

Package ‘COZIGAM’

February 14, 2012

Type Package

Title Constrained and Unconstrained Zero-Inflated Generalized Additive Models with Model Selection Criterion

Version 2.0-3

Date 2010-7-23

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Depends R (>= 2.7.1), mgcv

Description Constrained and Unconstrained Zero-Inflated Generalized Additive Models (ZIGAM) fitting with associated model plotting, prediction and selection.

License GPL (>= 2)

Repository CRAN

Date/Publication 2010-07-24 07:57:05

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COZIGAM-package	<i>Constrained and Unconstrained Zero-Inflated Generalized Additive Models with Model Selection Criterion</i>
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Description

Constrained and Unconstrained Zero-Inflated Generalized Additive Models (ZIGAM) fitting with associated model plotting, prediction and selection.

Details

Package: COZIGAM
 Type: Package
 Version: 2.0-3
 Date: 2010-7-23
 License: GPL version 2 or newer

COZIGAM.cts	Fitting Component-Specific-Proportionally Constrained Zero-Inflated Generalized Additive Models with
COZIGAM.dis	Fitting Component-Specific-Proportionally Constrained Zero-Inflated Generalized Additive Models with
PCOZIGAM.cts	Fitting Proportionally Constrained Zero-Inflated Generalized Additive Models with Continuous Responses
PCOZIGAM.dis	Fitting Proportionally Constrained Zero-Inflated Generalized Additive Models with Discrete Responses
ZIGAM.cts	Fitting Continuous Zero-Inflated Generalized Additive Models
ZIGAM.dis	Fitting Discrete Zero-Inflated Generalized Additive Models
alaska	Alaska Peninsula Coastline
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eggdata	Pollock Egg Data
plot.cozigam	Default COZIGAM plotting
predict.cozigam	Prediction from fitted COZIGAM
print.cozigam	Constrained Zero-Inflated Generalized Additive Model default print statement
summary.cozigam	Summary for a COZIGAM fit
test	Some Test Functions used in Simulation Study
zigam	Fitting (Unconstrained) Zero-Inflated Generalized Additive Models

Author(s)

Hai Liu and Kung-Sik Chan; Maintainer: Hai Liu <liuhai@iupui.edu>

alaska

Alaska Peninsula Coastline

Description

The coastline of the Alaska Peninsula.

Usage

```
data(alaska)
```

Format

A data frame with the following 2 variables.

lat A numeric vector: latitude

lon A numeric vector: longitude

Details

This data frame can be used to draw the coastline of the Alaska peninsula. See example below.

Author(s)

Hai Liu and Kung-Sik Chan

Examples

```
data(alaska)
plot(alaska$lon,alaska$lat,type="l",col="green")
```

cozigam

*Fitting Constrained Zero-Inflated Generalized Additive Models***Description**

Fit a CONstrained Zero-Inflated Generalized Additive Model (COZIGAM) to data.

Usage

```
cozigam (formula, constraint = "proportional", zero.delta = NULL,
        maxiter = 20, conv.crit.in = 1e-5, conv.crit.out = 1e-3, size = NULL,
        log.tran = FALSE, family, data=list(), ...)
```

Arguments

formula	A GAM formula. This is exactly like the formula for a GLM except that smooth terms can be added to the right hand side of the formula (and a formula of the form $y \sim .$ is not allowed). Smooth terms are specified by expressions of the form: <code>s(var1, var2, ..., k=12, fx=FALSE, bs="tp", by=a.var)</code> where <code>var1</code> , <code>var2</code> , etc. are the covariates which the smooth is a function of and <code>k</code> is the dimension of the basis used to represent the smooth term. <code>by</code> can be used to specify a variable by which the smooth should be multiplied.
constraint	Type of constraint on the zero-inflation probability, can be either "proportional" or "component". See details for more information.
zero.delta	A vector specifying which subset of constraint parameter delta set to be zero when the constraint is set to "component". For instance, <code>zero.delta=c(NA, 0)</code> means only the first smooth function is included in the zero-inflation constraint. See details for the model formulation.
maxiter	The maximum number of iterations allowed in the estimation procedure.
conv.crit.in	Convergence criterion in the inner loop.
conv.crit.out	Convergence criterion in the outer loop.
size	Number of trials. Must be specified when family is binomial.
log.tran	Logical. TRUE if log-transformation is needed for the response.
family	This is a family object specifying the distribution and link to use in fitting etc. See <code>glm</code> and <code>family</code> for more details. Currently support Gaussian/lognormal, Gamma, Poisson and binomial distributions.
data	A data frame or list containing the model response variable and covariates required by the formula.
...	Additional arguments to be passed to the low level regression fitting functions.

