Package 'MMAD'

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Type Package

Title MM Algorithm Based on the Assembly-Decomposition Technology

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Description

The Minorize-Maximization(MM) algorithm based on Assembly-Decomposition(AD) technology can be used for model estimation of parametric models, semi-parametric models and nonparametric models. We selected parametric models including left truncated normal distribution, type I multivariate zero-inflated generalized poisson distribution and multivariate compound zero-inflated generalized poisson distribution; semiparametric models include Cox model and gamma frailty model; nonparametric model is estimated for type II interval-censored data. These general methods are proposed based on the following papers,
Tian, Huang and Xu (2019) <doi:10.5705/SS.202016.0488>,
Huang, Xu and Tian (2019) <doi:10.5705/ss.202016.0516>,
Zhang and Huang (2022) <doi:10.1117/12.2642737>.

License GPL (>= 3)

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Contents

`bcos` *Breast Cosmesis Data*

Description

The often used data set for interval censored data, described and given in full in Finkelstein and Wolfe (1985).

Usage

```
bcos
```

Format

An object of class `data.frame` with 94 rows and 3 columns.

Value

Breast cosmesis data contains the following fields:

`left`	a numeric vector
`right`	a numeric vector
`treatment`	a factor with levels Rad and RadChem

References

Finkelstein D.M. and Wolfe R.A.(1985). "A semiparametric model for regression analysis of interval-censored failure time data." *Biometrics* **41**, 933-945.

Examples

```
data = data(bcos)
```

`cadi` *The children's absenteeism data in Indonesia*

Description

In a survey of Indonesian family life conducted by Strauss et al. the participants included 7000 households sampled from 321 communities randomly selected from 13 of the nation's 26 Provinces, in which 83% of the Indonesian population lived. Among those households with one child per household, 437 household heads were asked questions about the health of their children.

Usage

```
cadi
```

Format

An object of class `data.frame` with 437 rows and 2 columns.

Value

The children's absenteeism data in Indonesia contains the following fields:

`y1`	The number of days the children missed their primary activities due to illness in the last four weeks
`y2`	The number of days the children spent in bed due to illness in the last four weeks

References

Huang X.F., Tian G.L., Zhang, C. and Jiang, X.(2017). "Type I multivariate zero-inflated generalized Poisson distribution with applications." *Statistics and its Interface* **10**(2), 291-311.

Strauss J., Beegle K., Sikoki B., Dawiyanto A., Herawati Y. and Witoelar Y.(2004). "The Third Wave of the Indonesia Family Life Survey (IFLS): Overview and Field Report, WR-144/1-NIA/NICHD, RAND Corporation, Santa Monica, CA."

Examples

```
data = data(cadi)
```

CoxMM *MM algorithm based on AD technology for Cox model*

Description

Let T_i, C_i and $X_i = (x_{i1}, \cdots, x_{iq})^T$ denote the, survival time, the censoring time and a q dimension vector of coefficients for the i-th individual, respectively. And assume the censoring time C_i is independent of the survival time T_i are mutually independent, and $I_i = I(T_i \leqslant C_i)$ is the censoring indicator. Then the instantaneous hazard rate function of T_i is

$$\lambda(t|X_i) = \lambda_0(t)\exp(X_i^T\beta)$$

where $\lambda_0(.)$ is a baseline hazard rate and $\beta = (\beta_1, \cdots, \beta_q)^T$ is a vector of regression parameters. We denote Λ as the accumulative hazard rate. Then the observed data likelihood function is

$$L(\alpha|Y_{obs}) = \prod_{i=1}^{n}(\lambda_0(t_i)\exp(X_i^T\beta))^{I_i}\exp(-\Lambda(t_i)\exp(X_i^T\beta))$$

where $\alpha = (\beta, \Lambda)$. The `CoxMM` function is used to calculate the Cox model.

