Package 'dglm'

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Title Double Generalized Linear Models

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Description Model fitting and evaluation tools for double generalized linear
models (DGLMs). This class of models uses one generalized linear model (GLM)
to fit the specified response and a second GLM to fit the deviance of the first
model.

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R topics documented:

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anova.dglm   *Analysis of Deviance for Double Generalized Linear Model Fits*

Description

Compute an analysis of deviance table for one or more double generalized linear model fits.

Usage

```
## S3 method for class 'dglm'
anova(object, ...)
```

Arguments

object	objects of class dglm, typically the result of a call to dglm.
...	Not used.

Details

Specifying a single object gives sequential and adjusted likelihood ratio tests for the mean and dispersion model components of the fit. The aim is to test overall significance for the mean and dispersion components of the double generalized linear model fit. The sequential tests (i) set both mean and dispersion models constant, add the mean model and (ii) sequentially add the dispersion model. The adjusted tests determine whether the mean and dispersion models can be set constant separately.

Value

An object of class "anova" inheriting from class "data.frame".

Warning

The anova method is questionable when applied to an "dglm" object with method="reml" (stick to method="ml").

Author(s)

Gordon Smyth, ported to R\ by Peter Dunn (<pdunn2@usc.edu.au>)

References

Hastie, T. J. and Pregibon, D. (1992) *Generalized linear models.* Chapter 6 of *Statistical Models in S* eds J. M. Chambers and T. J. Hastie, Wadsworth \& Brooks/Cole.

Smyth, G. K. (1989). Generalized linear models with varying dispersion. *J. R. Statist. Soc. B*, **51**, 47–60.

Smyth, G. K., and Verbyla, A. P. (1999). Adjusted likelihood methods for modelling dispersion in generalized linear models. *Environmetrics*, **10**, 696-709.

Verbyla, A. P., and Smyth, G. K. (1998). Double generalized linear models: approximate residual maximum likelihood and diagnostics. Research Report, Department of Statistics, University of Adelaide.

See Also

dglm, anova.

Examples

```
# Continuing the example from  glm, but this time try
# fitting a Gamma double generalized linear model also.
library(statmod)
clotting <- data.frame(
     u = c(5,10,15,20,30,40,60,80,100),
     lot1 = c(118,58,42,35,27,25,21,19,18),
     lot2 = c(69,35,26,21,18,16,13,12,12))

# The same example as in  glm: the dispersion is modelled as constant
out <- dglm(lot1 ~ log(u), ~1, data=clotting, family=Gamma)
summary(out)

# Try a double glm
out2 <- dglm(lot1 ~ log(u), ~u, data=clotting, family=Gamma)

summary(out2)
anova(out2)
```

---

dglm   *Double generalised linear models*

Description

Fits a generalized linear model with a link-linear model for the dispersion as well as for the mean.

Usage

```
dglm(formula=formula(data), dformula = ~ 1, family = stats::gaussian, dlink = "log",
data = parent.frame(), subset = NULL, weights = NULL, contrasts = NULL,
method = "ml", mustart = NULL, betastart = NULL, etastart = NULL, phistart = NULL,
control = dglm.control(...), ykeep = TRUE, xkeep = FALSE, zkeep = FALSE, ...)

dglm.constant(y,family,weights=1)
```

Arguments

formula   a symbolic description of the model to be fit. The details of model specification
                 are found in dglm.