Details

A COstrained Zero-Inflated Generalized Additive Model (COZIGAM) assumes the response variable Y_i is distributed from a zero-inflated 1-parameter exponential family with covariate x_i (could be high dimensional). More specifically, Y_i comes from a regular exponential family distribution $f(x_i)$ with probability p_i and equals zero with probability $1 - p_i$, with the further assumption that the probability of non-zero-inflation p_i is related to the regular mean response or its smooth components, depending on the type of the constraint. If constraint is “proportional”, p_i is assumed to be some monotone function of the regular mean response function on the link scale, e.g., if a logit link is used, p_i is linearly constrained by:

$$\text{logit}(p_i) = \alpha + \delta g(\mu_i),$$

where $g()$ is the link function of the regular exponential family with mean μ_i and α and δ are two unknown parameters to be estimated; If constraint is “component”, p_i is assumed to be linearly related to the smooth components of the regular mean response on the link scale, i.e.,

$$\text{logit}(p_i) = \alpha + \delta_1 s(x_{1i}, x_{2i}) + \delta_2 s(x_{3i}) + \dots,$$

and the regular mean response has the structure

$$g(\mu_i) = b_0 + s(x_{1i}, x_{2i}) + s(x_{3i}) + \dots,$$

where $s()$'s are some centered smooth functions to be estimated nonparametrically by a Generalized Additive Model (GAM) and b_0 is the overall intercept. In the component-specific-proportional constraint case, a vector `zero.delta` must be specified. For instance, in the above model setting, `zero.delta=c(NA, 0)` would estimate δ_1 as an unknown parameter and set δ_2 to be fixed at 0. That is, the model would assume that p_i is not dependent on the covariate x_3 .

The estimation approach is a modified penalized iteratively reweighted least squares algorithm (P-IRLS) which requires the `magic()` function in the `mgcv` library. EM algorithm is used if the underlying regular exponential family has strictly positive probability mass at zero. The covariance matrix of the estimated coefficients is obtained by inverting the observed information matrix. See Liu and Chan (2010) for more detail.

Value

An object of class “cozigam” is a list containing the following components:

<code>coefficients</code>	A named vector of coefficients including the linear constraint parameters.
<code>V.theta</code>	The covariance matrix of the estimated parameters.
<code>V.beta</code>	The covariance matrix of the estimated parameters associated with the smooth functions.
<code>se.alpha</code> , <code>se.delta</code>	Estimated standard errors of parameters alpha and delta.
<code>mu</code>	The fitted regular mean values.
<code>linear.predictor</code>	The fitted values on the link scale.
<code>dispersion</code>	(Estimated) dispersion parameter.
<code>formula</code>	Model formula.

p	The fitted non-zero-inflation probabilities.
G	An object returned by <code>gam()</code> containing information used in the estimation procedure.
psi	Conditional expectation of the zero-inflation indicator (only for the discrete case which involves EM algorithm).
family	The family used.
loglik, ploglik	The (penalized) log-likelihood of the fitted model.
y	The response used.
converged	Logical. TRUE if the iterative procedure is converged.
est.disp	Logical. TRUE if the dispersion parameter is estimated.
fit.nonzero	Fitted GAM using only the nonzero data as in the presence/absence analysis
score	The GCV or UBRE score returned by <code>magic()</code> in the iterative procedure.
edf	Estimated degrees of freedom for each model parameter. Penalization means that many of these are less than 1.
edf.smooth	Estimated degrees of freedom of each smooth term.
sp	Estimated smoothing parameters.
logE	Approximated logarithmic marginal likelihood by Laplace method used for model selection.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

[plot.cozigam](#), [predict.cozigam](#), [summary.cozigam](#), [zigam](#)

