles.
- `xlab, ylab` axis labels.
- `id` settings for labelling points; see `link(showLabels)` for details. To omit point labelling, set `id=FALSE`; the default, `id=TRUE` is equivalent to `id=list(method="noteworthy",n=2,cex=1,col=carPalette()[1],location="lr")`. The default method="noteworthy" is used only in this function and indicates setting labels for points with large Studentized residuals, hat-values or Cook’s distances. Set `id=list(method="identify")` for interactive point identification.
- `...` arguments to pass to the plot and points functions.
**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)**

John Fox <jfox@mcmaster.ca>, minor changes by S. Weisberg <sandy@umn.edu>

**References**


**See Also**

cooks.distance, rstudent, hatvalues, showLabels

**Examples**

```r
influencePlot(lm(prestige ~ income + education, data=Duncan))
## Not run:
influencePlot(lm(prestige ~ income + education, data=Duncan),
   id=list(method="identify"))
## End(Not run)
```

---

**invResPlot**

*Inverse Response Plots to Transform the Response*

**Description**

For a `lm` model, draws an inverse.response plot with the response Y on the vertical axis and the fitted values \( \hat{Y} \) on the horizontal axis. Uses `nls` to estimate \( \lambda \) in the function \( \hat{Y} = b_0 + b_1 Y^\lambda \). Adds the fitted curve to the plot. `invResPlot` is an alias for `inverseResponsePlot`.

**Usage**

```r
inverseResponsePlot(model, lambda=c(-1,0,1), robust=FALSE, xlab=NULL, ...)
```

## S3 method for class 'lm'
```r
inverseResponsePlot(model, lambda=c(-1, 0, 1),
   robust=FALSE, xlab=NULL, id=FALSE, ...)
```

invResPlot(model, ...)
invResPlot

Arguments

- **model**: A "lm" regression object.
- **lambda**: A vector of values for lambda. A plot will be produced with curves corresponding to these lambdas and to the nonlinear least squares estimate of lambda.
- **robust**: If TRUE, then estimation uses Huber M-estimates with the median absolute deviation to estimate scale and k= 1.345. The default is FALSE.
- **xlab**: The horizontal axis label. If NULL, it is constructed by the function.
- **id**: controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method=list(method="x",n=2,cex=1,col=carPalette()[1],location="lr"), which identifies the 2 points with the most extreme horizontal (X) values.
- **...**: Other arguments passed to invTranPlot and then to plot.

Value

As a side effect, a plot is produced with the response on the horizontal axis and fitted values on the vertical axis. Several lines are added to be plot as the ols estimates of the regression of \( \hat{Y} \) on \( Y^\lambda \), interpreting \( \lambda = 0 \) to be natural logarithms.

Numeric output is a list with elements

- **lambda**: Estimate of transformation parameter for the response
- **RSS**: The residual sum of squares at the minimum if robust=FALSE. If robust = TRUE, the value of Huber objective function is returned.

Author(s)

Sanford Weisberg, sandy@umn.edu

References


See Also

- `invTranPlot`, `powerTransform`, `showLabels`

Examples

```r
m2 <- lm(rate ~ log(len) + log(adt) + slim + shld + log(sigs1), Highway1)
invResPlot(m2)
```
invTranPlot

Choose a Predictor Transformation Visually or Numerically

Description

invTranPlot draws a two-dimensional scatterplot of $Y$ versus $X$, along with the OLS fit from the regression of $Y$ on $(X^\lambda - 1)/\lambda$. invTranEstimate finds the nonlinear least squares estimate of $\lambda$ and its standard error.

Usage

invTranPlot(x, ...)

## S3 method for class 'formula'
invTranPlot(x, data, subset, na.action, id=FALSE, ...)

## Default S3 method:
invTranPlot(x, y, lambda=c(-1, 0, 1), robust=FALSE,
            lty.lines=rep(c("solid", "dashed", "dotdash", "longdash", "twodash"),
                          length=1 + length(lambda)), lwd.lines=2,
            col=carPalette()[1], col.lines=carPalette(),
            xlab=deparse(substitute(x)), ylab=deparse(substitute(y)),
            family="bcPower", optimal=TRUE, key="auto", id=FALSE,
            grid=TRUE, ...)

invTranEstimate(x, y, family="bcPower", confidence=0.95, robust=FALSE)

Arguments

x

The predictor variable, or a formula with a single response and a single predictor

y

The response variable

data

An optional data frame to get the data for the formula

subset

Optional, as in lm, select a subset of the cases

na.action

Optional, as in lm, the action for missing data

lambda

The powers used in the plot. The optimal power than minimizes the residual sum of squares is always added unless optimal is FALSE.

robust

If TRUE, then the estimated transformation is computed using Huber M-estimation with the MAD used to estimate scale and k=1.345. The default is FALSE.

family

The transformation family to use, "bcPower", "yjPower", or a user-defined family.

confidence

returns a profile likelihood confidence interval for the optimal transformation with this confidence level. If FALSE, or if robust=TRUE, no interval is returned.

optimal

Include the optimal value of lambda?
invTranPlot

ltypes  line types corresponding to the powers
lwd.lines  the width of the plotted lines, defaults to 2 times the standard
col  color(s) of the points in the plot. If you wish to distinguish points according to the levels of a factor, we recommend using symbols, specified with the pch argument, rather than colors.

col.lines  color of the fitted lines corresponding to the powers. The default is to use the colors returned by carPalette
key  The default is "auto", in which case a legend is added to the plot, either above the top margin or in the bottom right or top right corner. Set to NULL to suppress the legend.
xlab  Label for the horizontal axis.
ylab  Label for the vertical axis.
id  controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method=list(method="x", n=2, cex=1, col=carPalette()[1], location="lr")), which identifies the 2 points with the most extreme horizontal values — i.e., the response variable in the model.

Additional arguments passed to the plot method, such as pch.
grid  If TRUE, the default, a light-gray background grid is put on the graph.

Value

invTranPlot plots a graph and returns a data frame with \( \lambda \) in the first column, and the residual sum of squares from the regression for that \( \lambda \) in the second column.

invTranEstimate returns a list with elements lambda for the estimate, se for its standard error, and RSS, the minimum value of the residual sum of squares.

Author(s)

Sanford Weisberg, <sandy@umn.edu>

References


See Also

inverseResponsePlot optimize

Examples

with(UN, invTranPlot(ppgdp, infantMortality))
with(UN, invTranEstimate(ppgdp, infantMortality))
leveneTest

Levene's Test

Description

Computes Levene's test for homogeneity of variance across groups.

Usage

leveneTest(y, ...)
## S3 method for class 'formula'
leveneTest(y, data, ...)
## S3 method for class 'lm'
leveneTest(y, ...)
## Default S3 method:
leveneTest(y, group, center=median, ...)

Arguments

y response variable for the default method, or a lm or formula object. If y is a linear-model object or a formula, the variables on the right-hand-side of the model must all be factors and must be completely crossed.
group factor defining groups.
center The name of a function to compute the center of each group; mean gives the original Levene's test; the default, median, provides a more robust test.
data a data frame for evaluating the formula.
... arguments to be passed down, e.g., data for the formula and lm methods; can also be used to pass arguments to the function given by center (e.g., center=mean and trim=0.1 specify the 10% trimmed mean).

Value

returns an object meant to be printed showing the results of the test.

Note

adapted from a response posted by Brian Ripley to the r-help email list.

Author(s)

John Fox <jfox@mcmaster.ca>; original generic version contributed by Derek Ogle

References

leveragePlots

Examples

```r
with(Moore, leveneTest(conformity, fcategory))
with(Moore, leveneTest(conformity, interaction(fcategory, partner.status)))
leveneTest(conformity ~ fcategory*partner.status, data=Moore)
leveneTest(lm(conformity ~ fcategory*partner.status, data=Moore))
leveneTest(conformity ~ fcategory*partner.status, data=Moore, center=mean)
leveneTest(conformity ~ fcategory*partner.status, data=Moore, center=mean, trim=0.1)
```

---

leveragePlots  Regression Leverage Plots

Description

These functions display a generalization, due to Sall (1990) and Cook and Weisberg (1991), of added-variable plots to multiple-df terms in a linear model. When a term has just 1 df, the leverage plot is a rescaled version of the usual added-variable (partial-regression) plot.

Usage

```r
leveragePlots(model, terms = ~., layout = NULL, ask, main, ...) 
leveragePlot(model, ...) 
## S3 method for class 'lm'
leveragePlot(model, term.name, id=TRUE, col=carPalette()[1], col.lines=carPalette()[2], lwd=2, xlab, ylab, main="Leverage Plot", grid=TRUE, ...)
## S3 method for class 'glm'
leveragePlot(model, ...) 
```

Arguments

- `model`: model object produced by `lm`
- `terms`: A one-sided formula that specifies a subset of the numeric regressors, factors and interactions. One added-variable plot is drawn for each term, either a main effect or an interactions. The default `~.` is to plot against all terms in the model. For example, the specification `terms = ~ . -X3` would plot against all predictors except for X3. If this argument is a quoted name of one of the predictors, the added-variable plot is drawn for that predictor only. The plots for main effects with interactions present violate the marginality principle and may not be easily interpreted.
- `layout`: If set to a value like c(1,1) or c(4,3), the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you
leveragePlots

will get a maximum of nine per page. If layout=NA, the function does not set
the layout and the user can use the par function to control the layout, for example
to have plots from two models in the same graphics window.

ask
if TRUE, a menu is provided in the R Console for the user to select the term(s) to
plot.

xlab, ylab
axis labels; if missing, labels will be supplied.

main
title for plot; if missing, a title will be supplied.

...arguments passed down to method functions.
term.name
Quoted name of term in the model to be plotted; this argument is omitted for
leveragePlots.
id
controls point identification; if FALSE, no points are identified; can be a list of
named arguments to the showLabels function; TRUE, the default, is equivalent to
list(method=list(abs(residuals(model,type="pearson")),"x"),n=2,cex=1,col=carPalette()
which identifies the 2 points with the largest residuals and the 2 points with the
greatest partial leverage.

col
color(s) of points

col.lines
color of the fitted line

lwd
line width; default is 2 (see par).

grid
If TRUE, the default, a light-gray background grid is put on the graph

Details

The function intended for direct use is leveragePlots.
The model can contain factors and interactions. A leverage plot can be drawn for each term in the
model, including the constant.

leveragePlot.glm is a dummy function, which generates an error message.

Value

NULL. These functions are used for their side effect: producing plots.

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

avPlots
linearHypothesis

Examples

leveragePlots(lm(prestige~(income+education)*type, data=Duncan))

linearHypothesis  Test Linear Hypothesis

Description

Generic function for testing a linear hypothesis, and methods for linear models, generalized linear models, multivariate linear models, linear and generalized linear mixed-effects models, generalized linear models fit with svyglm in the survey package, robust linear models fit with rlm in the MASS package, and other models that have methods for coef and vcov. For mixed-effects models, the tests are Wald chi-square tests for the fixed effects.

Usage

linearHypothesis(model, ...)

lht(model, ...)

## Default S3 method:
linearHypothesis(model, hypothesis.matrix, rhs=NULL, test=c(“Chisq”, “F”), vcov.=NULL, singular.ok=FALSE, verbose=FALSE, coef. = coef(model), ...)

## S3 method for class ’lm’
linearHypothesis(model, hypothesis.matrix, rhs=NULL, test=c(“F”, “Chisq”), vcov.=NULL, white.adjust=c(FALSE, TRUE, “hc3”, “hc0”, “hc1”, “hc2”, “hc4”), singular.ok=FALSE, ...)

## S3 method for class ’glm’
linearHypothesis(model, ...)

## S3 method for class ’nlsList’
linearHypothesis(model, ..., vcov., coef.)

## S3 method for class ’mlm’
linearHypothesis(model, hypothesis.matrix, rhs=NULL, SSPE, V, test, idata, icontрастs=c(“contr.sum”, “contr.poly”), idesign, iterms, check.imatrix=TRUE, P=NULL, title=“”, singular.ok=FALSE, verbose=FALSE, ...)

## S3 method for class ’polr’
linearHypothesis(model, hypothesis.matrix, rhs=NULL, vcov., verbose=FALSE, ...)


Arguments

- **model**: fitted model object. The default method of `linearHypothesis` works for models for which the estimated parameters can be retrieved by `coef` and the corresponding estimated covariance matrix by `vcov`. See the Details for more information.

- **hypothesis.matrix**: matrix (or vector) giving linear combinations of coefficients by rows, or a char-
linearHypothesis

character vector giving the hypothesis in symbolic form (see Details).

rhs
right-hand-side vector for hypothesis, with as many entries as rows in the hypothesis matrix; can be omitted, in which case it defaults to a vector of zeroes. For a multivariate linear model, rhs is a matrix, defaulting to 0. This argument isn’t available for F-tests for linear mixed models.

singular.ok
if FALSE (the default), a model with aliased coefficients produces an error; if TRUE, the aliased coefficients are ignored, and the hypothesis matrix should not have columns for them. For a multivariate linear model: will return the hypothesis and error SSP matrices even if the latter is singular; useful for computing univariate repeated-measures ANOVAs where there are fewer subjects than df for within-subject effects.

idata
an optional data frame giving a factor or factors defining the intra-subject model for multivariate repeated-measures data. See Details for an explanation of the intra-subject design and for further explanation of the other arguments relating to intra-subject factors.

icontrasts
names of contrast-generating functions to be applied by default to factors and ordered factors, respectively, in the within-subject “data”; the contrasts must produce an intra-subject model matrix in which different terms are orthogonal.

idesign
a one-sided model formula using the “data” in idata and specifying the intra-subject design.

iterms
the quoted name of a term, or a vector of quoted names of terms, in the intra-subject design to be tested.

check.imatrix
check that columns of the intra-subject model matrix for different terms are mutually orthogonal (default, TRUE). Set to FALSE only if you have already checked that the intra-subject model matrix is block-orthogonal.

P
transformation matrix to be applied to the repeated measures in multivariate repeated-measures data; if NULL and no intra-subject model is specified, no response-transformation is applied; if an intra-subject model is specified via the idata, idesign, and (optionally) icontrasts arguments, then P is generated automatically from the terms argument.

SSPE
in linearHypothesis method for mlm objects: optional error sum-of-squares-and-products matrix; if missing, it is computed from the model. In print method for linearHypothesis.mlm objects: if TRUE, print the sum-of-squares and cross-products matrix for error.

test
character string, "F" or "Chisq", specifying whether to compute the finite-sample F statistic (with approximate F distribution) or the large-sample Chi-squared statistic (with asymptotic Chi-squared distribution). For a multivariate linear model, the multivariate test statistic to report — one or more of "Pillai", "Wilks", "Hotelling-Lawley", or "Roy", with "Pillai" as the default.

title
an optional character string to label the output.

V
inverse of sum of squares and products of the model matrix; if missing it is computed from the model.

vcov.
a function for estimating the covariance matrix of the regression coefficients, e.g., hccm, or an estimated covariance matrix for model. See also white.adjust.
linearHypothesis

coef. a vector of coefficient estimates. The default is to get the coefficient estimates from the model argument, but the user can input any vector of the correct length.

white.adjust logical or character. Convenience interface to \code{hccm} (instead of using the argument \code{vcov.}). Can be set either to a character value specifying the type argument of \code{hccm} or \code{TRUE}, in which case \code{"hc3"} is used implicitly. The default is \code{FALSE}.

verbose If \code{TRUE}, the hypothesis matrix, right-hand-side vector (or matrix), and estimated value of the hypothesis are printed to standard output; if \code{FALSE} (the default), the hypothesis is only printed in symbolic form and the value of the hypothesis is not printed.

x an object produced by \code{linearHypothesis.mlm}.

SSP if \code{TRUE} (the default), print the sum-of-squares and cross-products matrix for the hypothesis and the response-transformation matrix.

digits minimum number of significant digits to print.

pattern a regular expression to be matched against coefficient names.

... arguments to pass down.

Details

\code{linearHypothesis} computes either a finite-sample F statistic or asymptotic Chi-squared statistic for carrying out a Wald-test-based comparison between a model and a linearly restricted model. The default method will work with any model object for which the coefficient vector can be retrieved by \code{coef} and the coefficient-covariance matrix by \code{vcov} (otherwise the argument \code{vcov.} has to be set explicitly). For computing the F statistic (but not the Chi-squared statistic) a \code{df.residual} method needs to be available. If a \code{formula} method exists, it is used for pretty printing.

The method for \code{"lm"} objects calls the default method, but it changes the default test to \code{"F"}, supports the convenience argument \code{white.adjust} (for backwards compatibility), and enhances the output by the residual sums of squares. For \code{"glm"} objects just the default method is called (bypassing the \code{"lm"} method). The \code{svyglm} method also calls the default method.

The function \code{lht} also dispatches to \code{linearHypothesis}.

The hypothesis matrix can be supplied as a numeric matrix (or vector), the rows of which specify linear combinations of the model coefficients, which are tested equal to the corresponding entries in the right-hand-side vector, which defaults to a vector of zeroes.