Usage

```
CoxMM(formula, data, beta = NULL, Maxiter = 2000, convergence = 1e-06, ...)
```

Arguments

`formula`	A formula object, which contains on the left hand side an object of the type `Surv` and on the right hand side is the terms, e.g. `formula=Surv(time, status) ~ x`.
`data`	A `data.frame` in which to interpret the variables named in the formula.
`beta`	A vector of unknown regression parameters, default is `NULL`. If is `NULL`, then make all `beta=0` during calculation.
`Maxiter`	The maximum number of iterations is specified by default as 2000.
`convergence`	Specify the convergence criterion, the default is 1e-6.
`...`	Additional arguments

Details

The `CoxMM` function is used to calculate the Cox model using MM algorithms based on AD technology. EM algorithms rely on the fact that, after profiling out the nonparametric component Λ, the resulting function is concave. However, when this assumption does not hold, maximizing the resulting function using Newton's method becomes difficult, especially when there are a large number of covariates. MM algorithms can avoid the concavity requirement and bypass the need for Newton method and matrix inversion.

Value

An object of class CoxMM that contains the following fields: the Time, total amount of observations, total number of failure events, the variable name, the β, the λ, the Λ, convergence result, the log likelihood value, the standard deviation of the estimated β, the likelihood-based 95% confidence interval for the β.

References

D.R. Cox.(1972). 'Regression models and life tables.' *Journal of the Royal Statistical Society(Series B)* **34**(2), 187-220.

Zhang L.L. and Huang X.F.(2022). 'On MM algorithms for Cox model with right-censored data.' *In International Conference on Cloud Computing, Internet of Things, and Computer Applications (CICA 2022)* **12303**, 29-38.

Examples

```
library(survival)
CoxMM(Surv(time, status) ~ age + sex, lung)
```

CZIGPMM *MM algorithm based on the AD method for multivariate compound zero-inflated generalized poisson distribution*

Description

Let $Z_0 \sim Bernoulli(1-\phi_0)$, $\mathbf{x} = (\mathbf{X_1}, \cdots, \mathbf{X_m})^{\mathbf{T}}$, $X_i \sim ZIGP(\phi_i, \lambda_i, \theta_i)$, for $i = 1, \cdots, m$, and $(Z_0, X_1, \cdots, X_m)$ be mutually independent. A random vector $\mathbf{y} = (\mathbf{Y_1}, \cdots, \mathbf{Y_m})^{\mathbf{T}}$ follows a multivariate compound zero-inflated generalized poisson distribution if

$$\mathbf{y} \overset{\mathrm{d}}{=} \mathbf{Z_0 x} = \begin{cases} \mathbf{0} & \text{with probability } \lambda_0 \\ \mathbf{x} & \text{with probability } 1-\lambda_0 \end{cases}$$

where $\lambda_0 \in [0,1)$, $\phi = (\phi_{\mathbf{1}}, \cdots, \phi_{\mathbf{m}})^{\mathbf{T}} \in [\mathbf{0},\mathbf{1})^{\mathbf{m}}$, $\lambda = (\lambda_{\mathbf{1}}, \cdots, \lambda_{\mathbf{m}})^{\mathbf{T}} \in \mathbb{R}_+^{\mathbf{m}}$, $\theta = (\theta_{\mathbf{1}}, \cdots, \theta_{\mathbf{m}})^{\mathbf{T}} \in [\mathbf{0},\mathbf{1})^{\mathbf{m}}$. The CZIGPMM function is used to calculate the multivariate compound ZIGP model.

Usage

```
CZIGPMM(data, phi0, phi, la, th, Maxiter = 2000, convergence = 1e-06, ...)
```

Arguments

data	Data.frame or Matrix that contains corresponding covariates.
phi0	Probability value for the zero-inflated parameter for CZIGP model.
phi	Probability value for the zero-inflated parameter for ZIGP model.
la	The scale parameter for ZIGP model.

th	The discrete parameter for ZIGP model.
Maxiter	The maximum number of iterations is specified by default as 2000.
convergence	Specify the convergence criterion, the default is 1e-6.
...	Additional arguments

Details

The CZIGPMM function is used to calculate multivariate compound zero-inflated generalized poisson distribution model using MM algorithms based on AD technology. data is provided by user by default, it can be a data frame or a matrix. In addition, unknown parameters require users to give appropriate initial values, where 0<=phi0<1, each phi should 0<=phi<1, th should 0<=th<1, and each la should be greater than 0.

Value

An object of class CZIGPMM that contains the following fields: total amount of observations, the number of iterations, convergence rate, the log likelihood value, estimated results for the unknown parameters, the standard deviation of estimate for the unknown parameters, the likelihood-based 95% confidence interval for the unknown parameters, information criterion: AIC value and BIC value.