Examples

```
## Normal/Log-Normal Response with proportional constraint
set.seed(11)
n <- 400
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

f <- test(x1,x2)*4-mean(test(x1,x2)*4) + f0(x3)/2-mean(f0(x3)/2)
sig <- 0.5
mu0 <- f + 3
```

```

y <- mu0 + rnorm(n, 0, sig)

alpha0 <- -2.2
delta0 <- 1.2
p0 <- .Call("logit_linkinv", alpha0 + delta0 * mu0, PACKAGE = "stats")
z <- rbinom(rep(1,n), 1, p0)
y[z==0] <- 0

res <- cozigam(y~s(x1,x2)+s(x3), constraint = "proportional", family = gaussian)

plot(res)

## Poisson Response with component-specific constraint
set.seed(11)
n <- 600
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

f <- test(x1, x2)*2 + f0(x3)/5
eta0 <- f/1.1
mu0 <- exp(eta0)

eta.p10 <- (test(x1,x2) - mean(test(x1,x2)))*2/1.1
eta.p20 <- (f0(x3) - mean(f0(x3)))/5/1.1

alpha0 <- 0.2
delta10 <- 1.2
delta20 <- 0
eta.p0 <- delta10*eta.p10 + delta20*eta.p20
p0 <- .Call("logit_linkinv", alpha0 + eta.p0, PACKAGE = "stats")

z <- rbinom(rep(1,n), 1, p0)
y <- rpois(rep(1,n), mu0)
y[z==0] <- 0; rm(z)

res <- cozigam(y~s(x1,x2)+s(x3), constraint="component", zero.delta=c(NA, 0),
  conv.crit.out = 1e-3, family=poisson)

## A Tensor Product Smooth Example
test.ten <- function(x,z,sx=0.3,sz=0.4)
{ x<-x*20
  (pi**sx*sz)*(1.2*exp(-(x-0.2)^2/sx^2-(z-0.3)^2/sz^2)+
  0.8*exp(-(x-0.7)^2/sx^2-(z-0.8)^2/sz^2))
}

set.seed(11)
n <- 400
x1 <- runif(n, 0, 1)/20
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

```

```

f <- test.ten(x1, x2)*4-mean(test.ten(x1, x2)*4) + f0(x3)/2-mean(f0(x3)/2)
sig <- 0.5
mu0 <- f + 3
y <- mu0 + rnorm(n, 0, sig)

alpha0 <- -2.2
delta0 <- 1.2
p0 <- .Call("logit_linkinv", alpha0 + delta0 * mu0, PACKAGE = "stats")

z <- rbinom(rep(1,n), 1, p0)
y[z==0] <- 0

# If use thin plate spline ...
res.tps <- cozigam(y~s(x1,x2)+s(x3), constraint = "proportional", family=gaussian)
par(mfrow=c(1,2))
plot(res.tps, select=1)
# Compare with tensor product spline
res.ten <- cozigam(y~te(x1,x2)+s(x3), constraint = "proportional", family=gaussian)
plot(res.ten, select=1)

```

COZIGAM.cts

*Fitting Component-Specific-Proportionally Constrained Zero-Inflated
Generalized Additive Models with Continuous Responses*

Description

COZIGAM.cts fits a COZIGAM with component-specific-proportional constraint for continuous exponential family responses.

COZIGAM.dis fits a COZIGAM with discrete exponential family responses. One of the two functions is called from `cozigam` automatically depending on the distribution family if the argument `constraint="component"`.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

`cozigam`

COZIGAM.dis	<i>Fitting Component-Specific-Proportionally Constrained Zero-Inflated Generalized Additive Models with Discrete Responses</i>
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Description

COZIGAM.dis fits a COZIGAM with component-specific-proportional constraint for discrete zero-inflated exponential family responses, e.g. Poisson and binomial distributions. If the regular exponential family admits 0 as a possible realization with positive probability, the EM algorithm is used in the estimation procedure.

COZIGAM.cts fits a COZIGAM with continuous zero-inflated exponential family responses. One of the two functions is called from `cozigam` automatically depending on the distribution family if the argument `constraint="component"`.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

`cozigam`

disgam	<i>Fitting Discrete Generalized Additive Models with Model Selection Criterion</i>
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Description

Fit a discrete Generalized Additive Model (GAM) to data and calculate the logarithmic marginal likelihood.