Alternatively, the hypothesis can be specified symbolically as a character vector with one or more elements, each of which gives either a linear combination of coefficients, or a linear equation in the coefficients (i.e., with both a left and right side separated by an equals sign). Components of a linear expression or linear equation can consist of numeric constants, or numeric constants multiplying coefficient names (in which case the number precedes the coefficient, and may be separated from it by spaces or an asterisk); constants of 1 or -1 may be omitted. Spaces are always optional. Components are separated by plus or minus signs. Newlines or tabs in hypotheses will be treated as spaces. See the examples below.

If the user sets the arguments \code{coef.} and \code{vcov.}, then the computations are done without reference to the \code{model} argument. This is like assuming that \code{coef.} is normally distributed with estimated variance \code{vcov.} and the \code{linearHypothesis} will compute tests on the mean vector for \code{coef.}, without actually using the \code{model} argument.
A linear hypothesis for a multivariate linear model (i.e., an object of class "mlm") can optionally include an intra-subject transformation matrix for a repeated-measures design. If the intra-subject transformation is absent (the default), the multivariate test concerns all of the corresponding coefficients for the response variables. There are two ways to specify the transformation matrix for the repeated measures:

1. The transformation matrix can be specified directly via the `P` argument.
2. A data frame can be provided defining the repeated-measures factor or factors via `idata`, with default contrasts given by the `icontrasts` argument. An intra-subject model-matrix is generated from the one-sided formula specified by the `idesign` argument; columns of the model matrix corresponding to different terms in the intra-subject model must be orthogonal (as is insured by the default contrasts). Note that the contrasts given in `icontrasts` can be overridden by assigning specific contrasts to the factors in `idata`. The repeated-measures transformation matrix consists of the columns of the intra-subject model matrix corresponding to the term or terms in `iterms`. In most instances, this will be the simpler approach, and indeed, most tests of interests can be generated automatically via the `Anova` function.

`matchCoefs` is a convenience function that can sometimes help in formulating hypotheses; for example `matchCoefs(mod,"::")` will return the names of all interaction coefficients in the model `mod`.

Value

For a univariate model, an object of class "anova" which contains the residual degrees of freedom in the model, the difference in degrees of freedom, Wald statistic (either "F" or "Chisq"), and corresponding `p` value. The value of the linear hypothesis and its covariance matrix are returned respectively as "value" and "vcov" attributes of the object (but not printed).

For a multivariate linear model, an object of class "linearHypothesis.mlm", which contains sums-of-squares-and-product matrices for the hypothesis and for error, degrees of freedom for the hypothesis and error, and some other information.

The returned object normally would be printed.

Author(s)

Achim Zeileis and John Fox <jfox@mcmaster.ca>

References


See Also

`anova`, `Anova`, `waldtest`, `hccm`, `vcovHC`, `vcovHAC`, `coef`, `vcov`
linearHypothesis

Examples

mod.davis <- lm(weight ~ repwt, data=Davis)

## the following are equivalent:
linearHypothesis(mod.davis, diag(2), c(0,1))
linearHypothesis(mod.davis, c("(Intercept) = 0", "repwt = 1"))
linearHypothesis(mod.davis, c("(Intercept)", "repwt"), c(0,1))
linearHypothesis(mod.davis, c("(Intercept)", "repwt = 1"))

## use asymptotic Chi-squared statistic
linearHypothesis(mod.davis, c("(Intercept) = 0", "repwt = 1"), test = "Chisq")

## the following are equivalent:
## use HC3 standard errors via white.adjust option
linearHypothesis(mod.davis, c("(Intercept) = 0", "repwt = 1"),
                 white.adjust = TRUE)
## covariance matrix *function*
linearHypothesis(mod.davis, c("(Intercept) = 0", "repwt = 1"), vcov = hccm)
## covariance matrix *estimate*
linearHypothesis(mod.davis, c("(Intercept) = 0", "repwt = 1"),
                 vcov = hccm(mod.davis, type = "hc3"))

mod.duncan <- lm(prestige ~ income + education, data=Duncan)

## the following are all equivalent:
linearHypothesis(mod.duncan, "1*income - 1*education = 0")
linearHypothesis(mod.duncan, "income = education")
linearHypothesis(mod.duncan, "income - education")
linearHypothesis(mod.duncan, "1*income - 1*education = 0")
linearHypothesis(mod.duncan, "0 = 1*income - 1*education")
linearHypothesis(mod.duncan, "income-education=0")
linearHypothesis(mod.duncan, "1*income - 1*education + 1 = 1")
linearHypothesis(mod.duncan, "2income = 2*education")

mod.duncan.2 <- lm(prestige ~ type*(income + education), data=Duncan)
coefs <- names(coef(mod.duncan.2))

## test against the null model (i.e., only the intercept is not set to 0)
linearHypothesis(mod.duncan.2, coefs[-1])

## test all interaction coefficients equal to 0
linearHypothesis(mod.duncan.2, coefs[grep("::", coefs)], verbose=TRUE)
linearHypothesis(mod.duncan.2, matchCoefs(mod.duncan.2, "::"), verbose=TRUE) # equivalent
lh <- linearHypothesis(mod.duncan.2, coefs[grep("::", coefs)])
attr(lh, "value") # value of linear function
attr(lh, "vcov") # covariance matrix of linear function

## a multivariate linear model for repeated-measures data
## see ?OBrienKaiser for a description of the data set used in this example.
mod.ok <- lm(cbind(pre.1, pre.2, pre.3, pre.4, pre.5,
logit

Logit Transformation

Description

Compute the logit transformation of proportions or percentages.

Usage

logit(p, percents=range.p[2] > 1, adjust)
Arguments

- `p` numeric vector or array of proportions or percentages.
- `percents` TRUE for percentages.
- `adjust` adjustment factor to avoid proportions of 0 or 1; defaults to 0 if there are no such proportions in the data, and to 0.025 if there are.

Details

Computes the logit transformation \( \text{logit} = \log\left(\frac{p}{1 - p}\right) \) for the proportion \( p \).

If \( p = 0 \) or 1, then the logit is undefined. \texttt{logit} can remap the proportions to the interval \((\text{adjust}, 1 - \text{adjust})\) prior to the transformation. If it adjusts the data automatically, \texttt{logit} will print a warning message.

Value

a numeric vector or array of the same shape and size as \( p \).

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

\texttt{probabilityAxis}

Examples

```r
options(digits=4)
logit(.1*0:10)
## [1] -3.6636 -1.9924 -1.2950 -0.8001 -0.3847  0.0000  0.3847
## [8]  0.8001  1.2950  1.9924  3.6636
## Warning message:
## proportions remapped to (0.025, 0.975) in: logit(0.1 * 0:10)

logit(.1*0:10, adjust=0)
## [1] -Inf -2.1972 -1.3863 -0.8473 -0.4055  0.0000  0.4055
## [8]  0.8473  1.3863  2.1972  Inf
```
the mcPlots function draws two graphs or overlays the two graphs. For a response Y and a regressor X, the first plot is the marginal plot of Y versus X with both variables centered, visualizing the conditional distribution of Y given X ignoring all other regressors. The second plot is an added-variable for X after all other regressors, visualizing the conditional distribution of Y given X after adjusting for all other predictors. The added variable plot by default is drawn using the same xlim and ylim as the centered marginal plot to emphasize that conditioning removes variation in both the regressor and the response. The plot is primarily intended as a pedagogical tool for understanding coefficients in first-order models.

Usage

mcPlots(model, terms=~, layout=NULL, ask, overlaid=TRUE, ...)

mcPlot(model, ...)

## S3 method for class 'lm'
mcPlot(model, variable, id=FALSE, 
      col.marginal=carPalette()[2], col.conditional=carPalette()[3], 
      col.arrows="gray", pch = c(16,1), lwd = 2, grid=TRUE, 
      ellipse=FALSE, overlaid=TRUE, new=TRUE, title=TRUE, ...)

Arguments

model model object produced by lm.

terms A one-sided formula that specifies a subset of the predictors. One added-variable plot is drawn for each regressor and for each basis vector used to define a factor. For example, the specification terms = ~ . -X3 would plot against all terms except for X3. If this argument is a quoted name of one of the regressors or factors, the added-variable plot is drawn for that regressor or factor only. Unlike other car functions, the formula should include the names of regressors, not predictors. That is, if log(X4) is used to represent a predictor X4, the formula should specify terms = ~ log(X4).

variable A quoted string giving the name of a numeric predictor in the model matrix for the horizontal axis. To plot against a factor, you need to specify the full name of one of the indicator variables that define the factor. For example, for a factor called type with levels A, B and C, using the usual drop-first level parameterization of the factor, the regressors for type would be typeB or typeC. Similarly, to plot against the regressor log(X4), you must specify "log((X4)", not "X4".

layout If set to a value like c(1,2) or c(6,2), the layout of the graph will have this many rows and columns. If not set, behavior depends on the value of the overlaid argument; see the details
ask
If TRUE, ask the user before drawing the next plot; if FALSE don’t ask.

mcPlots passes these arguments to mcPlot. mcPlot passes arguments to plot.

id
controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to
list(method=list(abs(residuals(model,type="pearson"));",n=2,cex=1,col=carPalette()
which identifies the 2 points with the largest residuals and the 2 points with the
most extreme horizontal (X) values.

overlaid
If TRUE, the default, overlay the marginal and conditional plots on the same
graph; otherwise plot them side-by-side. See the details below

col.marginal, col.conditional
colors for points, lines, ellipses in the marginal and conditional plots, respec-

tively. The defaults are determined by the carPalette function.

col.arrows
color for the arrows with overlaid=TRUE

pch
Plotting character for marginal and conditional plots, respectively.

lwd
line width; default is 2 (see par).

grid
If TRUE, the default, a light-gray background grid is put on the graph.

ellipse
Arguments to pass to the dataEllipse function, in the form of a list with named
elements; e.g., ellipse.args=list(robust=TRUE)) will cause the ellipse to
be plotted using a robust covariance-matrix. if FALSE, the default, no ellipse
is plotted. TRUE is equivalent to ellipse=list(levels=0.5), which plots a
bivariate-normal 50 percent concentration ellipse.

new
if TRUE, the default, the plot window is reset when overlaid=FALSE using
par{mfrow=c(1,2)}. If FALSE, the layout of the plot window is not reset. Users
will ordinarily ignore this argument.

title
If TRUE, the default, the standard main argument in plot is used to add a stan-
dard title to each plot. If FALSE no title is used.

Details
With an lm object, suppose the response is Y, X is a numeric regressor of interest, and Z is all
the remaining predictors, possibly including interactions and factors. This function produces two
graphs. The first graph is the marginal plot of Y versus X, with each variable centered around
its mean. The second conditional plot is the added-variable plot of e(Y|Z) versus e(X|Z) where
e(a|b) means the Pearson residuals from the regression of a on b. If overlaid=TRUE, these two
plots are overlaid in one graph, with the points in different colors. In addition, each point in the
marginal plot is joined to its value in the conditional plot by an arrow. Least squares regression
lines fit to the marginal and conditional graphs are also shown; data ellipsoids can also be added.
If overlaid=FALSE, then the two graphs are shown in side-by-side plots as long as the second
argument to layout is equal to 2, or layout is set by the function. The arrows are omitted if the
graphs are not overlaid.

These graphs are primarily for teaching, as the marginal plot shows the relationship between Y and
X ignoring Z, while the conditional is the relationship between Y and X given X. By keeping the
scales the same in both graphs the effect of conditioning on both X and Y can be visualized.

This function is intended for first-order models with numeric predictors only. For a factor, one (pair)
of mcPlots will be produced for each of the dummy variables in the basis for the factor, and the
resulting plots are not generally meaningful because they depend on parameterization. If the mean function includes interactions, then mcPlots for main effects may violate the hierarchy principle, and may also be of little interest. mcPlots for interactions of numerical predictors, however, can be useful.

These graphs are closely related to the ARES plots proposed by Cook and Weisberg (1989). This plot would benefit from animation.

Value

These functions are used for their side effect of producing plots.

Author(s)

John Fox <jfox@mcmaster.ca>, Sanford Weisberg <sandy@umn.edu>

References


See Also

`avPlots, residualPlots, crPlots, ceresPlots, dataEllipse`

Examples

```r
m1 <- lm(partic ~ tfr + menwage + womwage + debt + parttime, data = Bfox)
mcPlot(m1, "womwage")
mcPlot(m1, "womwage", overlaid=FALSE, ellipse=TRUE)
```

**mmps**

Marginal Model Plotting

Description

For a regression object, draw a plot of the response on the vertical axis versus a linear combination $u$ of regressors in the mean function on the horizontal axis. Added to the plot are a smooth for the graph, along with a smooth from the plot of the fitted values on $u$. mmps is an alias for marginalModelPlots, and mmp is an alias for marginalModelPlot.
Usage

marginalModelPlots(...)

mmps(model, terms= ~ ., fitted=TRUE, layout=NULL, ask,
main, groups, key=TRUE, ...)

marginalModelPlot(...)

mmp(model, ...)

## S3 method for class 'lm'
mmp(model, variable, sd = FALSE,
xlab = deparse(substitute(variable)),
smooth=TRUE, key=TRUE, pch, groups=NULL, ...)

## Default S3 method:
mmp(model, variable, sd = FALSE,
xlab = deparse(substitute(variable)), ylab, smooth=TRUE,
key=TRUE, pch, groups=NULL,
col.line = carPalette()[c(2, 8)], col=carPalette()[1],
id=FALSE, grid=TRUE, ...)

## S3 method for class 'glm'
mmp(model, variable, sd = FALSE,
xlab = deparse(substitute(variable)), ylab,
smooth=TRUE, key=TRUE, pch, groups=NULL,
col.line = carPalette()[c(2, 8)], col=carPalette()[1],
id=FALSE, grid=TRUE, ...)

Arguments

model A regression object, usually of class either lm or glm, for which there is a predict method defined.

terms A one-sided formula. A marginal model plot will be drawn for each term on the right-side of this formula that is not a factor. The default is ~ ., which specifies that all the terms in formula(object) will be used. If a conditioning argument is given, eg terms = ~ . | a, then separate colors and smoothers are used for each unique non-missing value of a. See examples below.

fitted If TRUE, the default, then a marginal model plot in the direction of the fitted values for a linear model or the linear predictor of a generalized linear model will be drawn.

layout If set to a value like c(1,1) or c(4,3), the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If layout=NA, the function does not set the layout and the user can use the par function to control the layout, for example to have plots from two models in the same graphics window.
ask
If TRUE, ask before clearing the graph window to draw more plots.

main
Main title for the array of plots. Use main="" to suppress the title; if missing, a title will be supplied.

...
Additional arguments passed from mmps to mmp and then to plot. Users should generally use mmps, or equivalently marginalModelPlots.

variable
The quantity to be plotted on the horizontal axis. If this argument is missing, the horizontal variable is the linear predictor, returned by predict(object) for models of class lm, with default label "Fitted values", or returned by predict(object,type="link") for models of class glm, with default label "Linear predictor". It can be any other vector of length equal to the number of observations in the object. Thus the mmp function can be used to get a marginal model plot versus any regressor or predictor while the mmps function can be used only to get marginal model plots for the first-order regressors in the formula. In particular, terms defined by a spline basis are skipped by mmps, but you can use mmp to get the plot for the variable used to define the splines.

sd
If TRUE, display sd smooths. For a binomial regression with all sample sizes equal to one, this argument is ignored as the SD bounds don’t make any sense.

xlab
label for horizontal axis.

ylab
label for vertical axis, defaults to name of response.

smooth
specifies the smoother to be used along with its arguments; if FALSE, no smoother is shown; can be a list giving the smoother function and its named arguments; TRUE, the default, is equivalent to list(smoother=loessLine,span=2/3) for linear models and list(smoother=gamLine,k=3) for generalized linear models. See ScatterplotSmoothers for the smoothers supplied by the car package and their arguments; the spread argument is not supported for marginal model plots.

groups
The name of a vector that specifies a grouping variable for separate colors/smoothers. This can also be specified as a conditioning argument on the terms argument.

key
If TRUE, include a key at the top of the plot, if FALSE omit the key. If grouping is present, the key is only printed for the upper-left plot.

id
controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method="y",n=2,cex=1,col=carPalette()[1],location="lr"), which identifies the 2 points with the most unusual response (Y) values.

pch
plotting character to use if no grouping is present.

col.line
colors for data and model smooth, respectively. The default is to use carPalette, carPalette()[c(2,8)], blue and red.

col
color(s) for the plotted points.

grid
If TRUE, the default, a light-gray background grid is put on the graph.