dformula	a formula expression of the form ~ predictor, the response being ignored. This specifies the linear predictor for modelling the dispersion. A term of the form offset(expression) is allowed.
family	a description of the error distribution and link function to be used in the model. See glm for more information.
dlink	link function for modelling the dispersion. Any link function accepted by the quasi family is allowed, including power(x). See details below.
data	an optional data frame containing the variables in the model. See glm for more information.
subset	an optional vector specifying a subset of observations to be used in the fitting process.
weights	an optional vector of weights to be used in the fitting process.
contrasts	an optional list. See the contrasts.arg of model.matrix.default.
method	the method used to estimate the dispersion parameters; the default is "reml" for restricted maximum likelihood and the alternative is "ml" for maximum likelihood. Upper case and partial matches are allowed.
mustart	numeric vector giving starting values for the fitted values or expected responses. Must be of the same length as the response, or of length 1 if a constant starting vector is desired. Ignored if betastart is supplied.
betastart	numeric vector giving starting values for the regression coefficients in the link-linear model for the mean.
etastart	numeric vector giving starting values for the linear predictor for the mean model.
phistart	numeric vector giving starting values for the dispersion parameters.
control	a list of iteration and algorithmic constants. See dglm.control for their names and default values. These can also be set as arguments to dglm itself.
ykeep	logical flag: if TRUE, the vector of responses is returned.
xkeep	logical flag: if TRUE, the model.matrix for the mean model is returned.
zkeep	logical flag: if TRUE, the model.matrix for the dispersion model is returned.
...	further arguments passed to or from other methods.
y	numeric response vector

Details

Write $\mu_i = \mathrm{E}[y_i]$ for the expectation of the ith response. Then $\mathrm{Var}[Y_i] = \phi_i V(\mu_i)$ where V is the variance function and ϕ_i is the dispersion of the ith response (often denoted as the Greek character 'phi'). We assume the link linear models $g(\mu_i) = \mathbf{x}_i^T \mathbf{b}$ and $h(\phi_i) = \mathbf{z}_i^T \mathbf{z}$, where $\mathbf{x}_i$ and $\mathbf{z}_i$ are vectors of covariates, and $\mathbf{b}$ and $\mathbf{a}$ are vectors of regression cofficients affecting the mean and dispersion respectively. The argument dlink specifies h. See family for how to specify g. The optional arguments mustart, betastart and phistart specify starting values for μ_i, $\mathbf{b}$ and ϕ_i respectively.

The parameters $\mathbf{b}$ are estimated as for an ordinary GLM. The parameters $\mathbf{a}$ are estimated by way of a dual GLM in which the deviance components of the ordinary GLM appear as responses. The estimation procedure alternates between one iteration for the mean submodel and one iteration for the dispersion submodel until overall convergence.

The output from dglm, out say, consists of two glm objects (that for the dispersion submodel is out$dispersion.fit) with a few more components for the outer iteration and overall likelihood. The summary and anova functions have special methods for dglm objects. Any generic function which has methods for glms or lms will work on out, giving information about the mean submodel. Information about the dispersion submodel can be obtained by using out$dispersion.fit as argument rather than out itself. In particular drop1(out,scale=1) gives correct score statistics for removing terms from the mean submodel, while drop1(out$dispersion.fit,scale=2) gives correct score statistics for removing terms from the dispersion submodel.

The dispersion submodel is treated as a gamma family unless the original reponses are gamma, in which case the dispersion submodel is digamma. (Note that the digamma and trigamma functions are required to fit a digamma family.) This is exact if the original GLM family is gaussian, Gamma or inverse.gaussian. In other cases it can be justified by the saddle-point approximation to the density of the responses. The results will therefore be close to exact ML or REML when the dispersions are small compared to the means. In all cases the dispersion submodel as prior weights 1, and has its own dispersion parameter which is 2.

Value

an object of class dglm is returned, which inherits from glm and lm. See dglm.object for details.

Note

The anova method is questionable when applied to an dglm object with method="reml" (stick to method="ml").

Author(s)

Gordon Smyth, ported to R\ by Peter Dunn (<pdunn2@usc.edu.au>)

References

Smyth, G. K. (1989). Generalized linear models with varying dispersion. *J. R. Statist. Soc. B*, **51**, 47–60.

Smyth, G. K., and Verbyla, A. P. (1999). Adjusted likelihood methods for modelling dispersion in generalized linear models. *Environmetrics*, **10**, 696-709.

Verbyla, A. P., and Smyth, G. K. (1998). Double generalized linear models: approximate residual maximum likelihood and diagnostics. Research Report, Department of Statistics, University of Adelaide.