Usage

```
disgam (formula, size=NULL, family = poisson(), data=list(), ...)
```

Arguments

formula	A GAM formula. This is exactly like the formula for a GLM except that smooth terms can be added to the right hand side of the formula (and a formula of the form $y \sim .$ is not allowed). Smooth terms are specified by expressions of the form: <code>s(var1,var2,...,k=12,fx=FALSE,bs="tp",by=a.var)</code> where <code>var1</code> , <code>var2</code> , etc. are the covariates which the smooth is a function of and <code>k</code> is the dimension of the basis used to represent the smooth term. <code>by</code> can be used to specify a variable by which the smooth should be multiplied.
size	Number of trials. Must be specified when family is binomial.
family	This is a family object specifying the distribution and link to use in fitting etc. See <code>glm</code> and <code>family</code> for more details. Currently support Poisson and binomial distributions.
data	A data frame or list containing the model response variable and covariates required by the formula.
...	Additional arguments to be passed to the low level regression fitting functions.

Details

It is necessary to assess whether there is zero-inflation in count data, e.g., Poisson or binomial data. The model selection approach can be used to determine whether a zero-inflated model is needed. To do that, we can fit both a ZIGAM and a regular GAM to the data, and then compare the logarithmic marginal likelihoods from these two models. Higher logarithmic marginal likelihood from the ZIGAM would indicate that there is zero-inflation in the count data. Otherwise, we can simply fit a regular GAM instead of a ZIGAM. See Liu and Chan (2010) for more detail.

Value

A list containing the following components:

<code>fit.gam</code>	A fitted GAM assuming there is no zero-inflation in the data.
<code>V.beta</code>	The estimated covariance matrix of the GAM.
<code>mu</code>	The fitted mean values.
<code>formula</code>	Model formula.
<code>family</code>	The family used.
<code>loglik</code> , <code>ploglik</code>	The (penalized) log-likelihood of the fitted model.
<code>logE</code>	Approximated logarithmic marginal likelihood by Laplace method used for model selection.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also[zigam](#)**Examples**

```
## Poisson Response
set.seed(11)
n <- 200
x1 <- runif(n, 0, 1)

eta0 <- f0(x1)/4 - 0.5
mu0 <- exp(eta0)

y <- rpois(rep(1,n), mu0) # generating non-zero-inflated data

res.gam <- disgam(y~s(x1), family=poisson) # fit a regular GAM
res.zigam <- zigam(y~s(x1), maxiter=10, family=poisson) # fit a ZIGAM

res.gam$logE > res.zigam$logE # compare the model selction criterion

# Another example
set.seed(11)
n <- 200
x1 <- runif(n, 0, 1)
eta0 <- f0(x1)/4 - 0.5
mu0 <- exp(eta0)

alpha0 <- 0.4
delta0 <- 0.8
p0 <- .Call("logit_linkinv", alpha0 + delta0 * eta0, PACKAGE = "stats")

# Generating zero-inflated Poisson count data
z <- rbinom(rep(1,n), 1, p0)
y <- rpois(rep(1,n), mu0)
y[z==0] <- 0

res.gam <- disgam(y~s(x1), family=poisson) # fit a regular GAM
res.zigam <- zigam(y~s(x1), family=poisson) # fit a ZIGAM

res.gam$logE < res.zigam$logE # compare the model selction criterion
```

eggdata

Pollock Egg Data

Description

This data set gives Pollock egg count data from cruise studies off the tip of Alaska in year of 1987.

Usage

```
data(eggdata)
```

Format

A data frame with 274 observations on the following 6 variables.

bottom A numeric vector: bottom depth at the sampling spot

lat A numeric vector: latitude of the sampling spot

lon A numeric vector: longitude of the sampling spot

catch A numeric vector: the number of eggs caught in the unit of CPUE (Capture Per Unit Effort) and "0" indicates a zero catch

j.day Julian day

year Year: 1987

Author(s)

Hai Liu and Kung-Sik Chan

PCOZIGAM.cts

Fitting Proportionally Constrained Zero-Inflated Generalized Additive Models with Continuous Responses

Description

PCOZIGAM.cts fits a COZIGAM with proportional constraint for continuous exponential family responses.