Details
mmp and marginalModelPlot draw one marginal model plot against whatever is specified as the horizontal axis. mmps and marginalModelPlots draws marginal model plots versus each of the
terms in the \texttt{terms} argument and versus fitted values. \texttt{mmps} skips factors and interactions if they are specified in the \texttt{terms} argument. Terms based on polynomials or on splines (or potentially any term that is represented by a matrix of regressors) will be used to form a marginal model plot by returning a linear combination of the terms. For example, if you specify \texttt{terms = ~ X1 + poly(X2, 3)} and \texttt{poly(X2, 3)} was part of the original model formula, the horizontal axis of the marginal model plot for \texttt{X2} will be the value of \texttt{predict(model,type="terms")[,\text{"poly(X2, 3)"}].} If the predict method for the model you are using doesn’t support \texttt{type="terms"}, then the polynomial/spline term is skipped. Adding a conditioning variable, e.g., \texttt{terms = ~ a + b | c}, will produce marginal model plots for \texttt{a} and \texttt{b} with different colors and smoothers for each unique non-missing value of \texttt{c}.

For linear models, the default smoother is loess. For generalized linear models, the default smoother uses \texttt{gamLine}, fitting a generalized additive model with the same family, link and weights as the fit of the model. SD smooths are not computed for for generalized linear models.

For generalized linear models the default number of elements in the spline basis is \texttt{k=3}; this is done to allow fitting for predictors with just a few support points. If you have many support points you may wish to set \texttt{k} to a higher number, or \texttt{k=-1} for the default used by \texttt{gam}.

\textbf{Value}

Used for its side effect of producing plots.

\textbf{Author(s)}

Sanford Weisberg, <sandy@umn.edu>

\textbf{References}


\textbf{See Also}

\texttt{ScatterplotSmoothers, plot}

\textbf{Examples}

\begin{verbatim}
c1 <- lm(infantMortality ~ ppgdp, UN)
mmps(c1)
c2 <- update(c1, ~ log(ppgdp))
mmps(c2)
# include SD lines
p1 <- lm(prestige ~ income + education, Prestige)
mmps(p1, sd=TRUE)
# condition on type:
mmps(p1, ~ . | type)
# logistic regression example
# smoothers return warning messages.
# fit a separate smoother and color for each type of occupation.
\end{verbatim}
m1 <- glm(lfp ~ ., family=binomial, data=Mroz)
mmps(m1)

ncvTest

Score Test for Non-Constant Error Variance

Description
Computes a score test of the hypothesis of constant error variance against the alternative that the error variance changes with the level of the response (fitted values), or with a linear combination of predictors.

Usage
ncvTest(model, ...)
## S3 method for class 'lm'
ncvTest(model, var.formula, ...)
## S3 method for class 'glm'
ncvTest(model, ...) # to report an error

Arguments
model a weighted or unweighted linear model, produced by lm.
var.formula a one-sided formula for the error variance; if omitted, the error variance depends on the fitted values.
... arguments passed down to methods functions; not currently used.

Details
This test is often called the Breusch-Pagan test; it was independently suggested with some extension by Cook and Weisberg (1983).
ncvTest.glm is a dummy function to generate an error when a glm model is used.

Value
The function returns a chisqTest object, which is usually just printed.

Author(s)
John Fox <jfox@mcmaster.ca>, Sandy Weisberg <sandy@umn.edu>
References


See Also

*hccm*, *spreadLevelPlot*

Examples

```r
ncvTest(lm(interlocks ~ assets + sector + nation, data=Ornstein))
ncvTest(lm(interlocks ~ assets + sector + nation, data=Ornstein), ~ assets + sector + nation, data=Ornstein)
```

---

**outlierTest**

**Bonferroni Outlier Test**

Description

Reports the Bonferroni p-values for testing each observation in turn to be a mean-shift outlier, based on Studentized residuals in linear (t-tests), generalized linear models (normal tests), and linear mixed models.

Usage

```r
outlierTest(model, ...)
```

## S3 method for class ‘lm’
outlierTest(model, cutoff=0.05, n.max=10, order=TRUE, labels=names(rstudent), ...)

## S3 method for class ‘lmerMod’
outlierTest(model, ...)

## S3 method for class ‘outlierTest’
print(x, digits=5, ...)
Arguments

model: an `lm`, `glm`, or `lmerMod` model object; the "lmerMod" method calls the "lm" method and can take the same arguments.
cutoff: observations with Bonferroni p-values exceeding `cutoff` are not reported, unless no observations are nominated, in which case the one with the largest Studentized residual is reported.
n.max: maximum number of observations to report (default, 10).
order: report Studentized residuals in descending order of magnitude? (default, TRUE).
labels: an optional vector of observation names.
... arguments passed down to methods functions.
x: `outlierTest` object.
digits: number of digits for reported p-values.

details

For a linear model, p-values reported use the t distribution with degrees of freedom one less than the residual df for the model. For a generalized linear model, p-values are based on the standard-normal distribution. The Bonferroni adjustment multiplies the usual two-sided p-value by the number of observations. The `lm` method works for `glm` objects. To show all of the observations set `cutoff=Inf` and `n.max=Inf`.

value

an object of class `outlierTest`, which is normally just printed.

Author(s)

John Fox <jfox@mcmaster.ca> and Sanford Weisberg

References


Examples

```r
outlierTest(lm(prestige ~ income + education, data=Duncan))
```
panel.car  

Panel Function for Coplots

Description

A panel function for use with coplot that plots points, a lowess line, and a regression line.

Usage

```r
panel.car(x, y, col, pch, cex=1, span=0.5, lwd=2,
           reg.line=lm, lowess.line=TRUE, ...)
```

Arguments

- `x` vector giving horizontal coordinates.
- `y` vector giving vertical coordinates.
- `col` point color.
- `pch` plotting character for points.
- `cex` character expansion factor for points.
- `span` span for lowess smoother.
- `lwd` line width, default is 2.
- `reg.line` function to compute coefficients of regression line, or FALSE for no line.
- `lowess.line` if TRUE plot lowess smooth.
- `...` other arguments to pass to functions lines and regLine.

Value

NULL. This function is used for its side effect: producing a panel in a coplot.

Author(s)

John Fox <jfox@mcmaster.ca>

See Also

coplot, regLine

Examples

```r
coplot(prestige ~ income|education, panel=panel.car,
       col="red", data=Prestige)
```
poTest

Test for Proportional Odds in the Proportional-Odds Logistic-Regression Model

Description

The poTest function implements tests proposed by Brant (1990) for proportional odds for logistic models fit by the polr function in the MASS package.

Usage

poTest(model, ...)
## S3 method for class 'polr'
poTest(model, ...)
## S3 method for class 'poTest'
print(x, digits=3, ...)

Arguments

model  a proportional-odds logit model fit by polr.
x      an object produced by poTest.
digits number of significant digits to print.
...    ignored.

Value

poTest returns an object meant to be printed showing the results of the tests.

Author(s)

John Fox <jfox@mcmaster.ca>

References


Examples

if (require("MASS")){
  .W <- Women1f
  .W$partic <- factor(.W$partic, levels=c("not.work", "parttime", "fulltime"))
  poTest(polr(partic ~ hincome + children + region, data=.W))
}


Finding Univariate or Multivariate Power Transformations

Description

powerTransform uses the maximum likelihood-like approach of Box and Cox (1964) to select a transformation of a univariate or multivariate response for normality, linearity and/or constant variance. Available families of transformations are the default Box-Cox power family and two additional families that are modifications of the Box-Cox family that allow for (a few) negative responses. The summary method automatically computes two or three likelihood ratio type tests concerning the transformation powers.

Usage

powerTransform(object, ...)  
## Default S3 method:  
powerTransform(object, family="bcPower", ...)  
## S3 method for class 'lm'  
powerTransform(object, family="bcPower", ...)  
## S3 method for class 'formula'  
powerTransform(object, data, subset, weights, na.action,  
   family="bcPower", ...)  
## S3 method for class 'lmerMod'  
powerTransform(object, family="bcPower", ...)

Arguments

object This can either be an object of class lm or lmerMod, a formula, or a matrix or vector; see below.
family The quoted name of a family of transformations. The available options are "bcPower" for the default for the Box-Cox power family; "bcnPower" for a two-parameter modification of the Box-Cox family that allows negative responses (Hawkins and Weisberg (2017)), and the "yjPower" family (Yeo and Johnson(2000)), another modification of the Box-Cox family that allows a few negative values. All three families are documented at bcPower.
data A data frame or environment, as in 'lm'.
subset Case indices to be used, as in 'lm'.
weights Weights as in 'lm'.
a.action Missing value action, as in 'lm'.
... Additional arguments that used in the interative algorithm; defaults are generally adequate. For use with the bcnPower family, a convergence criterion can be set with conv=.0001 the default, and a minimum positive value of the location parameter can be set, with default gamma.min=.1.
**powerTransform**

**Details**

This function implements the Box and Cox (1964) method of selecting a power transformation of a variable toward normality, and its generalization by Velilla (1993) to a multivariate response. Cook and Weisberg (1999) and Weisberg (2014) suggest the usefulness of transforming a set of predictors \( z_1, z_2, z_3 \) for multivariate normality. It also includes two additional families that allow for negative values.

If the object argument is of class ‘lm’ or ‘lmerMod’, the Box-Cox procedure is applied to the conditional distribution of the response given the predictors. For ‘lm’ objects, the response may be multivariate, and each column will have its own transformation. With ‘lmerMod’ the response must be univariate.

The object argument may also be a formula. For example, \( z \sim x_1 + x_2 + x_3 \) will estimate a transformation for the response \( z \) from a family after fitting a linear model with the given formula. \( \text{cbind}(y_1,y_2,y_3) \sim 1 \) specifies transformations to multivariate normality with no predictors. A vector value for object, for example `powerTransform(ais$LBM)` is equivalent to `powerTransform(LBM ~ 1,ais)`. Similarly, `powerTransform(cbind(ais$LBM,ais$SSF))`, where the first argument is a matrix rather than a formula is equivalent to specification of a multivariate linear model `powerTransform(cbind(LBM,SSF) ~ 1,ais)`.

Three families of power transformations are available. The default Box-Cox power family (`family="bcPower"`) of power transformations effectively replaces a vector by that vector raised to a power, generally in the range from -3 to 3. For powers close to zero, the log-transformation is suggested. In practical situations, after estimating a power using the `powerTransform` function, a variable would be replaced by a simple power transformation of it, for example, if \( \lambda \approx 0.5 \), then the corresponding variable would be replaced by its square root; if \( \lambda \) is close enough to zero, the the variable would be replaced by its natural logarithm. The Box-Cox family requires the responses to be strictly positive.

The `family="bcnPower"`, or Box-Cox with negatives, family proposed by Hawkins and Weisberg (2017) allows for (a few) non-positive values, while allowing for the transformed data to be interpreted similarly to the interpretation of Box-Cox transformed values. This family is the Box-Cox transformation of \( z = 0.5 \times (y + (y^2 + \gamma^2)^{1/2}) \) that depends on a location parameter \( \gamma \). The quantity \( z \) is positive for all values of \( y \). If \( \gamma = 0 \) and \( y \) is strictly positive, then the Box-Cox and the bcnPower transformations are identical. When fitting the Box-Cox with negatives family, \( \lambda \) is restricted to the range [-3, 3], and \( \gamma \) is restricted to the range from gamma.min=1 to the largest positive value of the variable, since values outside these ranges are unreasonable in practice. The value of gamma.min can be changed with an argument to `powerTransform`.

The final family `family="yjPower"` uses the Yeo-Johnson transformation, which is the Box-Cox transformation of \( U + 1 \) for nonnegative values, and of \( |U| + 1 \) with parameter \( 2 - \lambda \) for \( U \) negative and thus it provides a family for fitting when (a few) observations are negative. Because of the unusual constraints on the powers for positive and negative data, this transformation is not used very often, as results are difficult to interpret. In practical problems, a variable would be replaced by its Yeo-Johnson transformation computed using the `yjPower` function.

The function `testTransform` is used to obtain likelihood ratio tests for any specified value for the transformation parameter(s).

Computations maximize the likelihood-like functions described by Box and Cox (1964) and by Velilla (1993). For univariate responses, the computations are very stable and problems are unlikely, although for ‘lmer’ models computations may be very slow because the model is refit many times. For multivariate responses with the bcnPower family, the computing algorithm may fail. In this case we recommend adding the argument `itmax = 1` to the call to `powerTransform`. This will return the
starting value estimates of the transformation parameters, fitting a d-dimensional response as if all the d responses were independent.

**Value**

An object of class `powerTransform` or class `bcnPowerTransform` if `family="bcnPower"` that inherits from `powerTransform` is returned, including the components listed below.

A summary method presents estimated values for the transformation power `lambda` and for the `bcnPower` family the location parameter `gamma` as well. Standard errors and Wald 95% confidence intervals based on the standard errors are computed from the inverse of the sample Hessian matrix evaluated at the estimates. The interval estimates for the `gamma` parameters will generally be very wide, reflecting little information available about the location parameter. Likelihood ratio type tests are also provided. For the `bcnPower` family these are based on the profile loglikelihood for `lambda` alone; that is, we treat `gamma` as a nuisance parameter and average over it.

The components of the returned object includes

- `lambda`: Estimated transformation parameter
- `roundlam`: Convenient rounded values for the estimates. These rounded values will usually be the desired transformations.
- `gamma`: Estimated location parameters for `bcnPower`, NULL otherwise
- `invHess`: Estimated covariance matrix of the estimated parameters
- `llik`: Value of the log-likelihood at the estimates

The summary method for `powerTransform` returns an array with columns labeled "Est Power" for the value of `lambda` that maximizes the likelihood; "Rounded Pwr" for `roundlam`, and columns "Wald Lwr Bnd" and "Wald Ur Bnd" for a 95 percent Wald normal theory confidence interval for `lambda` computed as the estimate plus or minus 1.96 times the standard error.

**Author(s)**

Sanford Weisberg, <sandy@umn.edu>

**References**


powerTransform

See Also
testTransform, bcPower, bcnPower, transform, optim, boxCox.

Examples

# Box Cox Method, univariate
summary(p1 <- powerTransform(cycles ~ len + amp + load, Wool))
# fit linear model with transformed response:
coef(p1, round=TRUE)
summary(m1 <- lm(bcPower(cycles, p1$roundlam) ~ len + amp + load, Wool))

# Multivariate Box Cox uses Highway1 data
summary(powerTransform(cbind(len, adt, trks, sigs1) ~ 1, Highway1))

# Multivariate transformation to normality within levels of htype
summary(a3 <- powerTransform(cbind(len, adt, trks, sigs1) ~ htype, Highway1))
# test lambda = (0 0 0 -1)
testTransform(a3, c(0, 0, 0, -1))

# save the rounded transformed values, plot them with a separate
# color for each highway type
transformedY <- bcPower(with(Highway1, cbind(len, adt, trks, sigs1)),
                      coef(a3, round=TRUE))
## Not run: scatterplotMatrix(~ transformedY|htype, Highway1)

# With negative responses, use the bcnPower family
m2 <- lm(I1L1 ~ pool, LoBD)
summary(p2 <- powerTransform(m2, family="bcnPower")
testTransform(p2, .5)
summary(powerTransform(update(m2, cbind(LoBD$I1L2, LoBD$I1L1) ~ .), family="bcnPower"))

## Not run:
# takes a few seconds:
# multivariate bcnPower, with 8 responses
summary(powerTransform(update(m2, as.matrix(LoBD[, -1]) ~ .), family="bcnPower"))
# multivariate bcnPower, fit with one iteration using starting values as estimates
summary(powerTransform(update(m2, as.matrix(LoBD[, -1]) ~ .), family="bcnPower", itmax=1))
## End(Not run)

# mixed effects model
## Not run:
# uses the lme4 package
data <- reshape(LoBD[1:20, ], varying=names(LoBD)[-1], direction="long", v.names="y")
names(data) <- c("pool", "assay", "y", "id")
data$assay <- factor(data$assay)
require(lme4)
m2 <- lmer(y ~ pool + (1|assay), data)
summary(l2 <- powerTransform(m2, family="bcnPower", verbose=TRUE))
## End(Not run)
Predict is a generic function with, at present, a single method for "lm" objects, \texttt{Predict.lm}, which is a modification of the standard \texttt{predict.lm} method in the \texttt{stats} package, but with an additional \texttt{vcov.} argument for a user-specified covariance matrix for interval estimation.

\textbf{Usage}

\begin{verbatim}
Predict(object, ...) 
\end{verbatim}

\begin{verbatim}
## S3 method for class 'lm'
Predict(object, newdata, se.fit = FALSE,
   scale = NULL, df = Inf,
   interval = c("none", "confidence", "prediction"),
   level = 0.95, type = c("response", "terms"),
   terms = NULL, na.action = na.pass,
   pred.var = res.var/weights, weights = 1, vcov., ...)
\end{verbatim}

\textbf{Arguments}

- \texttt{object} a model object for which predictions are desired.
- \texttt{newdata, se.fit, scale, df, interval, level, type, terms, na.action, pred.var, weights} see \texttt{predict.lm}.
- \texttt{vcov.} optional, either a function to compute the coefficient covariance matrix of object (e.g., \texttt{hccm}) or a coefficient covariance matrix (as returned, e.g., by \texttt{hccm}).
- \texttt{...} arguments to pass down to \texttt{Predict} or \texttt{predict} methods.