See Also

dglm.object, dglm.control, Digamma family, Polygamma

Examples

```
# Continuing the example from  glm, but this time try
# fitting a Gamma double generalized linear model also.
library(statmod)
clotting <- data.frame(
```

```
        u = c(5,10,15,20,30,40,60,80,100),
        lot1 = c(118,58,42,35,27,25,21,19,18),
        lot2 = c(69,35,26,21,18,16,13,12,12))

# The same example as in  glm: the dispersion is modelled as constant
# However, dglm uses  ml  not  reml,  so the results are slightly different:
out <- dglm(lot1 ~ log(u), ~1, data=clotting, family=Gamma)
summary(out)

# Try a double glm
out2 <- dglm(lot1 ~ log(u), ~u, data=clotting, family=Gamma)

summary(out2)
anova(out2)

# Summarize the mean model as for a glm
summary.glm(out2)

# Summarize the dispersion model as for a glm
summary(out2$dispersion.fit)

# Examine goodness of fit of dispersion model by plotting residuals
plot(fitted(out2$dispersion.fit),residuals(out2$dispersion.fit))
```

---

dglm.control	*Auxiliary for controlling double glm fitting*

Description

Auxiliary function as user interface for fitting double generalized linear models. Typically only used when calling dglm.

Usage

```
dglm.control(epsilon = 1e-007, maxit = 50, trace = FALSE, ...)
```

Arguments

epsilon	positive convergence tolerance epsilon; the iterations converge when $(\|L_o - L\|)/(\|L_o\| + 1) > \epsilon$, where L_o is minus twice the values of log-likelihood on the previous iteration, and L is minus twice the values of log-likelihood on the current.
maxit	integer giving the maximal number of outer iterations of the alternating iterations.
trace	logical indicating if (a small amount of) output should be produced for each iteration.
...	not currently implemented

Details

When 'trace' is true, calls to 'cat' produce the output for each outer iteration. Hence, 'options(digits = *)' can be used to increase the precision; see the example for glm.control.

Author(s)

Gordon Smyth, ported to R\ by Peter Dunn (<pdunn2@usc.edu.au>)

References

Smyth, G. K. (1989). Generalized linear models with varying dispersion. *J. R. Statist. Soc. B*, **51**, 47–60.

Smyth, G. K., and Verbyla, A. P. (1999). Adjusted likelihood methods for modelling dispersion in generalized linear models. *Environmetrics*, **10**, 696-709.

Verbyla, A. P., and Smyth, G. K. (1998). Double generalized linear models: approximate residual maximum likelihood and diagnostics. Research Report, Department of Statistics, University of Adelaide.

See Also

dglm.object, dglm

Examples

```
### A variation on  example(dglm) :
# Continuing the example from  glm, but this time try
# fitting a Gamma double generalized linear model also.
clotting <- data.frame(
     u = c(5,10,15,20,30,40,60,80,100),
     lot1 = c(118,58,42,35,27,25,21,19,18),
     lot2 = c(69,35,26,21,18,16,13,12,12))

# The same example as in  glm: the dispersion is modelled as constant
out <- dglm(lot1 ~ log(u), ~1, data=clotting, family=Gamma)
summary(out)

# Try a double glm
oo <- options()
options(digits=12) # See more details in tracing
out2 <- dglm(lot1 ~ log(u), ~u, data=clotting, family=Gamma,
   control=dglm.control(epsilon=0.01, trace=TRUE))
   # With this value of epsilon, convergence should be quicker
   # and the results less reliable (compare to example(dglm) )

summary(out2)
options(oo)
```

---

dglm.object   *Double generalized linear model object*

Description

Class of objects returned by fitting double generalized linear models.

Details

Write $\mu_i = \mathrm{E}[y_i]$ for the expectation of the ith response. Then $\mathrm{Var}[Y_i] = \phi_i V(\mu_i)$ where V is the variance function and ϕ_i is the dispersion of the ith response (often denoted as the Greek character 'phi'). We assume the link linear models $g(\mu_i) = \mathbf{x}_i^T \mathbf{b}$ and $h(\phi_i) = \mathbf{z}_i^T \mathbf{z}$, where $\mathbf{x}_i$ and $\mathbf{z}_i$ are vectors of covariates, and $\mathbf{b}$ and $\mathbf{a}$ are vectors of regression cofficients affecting the mean and dispersion respectively. The argument dlink specifies h. See [family](#) for how to specify g. The optional arguments mustart, betastart and phistart specify starting values for μ_i, $\mathbf{b}$ and ϕ_i respectively.