PCOZIGAM.dis fits a COZIGAM with proportional constraint for discrete exponential family responses. One of the two functions is called from `cozigam` automatically depending on the distribution family if the argument `constraint="proportional"`.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

[cozigam](#)

PCOZIGAM.dis	<i>Fitting Proportionally Constrained Zero-Inflated Generalized Additive Models with Discrete Responses</i>
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Description

PCOZIGAM.dis fits a COZIGAM with proportional constraint for discrete zero-inflated exponential family responses, e.g. Poisson and binomial distributions. If the regular exponential family admits 0 as a possible realization with positive probability, the EM algorithm is used in the estimation procedure.

PCOZIGAM.cts fits a COZIGAM with proportional constraint for continuous zero-inflated exponential family responses. One of the two functions is called from `cozigam` automatically depending on the distribution family if the argument `constraint="proportional"`.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

`cozigam`

plot.cozigam	<i>Default COZIGAM plotting</i>
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Description

Takes a fitted `cozigam` object produced by `cozigam()` and plots the component smooth functions that make it up, on the scale of the linear predictor.

Usage

```
## S3 method for class 'cozigam'
plot(x, plot.2d = "contour", too.far = 0,
     n.1d = 100, n.2d = 30, theta = 30, phi = 30, select = NULL, image.col = "topo",
     persp.col = "lightblue", contour.col = "red", n.Col = 100, shade.ci = FALSE,
     shade.col = "gray80", Rug = TRUE, xlab, ylab, ...)
```

Arguments

x	A fitted cozigam object produced by cozigam().
plot.2d	One of “contour” (default) or “persp”.
select	Allows the plot for a single model term to be selected for printing. e.g. if you just want the plot for the second smooth term set select=2.
n.1d	Number of points used for each 1-D plot. Default value 100.
n.2d	Square root of number of points used to grid estimates of 2-D functions for contouring.
theta	One of the perspective plot angles.
phi	The other perspective plot angle.
too.far	If greater than 0 then this is used to determine when a location is too far from data to be plotted when plotting 2-D smooths. This is useful since smooths tend to go wild away from data. The data are scaled into the unit square before deciding what to exclude, and too.far is a distance within the unit square.
shade.ci	Logical. If TRUE, produce shaded regions as confidence bands for smooths.
shade.col	Define the color used for shading confidence bands.
image.col	Define the color used for 2-D image plots.
persp.col	Define the color used for 2-D perspective plots.
contour.col	Define the color used for the 2-D contour lines.
n.Col	Control the number of colors in 2-D image plots.
Rug	Logical, if TRUE (default) then the covariate to which the plot applies is displayed as a rug plot at the foot of each plot of a 1-D smooth, and the locations of the covariates are plotted as points on the contour plot representing a 2-D smooth.
xlab, ylab	Titles for the x and y axes.
...	Other graphics parameters to pass on to plotting commands.

Details

Produces default plot showing the smooth components of a fitted cozigam.

Smooths of more than 2 variables are not currently dealt with, but simply generate a warning.

Value

The function simply generates plots.

Author(s)

Hai Liu and Kung-Sik Chan

See Also

[cozigam](#), [predict.cozigam](#)

Examples

```

set.seed(11)
n <- 400
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

f <- test(x1,x2)*4-mean(test(x1,x2)*4) + f0(x3)/2-mean(f0(x3)/2)
sig <- 0.5
mu0 <- f + 3
y <- mu0 + rnorm(n, 0, sig)

alpha0 <- -2.2
delta0 <- 1.2
p0 <- .Call("logit_linkinv", alpha0 + delta0 * mu0, PACKAGE = "stats")
z <- rbinom(rep(1,n), 1, p0)
y[z==0] <- 0

res <- cozigam(y~s(x1,x2)+s(x3), constraint = "proportional", family = gaussian)

plot(res, plot.2d = "contour", image.col="topo") # contour plot
plot(res, plot.2d = "persp", select=1) # perspective plot

```

predict.cozigam

Prediction from fitted COZIGAM

Description

Takes a fitted cozigam object produced by cozigam() and produces predictions given a new set of values for the model covariates or the original values used for the model fit. Predictions can be accompanied by standard errors, based on the distribution of the model coefficients obtained by Louis' method.

Usage

```

## S3 method for class 'cozigam'
predict(object, newdata, type="link", se.fit=FALSE, ...)