References

Tian G.L., Huang X.F. and Xu, J.(2019). 'An assembly and decomposition approach for constructing separable minorizing functions in a class of MM algorithms.' *Statistica Sinica* **29**(2), 961-982.

Huang X.F., Tian G.L., Zhang, C. and Jiang, X.(2017). 'Type I multivariate zero-inflated generalized Poisson distribution with applications.' *Statistics and its Interface* **10**(2), 291-311.

Examples

```
x1 <- c(0,35,23,34,8,19,0,0,0,0)
x2 <- c(38,15,0,25,34,0,0,0,0,0)
y <- cbind(x1, x2)
phi0 = 0.5; phi = rep(0.5,2); la = rep(1,2); th = rep(0.1,2)
CZIGPMM(y, phi0, phi, la, th)
```

GaFrailtyMM *MM algorithm based on AD technology for gamma frailty model*

Description

Let T_{ij}, C_{ij} and $X_{ij} = (X_{ij1}, \cdots, X_{ijq})^T$ denote the survival time, the censoring time and a vector of covariates, respectively. For the j-th individual in the i-th cluster, for $j = 1, \cdots, M_i$ and $i = 1, \cdots, B$. And assume the censoring time C_{ij} is independent of the survival time T_{ij} given X_{ij}, and $I_{ij} = I(T_{ij} \leqslant C_{ij})$ is the censoring indicator. Conditional on a cluster-specific frailty ω_i, then the frailty model postulates that the instantaneous hazard rate function of T_{ij} is

$$\lambda(t|X_{ij},\omega_i) = \lambda_0(t)\exp(X_{ij}^T\beta)\omega_i$$

where $\lambda_0(t)$ is a baseline hazard rate and β is a vector of regression parameters. We assume that the frailty ω has a gamma distribution with mean 1, variance θ and density

$$g(\omega) = \frac{\omega^{\frac{1}{1-\theta}}\exp(-\frac{\omega}{\theta})}{\Gamma(\frac{1}{\theta})\theta^{\frac{1}{\theta}}}$$

and we denote Λ as the accumulative hazard rate. The `GaFrailtyMM` function is used to calculate the gamma frailty model.

Usage

```
GaFrailtyMM(
  formula,
  data,
  beta = NULL,
  theta = NULL,
  lambda = NULL,
  Maxiter = 2000,
  convergence = 1e-06,
  ...
)
```

Arguments

`formula`	A formula object, which contains on the left hand side an object of the type `Surv` and on the right hand side a `+cluster(id)` statement. e.g. `formula=Surv(time, status) ~ x + cluster(id)`
`data`	A `data.frame` in which to interpret the variables named in the formula.
`beta`	A vector of unknown regression parameters, default is `NULL`. If is `NULL`, then make all `beta=1` during calculation.
`theta`	The variance of frailty factors subject to gamma distribution, default is `NULL`. If is `NULL`, then let `theta=1` during calculation.
`lambda`	Baseline hazard rate, default set to `NULL`. If is `NULL`, then let each `lambda` equals to `1/N` during calculation, which `N` is the number of observed.
`Maxiter`	The maximum number of iterations is specified by default as 2000.
`convergence`	Specify the convergence criterion, the default is 1e-6.
`...`	Additional arguments

Details

The `GaFrailtyMM` function is used to calculate gamma frailty survival model using MM algorithms based on AD technology. EM algorithms relies on the fact that, after profiling out the nonparametric component Λ_0, the resulting function is concave. When it does not hold, using Newton method to maximize the resulting function is difficult especially when there exist a large number of covariates. MM algorithms that can avoid the concavity requirement and bypass Newton method and matrix inversion.

Value

An object of class GaFrailtyMM that contains the following fields: total amount of observations, the Time, the Λ, the λ, total number of failure events, total number of iterations, convergence result, the log likelihood value, the θ, the standard deviation of the estimated θ, the likelihood-based 95% confidence interval for the θ, β, the standard deviation of the estimated β, the likelihood-based 95% confidence interval for the β, the variable name.

References

Huang X.F., Xu J.F. and Tian G.L.(2019). 'On profile MM algorithms for gamma frailty survival models.' *Statistica Sinica* **29**(2), 895-916.

