

# Package ‘glmxdiaq’

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**Title** A Collection of Graphic Tools for GLM Diagnostics and some Extensions

**Depends** R (>= 3.6.0)

**Description** Provides diagnostic graphic tools for GLMs, beta-binomial regression model (estimated by 'VGAM' package), beta regression model (estimated by 'betareg' package) and negative binomial regression model (estimated by 'MASS' package). Since most of functions implemented in 'glmxdiaq' already exist in other packages, the aim is to provide the user unique functions that work on almost all regression models previously specified. Details about some of the implemented functions can be found in Brown (1992) <[doi:10.2307/2347617](https://doi.org/10.2307/2347617)>, Dunn and Smyth (1996) <[doi:10.2307/1390802](https://doi.org/10.2307/1390802)>, O'Hara Hine

**License** GPL (>= 2)

**NeedsCompilation** no

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avplot	<i>Added Variable Plot</i>
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## Description

Constructs added variable plots for generalized linear models and extensions admitted by `glmxdia`.

## Usage

```
avplot(model, variables, type = c("Wang", "Hines-Carter"), label.id,
        n.label.id, xlab, ylab, main, pos, pch, cex, lcol, lwd, lty, ...)
```

## Arguments

<code>model</code>	a model supported by <code>glmxdia</code> .
<code>variables</code>	a vector of characters containing names of regressors; must be included inside the model matrix. If nothing is specified, <code>avplot</code> is applied on all variables.
<code>type</code>	default is "Wang" developed by Wang (1985); if "Hines-Carter" the method developed by Hines and Carter (1993) is used.
<code>label.id</code>	labels of observations, should be a vector with <code>n</code> elements
<code>n.label.id</code>	number of observations to label in the plot that most influence the "clean" relationship of considered variables. Cook's distance is used as the measure of influence.
<code>xlab</code>	title for the x axis.
<code>ylab</code>	title for the y axis.
<code>main</code>	an overall title for the plot.
<code>pos</code>	position of observations labels. Values 1, 2, 3, 4 respectively indicate below, left, above, right.
<code>pch</code>	type of points.
<code>cex</code>	size of points.
<code>lcol</code>	color of line.
<code>lwd</code>	width of line.
<code>lty</code>	type of line.
<code>...</code>	further arguments passed to plot.

## Details

The aim of added variable plot is to isolate the relationship between a specific variable and the response, i.e. fixing all the other variables included in the linear predictor. In the y-axis there are the *working residuals* of the reduced model (i.e. a model where the variable we're interested in, say "x", is excluded) while on the x-axis there are the residuals of regression of x using all the other variables. Values in both axis are weighted: Wang (1985) uses the *working weights* of the reduced model while Hines and Carter (1993) suggest that using the weights of the full model is more reliable in indicating the presence of influential observations.

## Value

Doesn't return a value, called for side effects.

## Author(s)

Giuseppe Reale

## References

- Wang, P. C. (1985) Adding a variable in generalized linear models. *Technometrics* 27, 273-276.
- R. J. O'Hara Hines, & Carter, E. M. (1993). Improved Added Variable and Partial Residual Plots for the Detection of Influential Observations in Generalized Linear Models. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 42(1), 3-20.

## Examples

```
data(moons)
m <- glm(Moons ~ Mass + Distance + Diameter,
         family = poisson, data = moons)
summary(m)
avplot(m, 'Distance', label.id = moons$Name)
```

---

cookDist

*Visualize Cook's distances*

---

## Description

Graphical visualization of Cook's distances for each observation within input model.

## Usage

```
cookDist(object, label.id, n.label.id, xlab, ylab, pos, ...)
```

**Arguments**

object	object of class 'influence', see Details.
label.id	labels of observations, should be a vector with n elements.
n.label.id	number of observations with highest Cook's distance to label in the plot.
xlab	title for the x axis.
ylab	title for the y axis.
pos	position of observations labels. Values 1, 2, 3, 4 respectively indicate below, left, above, right.
...	further arguments passed to plot.

**Details**

This function only works with objects given as output from `influenceDiag`, it takes Cook's distances and plot them as vertical segments.

High values are associated to high influence within the model.

**Value**

Doesn't return a value, called for side effects.