\textbf{Details}

If there is no appropriate method for \texttt{Predict}, then a \texttt{predict} method is invoked. If there is a specific \texttt{predict} method for the primary class of \texttt{object} but only an inherited \texttt{Predict} method, then the predict method is invoked. Thus an object of class c("glm", "lm") will invoke method \texttt{predict.glm} rather than \texttt{Predict.lm}, but an object of class c("aov", "lm") will invoke \texttt{Predict.lm} rather than \texttt{predict.lm}.

\textbf{Value}

See \texttt{predict} and \texttt{predict.lm}.

\textbf{Author(s)}

John Fox <jfox@mcmaster.ca>
References

See Also
predict, predict.lm

Examples
mod <- lm(interlocks ~ log(assets), data=Ornstein)
newd <- data.frame(assets=exp(4:12))
(p1 <- predict(mod, newd, interval="prediction"))
p2 <- Predict(mod, newd, interval="prediction", vcov.=vcov)
all.equal(p1, p2) # the same

(p3 <- predict(mod, newd, se=TRUE, vctype="hccm")) # larger SEs
(p4 <- Predict(mod, newd, se=TRUE, vctype="hccm(mod, type="hc3")")
all.equal(p3, p4) # the same

qqPlot

Quantile-Comparison Plot

Description
Plots empirical quantiles of a variable, or of studentized residuals from a linear model, against theoretical quantiles of a comparison distribution. Includes options not available in the qqnorm function.

Usage
qqPlot(x, ...)
qqp(...)

# Default S3 method:
qqPlot(x, distribution="norm", groups, layout,
ylim=range(x, na.rm=TRUE), ylab=deparse(substitute(x)),
xlab=paste(distribution, "quantiles"), glab=deparse(substitute(groups)),
main=NULL, las=par("las"),
envelope=.95, col=carPalette()[1], col.lines=carPalette()[2],
lwd=2, pch=1, cex=par("cex"),
line=c("quartiles", "robust", "none"), id=TRUE, grid=TRUE, ...)

# S3 method for class 'formula'
qqPlot(formula, data, subset, id=TRUE, ylab, glab, ...)

# S3 method for class 'lm'
qqPlot(x, xlab=paste(distribution, "Quantiles"),
    ylab=paste("Studentized Residuals(",
        deparse(substitute(x)), ",")", sep=""),
    main=NULL, distribution=c("t", "norm"),
    line=c("robust", "quartiles", "none"), las=par("las"),
    simulate=TRUE, envelope=.95, reps=100,
    col=carPalette()[1], col.lines=carPalette()[2], lwd=2, pch=1, cex=par("cex"),
    id=TRUE, grid=TRUE, ...)

Arguments

x vector of numeric values or lm object.

distribution root name of comparison distribution – e.g., "norm" for the normal distribution; t for the t-distribution.

groups an optional factor; if specified, a QQ plot will be drawn for x within each level of groups.

layout a 2-vector with the number of rows and columns for plotting by groups – for example c(1,3) for 1 row and 3 columns; if omitted, the number of rows and columns will be selected automatically; the specified number of rows and columns must be sufficient to accomodate the number of groups; ignored if there is no grouping factor.

formula one-sided formula specifying a single variable to be plotted or a two-sided formula of the form variable ~ factor, where a QQ plot will be drawn for variable within each level of factor.

data optional data frame within which to evaluate the formula.

subset optional subset expression to select cases to plot.

ylim limits for vertical axis; defaults to the range of x. If plotting by groups, a common y-axis is used for all groups.

ylab label for vertical (empirical quantiles) axis.

xlab label for horizontal (comparison quantiles) axis.

glab label for the grouping variable.

main label for plot.

envelope confidence level for point-wise confidence envelope, or FALSE for no envelope.

las if 0, ticks labels are drawn parallel to the axis; set to 1 for horizontal labels (see par).

col color for points; the default is the first entry in the current car palette (see carPalette and par).

col.lines color for lines; the default is the second entry in the current car palette.

pch plotting character for points; default is 1 (a circle, see par).

cex factor for expanding the size of plotted symbols; the default is 1.

id controls point identification; if FALSE, no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method="y",n=2,cex=1,col=)

which identifies the 2 points with the 2 points with the most extreme vertical values — studentized residuals for the "lm" method. Points labels are by default
taken from the names of the variable being plotted is any, else case indices are used. Unlike most graphical functions in car, the default is id=TRUE to include point identification.

**lwd**
line width; default is 2 (see par).

**line**
"quartiles" to pass a line through the quartile-pairs, or "robust" for a robust-regression line; the latter uses the rlm function in the MASS package. Specifying line = "none" suppresses the line.

**simulate**
if TRUE calculate confidence envelope by parametric bootstrap; for lm object only. The method is due to Atkinson (1985).

**reps**
integer; number of bootstrap replications for confidence envelope.

**...**
arguments such as df to be passed to the appropriate quantile function.

**grid**
If TRUE, the default, a light-gray background grid is put on the graph

**Details**

Draws theoretical quantile-comparison plots for variables and for studentized residuals from a linear model. A comparison line is drawn on the plot either through the quartiles of the two distributions, or by robust regression.

Any distribution for which quantile and density functions exist in R (with prefixes q and d, respectively) may be used. When plotting a vector, the confidence envelope is based on the SEs of the order statistics of an independent random sample from the comparison distribution (see Fox, 2016). Studentized residuals from linear models are plotted against the appropriate t-distribution with a point-wise confidence envelope computed by default by a parametric bootstrap, as described by Atkinson (1985). The function qqp is an abbreviation for qqPlot.

**Value**

These functions return the labels of identified points, unless a grouping factor is employed, in which case NULL is returned invisibly.

**Author(s)**

John Fox <jfox@mcmaster.ca>

**References**


**See Also**

qqplot, qnorm, qline, showLabels
Examples

```r
x<-rchisq(100, df=2)
qqPlot(x)
qqPlot(x, dist="chisq", df=2)

qqPlot(~ income, data=Prestige, subset = type == "prof")
qqPlot(income ~ type, data=Prestige, layout=c(1, 3))

qqPlot(lm(prestige ~ income + education + type, data=Duncan),
envelope=.99)
```

---

recode  

Recode a Variable

Description

Recodes a numeric vector, character vector, or factor according to simple recode specifications. Recode is an alias for recode that avoids name clashes with packages, such as Hmisc, that have a recode function.

Usage

```r
recode(var, recodes, as.factor, as.numeric=TRUE, levels)
```

Recode(...)  

Arguments

`var`  
numeric vector, character vector, or factor.

`recodes`  
character string of recode specifications: see below.

`as.factor`  
return a factor; default is TRUE if var is a factor, FALSE otherwise.

`as.numeric`  
if TRUE (the default), and as.factor is FALSE, then the result will be coerced to numeric if all values in the result are numerals—i.e., represent numbers.

`levels`  
an optional argument specifying the order of the levels in the returned factor; the default is to use the sort order of the level names.

`...`  
arguments to be passed to recode.

Details

Recode specifications appear in a character string, separated by semicolons (see the examples below), of the form `input=output`. If an input value satisfies more than one specification, then the first (from left to right) applies. If no specification is satisfied, then the input value is carried over to the result. `NA` is allowed on input and output. Several recode specifications are supported:

**single value**  
For example, `0=NA`.

**vector of values**  
For example, `c(7,8,9)='high'`. 
range of values For example, 7:9='C'. The special values lo and hi may appear in a range. For example, lo:10=1. Note: : is not the R sequence operator. In addition you may not use : with the collect operator, so for example c(1,3,5:7) will cause an error.
else everything that does not fit a previous specification. For example, else=NA. Note that else matches all otherwise unspecified values on input, including NA.
If all of the output values are numeric, and if as.factor is FALSE, then a numeric result is returned; if var is a factor, then by default so is the result.

Value
a recoded vector of the same length as var.

Author(s)
John Fox <jfox@mcmaster.ca>

References

See Also
cut, factor

Examples
x<-rep(1:3,3)
x
## [1] 1 2 3 1 2 3 1 2 3
recode(x, "c(1,2)="A";
else="B")
## [1] "A" "A" "B" "A" "A" "B" "A" "A" "B"
Recode(x, "1:2=\'A\'; 3=\'B\'")
## [1] "A" "A" "B" "A" "A" "B" "A" "A" "B"

regLine

Plot Regression Line

Description
Plots a regression line on a scatterplot; the line is plotted between the minimum and maximum x-values.

Usage
regLine(mod, col=carPalette()[2], lwd=2, lty=1,...)
### Arguments

- **mod**: a model, such as produced by `lm`, that responds to the `coef` function by returning a 2-element vector, whose elements are interpreted respectively as the intercept and slope of a regression line.
- **col**: color for points and lines; the default is the second entry in the current `car` palette (see `carPalette` and `par`).
- **lwd**: line width; default is 2 (see `par`).
- **lty**: line type; default is 1, a solid line (see `par`).
- **...**: optional arguments to be passed to the `lines` plotting function.

### Details

In contrast to `abline`, this function plots only over the range of the observed x-values. The x-values are extracted from `mod` as the second column of the model matrix.

### Value

NULL. This function is used for its side effect: adding a line to the plot.

### Author(s)

John Fox <jfox@mcmaster.ca>

### See Also

- `abline`, `lines`

### Examples

```r
plot(repwt ~ weight, pch=c(1,2)[sex], data=Davis)
regLine(lm(repwt~weight, subset=sex=="M", data=Davis))
regLine(lm(repwt~weight, subset=sex=="F", data=Davis), lty=2)
```

---

**residualPlots**

**Residual Plots for Linear and Generalized Linear Models**

### Description

Plots the residuals versus each term in a mean function and versus fitted values. Also computes a curvature test for each of the plots by adding a quadratic term and testing the quadratic to be zero. For linear models, this is Tukey’s test for nonadditivity when plotting against fitted values.
Usage

### This is a generic function with only one required argument:

residualPlots (model, ...)

## Default S3 method:
residualPlots(model, terms = ~., layout = NULL, ask,
              main = "", fitted = TRUE, AsIs=TRUE, plot = TRUE,
              tests = TRUE, groups, ...)

## S3 method for class 'lm'
residualPlots(model, ...)

## S3 method for class 'glm'
residualPlots(model, ...)

### residualPlots calls residualPlot, so these arguments can be
### used with either function

residualPlot(model, ...)

## Default S3 method:
residualPlot(model, variable = "fitted", type = "pearson",
              groups, plot = TRUE, linear = TRUE,
              quadratic = if(missing(groups)) TRUE else FALSE,
              smooth=FALSE, id=FALSE,
              col = carPalette()[1], col.quad = carPalette()[2], pch=1,
              xlab, ylab, lwd = 1, lty = 1,
              grid=TRUE, key=!missing(groups), ...)

## S3 method for class 'lm'
residualPlot(model, ...)

## S3 method for class 'glm'
residualPlot(model, variable = "fitted", type = "pearson",
              plot = TRUE, quadratic = FALSE, smooth=TRUE, ...)

Arguments

model A regression object.
terms A one-sided formula that specifies a subset of the factors and the regressors that appear in the formula that defined the model. The default ~ . is to plot against all first-order terms, both regressors and factors. Higher order terms are skipped. For example, the specification terms = ~ . -X3 would plot against all regressors except for X3. To get a plot against fitted values only, use the arguments terms = ~ 1. Interactions are skipped. For polynomial terms, the plot is against the first-order variable (which may be centered and scaled depending on how the poly function is used). Plots against factors are boxplots. Plots against other matrix
terms, like splines, use the result of `predict(model, type="terms")[, variable]` as the horizontal axis; if the predict method doesn’t permit this type, then matrix terms are skipped.

A grouping variable can also be specified in the terms, so, for example `terms=~ .|type` would use the factor `type` to set a different color and symbol for each level of type. Any fits in the plots will also be done separately for each level of group.

- **layout**: If set to a value like `c(1,1)` or `c(4,3)`, the layout of the graph will have this many rows and columns. If not set, the program will select an appropriate layout. If the number of graphs exceed nine, you must select the layout yourself, or you will get a maximum of nine per page. If `layout=NA`, the function does not set the layout and the user can use the `par` function to control the layout, for example to have plots from two models in the same graphics window.

- **ask**: If `TRUE`, ask the user before drawing the next plot; if `FALSE`, don’t ask.

- **main**: Main title for the graphs. The default is `main=""` for no title.

- **fitted**: If `TRUE`, the default, include the plot against fitted values.

- **AsIs**: If `FALSE`, terms that use the “as-is” function `I` are skipped; if `TRUE`, the default, they are included.

- **plot**: If `TRUE`, draw the plot(s).

- **tests**: If `TRUE`, display the curvature tests. With glm’s, the argument `start` is ignored in computing the curvature tests.

- **...**: Additional arguments passed to `residualPlot` and then to `plot`.

- **variable**: Quoted variable name for the factor or regressor to be put on the horizontal axis, or the default "fitted" to plot versus fitted values.

- **type**: Type of residuals to be used. Pearson residuals are appropriate for `lm` objects since these are equivalent to ordinary residuals with ols and correctly weighted residuals with wls. Any quoted string that is an appropriate value of the type argument to `residuals.lm` or "rstudent" or "rstandard" for Studentized or standardized residuals.

- **groups**: A grouping indicator. Points in different groups will be plotted with different colors and symbols. If missing, no grouping is used. In `residualPlots`, the grouping variable can also be set in the `terms` argument, as described above. The default is no grouping. If used, the groups argument should be a vector of values of the same length as the vector of residuals, for example `groups = subject` where subject indicates the grouping.

- **linear**: If `TRUE`, adds a horizontal line at zero if no groups. With groups, display the within level of groups ols regression of the residuals as response and the horizontal axis as the regressor.

- **quadratic**: If `TRUE`, fits the quadratic regression of the vertical axis on the horizontal axis and displays a lack of fit test. Default is `TRUE` for `lm` and `FALSE` for `glm` or if groups not missing.

- **smooth**: specifies the smoother to be used along with its arguments; if `FALSE`, which is the default except for generalized linear models, no smoother is shown; can be a list giving the smoother function and its named arguments; `TRUE` is equivalent to...
residualPlots

list(smoother=loessLine, span=2/3, col=carPalette()[3]), which is the default for a GLM. See ScatterplotSmoothers for the smoothers supplied by the car package and their arguments.

id controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the showLabels function; TRUE is equivalent to list(method="r", n=2, cex=1, col=carPalette()[1], location="lr"), which identifies the 2 points with the largest absolute residuals.

col default color for points. If groups is set, col can be a list at least as long as the number of levels for groups giving the colors for each groups.

col.quad default color for quadratic fit if groups is missing. Ignored if groups are used.

pch plotting character. The default is pch=1. If groups are used, pch can be set to a vector at least as long as the number of groups.

xlab X-axis label. If not specified, a useful label is constructed by the function.

ylab Y-axis label. If not specified, a useful label is constructed by the function.

lwd line width for lines.

lty line type for quadratic.

grid If TRUE, the default, a light-gray background grid is put on the graph.

key Should a key be added to the plot? Default is !is.null(groups).

Details

residualPlots draws one or more residuals plots depending on the value of the terms and fitted arguments. If terms = ~., the default, then a plot is produced of residuals versus each first-order term in the formula used to create the model. Interaction terms, spline terms, and polynomial terms of more than one predictor are skipped. In addition terms that use the “as-is” function, e.g., I(X^2), will also be skipped unless you set the argument AsIs=TRUE. A plot of residuals versus fitted values is also included unless fitted=FALSE.

In addition to plots, a table of curvature tests is displayed. For plots against a term in the model formula, say X1, the test displayed is the t-test for for I(X1^2) in the fit of update,model,~. + I(X1^2)). Econometricians call this a specification test. For factors, the displayed plot is a boxplot, no curvature test is computed, and grouping is ignored. For fitted values in a linear model, the test is Tukey’s one-degree-of-freedom test for nonadditivity. You can suppress the tests with the argument tests=FALSE. If grouping is used curvature tests are not displayed.

residualPlot, which is called by residualPlots, should be viewed as an internal function, and is included here to display its arguments, which can be used with residualPlots as well. The residualPlot function returns the curvature test as an invisible result.

residCurvTest computes the curvature test only. For any factors a boxplot will be drawn. For any polynomials, plots are against the linear term. Other non-standard predictors like B-splines are skipped.

Value

For lm objects, returns a data.frame with one row for each plot drawn, one column for the curvature test statistic, and a second column for the corresponding p-value. This function is used primarily for its side effect of drawing residual plots.
Author(s)
Sanford Weisberg, <sandy@umn.edu>

References

See Also
See Also lm, identify, showLabels

Examples
m1 <- lm(prestige ~ income, data=Prestige)
residualPlots(m1)
residualPlots(m1, terms= ~ 1 | type) # plot vs. yhat grouping by type

Description
The car package replacements for the summary (S) and confint (Confint) functions for lm, glm, multinom, and polr objects, with additional arguments but the same defaults as the original functions. The Confint method for “polr” objects profiles the likelihood to get confidence intervals for the regression parameters but uses Wald intervals for the thresholds. Default methods that call the standard R summary and confint functions are provided for the S and Confint generics, so the car functions should be safe to use in general. The default method for Confint also assumes that there is an appropriate coef method. For briefer model summaries, see brief.