```

Arguments

object	A fitted cozigam object as produced by cozigam().
newdata	A data frame containing the values of the model covariates at which predictions are required. If this is not provided then predictions corresponding to the original data are returned. If newdata is provided then it must contain all the variables needed for prediction.
type	When this has the value "link" (default) the linear predictor (possibly with associated standard errors) is returned. When type="terms" each component of the linear predictor is returned separately (possibly with standard errors): this

excludes any intercept. When `type="response"` predictions on the scale of the response are returned (possibly with approximate standard errors).

`se.fit` Logical. If TRUE (not default), standard error estimates are returned for each prediction.

... Other arguments.

Details

The standard errors produced by `predict.cozigam()` are based on the covariance matrix of the parameters obtained by Louis' method in the fitted gam object.

Value

If `se.fit` is TRUE then a 3 item list is returned with items (both arrays) `fit`, `se.fit` containing predictions and associated standard error estimates and `p` containing predictions of associated zero-inflation rates, otherwise a 2 item list without the array of standard error estimated is returned. The dimensions of the returned arrays depends on whether `type` is "terms" or not: if it is then the array is 2 dimensional with each term in the linear predictor separate, otherwise the array is 1 dimensional and contains the linear predictor/predicted values (or corresponding s.e.s). The linear predictor returned termwise will not include the intercept.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

Louis, T. A. (1982) Finding the Observed Information Matrix when Using EM Algorithm. *J. R. Statist. Soc. B*, 44, 226-233

See Also

[cozigam](#), [plot.cozigam](#)

Examples

```
set.seed(11)
n <- 400
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

f <- test(x1,x2)*4-mean(test(x1,x2)*4) + f0(x3)/2-mean(f0(x3)/2)
sig <- 0.5
mu0 <- f + 3
y <- mu0 + rnorm(n, 0, sig)
```

```

alpha0 <- -2.2
delta0 <- 1.2
p0 <- .Call("logit_linkinv", alpha0 + delta0 * mu0, PACKAGE = "stats")
z <- rbinom(rep(1,n), 1, p0)
y[z==0] <- 0

res <- cozigam(y~s(x1,x2)+s(x3), constraint = "proportional", family = gaussian)

newdata <- data.frame(x1=c(0.5,0.8), x2=c(0.2,0.1), x3=c(0.3,0.7))
predict(res, newdata=newdata, se.fit=TRUE, type="response")

```

print.cozigam	<i>Constrained Zero-Inflated Generalized Additive Model default print statement</i>
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Description

This is the default print statement for a COZIGAM object.

Author(s)

Hai Liu and Kung-Sik Chan

See Also

[cozigam](#), [summary.cozigam](#)

summary.cozigam	<i>Summary for a COZIGAM fit</i>
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Description

Takes a fitted cozigam object produced by cozigam() and produces various useful summaries from it.

Usage

```

## S3 method for class 'cozigam'
summary(object, dispersion = NULL, ...)

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

```

Arguments

object	a fitted cozigam object as produced by cozigam().
dispersion	a known dispersion parameter. NULL to use estimate or default (e.g. 1 for Poisson).
x	a summary.cozigam object produced by summary.cozigam().
digits	the number of significant digits to use when printing.
signif.stars	logical. If TRUE, "significance stars" are printed for each coefficient.
...	other arguments.

Details

print.summary.cozigam tries to be smart about formatting the coefficients, standard errors, etc. and additionally gives "significance stars" if signif.stars is TRUE.

Value

summary.cozigam produces a list of summary information for a fitted cozigam object.

p.coeff	an array of estimates of the strictly parametric model coefficients, including the linear constraints parameters.
p.t	an array of the p.coeff's divided by their standard errors.
p.pv	an array of p-values for the null hypothesis that the corresponding parameter is zero. Calculated with reference to the t distribution with the estimated residual degrees of freedom for the model fit if the dispersion parameter has been estimated, and the standard normal if not.
m	the number of smooth terms in the model.
chi.sq	an array of test statistics for assessing the significance of model smooth terms. If b_i is the parameter vector for the i th smooth term, and this term has estimated covariance matrix V_i then the statistic is $b_i' V_i^{k-} b_i$, where V_i^{k-} is the rank k pseudo-inverse of V_i , and k is estimated rank of V_i .
s.pv	an array of approximate p-values for the null hypotheses that each smooth term is zero. Be warned, these are only approximate. In the case of known dispersion parameter, they are obtained by comparing the chi.sq statistic given above to the chi-squared distribution with k degrees of freedom, where k is the estimated rank of V_i . If the dispersion parameter is unknown (in which case it will have been estimated) the statistic is compared to an F distribution with k upper d.f. and lower d.f. given by the residual degrees of freedom for the model. Typically the p-values will be somewhat too low, because they are conditional on the smoothing parameters, which are usually uncertain, but note that the statistic can also have low power if the rank, k , is too high relative to the EDF of the term.
se	array of standard error estimates for all parameter estimates.
edf	array of estimated degrees of freedom for the model terms.
residual.df	estimated residual degrees of freedom.
n	number of data.