Examples

```
library(survival)
GaFrailtyMM(Surv(time, status) ~ age + sex + cluster(id), data=kidney)
```

IC2Control *Control IC2Pro object*

Description

Control IC2Pro object

Usage

```
IC2Control(Maxiter = 2000, convergence = 1e-06, Idigits = 4, Pdigits = 4)
```

Arguments

Maxiter	The maximum number of iterations is specified by default as 2000.
convergence	Specify the convergence criterion, the default is 1e-6.
Idigits	The number of decimal places for the survival interval values.
Pdigits	The number of decimal places for the survival probability values.

Value

list of Maxiter, convergence, Idigits, Pdigits.

Examples

```
IC2Control()
```

IC2MM *MM algorithm based on the AD method for case II interval-censored data*

Description

The IC2MM function is used to calculate the case II interval-censored data model. A failure time study that consists of n independent subjects from a homogeneous population with survival function $S_{(t)}$. Let T_i denote the survival time, and $i = 1, \ldots, n$. Suppose that interval-censored data on the T_i are observed and given by

$$Y_{obs} = \{(L_i, R_i]; i = 1, \ldots, n\}$$

where $T_i \in (L_i, R_i]$. Let $\{s_i\}_{j=0}^{m}$ denote the unique ordered elements of $0, L_i, R_i, i = 1, \ldots, n$. Take $\alpha_{ij} = I(s_j \in (L_i, R_i])$ and $p_j = S(s_{j-1}) - S(s_j), j = 1, \ldots, m$. The log-likelihood function is

$$\ell(p|Y_{obs}) = \sum_{i=1}^{n} \log(S(L_i) - S(R_i)) = \sum_{i=1}^{n} \log\left(\sum_{j=1}^{m} \alpha_{ij} p_j\right)$$

where $p = (p_1, \ldots, p_m)^T$ and $\sum_{j=1}^{m} p_j = 1, p_j \geqslant 0$.

Usage

```
IC2MM(formula, data, ...)
```

Arguments

formula	A formula object, which contains on the left hand side an object of type = 'interval2' of the type Surv e.g. formula=Surv(L,R, type = 'interval2') ~ 1
data	A data.frame in which to interpret the variables named in the formula.
...	Additional arguments, e.g. control=IC2Control()

Details

The IC2MM function allows the distributions for multiple strata of dataset to be stored as one IC2 object, e.g. data=bcos.

Value

An object of class IC2MM that contains the following fields: error: convergence result; strata: dimensions of each df_tab; s: unique ordered elements of $0, L_i, R_i, Inf$, if more than one strata, elements are concatenated; S: the survival function, if more than one strata, values are concatenated; df_tab: the dataframe of survival intervals and survival probabilities for each interval, if more than one strata, dataframes are concatenated.

References

Tian G.L., Huang X.F. and Xu, J.(2019). 'An assembly and decomposition approach for constructing separable minorizing functions in a class of MM algorithms.' *Statistica Sinica* **29**(2), 961-982.

See Also

IC2Pro

Examples

```
library(survival)
L <- c(1.5, 0.1, 1.5, 0.5, 0.4, 0.2, 0.9, 0.2, 0.08, 1.9)
R <- c(2.1, 2.9, 2.7, 1.9, 1.3, 1.4, 2.3, 0.5, 1.5, 4.6 )
data <- data.frame(L, R)
IC2MM(Surv(L,R, type = 'interval2') ~ 1, data )

IC2MM(Surv(L,R, type = 'interval2') ~ 1, data, control=IC2Control(Pdigits=2) )
```

IC2Pro *Calculate non-parametric estimate for case II interval censored survival function*

Description

Calculate non-parametric estimate for case II interval censored survival function

Usage

```
IC2Pro(L, R, control = IC2Control(), ...)
```

Arguments

L	The numeric vector of left endpoints of censoring interval, the first element of Surv when type='interval2'.
R	The numeric vector of right endpoints of censoring interval, the second element of Surv function when type='interval2'.
control	An object as created by IC2Control
...	Additional arguments

Value

An object of class IC2Pro that contains the following fields: error: convergence result; strata: dimensions of df_tab; s: unique ordered elements of $0, L_i, R_i, Inf$; S: the survival function; df_tab: the data frame of survival intervals and survival probabilities for each interval.

References

Tian G.L., Huang X.F. and Xu, J.(2019). 'An assembly and decomposition approach for constructing separable minorizing functions in a class of MM algorithms.' *Statistica Sinica* **29**(2), 961-982.

