Package 'gvlma'

October 13, 2022

Type Package

Title Global Validation of Linear Models Assumptions

Version 1.0.0.3

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Description Methods from the paper: Pena, EA and Slate, EH, ``Global Validation of Linear Model Assumptions,'' J. American Statistical Association, 101(473):341-354, 2006.

Depends R (>= 2.1.1)

License GPL

NeedsCompilation no

Repository CRAN

Date/Publication 2019-01-05 19:30:03 UTC

R topics documented:

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gvlma-package   *Global Validation of Linear Model Assumptions*

Description

Perform a single global test to assess the linear model assumptions, as well as perform specific directional tests designed to detect skewness, kurtosis, a nonlinear link function, and heteroscedasticity.

Details

Package:	gvlma
Type:	Package
Version:	1.0
Date:	2006-06-07
License:	GPL

The function gvlma will take either a linear models object or a formula and data set for a linear model (single response) and compute the global and directional tests for assessing modeling assumptions as described in the reference listed below. The function deletion.gvlma will compute the deletion ("leave-one-out") global statistics described in that paper.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>

Maintainer: Slate, EH <slate@stat.fsu.edu>

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

gvlma

Examples

```
x1 <- rnorm(100,0,2)
x2 <- runif(100)
y <- 3*x1 -x2 + rnorm(100)
gvmodel <- gvlma(lm(y ~ x1 + x2))
plot(gvmodel)
summary(gvmodel)
gvmodel.del <- deletion.gvlma(gvmodel)
summary(gvmodel.del)
```

```
plot(gvmodel.del)
```

CarMileageData   *Car Mileage Data Recorded at Each Gasoline Fill-Up*

Description

Data on automobile gas mileage performace recorded at each gasoline fill-up from Oct. 20, 1996 through January 27, 1999.

Usage

```
data(CarMileageData)
```

Format

A data frame with 205 observations on the following 7 variables.

Date Date of gasoline fill-up

Lag1Date Lagged gasoline fill-up date

NumDaysBetw Number of days since last gasoline fill-up

TotalMiles Current odometer reading

NumGallons Number of gallons to fill tank

MilesLastFill Miles driven since last fill-up

AveMilesGal Average miles per gallon achieved since last fill-up

Details

Many people routinely record data on automobile mileage performance at each gasoline fill-up. Prof.\ E.\ Pena generously contributed his data for this time period.

Source

These data were used in Example 1 of the publication "Global Validation of Linear Model Assumptions" by E.\ Pena and E. Slate, *Journal of the American Statistical Association*, **101**(473):341-354, 2006. The data were recorded by Prof.\ E.\ Pena.

Examples

```
data(CarMileageData)
plot(CarMileageData)
```

---

deletion.gvlma   *Deletion Statistics for a Linear Model*

Description

Computes the deletion statistics (leave-one-out) for assessing unusual observations in a linear model.

Usage

```
deletion.gvlma(gvlmaobj)
```

Arguments

gvlmaobj   A gvlma object, as the result of a call to gvlma.

Details

Given a gvlma object, which contains in the component GlobalTest the test statistics and p-values for the global and directional tests to assess linear models assumptions, deletion.gvlma computes the leave-one-out global and directional statistics. The deletion statistics are reported as percent relative change from the corresponding statistic value based on the full data set.

Value

A dataframe is returned with variables DeltaGlobalStat, GStatpvalue, DeltaStat1, Stat1pvalue, DeltaStat2, Stat2pvalue, DeltaStat3, Stat3pvalue, DeltaStat4, and Stat4pvalue. Each "Delta" variable is the percent relative change in the statistic when the corresponding observation (row of the data frame) is dropped. Each "pvalue" variable is the p-value associated with the deletion statistic. (Note the p-value is NOT a change in the p-values for the full and leave-one-out statistic values.)

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

[gvlma](#)

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill, data = CarMileageData)
CarModelDel <- deletion.gvlma(CarModelAssess)
CarModelDel
```

---

display.delstats	*Plot Deletion Statistics and Their P-Values for Assessment of Unusual Observations*

Description

Creates a graph of the p-values associated with the deletion statistics versus the deletion statistics with unusual observations highlighted. This function is called by plot.gvlmaDel.

Usage