The parameters $\mathbf{b}$ are estimated as for an ordinary GLM. The parameters $\mathbf{a}$ are estimated by way of a dual GLM in which the deviance components of the ordinary GLM appear as responses. The estimation procedure alternates between one iteration for the mean submodel and one iteration for the dispersion submodel until overall convergence.

The output from dglm, out say, consists of two glm objects (that for the dispersion submodel is out$dispersion.fit) with a few more components for the outer iteration and overall likelihood. The summary and anova functions have special methods for dglm objects. Any generic function which has methods for glms or lms will work on out, giving information about the mean submodel. Information about the dispersion submodel can be obtained by using out$dispersion.fit as argument rather than out itself. In particular drop1(out,scale=1) gives correct score statistics for removing terms from the mean submodel, while drop1(out$dispersion.fit,scale=2) gives correct score statistics for removing terms from the dispersion submodel.

The dispersion submodel is treated as a gamma family unless the original reponses are gamma, in which case the dispersion submodel is digamma. (Note that the digamma and trigamma functions are required to fit a digamma family.) This is exact if the original GLM family is gaussian, Gamma or inverse.gaussian. In other cases it can be justified by the saddle-point approximation to the density of the responses. The results will therefore be close to exact ML or REML when the dispersions are small compared to the means. In all cases the dispersion submodel as prior weights 1, and has its own dispersion parameter which is 2.

Generation

This class of objects is returned by the [dglm](#) function to represent a fitted double generalized linear model. Class "dglm" inherits from class "glm", since it consists of two coupled generalized linear models, one for the mean and one for the dispersion. Like glm, it also inherits from lm. The object returned has all the components of a glm object. The returned component object$dispersion.fit is also a glm object in its own right, representing the result of modelling the dispersion.

Methods

Objects of this class have methods for the functions `print`, `plot`, `summary`, `anova`, `predict`, `fitted`, `drop1`, `add1`, and `step`, amongst others. Specific methods (not shared with `glm`) exist for `summary` and `anova`.

Structure

A `dglm` object consists of a `glm` object with the following additional components:

- dispersion.fit the dispersion submodel: a `glm` object representing the fitted model for the dispersions. The responses for this model are the deviance components from the original generalized linear model. The prior weights are 1 and the dispersion or scale of this model is 2.

- iter this component now represents the number of outer iterations used to fit the coupled mean-dispersion models. At each outer iteration, one IRLS is done for each of the mean and dispersion submodels.

- method fitting method used: `"ml"` if maximum likelihood was used or `"reml"` if adjusted profile likelihood was used.

- m2loglik minus twice the log-likelihood or adjusted profile likelihood of the fitted model.

Note

The anova method is questionable when applied to an `dglm` object with `method="reml"` (stick to `method="ml"`).

Author(s)

Gordon Smyth, ported to R\ by Peter Dunn (<pdunn2@usc.edu.au>)

References

Smyth, G. K. (1989). Generalized linear models with varying dispersion. *J. R. Statist. Soc. B*, **51**, 47–60.

Smyth, G. K., and Verbyla, A. P. (1999). Adjusted likelihood methods for modelling dispersion in generalized linear models. *Environmetrics*, **10**, 696-709.

Verbyla, A. P., and Smyth, G. K. (1998). Double generalized linear models: approximate residual maximum likelihood and diagnostics. Research Report, Department of Statistics, University of Adelaide.