See Also

IC2Control

Examples

```
L <- c(1.4, 1.5, 1.3, 0.9, 0.4, 0.2, 0.5, 0.03, 1.7, 0.2)
R <- c(2.2, 3, 2.4, 1.2, 2.8, 0.3, 1.6, 2.5, 2.6, 3.4)
IC2Pro(L, R, control=IC2Control())
```

---

kidney *Kidney Infection Data*

Description

The data consisted of the time to first and second infection relapse in 38 kidney disease patients using a portable dialysis machine. Infection may occur where the catheter was inserted. Catheters are subsequently removed if infection develops and may be removed for other reasons, in which case observations are censored.

Usage

```
kidney
```

Format

An object of class `data.frame` with 76 rows and 7 columns.

Value

Kidney infection data contains the following fields:

`patient`	id
`time`	time
`status`	event status
`age`	in years
`sex`	1=male, 2=female
`disease`	disease type (0=GN, 1=AN, 2=PKD, 3=Other)
`frail`	frailty estimate from original paper

References

McGilchrist C.A. and Aisbett C.W.(1991). "Regression with frailty in survival analysis." *Biometrics* **47**, 461-466.

Examples

```
data = data(Kidney)
```

LTNMM *MM algorithm based on the AD method for left-truncated normal distribution*

Description

The LTNMM function is used to calculate a left-truncated normal distribution model. A $LTN(\mu, \sigma^2; a)$ has the density function

$$f(y; \mu, \sigma^2; a) = \frac{1}{c\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(y-\mu)^2}{2\sigma^2}\right) \cdot I(y \geq a)$$

where (μ, σ^2) are two unknown parameters, a is a known constant, $c = 1 - \Phi(\frac{a-u}{\sigma})$, and $\Phi(.)$ is the cdf of the standard normal distribution.

Usage

```
LTNMM(
  formula,
  a,
  mu = NULL,
  sigma = NULL,
  data = sys.frame(sys.parent()),
  Maxiter = 2000,
  convergence = 1e-06,
  ...
)
```

Arguments

formula	A formula object which symbolically describes the model to calculated.
a	A numeric scalar of the known left truncation value.
mu	The mean of the normal distribution is set to NULL by default. If the distribution is truncated, we use estimates from OLS.
sigma	The variance of the normal distribution is set to NULL by default. If the distribution is truncated, we use estimates from OLS.
data	List that contains corresponding covariates. If none is provided then assumes objects are in user's environment.

Maxiter	The maximum number of iterations is specified by default as 2000.
convergence	Specify the convergence criterion, the default is 1e-6.
...	Additional arguments

Details

The LTNMM function is used to calculate a left-truncated normal distribution model using MM algorithms based on AD technology. The formula parameter can be used to provide the data that needs to be calculated, such as formula=y~1. By default, the data is provided by the user's environment. The initial values of the mean and variance of the normal distribution are estimated using OLS.

Value

An object of class LTNMM that contains the following fields: total amount of observations, the number of iterations, convergence rate, the log likelihood value, estimated results for the unknown parameters, the standard deviation of estimate for the unknown parameters, the likelihood-based 95% confidence interval for the unknown parameters, information criterion: AIC value and BIC value.

References

Tian G.L., Huang X.F., and Xu, J.(2019). 'An assembly and decomposition approach for constructing separable minorizing functions in a class of MM algorithms.' *Statistica Sinica* **29**(2), 961-982.

Examples

```
y=c(8.7, 5.4, 8.9, 5.8, 6.2, 9.9, 7.5, 9.5, 6.5, 6.3); a=5
LTNMM(y~1, a=5)
```

---

lung *NCCTG Lung Cancer Data*

Description

Survival in patients with advanced lung cancer from the North Central Cancer Treatment Group. Performance scores rate how well the patient can perform usual daily activities.

Usage

```
lung
```

Format

An object of class data.frame with 228 rows and 10 columns.

Value

Kidney infection data contains the following fields:

`inst`	Institution code
`time`	Survival time in days
`status`	censoring status 1=censored, 2=dead
`age`	Age in years
`sex`	Male=1 Female=2
`ph.ecog`	ECOG performance score as rated by the physician. 0=asymptomatic, 1= symptomatic but completely ambulatory
`ph.karno`	Karnofsky performance score (bad=0-good=100) rated by physician
`pat.karno`	Karnofsky performance score as rated by patient
`meal.cal`	Calories consumed at meals
`wt.loss`	Weight loss in last six months (pounds)

References

Finkelstein D.M. and Wolfe R.A.(1985). "A semiparametric model for regression analysis of interval-censored failure time data." *Biometrics* **41**, 933-945.