```
display.delstats(deletedStatvals, deletedpvals, nsd = 3,
                 TukeyStyle = TRUE, statname = "G", pointlabels)
```

Arguments

deletedStatvals

        The vector of deletion statistics, with i-th entry defined as the percent relative change in the global test statistic when the i-th observation is removed from the analysis.

deletedpvals   The vector of p-values associated with the global test statistics, with i-th entry being the p-value for the global test statistic with observation i removed.

nsd   Parameter that governs which observations are deemed unusual. When TukeyStyle = TRUE, "control limits" are drawn nsd times the interquartile range beyond the quartiles for both the deletedStatvals and deletedpvals. When TukeyStyle = FALSE, "control limits" are drawn at nsd standard deviations away from the sample means. Observations beyond these "control limits" are marked and labeled using the text in pointlabels, if provided (else by observation number).

TukeyStyle   Controls how unusual observations are determined. If TukeyStyle = TRUE (default), then unusual observations are farther than nsd times the interquartile range from the quartiles (in either of the deletedStatvals and deletedpvals directions). If TukeyStyle = FALSE, then unusual observations are farther than nsd times the sample standard deviation from the sample mean.

statname   A string used to label the deletedStatvals axis of the plot. If missing, this label is determined from the variable name passed as the deletedStatvals argument, if possible; otherwise defaults to "Deleted statistics."

pointlabels   Character vector of same length as deletedStatvals and deletedpvals used for labelling unusual observations.

Details

Generally `display.delstats` is not called directly, but rather by the function `plot.gvlmaDel`.

Plots the `deletedpvals` versus the `deletedStatvals` and adds "control limits" determined by the parameters `nsd` and `TukeyStyle`. Points outside the "control limits" (in either the `deletedStatval` or `deletedpval`) are labeled as unusual.

Value

A dataframe consisting of the unusual observations with variables `deletedStatval` and `deletedpval`.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

gvlma

Examples

```
data(CarMileageData)
CarMileageAssess <- gvlma(NumGallons ~ MilesLastFill + NumDaysBetw,
data = CarMileageData)
CarMileageDel <- deletion.gvlma(CarMileageAssess)
plot(CarMileageDel)
display.delstats(CarMileageDel$DeltaGlobalStat, CarMileageDel$GStatpvalue)
display.delstats(CarMileageDel$DeltaStat1, CarMileageDel$Stat1pvalue)
```

---

gvlma   *Create a Gvlma Object*

Description

Top-level function for Global Validation of Linear Models Assumptions.

Usage

```
gvlma(x, data, alphalevel = 0.05, timeseq, ...)
gvlma.form(formula, data, alphalevel = 0.05, timeseq = 1:nrow(data), ...)
gvlma.lm(lmobj, alphalevel = 0.05, timeseq)
```

Arguments

x	Either a formula, in which case gvlma.form will be called, or a linear models object, in which case gvlma.lm will be invoked.
formula	A linear models formula interpretable within the dataframe data. Should have a single reponse variable.
lmobj	An object resulting from a call to lm.
data	Required if x is a formula, ignored if x is an lm object. A dataframe in which the variables in the formula x can be interpreted.
alphalevel	Level of significance at which to perform the global and directional tests for linear models assumptions.
timeseq	A vector of length the number of observations in the linear model that gives a "time ordering" for the observations. This time sequence is used in the heteroscedasticity test statistic. Defaults to 1:n where n is the number of observations in the linear model.
...	Additional arguments such as subset that are passed on to the call to lm when x is a formula. Note that weights, while being passed on to the call to lm, will not be used in any special way in the gvlma computations.

Details

gvlma is the top-level function to create a gvlma object for assessment of linear models assumptions.

Value

A gvlma object is returned. This is a list of class "gvlma" that contains all of the components returned by the call to lm for fitting the linear model, plus an additional component entitled "GlobalTest." This new GlobalTest component is a list with the following components:

LevelOfSignificance

 The level of significance at which the decisions reported for the global and directional tests were made.

GlobalStat4   A list consisting of the components Value, pvalue and Decision containing the global test statistic value, associated p-value, and text phrase reporting the decision concerning appropriateness of the linear model assumptions.

DirectionalStat1

 A list consisting of the Value, pvalue and Decision associated with the skewness directional test statistic.

DirectionalStat2

 A list consisting of the Value, pvalue and Decision associated with the kurtosis directional test statistic.

DirectionalStat3

 A list consisting of the Value, pvalue and Decision associated with the link function directional test statistic.

DirectionalStat4

 A list consisting of the Value, pvalue and Decision associated with the heteroscedasticity directional test statistic.

timeseq	The ordering of the observations used when computing the heteroscedasticity directional statistic.
call	The call used to invoke gvlma.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

[plot.gvlma](), [deletion.gvlma](), [update.gvlma](), [lm]()

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill + NumDaysBetw,
                        data = CarMileageData)
CarModelAssess
summary(CarModelAssess)
CarModel2 <- gvlma(lm(NumGallons ~ MilesLastFill + NumDaysBetw,
                      data = CarMileageData))
CarModel2
summary(CarModel2)
plot(CarModel2)
```

---

plot.gvlma   *Various Plots for a Gvlma Object*

Description

Diagnostic plots for a single-response gvlma linear model.