**Author(s)**

Giuseppe Reale

**Examples**

```
data("mtcars")
mod <- glm(mpg ~ cyl + hp + carb, family = Gamma, data = mtcars)
inf <- influenceDiag(mod)
cookDist(inf, label.id = rownames(mtcars))
```

---

devAnalysis

*Graphical analysis of Deviance*


---

**Description**

A graphical tool developed by Brown (1992) to assess the contribution of one or more of the explanatory variables inside a Generalized Linear Model. This plot displays all single variable comparisons and shows how they relate to other terms that are already in the model in terms of deviance. The output plot is divided into three frames, see Details.

**Usage**

```
devAnalysis(model, cex.pl = .8, cex.vars = 1, cex.vars2 = 1,
            layout.heights = c(1.2,0.8,4), pl.scale = 1,
            xlab, ylab, title)
```

## Arguments

<code>model</code>	a model supported by <code>glm.diag</code> .
<code>cex.pl</code>	dimension of points of linear predictors.
<code>cex.vars</code>	dimension of variables names inside lower frame.
<code>cex.vars2</code>	dimension of variables names inside medium frame.
<code>layout.heights</code>	a vector with three heights for the frames, from upper to lower.
<code>pl.scale</code>	proportion given to the sub-frame of the lower frame indicating the linear predictors.
<code>xlab</code>	a title for the x axis of lower frame.
<code>ylab</code>	a title for the y axis of lower frame.
<code>title</code>	an overall title for the plot.

## Details

In order to give a clear explanation of the plot, these will be given referred to the output plot of example code. The plot is divide into three frames: upper, medium and lower; we will start by explaining the lower one.

On the y axis we have the residual deviance and each horizontal line corresponds to the (residual) deviance of a particular fitted model. On the right side of each horizontal line there are plus signs: based on the column they're in, they indicate if that specific variable is included in the linear predictor. For example, looking at the first horizontal line (right under the names `diam`, `mass`, `dist`), there are no plus signs on the adjacent columns: that is the null model. The line under the null model has a plus sign in corpespondece of `dist`, i.e. only variable distance is included within that model.

The differences in deviance corresponding to the addition of a term to the various possible models (i.e. models not containing the term in question) are represented by vertical lines connecting the two appropriate horizontal model lines. For example the first vertical line connects the null model to the one that has just `diam` in the linear predictor. Note that this frame is divided into blocks and each one contains the differences in deviance (i.e. vertical lines) corresponding to addition of a specific variable; in this case there are three blocks for three variables.

The upper frame is just a summary of the lower one; the vertical lines are the same but in a reduced scale. The medium frame indicates the linear predictors of a model before adding the block-specific variable. For example the are no plus signs under the first vertical line; this means that it corresponds to the change in deviance when `diam` is added to the null model (because we are in the `diam` block as in the lower frame). The second line corresponds to the difference in deviance in a model containing only `mass` due to adding `diam`, and so on.

This graph is really useful to investigate the relationship between variable inside a model. In this case we may notice that adding `mass` is relevant when there are no variables or only `dist`; on the other hand its contribution is almost imperceptible when `diam` is already included within linear predictor.

If the description of arguments `layout.heights` and `pl.scale` is not clear, the best way to understand their role is to run the code a few times changing these parameters: this will do it.

The best advice is to use this function with a maximum of 4-5 variables or else the plot will result confusing.

**Value**

Doesn't return a value, called for side effects.

**Author(s)**

Giuseppe Reale

**References**

Brown, D. (1992). A Graphical Analysis of Deviance. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 41(1), 55-62.

M. Sciandra & A. Plaia (2018) A graphical model selection tool for mixed models, *Communications in Statistics - Simulation and Computation*, 47:9, 2624-2638

**Examples**

```
data(moons)
dist <- moons$Distance
diam <- moons$Diameter
mass <- moons$Mass
mod <- glm(moons$Moons ~ diam + mass + dist, family = poisson)
devAnalysis(mod, cex.vars = 1.3, cex.vars2 = 1.1)
```

---

DFbeta

*Visualize DFbetas*


---

**Description**

Graphical visualization of DFbetas for each observation and chosen variables within input model.

**Usage**

```
DFbeta(object, variables, centered = TRUE, label.id, n.label.id,
        xlab, ylab, main, pos, pch, cex, lcol, lwd, lty, ...)
```

**Arguments**

object	object of class 'influence', see Details.
variables	a vector of characters containing names of variables; if nothing is specified, DFbetas for all variables are plotted.
centered	logical, if TRUE the plot is centered on the coefficients of the full model and each point corresponds to the coefficient if the i-th observation is excluded. if FALSE, usual DFbetas centered on zero are plotted.
label.id	labels of observations, should be a vector with n elements.
n.label.id	number of observations with highest DFbetas to label in the plot.

xlab	title for the x axis.
ylab	title for the y axis.
main	an overall title for the plot.
pos	position of observations labels. Values 1, 2, 3, 4 respectively indicate below, left, above, right.
pch	type of points.
cex	size of points.
lcol	color of line.
lwd	width of line.
lty	type of line.
...	further arguments passed to plot

### Details

This function only works with objects given as output from `influenceDiag`.