family	the family used.
formula	the original GAM formula.
dispersion	estimated (or given) scale parameter.
cov.unscaled	the estimated covariance matrix of the parameters, divided by scale parameter.
cov.scaled	the estimated covariance matrix of the parameters.
p.table	significance table for parameters.
s.table	significance table for smooths.

Author(s)

Hai Liu and Kung-Sik Chan

See Also

[cozigam](#), [predict.cozigam](#)

Examples

```

set.seed(1)
n <- 600
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)
x3 <- runif(n, 0, 1)

f <- test(x1, x2)*2 + f0(x3)/5
eta0 <- f/1.1
mu0 <- exp(eta0)

eta.p10 <- (test(x1,x2) - mean(test(x1,x2)))*2/1.1
eta.p20 <- (f0(x3) - mean(f0(x3)))/5/1.1

alpha0 <- 0.5
delta10 <- 1
delta20 <- 0
eta.p0 <- delta10*eta.p10 + delta20*eta.p20
p0 <- .Call("logit_linkinv", alpha0 + eta.p0, PACKAGE = "stats")

z <- rbinom(rep(1,n), 1, p0)
y <- rpois(rep(1,n), mu0)
y[z==0] <- 0; rm(z)

res <- cozigam(y~s(x1,x2)+s(x3), constraint="component", zero.delta=c(NA, 0), family=poisson)
summary(res)

```

test	<i>Some Test Functions used in Simulation Study</i>
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Description

test defines a 2-D test function.

f0 and f1 define two 1-D test functions. The three test functions will be used in the simulation study of COZIGAM fits.

Author(s)

Hai Liu and Kung-Sik Chan

See Also

[cozigam](#)

zigam	<i>Fitting (Unconstrained) Zero-Inflated Generalized Additive Models</i>
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Description

Fit a Zero-Inflated Generalized Additive Model (ZIGAM) to data.

Usage

```
zigam (formula, maxiter = 20, conv.crit = 1e-3,
      size = NULL, log.tran = FALSE, family, data=list(), ...)
```

Arguments

formula	A GAM formula. This is exactly like the formula for a GLM except that smooth terms can be added to the right hand side of the formula (and a formula of the form $y \sim .$ is not allowed). Smooth terms are specified by expressions of the form: <code>s(var1, var2, ..., k=12, fx=FALSE, bs="tp", by=a.var)</code> where <code>var1</code> , <code>var2</code> , etc. are the covariates which the smooth is a function of and <code>k</code> is the dimension of the basis used to represent the smooth term. <code>by</code> can be used to specify a variable by which the smooth should be multiplied.
maxiter	The maximum number of iterations allowed in the EM algorithm in estimating discrete ZIGAMs.
conv.crit	Convergence criterion in the iterative estimation algorithm.
size	Number of trials. Must be specified when family is binomial.
log.tran	Logical. TRUE if log-transformation is needed for the response.

family	This is a family object specifying the distribution and link to use in fitting etc. See <code>glm</code> and <code>family</code> for more details. Currently support Gaussian/lognormal, Gamma, Poisson and binomial distributions.
data	A data frame or list containing the model response variable and covariates required by the formula.
...	Additional arguments to be passed to the low level regression fitting functions.

Details

A Zero-Inflated Generalized Additive Model (ZIGAM) assumes the response variable Y_i is distributed from a zero-inflated 1-parameter exponential family with covariate x_i (could be high dimensional). More specifically, Y_i comes from a non-zero-inflated exponential family distribution $f(x_i)$ (regular component) with probability p_i and equals zero with probability $1-p_i$. The probability of non-zero-inflation p_i also depends on the covariates through some unknown smooth functions. Different from the COstrained Zero-Inflated Generalized Additive Model (COZIGAM), the process of generating the non-zero-inflated responses and the zero-inflation process are assumed to be independent. The mean of the non-zero-inflated exponential family distribution is assumed to be

$$g(\mu_i) = s_1(x_i),$$

and the non-zero-inflation probability is linked to the covariates by

$$\text{logit}(p_i) = s_2(x_i),$$

where s_1 and s_2 are two possibly distinct smooth functions to be estimated nonparametrically by Generalized Additive Models. See Liu and Chan (2010) for more detail.