Usage

```
## S3 method for class 'gvlma'
plot(x, onepage = TRUE, ask = !onepage && prod(par("mfcol")) <
    ncol(model.matrix(x)) + 4 && dev.interactive(), ...)
```

Arguments

x	A gvlmaobj object.
onepage	If TRUE, all plots will be displayed in one page of graphs.
ask	If TRUE, user will be prompted before plots begin a new page.
...	Additional arguments that are ignored.

Details

A series of plots is generated for diagnostic assessment of a linear model for a single response variable. The plots are similar to those generated by `plot.lm`. The plots are (a) the response versus each of the predictors in the model, (b) the response versus the time sequence in the gvlma object (gvlmaobj\$GlobalTest\$timeseq), which is the time sequence used for computing the directional test statistic S_4^2, (c) the standardized residuals vs the fitted values, (d) a histogram of the standardized residuals, (e) a normal probability plot of the standardized residuals, and (f) a plot of the standardized residuals versus the time sequence.

Note that the standardized residuals here are computed as the raw residuals divided by the MLE of the error standard deviation (i.e. sqrt(SSE/n)).

Value

No value is returned.

Note

The standardized residuals here are computed as the raw residuals divided by the MLE of the error standard deviation (i.e. sqrt(SSE/n)).

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

gvlma

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill + NumDaysBetw,
    data = CarMileageData)
plot(CarModelAssess)
par(mfrow=c(2,2))
plot(CarModelAssess, onepage = FALSE)
```

plot.gvlmaDel   *Various Plots for a Gvlmadel Object*

Description

Plots to display the behavior of the deletion statistics stored in a gvlmaDel object.

Usage

```
## S3 method for class 'gvlmaDel'
plot(x, which = 1:2, TukeyStyle = TRUE, ask
= prod(par("mfcol")) < max(c(10, 5)[which]) && dev.interactive(),
pointlabels, ...)
```

Arguments

x	A gvlmaDel object.
which	Vector indicating which, or both, of two types of plots to show.
TukeyStyle	If TRUE, determine unusual observations in a robust way based on inter-quartile ranges, else based on standard deviations.
ask	If TRUE, prompt the user before beginning a new page of graphs.
pointlabels	A vector of length the number of observations in the linear model fit in the gvlmaDel object containing character strings to be used as labels for unusual points.
...	Additional arguments that are ignored.

Details

If which = 1, each of the 5 deletion statistics (deletion global statistic and each of the 4 directional statistics) is plotted against the time sequence used for the 4th directional statistic (assessing heteroscedasticity).

If which = 2, the function display.delstats is called for each of the 5 deletion statistics. The argument TukeyStyle is passed directly to display.delstats. See the help for display.delstats for details.

If which = c(1,2), the default, then all 10 plots are generated.

The deletion statistics in the gvlmaDel object are the percent relative change when each observation, in turn, is omitted from the model fitting.

Value

No value is returned.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

gvlma, deletion.gvlma

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill + NumDaysBetw,
    data = CarMileageData)
CarModelDel <- deletion.gvlma(CarModelAssess)
par(mfrow=c(1,1))
plot(CarModelDel)
par(mfrow=c(2,2))
plot(CarModelDel)
plot(CarModelDel, TukeyStyle = FALSE)
plot(CarModelDel, which = 2)
```

---

summary.gvlma   *Print Basic Information for a Gvlma Object*

Description

Prints the basic information for a gvlma object, which is the output object from the function gvlma.

Usage

```
## S3 method for class 'gvlma'
summary(object, ...)
## S3 method for class 'gvlma'
print(x, ...)
display.gvlmatests(gvlmaobj)
```

Arguments

x, object, gvlmaobj

> An object resulting from a call to gvlma. It is a list containing the components of a call to lm plus an item with the name GlobalTest.

...   Additional arguments that are passed to summary.lm.

Details

`print.gvlma` invokes print on the `lm` object and then calls `display.gvlmatests`.

`summary.gvlma` invokes `summary` on the `lm` object with the additional ... arguments and then calls `display.gvlmatests`.