DFbetas are calculated as  $B - B(-i)$  hence they are not standardized; if `centered` is set to `TRUE` then each plotted point corresponds to  $B(-i)$ , otherwise to  $B - B(-i)$ .

### Value

Doesn't return a value, called for side effects.

### Author(s)

Giuseppe Reale

### Examples

```
data("mtcars")
mod <- glm(mpg ~ cyl + hp + carb, family = Gamma, data = mtcars)
inf <- influenceDiag(mod)
DFbeta(inf, label.id = rownames(mtcars))
DFbeta(inf, variables = 'cyl', label.id = rownames(mtcars), pos = 2)

# to visualize all of them in a single plot
par(mfrow = c(2, 2))
DFbeta(inf, label.id = rownames(mtcars))
# press <Enter> four times
par(mfrow = c(1, 1))
```

---

diabetes

*Diabetes*

---

### Description

This data comes from a study (Sockett et al, 1987) of the factors affecting patterns of insulin-dependent mellitus in children. The objective is to investigate the dependence of the level of serum C-peptide on the various other factors in order to understand the patterns of residual insulin secretion. The response measurement is the logarithm of C-peptide concentration (pmol/ml) at the diagnosis, and the predictor measurements age and base deficit, a measure of acidity.

### Usage

```
data("diabetes")
```

### Format

A data frame with 43 observations on the following 3 variables.

Age age of the child.

Def base deficit, a measure of acidity.

C\_peg logarithm of C-peptide concentration (pmol/ml).

### Source

Generalized Additive Models (p.304) by Hastie & Tibshirani, Chapman & Hall.

---

funComp

*Compatibility of functions*

---

### Description

Not all functions inside `glmxdia` are available for quasi-GLM or GLM extensions. The output table helps the user orientate inside the package in order to check which function can be used according to the model under analysis.

### Usage

```
funComp()
```

### Value

Returns a dataframe. 'X' inside a cell means that the row-function can be used with the specific column-model, otherwise it cannot be used.



**Author(s)**

Giuseppe Reale

**Examples**

funComp()

---

influenceDiag	<i>Influence Diagnostic Measures</i>
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---

**Description**

Calculates or extracts some influence diagnostic measures such as DFbetas, Cook's distance and leverage.

**Usage**

```
influenceDiag(model, approx = TRUE)
```

**Arguments**

model	a model supported by glmxdia.
approx	logical, if TRUE the function is faster but returns approximated results.

**Details**

Leverage is extracted from the models using hatvalues function of each model class.

The elements for GLMs and negative binomial regression models are always approximated as they are extracted from influence function.

The argument approx can be useful only with models of class *vglm* and *betareg* since influence method function is not defined and items are fully calculated. It estimates  $n$  models where observations are excluded one by one. When approx = T one step approximation is used; the *tol* parameter within every fitting model function is set high such that the fitting process stops at the first iteration hence results are not exact but they are supposed to be close.

For betabinomial models, cook's distance is replaced with the quantity  $(b - b(-i)) \text{Var}(b) (b - b(-i))/p$  as suggested by *glmtoolbox* package..

The aim of the function is to group these diagnostic measures in one list; one should use influenceDiag to calculate the measures and use the output object inside functions DFbeta, cookDist and leverage in order to graphically visualize results.

**Value**

Returns a list of class "influence" with the following elements:

DFbeta	data frame containing dfbetas for all observations and variables.
cookDist	a vector containing cook's distances.
leverage	hat values, i.e. the diagonal of the hat matrix.
full.beta	coefficients of the full model.
family	family name

**Author(s)**

Giuseppe Reale

**Examples**

```
data("mtcars")
mod <- glm(mpg ~ cyl + hp + carb + wt, family = Gamma, data = mtcars)
inf <- influenceDiag(mod)
cookDist(inf)
leverage(inf)
DFbeta(inf)
```

---

leverage

*Visualize Leverages*


---

**Description**

Graphical visualization of leverages for each observation within input model. Corresponds to the main diagonal of the hat matrix, i.e  $H[i,i]$ .