Usage
S(object, brief, ...)

## S3 method for class 'lm'
S(object, brief=FALSE,
correlation = FALSE, symbolic.cor = FALSE,
vcov. = vcov(object, complete=FALSE), header = TRUE,
resid.summary = FALSE, adj.r2 = FALSE,
...)

## S3 method for class 'glm'
S(object, brief=FALSE,
exponentiate, dispersion, correlation = FALSE, symbolic.cor = FALSE,
vcov. = vcov(object, complete=FALSE), header = TRUE,
resid.summary = FALSE, ...)

## S3 method for class 'multinom'
S(object, brief=FALSE, exponentiate=FALSE, ...)

## S3 method for class 'polr'
S(object, brief=FALSE, exponentiate=FALSE, ...)

## S3 method for class 'lme'
S(object, brief=FALSE, correlation=FALSE, ...)

## S3 method for class 'lmerMod'
S(object, brief=FALSE, KR=FALSE, correlation=FALSE, ...)

## S3 method for class 'glmerMod'
S(object, brief=FALSE, correlation=FALSE, exponentiate, ...)

## Default S3 method:
S(object, brief, ...)

## S3 method for class 'S.lm'
print(x, digits = max(3, getOption("digits") - 3),
symbolic.cor = x$symbolic.cor, signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.glm'
print(x, digits = max(3L, getOption("digits") - 3L),
symbolic.cor = x$symbolic.cor, signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.multinom'
print(x, digits = max(3, getOption("digits") - 3),
signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.polr'
print(x, digits = max(3, getOption("digits") - 3),
signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.lme'
print(x, digits=max(3, getOption("digits") - 3),
signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.lmerMod'
print(x, digits=max(3, getOption("digits") - 3),
signif.stars = getOption("show.signif.stars"), ...)

## S3 method for class 'S.glmerMod'
print(x, digits=max(3, getOption("digits") - 3),
signif.stars = getOption("show.signif.stars"), ...)
Confint(object, ...)  
## S3 method for class 'lm'
Confint(object, estimate=TRUE,  
        parm, level=0.95, vcov.=vcov(object, complete=FALSE), ...)

## S3 method for class 'glm'
Confint(object, estimate=TRUE, exponentiate=FALSE,  
        vcov., dispersion, type=c("LR", "Wald"), ...)

## S3 method for class 'polr'
Confint(object, estimate=TRUE, exponentiate=FALSE,  
        thresholds=!exponentiate, ...)

## S3 method for class 'multinom'
Confint(object, estimate=TRUE, exponentiate=FALSE, ...)

## S3 method for class 'lme'
Confint(object, estimate=TRUE, level=0.95, ...)

## S3 method for class 'lmerMod'
Confint(object, estimate=TRUE, level=0.95, ...)

## S3 method for class 'glmerMod'
Confint(object, estimate=TRUE, level=0.95,  
        exponentiate=FALSE, ...)

## Default S3 method:
Confint(object, estimate=TRUE, level=0.95, vcov., ...)

Arguments

- **object**: a model object, e.g., of class "lm" as produced by a call to lm.
- **exponentiate**: for a "glm" or "glmerMod" model using the log or logit link, or a "polr" or "multinom" model, show exponentiated coefficient estimates and confidence bounds.
- **correlation**, **symbolic.cor**: see summary.lm
- **x**, **digits**, **signif.stars**: see summary.lm
- **dispersion**: see summary.glm
- **vcov.**: either a matrix giving the estimated covariance matrix of the estimates, or a function that when called with object as an argument returns an estimated covariance matrix of the estimates. The default of vcov. = vcov uses the usual estimated covariance matrix. Other choices include the functions documented at hccm. See example below for using a bootstrap to estimate the covariance.
matrix. For the glm methods of Confint and S, if the vcov. or dispersion argument is specified, then Wald-based confidence limits are computed; otherwise the reported confidence limits are computed by profiling the likelihood. NOTE: The dispersion and vcov. arguments may not both be specified.

header if TRUE, print the header for the summary output, default is TRUE

resid.summary if TRUE, print the five-number summary of the residuals in the summary, defaults to FALSE

adj.r2 if TRUE, print the adjusted r-squared in the summary, default is FALSE

brief if TRUE, set header, resid.summary and adj.r.squared to FALSE, and suppress exponentiated coefficients for GLMs with log or logit link.

KR if TRUE (default is FALSE), compute Kenward-Roger standard errors and Satterthwaite degrees of freedom for t-tests. Warning: This computation can be very time-consuming.

parm, level see confint

estimate show the estimated coefficients in the confidence-interval table; default is TRUE.

thresholds show confidence intervals for the estimated thresholds in the "polr" model.

type if "LR" (the default) compute confidence intervals based on the LR statistics by profiling the likelihood; if "Wald" base confidence intervals on the Wald statistic using the coefficient standard error and the normal distribution.

... additional arguments to be passed down, for consistency with summary and confint methods

Details

All these functions mimic functions in the stats and other standard R packages for summarizing aspects of linear, generalized linear, and some other statistical models.

The S and Confint functions add support for the vcov. argument for linear models, which allows specifying a covariance matrix for the regression coefficients other than the usual covariance matrix returned by the function vcov. This argument may be either the name of a function, so that the call to vcov.(object) returns a covariance matrix, or else vcov. is set equal to a covariance matrix. For example, setting vcov. = hccm uses 'proposal 3' described by Long and Ervin (2000) for a sandwich coefficient-variance estimator that may be robust against nonconstant variance (see hccm). Setting vcov. = hccm(object,type = "hc2") would use the matrix returned by the hccm function using proposal 2. For use with a bootstrap, see the examples below. The overall F-test in the S.lm output uses the supplied covariance matrix in a call to the linearHypothesis function.

The supplied print method for S.1m (and for other S methods) has additional arguments to customize the standard summary.1m output. Standard output is obtained by setting resid.summary=TRUE,adj.r2=TRUE.

Using a heteroscedasticity-corrected covariance matrix computed using hccm with GLMs other than Gaussian is not justified; see the article by Freedman (2006).

The Summary.glm method for models fit with the log or logit link by default prints a table of exponentiated coefficients and their confidence limits; Summary.multinom and Summary.polr optionally print tables of exponentiated coefficients.
Value

The S.lm and S.glm functions return a list with all the elements shown at summary.lm and summary.glm. The S.multinom and S.polr functions return a list with all the elements shown at summary.multinom and summary.polr plus potentially a table of exponentiated coefficients and confidence bounds.

The Confint.lm function returns either the output from confint.lm if vcov. = vcov or Wald-type confidence intervals using the supplied covariance matrix for any other choice of vcov..

Finally, Confint applied to any object that does not inherit from "lm", "multinom", or "polr" simply calls confint, along with, by default, using coef to add a column of estimates to the confidence limits.

Author(s)

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References


See Also

brief, summary, confint, coef, summary.lm, confint.vcov.lm, hccm, Boot, linearHypothesis

Examples

mod.prestige <- lm(prestige ~ education + income + type, Prestige)
S(mod.prestige, vcov.=hccm)
S(mod.prestige, brief=TRUE)
Confint(mod.prestige, vcov.=hccm)

# A logit model
mod.mroz <- glm(lfp ~ ., data=Mroz, family=binomial)
S(mod.mroz)

## Not run:
# Using the bootstrap for standard errors
b1 <- Boot(mod.prestige)
S(mod.prestige, vcov.= vcov(b1))
Confint(b1) # run with the boot object to get corrected confidence intervals

## End(Not run)
Description

The `scatter3d` function uses the `rgl` package to draw 3D scatterplots with various regression surfaces. The function `Identify3d` allows you to label points interactively with the mouse: Press the right mouse button (on a two-button mouse) or the centre button (on a three-button mouse), drag a rectangle around the points to be identified, and release the button. Repeat this procedure for each point or set of “nearby” points to be identified. To exit from point-identification mode, click the right (or centre) button in an empty region of the plot.

Usage

```r
scatter3d(x, ...) 
## S3 method for class 'formula'
scatter3d(formula, data, subset, radius, xlab, ylab, zlab, id=FALSE, ...)
## Default S3 method:
scatter3d(x, y, z, 
  xlab=deparse(substitute(x)), ylab=deparse(substitute(y)),
  zlab=deparse(substitute(z)), axis.scales=TRUE, axis.ticks=FALSE,
  revolutions=0,
  bg.col=c("white", "black"),
  axis.col=if (bg.col == "white") c("darkmagenta", "black", "darkcyan")
    else c("darkmagenta", "white", "darkcyan"),
  surface.col=carPalette()[-1], surface.alpha=0.5,
  neg.res.col="magenta", pos.res.col="cyan",
  square.col=if (bg.col == "white") "black" else "gray",
  point.col="yellow", text.col=axis.col,
  grid.col=if (bg.col == "white") "black" else "gray",
  fogtype=c("exp2", "linear", "exp", "none"),
  residuals=(length(fit) == 1),
  surface=TRUE, fill=TRUE,
  grid=TRUE, grid.lines=26, df.smooth=NULL, df.additive=NULL,
  sphere.size=1, radius=1, threshold=0.01, speed=1, fov=60,
  fit="linear", groups=NULL, parallel=TRUE,
  ellipsoid=FALSE, level=0.5, ellipsoid.alpha=0.1, id=FALSE,
  model.summary=FALSE, ...)

Identify3d(x, y, z, axis.scales=TRUE, groups = NULL, labels = 1:length(x),
  col = c("blue", "green", "orange", "magenta", "cyan", "red", "yellow", "gray"),
  offset = ((100/length(x))^(1/3)) * 0.02)
```
Arguments

- **formula**: "model" formula, of the form \( y \sim x + z \) or to plot by groups \( y \sim x + z \mid g \), where \( g \) evaluates to a factor or other variable dividing the data into groups.
- **data**: data frame within which to evaluate the formula.
- **subset**: expression defining a subset of observations.
- **x**: variable for horizontal axis.
- **y**: variable for vertical axis (response).
- **z**: variable for out-of-screen axis.
- **xlab, ylab, zlab**: axis labels.
- **axis.scales**: if TRUE, label the values of the ends of the axes. **Note**: For Identify3d to work properly, the value of this argument must be the same as in scatter3d.
- **axis.ticks**: if TRUE, print interior axis-"tick" labels; the default is FALSE. (The code for this option was provided by David Winsemius.)
- **revolutions**: number of full revolutions of the display.
- **bg.col**: background colour; one of "white", "black".
- **axis.col**: colours for axes; if axis.scales is FALSE, then the second colour is used for all three axes.
- **surface.col**: vector of colours for regression planes, used in the order specified by fit; for multi-group plots, the colours are used for the regression surfaces and points in the several groups.
- **surface.alpha**: transparency of regression surfaces, from 0.0 (fully transparent) to 1.0 (opaque); default is 0.5.
- **neg.res.col, pos.res.col**: colours for lines representing negative and positive residuals.
- **square.col**: colour to use to plot squared residuals.
- **point.col**: colour of points.
- **text.col**: colour of axis labels.
- **grid.col**: colour of grid lines on the regression surface(s).
- **fogtype**: type of fog effect; one of "exp2", "linear", "exp", "none".
- **residuals**: plot residuals if TRUE; if residuals="squares", then the squared residuals are shown as squares (using code adapted from Richard Heiberger). Residuals are available only when there is one surface plotted.
- **surface**: plot surface(s) (TRUE or FALSE).
- **fill**: fill the plotted surface(s) with colour (TRUE or FALSE).
- **grid**: plot grid lines on the regression surface(s) (TRUE or FALSE).
- **grid.lines**: number of lines (default, 26) forming the grid, in each of the x and z directions.
- **df.smooth**: degrees of freedom for the two-dimensional smooth regression surface; if NULL (the default), the gam function will select the degrees of freedom for a smoothing spline by generalized cross-validation; if a positive number, a fixed regression spline will be fit with the specified degrees of freedom.
df.additive  
degrees of freedom for each explanatory variable in an additive regression; if NULL (the default), the `gam` function will select degrees of freedom for the smoothing splines by generalized cross-validation; if a positive number or a vector of two positive numbers, fixed regression splines will be fit with the specified degrees of freedom for each term.

sphere.size  
general size of spheres representing points; the actual size is dependent on the number of observations.

radius  
relative radii of the spheres representing the points. This is normally a vector of the same length as the variables giving the coordinates of the points, and for the `formula` method, that must be the case or the argument may be omitted, in which case spheres are the same size; for the `default` method, the default for the argument, 1, produces spheres all of the same size. The radii are scaled so that their median is 1.

threshold  
if the actual size of the spheres is less than the threshold, points are plotted instead.

speed  
relative speed of revolution of the plot.

fov  
field of view (in degrees); controls degree of perspective.

fit  
one or more of "linear", "quadratic", "smooth", "additive"; to display fitted surface(s); partial matching is supported – e.g., `c("lin","quad")`.

groups  
if NULL (the default), no groups are defined; if a factor, a different surface or set of surfaces is plotted for each level of the factor; in this event, the colours in `surface.col` are used successively for the points, surfaces, and residuals corresponding to each level of the factor.

parallel  
when plotting surfaces by groups, should the surfaces be constrained to be parallel? A logical value, with default `TRUE`.

ellipsoid  
plot concentration ellipsoid(s) (`TRUE` or `FALSE`).

level  
expected proportion of bivariate-normal observations included in the concentration ellipsoid(s); default is 0.5.

ellipsoid.alpha  
transparency of ellipsoids, from 0.0 (fully transparent) to 1.0 (opaque); default is 0.1.

id  
FALSE, `TRUE`, or a list controlling point identification, similar to `showLabels` for 2D plots (see Details).

model.summary  
print summary or summaries of the model(s) fit (`TRUE` or `FALSE`). `scatter3d` rescales the three variables internally to fit in the unit cube; this rescaling will affect regression coefficients.

labels  
text labels for the points, one for each point; defaults to the observation indices.

col  
colours for the point labels, given by group. There must be at least as many colours as groups; if there are no groups, the first colour is used. Normally, the colours would correspond to the `surface.col` argument to `scatter3d`.

offset  
vertical displacement for point labels (to avoid overplotting the points).

...  
arguments to be passed down.
Details

The `id` argument to `scatter3d` can be `FALSE`, `TRUE` (in which case 2 points will be identified according to their Mahalanobis distances from the center of the data), or a list containing any or all of the following elements:

- **method** if "mahal" (the default), relatively extreme points are identified automatically according to their Mahalanobis distances from the centroid (point of means); if "identify", points are identified interactively by right-clicking and dragging a box around them; right-click in an empty area to exit from interactive-point-identification mode; if "xz", identify extreme points in the predictor plane; if "y", identify unusual values of the response; if "xyz" identify unusual values of an variable; if "none", no point identification. See `showLabels` for more information.

- **n** Number of relatively extreme points to identify automatically (default, 2, unless `method="identify"`, in which case identification continues until the user exits).

- **labels** text labels for the points, one for each point; in the default method defaults to the observation indices, in the `formula` method to the row names of the data.

- **offset** vertical displacement for point labels (to avoid overplotting the points).

Value

`scatter3d` does not return a useful value; it is used for its side-effect of creating a 3D scatterplot. `Identify3d` returns the labels of the identified points.

Note

You have to install the `rgl` package to produce 3D plots. On a Macintosh (but not on Windows or Linux), you may also need to install the X11 windowing system. Go to https://www.xquartz.org/ and click on the link for XQuartz. Double-click on the downloaded disk-image file, and then double-click on `XQuartz.pkg` to start the installer. You may take all of the defaults in the installation. After XQuartz is installed, you should restart your Macintosh.