See Also

dglm.object, Digamma family, Polygamma

Examples

```
# Continuing the example from  glm, but this time try
# fitting a Gamma double generalized linear model also.
clotting <- data.frame(
     u = c(5,10,15,20,30,40,60,80,100),
```

```
        lot1 = c(118,58,42,35,27,25,21,19,18),
        lot2 = c(69,35,26,21,18,16,13,12,12))

# The same example as in  glm: the dispersion is modelled as constant
out <- dglm(lot1 ~ log(u), ~1, data=clotting, family=Gamma)
summary(out)

# Try a double glm
out2 <- dglm(lot1 ~ log(u), ~u, data=clotting, family=Gamma)

summary(out2)
anova(out2)

# Summarize the mean model as for a glm
summary.glm(out2)

# Summarize the dispersion model as for a glm
summary(out2$dispersion.fit)

# Examine goodness of fit of dispersion model by plotting residuals
plot(fitted(out2$dispersion.fit),residuals(out2$dispersion.fit))
```

---

residuals.dglm   *residuals.dglm function*

Description

This implements the 'residuals' generic for the dglm object

Usage

```
## S3 method for class 'dglm'
residuals(object, ...)
```

Arguments

object   The fitted dglm object whose residuals we want

...   additional parameters to residuals.glm

Value

the residuals from the mean portion of the dglm object

Author(s)

Robert W. Corty

---

summary.dglm   *Summarizing double generalized linear model fits*

Description

These functions are all methods for class dglm or summary.glm objects.

Usage

```
## S3 method for class 'dglm'
summary(object, dispersion=NULL, correlation = FALSE, ...)
```

Arguments

object	an object of class "dglm", usually, a result of a call to glm.
dispersion	the dispersion parameter for the fitting family. By default it is obtained from object.
correlation	logical; if TRUE, the correlation matrix of the estimated parameters is returned and printed.
...	further arguments to be passed to summary.glm

Details

For more details, see summary.glm.

If more than one of etastart, start and mustart is specified, the first in the list will be used.

Value

summary.dglm returns an object of class "summary.dglm", a list with components

call	the component from object
terms	the component from object
family	the component from object
deviance	the component from object
aic	NULL here
constrasts	(where relevant) the contrasts used. NOT WORKING??
df.residual	the component from object
null.deviance	the component from object
df.null	the residual degrees of freedom for the null model.
iter	the component from object
deviance.resid	the deviance residuals: see residuals.glm
coefficients	the matrix of coefficients, standard errors, z-values and p-values. Aliased coefficients are omitted.

aliased	named logical vector showing if the original coefficients are aliased.
dispersion	either the supplied argument or the estimated dispersion if the latter in NULL
df	a 3-vector of the rank of the model and the number of residual degrees of freedom, plus number of non-aliased coefficients.
cov.unscaled	the unscaled (dispersion = 1) estimated covariance matrix of the estimated coefficients.
cov.scaled	ditto, scaled by dispersion
correlation	(only if correlation is true.) The estimated correlations of the estimated coefficients.
dispersion.summary	
	the summary of the fitted dispersion model
outer.iter	the number of outer iteration of the alternating iterations
m2loglik	minus twice the log-likelihood of the fitted model

Note

The anova method is questionable when applied to an dglm object with method="reml" (stick to method="ml").

Author(s)

Gordon Smyth, ported to R\ by Peter Dunn (<pdunn2@usc.edu.au>)

References

Smyth, G. K. (1989). Generalized linear models with varying dispersion. *J. R. Statist. Soc. B*, **51**, 47–60.

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Verbyla, A. P., and Smyth, G. K. (1998). Double generalized linear models: approximate residual maximum likelihood and diagnostics. Research Report, Department of Statistics, University of Adelaide.

See Also

dglm.object, dglm.control, anova.dglm, summary.glm

Examples

```
# Continuing the example from  glm, but this time try
# fitting a Gamma double generalized linear model also.
clotting <- data.frame(
     u = c(5,10,15,20,30,40,60,80,100),
     lot1 = c(118,58,42,35,27,25,21,19,18),
     lot2 = c(69,35,26,21,18,16,13,12,12))

# The same example as in  glm: the dispersion is modelled as constant
```

```
out <- dglm(lot1 ~ log(u), ~1, data=clotting, family=Gamma)
summary(out)

# Try a double glm
out2 <- dglm(lot1 ~ log(u), ~u, data=clotting, family=Gamma)

summary(out2)
anova(out2)

# Summarize the mean model as for a glm
summary.glm(out2)

# Summarize the dispersion model as for a glm
summary(out2$dispersion.fit)
```

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