**Usage**

```
leverage(object, label.id, n.label.id, xlab, ylab, pos,
         hline, lcol, lwd, lty, ...)
```

**Arguments**

object	object of class 'influence', see Details.
label.id	labels of observations, should be a vector with n elements.
n.label.id	number of observations with highest leverage to label in the plot.
xlab	title for the x axis.
ylab	title for the y axis.
pos	position of observations labels. Values 1, 2, 3, 4 respectively indicate below, left, above, right.

hline	numeric, where to position the horizontal line; useful to individuate points that exceed a specific treshold. Defaults to $2 \cdot p/n$ .
lcol	color of line.
lwd	width of line.
lty	type of line.
...	further arguments passed to plot

### Details

This function only works with objects given as output from `influenceDiag`.

A rule of thumbs says that an observations has high leverage if  $H[i,i] > 2 \cdot p/n$  where  $p$  is the number of coefficients and  $n$  the sample size.

### Value

Doesn't return a value, called for side effects.

### Author(s)

Giuseppe Reale

### Examples

```
data("mtcars")
mod <- glm(mpg ~ cyl + hp + carb, family = Gamma, data = mtcars)
inf <- influenceDiag(mod)
leverage(inf, label.id = rownames(mtcars))
```

---

linkLin

*Checking linearity of link function*

---

### Description

According to Lovison (2014), if the link function is correctly specified then there is a linear relationship between the working response variable  $z$  and the linear predictor *eta*. This plot suggests if the link function is appropriate.

### Usage

```
linkLin(model, smooth = TRUE, xlab, ylab, main, pch, lcol, lwd, ...)
```

**Arguments**

model	a model supported by glmxdia.
smooth	logical, whether to plot a smoothing spline.
xlab	title for the x axis.
ylab	title for the y axis.
main	an overall title for the plot.
pch	type of points.
lcol	color of the smoothing line.
lwd	size of the smoothing line.
...	further arguments passed to plot

**Details**

The assumption behind the output plot is that the model is correctly specified. In the y-axis there is the working response variable while on the x-axis there is the linear predictor: the more their relationship is linear the more appropriate the link function should be.

**Value**

Doesn't return a value, called for side effects.

**Author(s)**

Giuseppe Reale

**Examples**

```
## Simulate the data

set.seed(5)
n.obs <- 100
x <- rnorm(n.obs)
shape <- 25
mu <- exp(1 + .5* x)
y <- rgamma(n.obs, rate = shape / mu, shape = shape)

true.mod <- glm(y ~ x, family = Gamma(link = 'log'))
wrong1 <- glm(y ~ x, family = Gamma(link = 'inverse'))
wrong2 <- glm(y ~ x, family = Gamma(link = 'identity'))

par(mfrow = c(2, 2))
linkLin(true.mod)
linkLin(wrong1)
linkLin(wrong2)
par(mfrow = c(1, 1))
```

---

 moons

*Moons of the 13 planets of the Solar System*


---

**Description**

This dataset contains informations about dimensions, number of moons and distance from the Sun of the eight planets and the five dwarf planets of the Solar System. The objective is to find a proper relationship between the number of moons and other variables. All variables are normalized in respect to the Earth, so that it has always value 1.

**Usage**

```
data("moons")
```

**Format**

A data frame with 13 observations on the following 5 variables.

Name name of the planet.

Distance distance from the sun.

Diameter diameter of the planet.

Mass mass of the planet.

Moons number of moons.

**Source**

<https://en.wikipedia.org/wiki/Planet>

---

 Qresiduals

*Graphical normality testing for quantile residuals*


---

**Description**

Derives quantile residuals of the input model and creates two plots: the first compares density of a standard normal distribution to the residuals' empirical density while the other one is a *QQplot*.

**Usage**

```
Qresiduals(model, plot.it = TRUE)
```

**Arguments**

model a model supported by glmxdia.

plot.it logical, whether to plot the results or not.

## Details

Quantile residuals are defined on a continuous cumulative distribution function; for binomial, beta-binomial, poisson and negative binomial regression models the *Randomized quantile residuals* are used.

Residuals have an important role inside the global diagnostic of a regression model. Any departure from the standard normal distribution can be considered as a warning that one or more aspects of the model are misspecified. Quantile residuals are particularly useful with models that do not have a continuous response variable, such as a binomial or poisson models; see examples.

## Value

Called for side effects but invisibly returns the calculated quantile residuals.