Author(s)

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References


See Also

- `rgl-package`, `gam`

Examples

```r
if(interactive() && require(rgl) && require(mgcv)){
  scatter3d(prestige ~ income + education, data=Duncan, id=list(n=3))
  Sys.sleep(5) # wait 5 seconds
  scatter3d(prestige ~ income + education | type, data=Duncan)
}
Sys.sleep(5)
scatter3d(prestige ~ income + education | type, surface=FALSE,
ellipsoid=TRUE, revolutions=3, data=Duncan)
scatter3d(prestige ~ income + education, fit=c("linear", "additive"),
data=Prestige)
Sys.sleep(5)
scatter3d(prestige ~ income + education | type,
    radius=(1 + women)^(1/3), data=Prestige)
}
## Not run:
# drag right mouse button to identify points, click right button in open area to exit
scatter3d(prestige ~ income + education, data=Duncan, id=list(method="identify"))
scatter3d(prestige ~ income + education | type, data=Duncan, id=list(method="identify"))
## End(Not run)

---

**scatterplot**  
Enhanced Scatterplots with Marginal Boxplots, Point Marking, Smoothers, and More

---

**Description**

This function uses basic R graphics to draw a two-dimensional scatterplot, with options to allow for plot enhancements that are often helpful with regression problems. Enhancements include adding marginal boxplots, estimated mean and variance functions using either parametric or nonparametric methods, point identification, jittering, setting characteristics of points and lines like color, size and symbol, marking points and fitting lines conditional on a grouping variable, and other enhancements. *sp* is an abbreviation for *scatterplot*.

**Usage**

```r
scatterplot(x, ...)
```

## S3 method for class 'formula'
```
scatterplot(formula, data, subset, xlab, ylab, id=FALSE, 
    legend=TRUE, ...)
```

## Default S3 method:
```
scatterplot(x, y, boxplots=if (by.groups) "" else "xy", 
    regline=TRUE, legend=TRUE, id=FALSE, ellipse=FALSE, grid=TRUE,
    smooth=TRUE,n=by.groups=!missing(groups),
    xlab=deparse(substitute(x)), ylab=deparse(substitute(y)),
    log="", jitter=list(), cex=par("cex"),
    col=carPalette()[-1], pch=1:n.groups,
    reset.par=TRUE, ...)
```

`sp(x, ...)`
scatterplot

Arguments

- **x**: vector of horizontal coordinates (or first argument of generic function).
- **y**: vector of vertical coordinates.
- **formula**: a model formula, of the form \( y \sim x \) or, if plotting by groups, \( y \sim x | z \), where \( z \) evaluates to a factor or other variable dividing the data into groups. If \( x \) is a factor, then parallel boxplots are produced using the `Boxplot` function.
- **data**: data frame within which to evaluate the formula.
- **subset**: expression defining a subset of observations.
- **boxplots**: if \( "x" \) a marginal boxplot for the horizontal \( x \)-axis is drawn below the plot; if \( "y" \) a marginal boxplot for vertical \( y \)-axis is drawn to the left of the plot; if \( "xy" \) both marginal boxplots are drawn; set to \( "" \) or \( FALSE \) to suppress both boxplots.
- **regLine**: controls adding a fitted regression line to the plot. if `regLine=FALSE`, no line is drawn. If `TRUE`, the default, an OLS line is fit. This argument can also be a list. The default of `TRUE` is equivalent to `regLine=list(method=lm,lty=1,lwd=2,col=col)`, which specifies using the `lm` function to estimate the fitted line, to draw a solid line \((\text{lty}=1)\) of width 2 times the nominal width \((\text{lwd}=2)\) in the color given by the first element of the `col` argument described below.
- **legend**: when the plot is drawn by groups and `legend=TRUE`, controls placement and properties of a legend; if `FALSE`, the legend is suppressed. Can be a list of named arguments, as follows: `title` for the legend; `inset`, giving space as a proportion of the axes to offset the legend from the axes; `coords` specifying the position of the legend in any form acceptable to the `legend` function or, if not given, the legend is placed above the plot in the upper margin; `columns` for the legend, determined automatically to prefer a horizontal layout if not given explicitly; `cex` giving the relative size of the legend symbols and text. `TRUE` (the default) is equivalent to `list(title=deparse(substitute(groups)),inset=0.02,cex=1)`.
- **id**: controls point identification; if `FALSE` (the default), no points are identified; can be a list of named arguments to the `showLabels` function; `TRUE` is equivalent to `list(method="mahal",n=2,cex=1,col=carPalette()[[-1]],location="lr")`, which identifies the 2 points (in each group) with the largest Mahalanobis distances from the center of the data. See `showLabels` for a description of the other arguments. The default behavior of `id` is not the same in all graphics functions in `car`, as the method used depends on the type of plot.
- **ellipse**: controls plotting data-concentration ellipses. If `FALSE` (the default), no ellipses are plotted. Can be a list of named values giving `levels`, a vector of one or more bivariate-normal probability-contour levels at which to plot the ellipses; `robust`, a logical value determining whether to use the `cov.trob` function in the `MASS` package to calculate the center and covariance matrix for the data ellipses; and `fill` and `fill.alpha`, which control whether the ellipse is filled and the transparency of the fill. `TRUE` is equivalent to `list(levels=c(.5,.95),robust=TRUE,fill=TRUE,fill.alpha=0.2)`.
- **grid**: If `TRUE`, the default, a light-gray background grid is put on the graph.
- **smooth**: specifies a nonparametric estimate of the mean or median function of the vertical axis variable given the horizontal axis variable and optionally a nonparametric estimate of the conditional variance. If `smooth=FALSE` neither function is drawn. If `smooth=TRUE`, then both the mean function and variance functions are drawn.
for ungrouped data, and the mean function only is drawn for grouped data. The default smoother is \texttt{loessLine}, which uses the \texttt{loess} function from the \texttt{stats} package. This smoother is fast and reliable. See the details below for changing the smoother, line type, width and color, of the added lines, and adding arguments for the smoother.

\textbf{groups} \\

a factor or other variable dividing the data into groups; groups are plotted with different colors, plotting characters, fits, and smooths. Using this argument is equivalent to specifying the grouping variable in the formula.

\textbf{by.groups} \\

if \texttt{TRUE} (the default when there are groups), regression lines are fit by groups.

\textbf{xlab} \\

label for horizontal axis.

\textbf{ylab} \\

label for vertical axis.

\textbf{log} \\

same as the \texttt{log} argument to \texttt{plot}, to produce log axes.

\textbf{jitter} \\

a list with elements \texttt{x} or \texttt{y} or both, specifying jitter factors for the horizontal and vertical coordinates of the points in the scatterplot. The \texttt{jitter} function is used to randomly perturb the points; specifying a factor of 1 produces the default jitter. Fitted lines are unaffected by the jitter.

\textbf{col} \\

with no grouping, this specifies a color for plotted points; with grouping, this argument should be a vector of colors of length at least equal to the number of groups. The default is value returned by \texttt{carPalette[-1]}.

\textbf{pch} \\

plotting characters for points; default is the plotting characters in order (see \texttt{par}).

\textbf{cex} \\

sets the size of plotting characters, with \texttt{cex=1} the standard size. You can also set the sizes of other elements with the arguments \texttt{cex.axis}, \texttt{cex.lab}, \texttt{cex.main}, and \texttt{cex.sub}. See \texttt{par}.

\textbf{reset.par} \\

if \texttt{TRUE} (the default) then plotting parameters are reset to their previous values when \texttt{scatterplot} exits; if \texttt{FALSE} then the \texttt{mar} and \texttt{mfcol} parameters are altered for the current plotting device. Set to \texttt{FALSE} if you want to add graphical elements (such as lines) to the plot.

\textbf{...} \\

other arguments passed down and to \texttt{plot}. For example, the argument \texttt{las} sets the style of the axis labels, and \texttt{xlim} and \texttt{ylim} set the limits on the horizontal and vertical axes, respectively; see \texttt{par}.

\section*{Details}

Many arguments to \texttt{scatterplot} were changed in version 3 of \texttt{car} to simplify use of this function. The \texttt{smooth} argument is usually either set to \texttt{TRUE} or \texttt{FALSE} to draw, or omit, the smoother. Alternatively smooth can be set to a list of arguments. The default behavior of \texttt{smooth=TRUE} is equivalent to \texttt{smooth=list(smooth=loessLine, var=!by.groups, lty.var=2, lty.var=4)}, specifying the smoother to be used, including the variance smooth, and the line widths and types for the curves. You can also specify the colors you want to use for the mean and variance smooths with the arguments \texttt{col.smooth} and \texttt{col.var}. Alternative smoothers are \texttt{gamline} which uses the \texttt{gam} function from the \texttt{mgcv} package, and \texttt{quantregLine} which uses quantile regression to estimate the median and quartile functions using \texttt{rqss} from the \texttt{quantreg} package. All of these smoothers have one or more arguments described on their help pages, and these arguments can be added to the \texttt{smooth} argument; for example, \texttt{smooth = list(span=1/2)} would use the default \texttt{loessLine} smoother, include the variance smooth, and change the value of the smoothing parameter to 1/2.
For `loessLine` and `gamLine` the variance smooth is estimated by separately smoothing the squared positive and negative residuals from the mean smooth, using the same type of smoother. The displayed curves are equal to the mean smooth plus the square root of the fit to the positive squared residuals, and the mean fit minus the square root of the smooth of the negative squared residuals. The lines therefore represent the conditional variability at each value on the horizontal axis. Because smoothing is done separately for positive and negative residuals, the variation shown will generally not be symmetric about the fitted mean function. For the `quantregLine` method, the center estimates the median for each value on the horizontal axis, and the variability estimates the lower and upper quartiles of the estimated conditional distribution for each value of the horizontal axis.

The sub-arguments `spread`, `lty.spread` and `col.spread` of the `smooth` argument are equivalent to the newer `var`, `col.var` and `lty.var`, respectively, recognizing that the spread is a measure of conditional variability.

**Value**

If points are identified, their labels are returned; otherwise `NULL` is returned invisibly.

**Author(s)**

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**References**


**See Also**

`boxplot`, `jitter`, `legend`, `scatterplotMatrix`, `dataEllipse`, `Boxplot`, `cov.trob`, `showLabels`, `ScatterplotSmoothers`.

**Examples**

```r
scatterplot(prestige ~ income, data=Prestige, ellipse=TRUE)
scatterplot(prestige ~ income, data=Prestige, smooth=list(smoother=quantregLine))
# use quantile regression for median and quartile fits
scatterplot(prestige ~ income | type, data=Prestige, 
           smooth=list(smoother=quantregLine, var=TRUE, span=1, lwd=4, lwd.var=2))
scatterplot(prestige ~ income | type, data=Prestige, legend=list(coords="topleft"))
scatterplot(vocabulary ~ education, jitter=list(x=1, y=1), 
            data=Vocab, smooth=FALSE, lwd=3)
scatterplot(infantMortality ~ ppgdp, log="xy", data=UN, id=list(n=5))
scatterplot(income ~ type, data=Prestige)
```

## Not run:
# remember to exit from point-identification mode
scatterplot(infantMortality ~ ppgdp, id=list(method="identify"), data=UN)

## End(Not run)

### Description

This function provides a convenient interface to the `pairs` function to produce enhanced scatterplot matrices, including univariate displays on the diagonal and a variety of fitted lines, smoothers, variance functions, and concentration ellipsoids. `spm` is an abbreviation for `scatterplotMatrix`.

### Usage

```r
scatterplotMatrix(x, ...)  
## S3 method for class 'formula'
scatterplotMatrix(formula, data=NULL, subset, ...)
## Default S3 method:
scatterplotMatrix(x, smooth = TRUE, id = FALSE, legend = TRUE, regLine = TRUE, ellipse = FALSE, var.labels = colnames(x), diagonal = TRUE, plot.points = TRUE, groups = NULL, by.groups = TRUE, use = c("complete.obs", "pairwise.complete.obs"), col = carPalette()[-1], pch = 1:n.groups, cex = par("cex"), cex.axis = par("cex.axis"), cex.labels = NULL, cex.main = par("cex.main"), rowlattop = TRUE, ...)

spm(x, ...)
```

### Arguments

- **x**: a data matrix or a numeric data frame.
- **formula**: a one-sided “model” formula, of the form `~ x1 + x2 + ... + xk` or `~ x1 + x2 + ... + xk | z` where `z` evaluates to a factor or other variable to divide the data into groups.
- **data**: for `scatterplotMatrix.formula`, a data frame within which to evaluate the formula.
- **subset**: expression defining a subset of observations.
- **smooth**: specifies a nonparametric estimate of the mean or median function of the vertical axis variable given the horizontal axis variable and optionally a nonparametric estimate of the spread or variance function. If `smooth=FALSE` neither function
is drawn. If smooth=TRUE, then both the mean function and variance functions are drawn for ungrouped data, and the mean function only is drawn for grouped data. The default smoother is `loessLine`, which uses the `loess` function from the `stats` package. This smoother is fast and reliable. See the details below for changing the smoother, line type, width and color, of the added lines, and adding arguments for the smoother.

**id** controls point identification; if FALSE (the default), no points are identified; can be a list of named arguments to the `showLabels` function; TRUE is equivalent to `list(method="mahal",n=2,cex=1,location="lr")`, which identifies the 2 points (in each group, if by.groups=TRUE) with the largest Mahalanobis distances from the center of the data; `list(method="identify")` for interactive point identification is not allowed.

**legend** controls placement of a legend if the plot is drawn by groups; if FALSE, the legend is suppressed. Can be a list with the named element `coords` specifying the position of the legend in any form acceptable to the `legend` function; TRUE (the default) is equivalent to `list(coords=NULL)`, for which placement will vary by the the value of the diagonal argument—e.g., "topleft" for `diagonal=TRUE`.

**regLine** controls adding a fitted regression line to each plot, or to each group of points if by.groups=TRUE. If regLine=FALSE, no line is drawn. This argument can also be a list with named list, with default `regLine=TRUE` equivalent to `regLine = list(method=lm,lty=1,lwd=2,col=col[1])` specifying the name of the function that computes the line, with line type 1 (solid) of relative line width 2 and the color equal to the first value in the argument `col`. Setting `method=MASS::rlm` would fit using a robust regression.

**ellipse** controls plotting data-concentration ellipses. If FALSE (the default), no ellipses are plotted. Can be a list of named values giving levels, a vector of one or more bivariate-normal probability-contour levels at which to plot the ellipses; robust, a logical value determining whether to use the `cov.trob` function in the `MASS` package to calculate the center and covariance matrix for the data ellipses; and fill and fill.alpha, which control whether the ellipse is filled and the transparency of the fill. TRUE is equivalent to `list(levels=c(.5,.95),robust=TRUE,fill=TRUE,fill.alpha=0.2)`.

**var.labels** variable labels (for the diagonal of the plot).

**diagonal** contents of the diagonal panels of the plot. If `diagonal=TRUE` adaptive kernel density estimates are plotted, separately for each group if grouping is present. `diagonal=FALSE` suppresses the diagonal entries. See details below for other choices for the diagonal.

**plot.points** if TRUE the points are plotted in each off-diagonal panel.

**groups** a factor or other variable dividing the data into groups; groups are plotted with different colors and plotting characters.

**by.groups** if TRUE, the default, regression lines and smooths are fit by groups.

**use** if "complete.obs" (the default), cases with missing data are omitted; if "pairwise.complete.obs", all valid cases are used in each panel of the plot.

**pch** plotting characters for points; default is the plotting characters in order (see `par`).

**col** colors for points; the default is `carPalette` starting at the second color. The color of the `regLine` and `smooth` are the same as for points but can be changed using the the `regLine` and `smooth` arguments.
scatterplotMatrix

cex relative size of plotted points
cex.axis relative size of axis labels
cex.labels relative size of labels on the diagonal
cex.main relative size of the main title, if any
row1attop If TRUE (the default) the first row is at the top, as in a matrix, as opposed to at the bottom, as in graph (argument suggested by Richard Heiberger).
... arguments to pass down.

Details

Many arguments to scatterplotMatrix were changed in version 3 of car, to simplify use of this function.

The smooth argument is usually either set to TRUE or FALSE to draw, or omit, the smoother. Alternatively smooth can be set to a list of arguments. The default behavior of smooth=TRUE is equivalent to smooth=list(smooth=loessLine, spread=TRUE, lty.smooth=1, lwd.smooth=1.5, lty.spread=3, lwd.spread=1), specifying the smoother to be used, including the spread or variance smooth, and the line widths and types for the curves. You can also specify the colors you want to use for the mean and variance smooths with the arguments col.smooth and col.spread. Alternative smoothers are gamline which uses the gam function from the mgcv package, and quantregLine which uses quantile regression to estimate the median and quartile functions using rqss from the quantreg package. All of these smoothers have one or more arguments described on their help pages, and these arguments can be added to the smooth argument; for example, smooth = list(span=1/2) would use the default loessLine smoother, include the variance smooth, and change the value of the smoothing parameter to 1/2. For loessLine and gamLine the variance smooth is estimated by separately smoothing the squared positive and negative residuals from the mean smooth, using the same type of smoother. The displayed curves are equal to the mean smooth plus the square root of the fit to the positive squared residuals, and the mean fit minus the square root of the smooth of the negative squared residuals. The lines therefore represent the conditional variability at each value on the horizontal axis. Because smoothing is done separately for positive and negative residuals, the variation shown will generally not be symmetric about the fitted mean function. For the quantregLine method, the center estimates the median for each value on the horizontal axis, and the spread estimates the lower and upper quartiles of the estimated conditional distribution for each value of the horizontal axis.

The sub-arguments spread, lty.spread and col.spread of the smooth argument are equivalent to the newer var, col.var and lty.var, respectively, recognizing that the spread is a measure of conditional variability.

By default the diagonal argument is used to draw kernel density estimates of the variables by setting diagonal=TRUE, which is equivalent to setting diagonal = list(method="adaptiveDensity", bw=bw.nrd0, adjust=1, kernel=dnorm, na.rm=TRUE). The additional arguments shown are described at adaptiveKernel. The other methods available, with their default arguments, are diagonal=list(method="density", bw="nrd0", adjust=1, kernel="gaussian", na.rm=TRUE) which uses density for nonadaptive kernel density estimation; diagonal=list(method = "histogram", breaks="FD") which uses hist for drawing a histogram that ignores grouping, if present; diagonal=list(method="boxplot") with no additional arguments which draws (parallel) boxplots; diagonal=list(method="qqplot") with no additional arguments which draws a normal QQ plot; and diagonal=list(method="oned") with no additional arguments which draws a rug plot tilted to the diagonal, as suggested by Richard Heiberger.
Earlier versions of `scatterplotMatrix` included arguments `transform` and `family` to estimate power transformations using the `powerTransform` function before drawing the plot. The same functionality can be achieved by calling `powerTransform` directly to estimate a transformation, saving the transformed variables, and then plotting.

**Value**

`NULL`, returned invisibly. This function is used for its side effect: producing a plot. If point identification is used, a vector of identified points is returned.

**Author(s)**

John Fox <jfox@mcmaster.ca>

**References**


**See Also**

`pairs`, `scatterplot`, `dataEllipse`, `powerTransform`, `bcPower`, `yjPower`, `cov.trob`, `showLabels`, `ScatterplotSmoothers`.

**Examples**