Value

A list containing the following components:

<code>fit.gam</code>	A fitted GAM of the regular component, i.e., non-zero-inflated exponential family regression model.
<code>fit.lr</code>	A logistic regression model on the zero-inflation process.
<code>V.beta</code>	The covariance matrix of the estimated parameters associated with the smooth functions in the non-zero-inflated data generating process.
<code>V.gamma</code>	The covariance matrix of the estimated parameters associated with the smooth functions in the zero-inflation process.
<code>mu</code>	The fitted regular mean values.
<code>dispersion</code>	(Estimated) dispersion parameter.
<code>formula</code>	Model formula.
<code>p</code>	The fitted non-zero-inflation probabilities.
<code>psi</code>	Conditional expectation of the zero-inflation indicator (only for the discrete case which involves EM algorithm).
<code>family</code>	The family used.
<code>loglik, ploglik</code>	The (penalized) log-likelihood of the fitted model.

logE	Approximated logarithmic marginal likelihood by Laplace method used for model selection.
X1	Design matrix in the non-zero-inflated exponential family regression model.
X2	Design matrix in the logistic regression model.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

[cozigam](#)

Examples

```
## Gaussian Response
set.seed(11)
n <- 200
x1 <- runif(n, 0, 1)
f <- (f0(x1)-mean(f0(x1)))/2
sig <- 0.3
mu0 <- f + 1.5
y <- mu0 + rnorm(n, 0, sig)

eta.p0 <- f1(x1)*2 - 1 # true function used in zero-inflation process
p0 <- .Call("logit_linkinv", eta.p0, PACKAGE = "stats")

z <- rbinom(rep(1,n), 1, p0)
y[z==0] <- 0

# Fit a ZIGAM
res.un <- zigam(y~s(x1), family=gaussian)

# Compare with a COZIGAM
res <- cozigam(y~s(x1), family=gaussian)
res.un$logE > res$logE

## Poisson Response
set.seed(11)
n <- 400
x1 <- runif(n, 0, 1)
x2 <- runif(n, 0, 1)

eta0 <- test(x1,x2)*3
mu0 <- exp(eta0)
```

```
alpha0 <- -0.2
delta0 <- 1.0
p0 <- .Call("logit_linkinv", alpha0 + delta0 * eta0, PACKAGE = "stats")

z <- rbinom(rep(1,n), 1, p0)
y <- rpois(rep(1,n), mu0)
y[z==0] <- 0

res.un <- zigam(y~s(x1,x2), maxiter=30, family=poisson) # fit a ZIGAM
res <- cozigam(y~s(x1,x2), maxiter=30, family=poisson) # fit a COZIGAM
res.un$logE < res$logE # compare the model selection criterion
```

ZIGAM.cts

Fitting Continuous Zero-Inflated Generalized Additive Models

Description

ZIGAM.cts fits a ZIGAM for continuous zero-inflated exponential family responses.

ZIGAM.dis fits a ZIGAM for discrete zero-inflated exponential family responses. One of the two functions is called from `zigam` automatically depending on the distribution family.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

`zigam`

`ZIGAM.dis`*Fitting Discrete Zero-Inflated Generalized Additive Models*

Description

`ZIGAM.dis` fits a ZIGAM for discrete zero-inflated exponential family responses.

`ZIGAM.cts` fits a ZIGAM for continuous zero-inflated exponential family responses. One of the two functions is called from `zigam` automatically depending on the distribution family.

Author(s)

Hai Liu and Kung-Sik Chan

References

Liu, H and Chan, K.S. (2010) Introducing COZIGAM: An R Package for Unconstrained and Constrained Zero-Inflated Generalized Additive Model Analysis. *Journal of Statistical Software*, 35(11), 1-26. <http://www.jstatsoft.org/v35/i11/>

See Also

`zigam`

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