## Author(s)

Giuseppe Reale

## References

Peter K. Dunn and Gordon K. Smyth (1996). Randomized Quantile Residuals. *Journal of Computational and Graphical Statistics*.

## Examples

```
# Simulate the data

set.seed(10)
n <- 100
x1 <- rt(n, df = 4)
x2 <- rnorm(n, sd = 2)
b <- c(1, .5, .5)
eta <- b[1] + b[2] * x1 + b[3] * x2
prob <- exp(eta)/(1 + exp(eta))
y <- rbinom(n, size = 1, prob = prob)

# The model is correctly specified
mod <- glm(y ~ x1 + x2, family = binomial)

res.p <- residuals(mod, type = 'pearson')
res.d <- residuals(mod, type = 'deviance')
qres <- Qresiduals(mod, plot.it = FALSE)

shapiro.test(res.p) # not normal
shapiro.test(res.d) # not normal
shapiro.test(qres) # normal

y.hat <- fitted(mod)

plot(y.hat, res.p) # uninformative
plot(y.hat, res.d) # uninformative
```

```
plot(y.hat, qres)
```

```
Qresiduals(mod)
```

---

 stopping

*Stopping*


---

### Description

This data set concerns the stopping distances for cars travelling at different speeds. There are replicate values for some speeds. The objective is to find a model for these data.

### Usage

```
data("stopping")
```

### Format

A data frame with 63 observations on the following 2 variables.

Speed travelling speed (miles per hour).

Distance stopping distance (feet).

### Source

Snee, R.D. (1986) An alternative approach to fitting models when re-expression of the response is useful. *Journal of Quality Technology*, 18,211-225.

A Handbook of Small Data Sets (p.354) by Hand, Daly, McConway, Lunn, Ostrowski. Chapman & Hall.

---

 varCheck

*Checking adequacy of variance function*


---

### Description

According to GLM theory, the true variance function can be estimated as  $(y-\mu)^2/\phi$ . Comparing this quantity with the variance function assumed by the model suggests if the chosen one is appropriate. If the model is correct, points should be arranged near the bisector; otherwise this plot suggests the direction of the error made by choosing the variance function.

### Usage

```
varCheck(model, xlab, ylab, pch, col, lcol, ...)
```

**Arguments**

model	a model supported by glmxdiag.
xlab	title for the x axis.
ylab	title for the y axis.
pch	type of points.
col	color of the points.
lcol	color of the bisector.
...	further arguments passed to plot.

**Value**

Doesn't return a value, called for side effects.

**Author(s)**

Giuseppe Reale

**Examples**

```
data(stopping, package = 'glmxdiag')
mod <- glm(Distance ~ Speed, family = Gamma(link = 'sqrt'), data = stopping)
varCheck(mod)
```

---

variableOut

*Excluding a variable from the model*

---

**Description**

Graphically compares models in terms of Information Criterion, each one corresponds to a model where a specific variable is deleted from the linear predictor.

**Usage**

```
variableOut(model, k = 2, update.it = FALSE, xlab, ylab, pch,
            col, lty, ylim, ...)
```



**Arguments**

model	a model supported by glm.diag.
k	numeric, the penalty per parameter to be used; the default $k = 2$ is the classical AIC.
update.it	logical; if TRUE, model without the variable corresponding to the lowest score is returned.
xlab	title for the x axis.
ylab	title for the y axis, by default is 'AIC'; should be changed if a different $k$ is chosen.
pch	type of points.
col	color of points and segments.
lty	type of horizontal line.
ylim	y limits of the plot.
...	further arguments passed to plot.

**Details**

Each plotted point corresponds to the score of the model where the variable indicated on x axis is excluded. A dashed line is drawn in correspondence of the full model score.

Points and segments corresponding to variables whose deletion lead to a increment of the scored are black, those who lead to a decrement are red.

The output plot can be seen as a graphic version of the first step of stepAIC function inside MASS package.

Theory about Information Criterion suggests that if the minimum score doesn't belong to the full model, then the linear predictor may not be appropriate.

**Value**

Called for side effects, but if update.it is set to TRUE returns a model without the variable corresponding to the lowest score.

**Author(s)**

Giuseppe Reale

**Examples**

```
data("moons")
model <- glm(Moons ~ Diameter * Mass + Distance, family = poisson, data = moons)
variableOut(model)

n <- nobs(model)
new.model <- variableOut(model, k = log(n), ylab = 'BIC', update.it = TRUE)
```

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