```r
scatterplotMatrix(~ income + education + prestige | type, data=Duncan)
scatterplotMatrix(~ income + education + prestige | type, data=Duncan,
                   regLine=FALSE, smooth=list(spread=FALSE))
scatterplotMatrix(~ income + education + prestige,
                   data=Duncan, id=TRUE, smooth=list(method=gamLine))
```

---

**ScatterplotSmoothers**  
**Smoothers to Draw Lines on Scatterplots**

**Description**

These smoothers are used to draw nonparametric-regression lines on scatterplots produced by the `scatterplot`, `scatterplotMatrix` and several other `car` functions. The functions are not meant to be called directly by the user, although the user can supply options via the `smoother.args` argument, the contents of which vary by the smoother (see Details below). The `gamLine` smoother uses the `gam` function in the `mgcv` package, the `loessLine` smoother uses the `loess` function in the `stats` package, and the `quantregLine` smoother uses the `rqss` function in the `quantreg` package.
Usage

gamLine(x, y, col=carPalette()[1], log.x=FALSE, log.y=FALSE, var=FALSE, spread=var, smoother.args=NULL, draw=TRUE, offset=0)

loessLine(x, y, col=carPalette()[1], log.x=FALSE, log.y=FALSE, var=FALSE, spread=var, smoother.args=NULL, draw=TRUE, offset=0)

quantregLine(x, y, col=carPalette()[1], log.x=FALSE, log.y=FALSE, var=FALSE, spread=var, smoother.args=NULL, draw=TRUE, offset=0)

Arguments

x horizontal coordinates of points.

y vertical coordinates of points.

col line color.

log.x should be set to TRUE (default is FALSE) if the horizontal axis is logged.

log.y should be set to TRUE (default is FALSE) if the vertical axis is logged.

spread, var the default is to plot only an estimated mean or median function. If either of these arguments is TRUE, then a measure of variability is also plotted.

smoother.args additional options accepted by the smoother, in the form of a list of named values (see Details below).

draw if TRUE, the default, draw the smoother on the currently active graph. If FALSE, return a list with coordinates x and y for the points that make up the smooth and if requested x.pos, y.pos, x.neg, y.neg for the spread smooths.

offset For use when spread=TRUE, the vertical axis is sqrt(offset^2 + variance smooth).

Details

The function loessLine is a re-implementation of the loess smoother that was used in car prior to September 2012. The main enhancement is the ability to set more arguments through the smoother.args argument.

The function gamLine is more general than the loess fitting because it allows fitting a generalized additive model using splines. You can specify an error distribution and link function.

The function quantregLine fits an additive model using splines with estimation based on L1 regression for the median and quantile regression if you ask for the spread. It is likely to be more robust than the other smoothers.

The argument smoother.args is a list of named elements used to pass additional arguments to the smoother. As of November, 2016, the smoother is evaluated at an equally spaced grid of 50 points in the range of the horizontal variable. With any of the smoothers you can change to say 100 evaluation points by using the argument smoother.args=list(evaluation=100). As of version 3.0-1, the arguments in smoother.args col.var, lty.var and lwd.var are equivalent to col.spread, lty.spread and lwd.spread, respectively.
ScatterplotSmoothers

For loessLine the default value is smoother.args=list(lty.smooth=1,lwd.smooth=2,lty.spread=4,lwd.spread=2,span=2/3,degree=1,family="symmetric",iterations=4). The arguments lty.smooth and lwd.smooth are the type and width respectively of the mean or median smooth, lty.spread and lwd.spread are the type and color of the spread smooths if requested. The arguments span, degree and family are passed to the loess function, iterations=4 robustness iterations.

For gamLine the default is smoother.args=list(lty.smooth=1,lwd.smooth=2,lty.spread=4,lwd.spread=2,k=-1,bs="tp",family="gaussian",link=NULL,weights=NULL). The first four arguments are as for loessLine. The next two arguments are passed to the gam function to control the smoothing: k=-1 allows gam to choose the number of splines in the basis function; bs="tp" provides the type of spline basis to be used with "tp" for the default thin-plate splines. The last three arguments allow providing a family, link and weights as in generalized linear models. See examples below. The spread argument is ignored unless family="gaussian" and link=NULL.

For quantregLine the default is smoother.args=list(lty.smooth=1,lwd.smooth=2,lty.spread=4,lwd.spread=2,lam=IQR(x)). The first four arguments are as for loessLine. The last argument is passed to the qss function in quantreg. It is a smoothing parameter, here a robust estimate of the scale of the horizontal axis variable. This is an arbitrary choice, and may not work well in all circumstances.

Author(s)

John Fox <jfox@mcmaster.ca> and Sanford Weisberg <sandy@umn.edu>.

See Also

scatterplot, scatterplotMatrix, gam, loess, and rqss.

Examples

scatterplot(prestige ~ income, data=Prestige)
scatterplot(prestige ~ income, data=Prestige, smooth=list(smoother=gamLine))
scatterplot(prestige ~ income, data=Prestige,
        smooth=list(smoother=quantregLine))

scatterplot(prestige ~ income | type, data=Prestige)
scatterplot(prestige ~ income | type, data=Prestige, smooth=list(smoother=gamLine))
scatterplot(prestige ~ income | type, data=Prestige,
        smooth=list(smoother=quantregLine))
scatterplot(prestige ~ income | type, data=Prestige, smooth=FALSE)
scatterplot(prestige ~ income | type, data=Prestige, spread=TRUE)
scatterplot(prestige ~ income | type, data=Prestige,
        smooth=list(smoother=gamLine), spread=TRUE)
scatterplot(prestige ~ income | type, data=Prestige,
        smooth=list(smoother=quantregLine), spread=TRUE)

scatterplot(weight ~ repwt | sex, spread=TRUE, data=Davis,
        smooth=list(smoother=loessLine))
scatterplot(weight ~ repwt | sex, spread=TRUE, data=Davis,
        smooth=list(smoother=gamLine)) # messes up
scatterplot(weight ~ repwt | sex, spread=TRUE, data=Davis,
```r
set.seed(12345)
w <- 1 + rpois(100, 5)
x <- rnorm(100)
p <- 1/(1 + exp(-(x + 0.5*x^2)))
y <- rbinom(100, w, p)
scatterplot(y/w ~ x, smooth=list(smoother=gamLine, family="binomial", weights=w))
scatterplot(y/w ~ x, smooth=list(smoother=gamLine, family=binomial, link="probit", weights=w))
scatterplot(y/w ~ x, smooth=list(smoother=loessLine), reg=FALSE)
```

```r
y <- rbinom(100, 1, p)
scatterplot(y ~ x, smooth=list(smoother=gamLine, family=binomial))
```

---

**showLabels**

*Functions to Identify and Mark Extreme Points in a 2D Plot.*

**Description**

This function is called by several graphical functions in the **car** package to mark extreme points in a 2D plot. Although the user is unlikely to call this function directly, the documentation below applies to all these other functions.

**Usage**

```r
showLabels(x, y, labels=NULL, method="identify", n = length(x), cex=1, col=carPalette()[1], location=c("lr", "ab", "avoid"), ...)
```

**Arguments**

- **x**
  - Plotted horizontal coordinates.

- **y**
  - Plotted vertical coordinates.

- **labels**
  - Plotting labels. When called from within a **car** plotting function, the labels are automatically obtained from the row names in the data frame used to create the modeling object. If labels=NULL, case numbers will be used. If labels are long, the `substr` or `abbreviate` functions can be used to shorten them. Users may supply their own labels as a character vector of length equal to the number of plotted points. For use with **car** plotting functions, the number of plotted points is equal to the number of rows of data that have neither missing values nor are excluded using the ‘subset’ argument. When called directly, the length of labels should equal the length of x.

- **method**
  - How points are to be identified. See Details below.

- **n**
  - Number of points to be identified. If set to 0, no points are identified.

- **cex**
  - Controls the size of the plotted labels. The default is 1.
Controls the color of the plotted labels. The default is the first element returned by `carPalette()`.

Where should the label be drawn? The default is "lr" to draw the label to the left of the point for points in the right-half of the graph and to the right for points in the left-half. The other option is "ab" for above the point for points below the middle of the graph and above the point below the middle. Finally, "avoid" tries to avoid over-plotting labels.

not used.

Details

The argument `method` determine how the points to be identified are selected. For the default value of `method="identify"`, the `identify` function is used to identify points interactively using the mouse. Up to \( n \) points can be identified, so if \( n=0 \), which is the default in many functions in the `car` package, then no point identification is done.

Automatic point identification can be done depending on the value of the argument `method`:

- `method = "x"` select points according to their value of \( \text{abs}(x - \text{mean}(x)) \)
- `method = "y"` select points according to their value of \( \text{abs}(y - \text{mean}(y)) \)
- `method = "r"` select points according to their value of \( \text{abs}(y) \), as may be appropriate in residual plots, or others with a meaningful origin at 0
- `method = "mahal"` Treat \((x,y)\) as if it were a bivariate sample, and select cases according to their Mahalanobis distance from \((\text{mean}(x),\text{mean}(y))\)
- `method` can be a vector of the same length as \( x \) consisting of values to determine the points to be labeled. For example, for a linear model \( m \), setting `method=cooks.distance(m)` will label the points corresponding to the largest values of Cook’s distance, or `method = which(abs(residuals(m,type="pearson") > 2)` would label all observations with Pearson residuals greater than 2 in absolute value. Warning: If missing data are present, points may be incorrectly labelled.
- `method` can be a vector of case numbers or case-labels, in which case those cases will be labeled. Warning: If missing data are present, a list of case numbers may identify the wrong points. A list of case labels, however, will work correctly with missing values.
- `method = "none"` causes no point labels to be shown.

With `showLabels`, the `method` argument can be a list, so, for example `method=list("x","y")` would label according to the horizontal and vertical axes variables.

Finally, if the axes in the graph are logged, the function uses logged-variables where appropriate.

Value

A function primarily used for its side-effect of drawing point labels on a plot. Returns invisibly the labels of the selected points, or `NULL` if no points are selected. Although intended for use with other functions in the `car` package, this function can be used directly.

Author(s)

John Fox <jfox@mcmaster.ca>, Sanford Weisberg <sandy@umn.edu>
sigmaHat

References


See Also

`avPlots`, `residualPlots`, `crPlots`, `leveragePlots`

Examples

```r
plot(income ~ education, Prestige)
with(Prestige, showLabels(education, income,
   labels = rownames(Prestige), method=list("x", "y"), n=3))
m <- lm(income ~ education, Prestige)
plot(income ~ education, Prestige)
abline(m)
with(Prestige, showLabels(education, income,
   labels=rownames(Prestige), method=abs(residuals(m)), n=4))
```

sigmaHat

*Return the scale estimate for a regression model*

Description

This function provides a consistent method to return the estimated scale from a linear, generalized linear, nonlinear, or other model.

Usage

`sigmaHat(object)`

Arguments

`object`          A regression object of type `lm`, `glm` or `nls`

Details

For an `lm` or `nls` object, the returned quantity is the square root of the estimate of $\sigma^2$. For a `glm` object, the returned quantity is the square root of the estimated dispersion parameter.

Value

A nonnegative number

Author(s)

Sanford Weisberg, <sandy@umn.edu>
Examples

```r
m1 <- lm(prestige ~ income + education, data=Duncan)
sigmaHat(m1)
```
**References**


**See Also**

`head`, `tail`, `brief`.

**Examples**

```r
some(Duncan)
some(Duncan, cols=names(Duncan)[1:3])
```

---

**Description**

Creates plots for examining the possible dependence of spread on level, or an extension of these plots to the studentized residuals from linear models.

**Usage**

```r
spreadLevelPlot(x, ...)
```

```r
slp(...)
```

```r
## S3 method for class 'formula'
spreadLevelPlot(x, data=NULL, subset, na.action,
                main=paste("Spread-Level Plot for", varnames[response],
                "by", varnames[-response]), ...)
```

```r
## Default S3 method:
spreadLevelPlot(x, by, robust.line=TRUE,
                start=0, xlab="Median", ylab="Hinge-Spread",
                point.labels=TRUE, las=par("las"),
                main=paste("Spread-Level Plot for", deparse(substitute(x)),
                "by", deparse(substitute(by))),
                col=carPalette()[1], col.lines=carPalette()[2],
                pch=1, lwd=2, grid=TRUE, ...)
```

```r
## S3 method for class 'lm'
spreadLevelPlot(x, robust.line=TRUE,
                xlab="Fitted Values", ylab="Absolute Studentized Residuals", las=par("las"),
                main=paste("Spread-Level Plot for
                Absolute Studentized Residuals", deparse(substitute(x))),
                pch=1, col=carPalette()[1], col.lines=carPalette()[2:3], lwd=2, grid=TRUE,
                id=FALSE, smooth=TRUE, ...)
```
## S3 method for class 'spreadLevelPlot'
print(x, ...)

### Arguments

- **x**: a formula of the form \( y \sim x \), where \( y \) is a numeric vector and \( x \) is a factor, or an \texttt{lm} object to be plotted; alternatively a numeric vector.
- **data**: an optional data frame containing the variables to be plotted. By default the variables are taken from the environment from which \texttt{spreadLevelPlot} is called.
- **subset**: an optional vector specifying a subset of observations to be used.
- **na.action**: a function that indicates what should happen when the data contain NAs. The default is set by the \texttt{na.action} setting of \texttt{options}.
- **by**: a factor, numeric vector, or character vector defining groups.
- **robust.line**: if \texttt{TRUE} a robust line is fit using the \texttt{rlm} function in the \texttt{MASS} package; if \texttt{FALSE} a line is fit using \texttt{lm}.
- **start**: add the constant \texttt{start} to each data value.
- **main**: title for the plot.
- **xlab**: label for horizontal axis.
- **ylab**: label for vertical axis.
- **point.labels**: if \texttt{TRUE} label the points in the plot with group names.
- **las**: if \( 0 \), ticks labels are drawn parallel to the axis; set to \( 1 \) for horizontal labels (see \texttt{par}).
- **col**: color for points; the default is the first entry in the current \texttt{car} palette (see \texttt{carPalette} and \texttt{par}).
- **col.lines**: for the default method, the line color, defaulting to the second entry in the \texttt{car} color palette; for the \texttt{"lm"} method, a vector of two colors for, respectively, the fitted straight line and a nonparametric regression smooth line, default to the second and third entries in the \texttt{car} color palette.
- **pch**: plotting character for points; default is 1 (a circle, see \texttt{par}).
- **lwd**: line width; default is 2 (see \texttt{par}).
- **grid**: If \texttt{TRUE}, the default, a light-gray background grid is put on the graph.
- **id**: controls point identification; if \texttt{FALSE} (the default), no points are identified; can be a list of named arguments to the \texttt{showLabels} function; \texttt{TRUE} is equivalent to \texttt{list(method=\texttt{\"x\",\"y\"},n=2,cex=1,col=\texttt{carPalette()}[1],location=\texttt{\"lr\")}, which identifies the 2 points the most extreme horizontal ("X", absolute studentized residual) values and the 2 points with the most extreme horizontal ("Y", fitted values) values.
- **smooth**: specifies the smoother to be used along with its arguments; if \texttt{FALSE}, no smoother is shown; can be a list giving the smoother function and its named arguments; \texttt{TRUE}, the default, is equivalent to \texttt{list(smooother=\texttt{loessLine})}. See \texttt{ScatterplotSmoothers} for the smoothers supplied by the \texttt{car} package and their arguments.
- **...**: arguments passed to plotting functions.
spreadLevelPlot

Details

Except for linear models, computes the statistics for, and plots, a Tukey spread-level plot of log(hinge-spread) vs. log(median) for the groups; fits a line to the plot; and calculates a spread-stabilizing transformation from the slope of the line.

For linear models, plots log(abs(studentized residuals)) vs. log(fitted values). Point labeling was added in November, 2016.

The function slp is an abbreviation for spreadLevelPlot.

Value

An object of class spreadLevelPlot containing:

Statistics a matrix with the lower-hinge, median, upper-hinge, and hinge-spread for each group. (Not for an lm object.)

PowerTransformation

spread-stabilizing power transformation, calculated as $1 - \text{slope}$ of the line fit to the plot.

Author(s)

John Fox <jfox@mcmaster.ca>

References


See Also

hccm, ncvTest

Examples

spreadLevelPlot(interlocks + 1 ~ nation, data=Ornstein)
slp(lm(interlocks + 1 ~ assets + sector + nation, data=Ornstein))
The `regsubsets` function in the `leaps` package finds optimal subsets of predictors based on some criterion statistic. This function plots a measure of fit against subset size.

**Usage**