`display.gvlmatests` provides the test statistics, p-values and decision (whether linear models assumptions are satisfied) for the global and directional tests associated with the gvlma object. The decision is reported at the level of significance used when the gvlma object was created. See the argument `alphalevel` to `gvlma`.

Value

The value returned invisibly is a dataframe with row names indicating the global test and the 4 directional tests. Variables are

Value	Value of the test statistic.
p-value	p-value associated with the test.
Decision	Text string indicating whether the test statistic is significant at the significance level specified in the original call to `gvlma`.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

[gvlma](), [display.gvlmatests](), [summary.lm]()

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill, data = CarMileageData)
CarModelAssess
summary(CarModelAssess)
```

---

summary.gvlmaDel   *Basic Information for the Leave-One-Out Global and Directional Tests for Linear Model Assumptions*

Description

Summarize the test statistic values and p-values for assessing unusual observations using the global and directional test statistics that were computed in a `gvlmaDel` object resulting from a call to `deletion.gvlma`.

Usage

```
## S3 method for class 'gvlmaDel'
summary(object, allstats = TRUE, ...)
## S3 method for class 'gvlmaDel'
print(x, ...)
```

Arguments

`object, x`	Object resulting from a call to `deletion.gvlma`, which takes a `gvlma` object and performs the leave-one-out analyses for assessment of the influence of each observation on the global and directional tests for linear model assumptions.
`allstats`	For `summary.gvlmaDel`, if `allstats = TRUE` (the default), then the summary statistics are provided for global test and all 4 directional test statistics. If `summary.gvlmaDel` is FALSE, then the summary is provided for the deletion global test statistics only.
`...`	Additional arguments that are ignored.

Details

The summary values are the min, first quartile, median, average, 3rd quartile and maximum of the deletion test statistic values and p-values. Additionally, observations and the corresponding deletion test statistic values and p-values for which the deletion test statistic value or its p-value is outside the outer fences (Q1 - 3*IQR, Q3 + 3*IQR) of the set of deletion statistics are reported.

`print.gvlmaDel` simply invokes `summary.gvlmaDel` with `allstats = TRUE`.

Value

A dataframe of dimension nobs x 5 is returned invisibly, where nobs is the number of observations in the linear model fit. The 5 columns are named `DeltaGlobalStat`, `DeltaStat1`, `DeltaStat2`, `DeltaStat3`, and `DeltaStat4`, indicating the deletion global test and the four deletion directional test statistics. Each entry in the dataframe is TRUE/FALSE, indicating whether the corresponding test statistic was unusual (i.e. beyond the outer fences) with respect to either its value or its p-value.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

[gvlma](#), [deletion.gvlma](#)

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill, data = CarMileageData)
CarModelAssess
CarModelDel <- deletion.gvlma(CarModelAssess)
CarModelDel
summary(CarModelDel)
summary(CarModelDel, allstats = FALSE)
```

---

update.gvlma   *Update a Gvlma Object*

Description

Update a gvlma object with changes to the linear model, the level of significance for global tests, or the time sequence used for the heteroscedasticity directional test.

Usage

```
## S3 method for class 'gvlma'
update(object, formula, ...)
```

Arguments

object	A gvlma object resulting from a call to gvlma.
formula	(optional) A new formula describing the underlying linear model.
...	Additional arguments to be changed from the original call to gvlma. These may include arguments to the lm function, such as subset, as well as the gvlma-specific arguments alphalevel and timeseq. Internal note: The function deletion.gvlma passes the argument warn = FALSE to suppress warnings about a time sequence of incorrect length.

Details

All arguments other than alphalevel and timeseq (and warn) are passed on to a call to update for the underlying linear model.

If alphalevel is specified, then subsequent displays of the global and directional test statistic decisions will be based on the new level of significance. If timeseq is specified, then the heteroscdasticity direction test, S_4^2, will be updated to use the new time sequence.

Value

A new gvlma object is returned.

Author(s)

Slate, EH <slate@stat.fsu.edu> and Pena, EA <pena@stat.sc.edu>.

References

Pena, EA and Slate, EH (2006). "Global validation of linear model assumptions," *J.\ Amer.\ Statist.\ Assoc.*, **101**(473):341-354.

See Also

gvlma,update.default

Examples

```
data(CarMileageData)
CarModelAssess <- gvlma(NumGallons ~ MilesLastFill + NumDaysBetw,
                        data = CarMileageData)
CarModelAssess
summary(CarModelAssess)
CarModelNew <- update(CarModelAssess, alphalevel = 0.01)
CarModelNew
CarModelNew <- update(CarModelAssess, subset = -(1:10))
CarModelNew
summary(CarModelNew)
```

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