```r
subsets(object, ...)  
## S3 method for class 'regsubsets'
subsets(object,  
  names=abbreviate(object$xnames, minlength = abbrev),  
  abbrev=1, min.size=1, max.size=length(names),  
  legend="interactive",  
  statistic=c("bic", "cp", "adjr2", "rsq", "rss"),  
  las=par('las'), cex.subsets=1, ...)  
```

**Arguments**

- `object` a `regsubsets` object produced by the `regsubsets` function in the `leaps` package.
- `names` a vector of (short) names for the predictors, excluding the regression intercept, if one is present; if missing, these are derived from the predictor names in `object`.
- `abbrev` minimum number of characters to use in abbreviating predictor names.
- `min.size` minimum size subset to plot; default is 1.
- `max.size` maximum size subset to plot; default is number of predictors.
- `legend` If not FALSE, in which case the legend is suppressed, the coordinates at which to place a legend of the abbreviated predictor names on the plot, in a form recognized by the `legend` function. If "interactive", the legend is placed on the plot interactively with the mouse. By expanding the left or right plot margin, you can place the legend in the margin, if you wish (see `par`).
- `statistic` statistic to plot for each predictor subset; one of: "bic", Bayes Information Criterion; "cp", Mallows’s $C_p$; "adjr2", $R^2$ adjusted for degrees of freedom; "rsq", unadjusted $R^2$; "rss", residual sum of squares.
- `las` if 0, ticks labels are drawn parallel to the axis; set to 1 for horizontal labels (see `par`).
- `cex.subsets` can be used to change the relative size of the characters used to plot the regression subsets; default is 1.
- `...` arguments to be passed down to `subsets.regsubsets` and `plot`.
symbox

Value

NULL if the legend is TRUE; otherwise a data frame with the legend.

Author(s)

John Fox

References


See Also

regsubsets

Examples

```r
if (require(leaps)){
  subsets(regsubsets(undercount ~ ., data=Ericksen),
         legend=c(3.5, -37))
}
```

Description

symbox first transforms `x` to each of a series of selected powers, with each transformation standardized to mean 0 and standard deviation 1. The results are then displayed side-by-side in boxplots, permitting a visual assessment of which power makes the distribution reasonably symmetric.

Usage

```r
symbox(x, ...)
```

## S3 method for class 'formula'

```r
symbox(formula, data=NULL, subset, na.action=NULL, ylab, ...)
```

## Default S3 method:

```r
symbox(x, powers = c(-1, -0.5, 0, 0.5, 1), start,
       trans=bcPower, xlab="Powers", ylab, ...)
```
Arguments

- **x**: a numeric vector.
- **formula**: a one-sided formula specifying a single numeric variable.
- **data, subset, na.action**: as for statistical modeling functions (see, e.g., `lm`).
- **xlab, ylab**: axis labels; if ylab is missing, a label will be supplied.
- **powers**: a vector of selected powers to which x is to be raised. For meaningful comparison of powers, 1 should be included in the vector of powers.
- **start**: a constant to be added to x. If start is missing and trans is `bcPower` (the default) or `bcnPower`, then a start will be automatically generated if there are zero or negative values in x, and a warning will be printed; the auto-generated start is the absolute value of the minimum x plus 1 percent of the range of x.
- **trans**: a transformation function whose first argument is a numeric vector and whose second argument is a transformation parameter, given by the powers argument; the default is `bcPower`, and another possibility is `yjPower`. `bcnPower` may also be used, in which case the gamma parameter is set to the value of start.
- **...**: arguments to be passed down.

Value

as returned by `boxplot`.

Author(s)

Gregor Gorjanc, John Fox <jfox@mcmaster.ca>.

References


See Also

`boxplot`, `boxcox`, `bcPower`, `yjPower`

Examples

`symbox(~ income, data=Prestige)`
**Tapply**

*Apply a Function to a Variable Within Factor Levels*

**Description**

Applies a function, typically to compute a single statistic, like a mean, median, or standard deviation, within levels of a factor or within combinations of levels of two or more factors to produce a table of statistics. This function provides a formula interface to the standard R `tapply` function.

**Usage**

```
Tapply(formula, fun, data, na.action = na.pass, ..., targs = list())
```

**Arguments**

- `formula` a two-sided formula of the form `variable ~ factor.1 + factor.2 + ... + factor.n` or, equivalently, `variable ~ factor.1*factor.2* ... *factor.n`. The variables on the right-hand side of the formula are normally factors or are otherwise coerced to factors.
- `fun` a function, like `mean`, `median`, or `sd`, that takes a vector first argument and typically returns a single number as its value.
- `data` an optional data frame within which to find the variable and factor(s).
- `na.action` a function to handle missing values, as in statistical modeling functions like `lm`; the default is `na.pass`.
- `...` arguments to pass to the function given in the `fun` argument, such as (commonly) `na.rm=TRUE`.
- `targs` a list of optional arguments to pass to `tapply`.

**Details**

The function given by `fun` is applied to the values of the left-hand-side variable in `formula` within (combination of) levels of the factor(s) given in the right-hand side of `formula`, producing a table of statistics.

**Value**

The object returned by `tapply`, typically simply printed.

**Author(s)**

John Fox <jfox@mcmaster.ca>

**References**

See Also
tapply.

Examples

\[
\text{tapply(conformity} \sim \text{partner.status + fcategory, mean, data=Moore)}
\]
\[
\text{tapply(conformity} \sim \text{partner.status + fcategory, mean, data=Moore, trim=0.2)}
\]
Moore[1, 2] <- NA
\[
\text{tapply(conformity} \sim \text{partner.status + fcategory, mean, data=Moore)}
\]
Tapply(conformity ~ partner.status + fcategory, mean, data=Moore, trim=TRUE)
\[
\text{tapply(conformity} \sim \text{partner.status + fcategory, mean, data=Moore, na.action=na.omit)} # \text{equivalent}
\]
remove("Moore")

---

**testTransform**

Likelihood-Ratio Tests for Univariate or Multivariate Power Transformations to Normality

Description
testTransform computes likelihood ratio tests for particular values of the power parameter based on powerTransform objects.

Usage
testTransform(object, lambda)

## S3 method for class 'powerTransform'
testTransform(object, lambda=rep(1, dim(object$y)[2]))

## S3 method for class 'lmerModpowerTransform'
testTransform(object, lambda=1)

## S3 method for class 'bcnPowerTransformlmer'
testTransform(object, lambda=1)

Arguments

object An object created by a call to powerTransform.
lambda A vector of powers of length equal to the number of variables transformed.
The function `powerTransform` is used to estimate a power transformation for a univariate or multivariate sample or multiple linear regression problem, using the method of Box and Cox (1964). It is usual to round the estimates to nearby convenient values, and this function is used to compute a likelihood ratio test for values of the transformation parameter other than the ml-type estimate.

For one-parameter families of transformations, namely the Box-Cox power family `bcPower` and the Yeo-Johnson power family `yjPower`, this function computes a test based on twice the difference in the log-likelihood between the maximum likelihood-like estimate and the log-likelihood evaluated at the value of \( \lambda \) specified.

For the `bcnPower` Box-Cox power with negatives allowed, the test is based on the profile loglikelihood maximizing over the location (or \( \gamma \)) parameter(s). Thus, \( \gamma \) is treated as a nuisance parameter.

A data frame with one row giving the value of the test statistic, its degrees of freedom, and a p-value. The test is the likelihood ratio test, comparing the value of the log-likelihood at the hypothesized value to the value of the log-likelihood at the maximum likelihood estimate.

Sanford Weisberg, <sandy@umn.edu>


`powerTransform` and `bcnPower` for examples of the use of this function and other tests that might be of interest in some circumstances.

```
summary(a3 <- powerTransform(cbind(len, adt, trks, sigs1) ~ htype, Highway1))
# test lambda = (0 0 0 -1)
testTransform(a3, c(0, 0, 0, -1))
summary(q1 <- powerTransform(lm(cbind(LoBD$I1L2, LoBD$I1L1) ~ pool, LoBD), family="bcnPower"))
testTransform(q1, c(.3, .8))
```
TransformationAxes

Axes for Transformed Variables

Description
These functions produce axes for the original scale of transformed variables. Typically these would appear as additional axes to the right or at the top of the plot, but if the plot is produced with axes=FALSE, then these functions could be used for axes below or to the left of the plot as well.

Usage

basicPowerAxis(power, base=exp(1),
    side=c("right", "above", "left", "below"),
    at, start=0, lead.digits=1, n.ticks, grid=FALSE, grid.col=gray(0.50),
    grid.lty=2,
    axis.title="Untransformed Data", cex=1, las=par("las"))

bcPowerAxis(power, side=c("right", "above", "left", "below"),
    at, start=0, lead.digits=1, n.ticks, grid=FALSE, grid.col=gray(0.50),
    grid.lty=2,
    axis.title="Untransformed Data", cex=1, las=par("las"))

bcnPowerAxis(power, shift, side=c("right", "above", "left", "below"),
    at, start=0, lead.digits=1, n.ticks, grid=FALSE, grid.col=gray(0.50),
    grid.lty=2,
    axis.title="Untransformed Data", cex=1, las=par("las"))

yjPowerAxis(power, side=c("right", "above", "left", "below"),
    at, lead.digits=1, n.ticks, grid=FALSE, grid.col=gray(0.50),
    grid.lty=2,
    axis.title="Untransformed Data", cex=1, las=par("las"))

probabilityAxis(scale=c("logit", "probit"),
    side=c("right", "above", "left", "below"),
    at, lead.digits=1, grid=FALSE, grid.lty=2, grid.col=gray(0.50),
    axis.title = "Probability", interval = 0.1, cex = 1, las=par("las"))

Arguments

power
    power for Box-Cox, Box-Cox with negatives, Yeo-Johnson, or simple power transformation.

shift
    the shift (gamma) parameter for the Box-Cox with negatives family.

scale
    transformation used for probabilities, "logit" (the default) or "probit".

side
    side at which the axis is to be drawn; numeric codes are also permitted: side = 1 for the bottom of the plot, side=2 for the left side, side = 3 for the top, side = 4 for the right side.
TransformationAxes

at
numeric vector giving location of tick marks on original scale; if missing, the
function will try to pick nice locations for the ticks.

start
if a start was added to a variable (e.g., to make all data values positive), it can
now be subtracted from the tick labels.

lead.digits
number of leading digits for determining 'nice' numbers for tick labels (default
is 1).

n.ticks
number of tick marks; if missing, same as corresponding transformed axis.

grid
if TRUE grid lines for the axis will be drawn.

grid.col
color of grid lines.

grid.lty
line type for grid lines.

axis.title
title for axis.

cex
relative character expansion for axis label.

las
if 0, ticks labels are drawn parallel to the axis; set to 1 for horizontal labels (see
par).

base
base of log transformation for power.axis when power = 0.

interval
desired interval between tick marks on the probability scale.

Details

The transformations corresponding to the three functions are as follows:

basicPowerAxis: Simple power transformation, \( x' = x^p \) for \( p \neq 0 \) and \( x' = \log x \) for \( p = 0 \).

bcPowerAxis: Box-Cox power transformation, \( x' = (x^\lambda - 1) / \lambda \) for \( \lambda \neq 0 \) and \( x' = \log x \) for
\( \lambda = 0 \).

bcnPowerAxis: Box-Cox with negatives power transformation, the Box-Cox power transformation
of \( z = 0.5 \times (y + (y^2 + \gamma^2)^{1/2}) \), where \( \gamma \) is strictly positive if \( y \) includes negative values and
non-negative otherwise. The value of \( z \) is always positive.

yjPowerAxis: Yeo-Johnson power transformation, for non-negative \( x \), the Box-Cox transforma-
tion of \( x + 1 \); for negative \( x \), the Box-Cox transformation of \( |x| + 1 \) with power \( 2 - p \).

probabilityAxis: logit or probit transformation, logit = \( \log[p/(1 - p)] \), or probit = \( \Phi^{-1}(p) \),
where \( \Phi^{-1} \) is the standard-normal quantile function.

These functions will try to place tick marks at reasonable locations, but producing a good-looking
graph sometimes requires some fiddling with the at argument.

Value

These functions are used for their side effects: to draw axes.

Author(s)

John Fox <jfox@mcmaster.ca>

References

vif

Variance Inflation Factors

Description

Calculates variance-inflation and generalized variance-inflation factors for linear, generalized linear, and other models.

Usage

vif(mod, ...)

## Default S3 method:
vif(mod, ...)

## S3 method for class 'merMod'
vif(mod, ...)

See Also

basicPower, bcPower, yjPower, logit.
Arguments

mod

for the default method, an object that responds to `coef`, `vcov`, and `model.matrix`, such as an `lm` or `glm` object.

... not used.

Details

If all terms in an unweighted linear model have 1 df, then the usual variance-inflation factors are calculated.

If any terms in an unweighted linear model have more than 1 df, then generalized variance-inflation factors (Fox and Monette, 1992) are calculated. These are interpretable as the inflation in size of the confidence ellipse or ellipsoid for the coefficients of the term in comparison with what would be obtained for orthogonal data.

The generalized vifs are invariant with respect to the coding of the terms in the model (as long as the subspace of the columns of the model matrix pertaining to each term is invariant). To adjust for the dimension of the confidence ellipsoid, the function also prints $GVIF^{1/(2 \times df)}$ where $df$ is the degrees of freedom associated with the term.

Through a further generalization, the implementation here is applicable as well to other sorts of models, in particular weighted linear models, generalized linear models, and mixed-effects models.

Value

A vector of vifs, or a matrix containing one row for each term in the model, and columns for the GVIF, df, and $GVIF^{1/(2 \times df)}$.

Author(s)

Henric Nilsson and John Fox <jfox@mcmaster.ca>

References


Examples

```r
vif(lm(prestige ~ income + education, data=Duncan))
vif(lm(prestige ~ income + education + type, data=Duncan))
```
**Description**

Given matrices \( x \) and \( y \) as arguments and an optional matrix or vector of weights, \( w \), return a weighted matrix cross-product, \( t(x) w y \). If no weights are supplied, or the weights are constant, the function uses `crossprod` for speed.

**Usage**

```r
wcrossprod(x, y, w)
```

**Arguments**

- **x, y**
  - \( x, y \) numeric matrices; `missing(y)` is taken to be the same matrix as \( x \). Vectors are promoted to single-column or single-row matrices, depending on the context.

- **w**
  - A numeric vector or matrix of weights, conformable with \( x \) and \( y \).

**Value**

A numeric matrix, with appropriate dimnames taken from \( x \) and \( y \).

**Author(s)**

Michael Friendly, John Fox <jfox@mcmaster.ca>

**See Also**

`crossprod`

**Examples**

```r
set.seed(12345)
N <- 24
drop <- 4
sex <- sample(c("M", "F"), n, replace=TRUE)
x1 <- 1:n
x2 <- sample(1:n)
extra <- c( rep(0, n - drop), floor(15 + 10 * rnorm(drop)) )
y1 <- x1 + 3*x2 + 6*(sex=="M") + floor(10 * rnorm(n)) + extra
y2 <- x1 - 2*x2 - 8*(sex=="M") + floor(10 * rnorm(n)) + extra
# assign non-zero weights to 'dropped' obs
wt <- c(rep(1, n-drop), rep(.2,drop))
X <- cbind(x1, x2)
Y <- cbind(y1, y2)
wcrossprod(X)
wcrossprod(X, w=wt)
```
whichNames

\begin{verbatim}
wcrossprod(X, Y)
wcrossprod(X, Y, w=wt)
wcrossprod(x1, y1)
wcrossprod(x1, y1, w=wt)
\end{verbatim}

<table>
<thead>
<tr>
<th>whichNames</th>
<th>Position of Row Names</th>
</tr>
</thead>
</table>

Description

These functions return the indices of the supplied row names of a data frame or names of another object, such as a vector or list. whichNames is just an alias for which.names.

Usage

whichNames(names, object, ...)
which.names(names, object, ...)

## S3 method for class 'data.frame'
whichNames(names, object, ...)

## Default S3 method:
whichNames(names, object, ...)

Arguments

names a name or character vector of names.
object a data frame or an object with a names attribute.
... not used.

Value

Returns the index or indices of names in row names of the data frame or names of an object of another class.

Author(s)

John Fox <jfox@mcmaster.ca>

References

Examples

whichNames(c('minister', 'conductor'), Duncan)
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