Examples

```
data = data(lung)
```

`plot.Cox` *Plot the Cox object*

Description

Plot the Cox object

Usage

```
## S3 method for class 'Cox'
plot(
  x,
  xlab = "Time",
  ylab = "Cumulative hazard",
  type = "s",
  lty = 1,
  lwd = 1,
  col = gray(0),
  digits = 4,
  ...
)
```

Arguments

x	The Cox object, see CoxMM.
xlab	x label, default is 'Time'.
ylab	y label, default is 'Cumulative hazard'.
type	type value, default is 's'.
lty	lty value for line, default is 1.
lwd	line width, default is 1.
col	color parameter, default is gray(0).
digits	The digits after the decimal point, default = 4.
...	Additional arguments

Value

the dataframe of 'Time' and accumulative hazard Λ.

Examples

```
library(survival)
result <- CoxMM(Surv(time, status) ~ age + sex, lung)

plot(result)
```

---

plot.GaF *Plot the GaF object*

Description

Plot the GaF object

Usage

```
## S3 method for class 'GaF'
plot(
  x,
  xlab = "Time",
  ylab = "Cumulative hazard",
  type = "s",
  lty = 1,
  lwd = 1,
  col = gray(0),
  digits = 4,
  ...
)
```

Arguments

x	The GaF object, see GaFrailtyMM.
xlab	x label, default is 'Time'.
ylab	y label, default is 'Cumulative hazard'.
type	type value, default is 's'.
lty	lty value for line, default is 1.
lwd	line width, default is 1.
col	color parameter, default is gray(0).
digits	The digits after the decimal point, default = 4.
...	Additional arguments

Value

the dataframe of 'Time' and accumulative hazard Λ.

Examples

```
library(survival)
result <- GaFrailtyMM(Surv(time, status) ~ age + sex + cluster(id), data=kidney)
plot(result)
```

---

plot.IC2 *Plot the IC2 object*

Description

Plot the IC2 object

Usage

```
## S3 method for class 'IC2'
plot(
  x,
  xlab = "Time",
  ylab = "Survival",
  legend = NULL,
  main = "Survival Function",
  lty = 1:9,
  lwd = 1,
  xleg = 0,
  yleg = 0.15,
  col = gray(0),
  ...
)
```

Arguments

x	The IC2 object, see IC2MM.
xlab	x label, default is 'Time'.
ylab	y label, default is 'Survival'.
legend	legend, default=NULL.
main	figure title, default is 'Survival Function'
lty	lty value for line, default is 1:9.
lwd	line width, default is 1.
xleg	positional parameters of the legend, default=0.
yleg	positional parameters of the legend, default=0.15 .
col	the color of the drawing, default=gray(0)
...	Additional arguments

Value

A list of arguments for the legend. Values are x, y, legend, fill, lty, bty, col.

Examples

```
library(survival)
result = IC2MM(Surv(left, right, type = 'interval2') ~ treatment, bcos)

plot(result, col=c('red', 'blue'))
```

---

summary.Cox *Summary of parameter estimates of a Cox model*

Description

This function returns the result of the CoxMM function

Usage

```
## S3 method for class 'Cox'
summary(object, digits = 4, ...)
```

Arguments

object	Output from a call to Cox.
digits	The desired number of digits after the decimal point. Default of 4 digits is used.
...	Additional arguments

Value

Summary for CoxMM objects.

See Also

CoxMM

Examples

```
library(survival)
result <- CoxMM(Surv(time, status) ~ age + sex, lung)

summary(result,digits=4)
```

---

summary.CZIGP *Summary of parameter estimates of a multivariate compound ZIGP model*

Description

This function returns the result of the CZIGPMM function

Usage

```
## S3 method for class 'CZIGP'
summary(object, digits = 4, ...)
```

Arguments

object	Output from a call to CZIGP.
digits	The desired number of digits after the decimal point. Default of 4 digits is used.
...	Additional arguments

Value

Summary for CZIGPMM objects.

See Also

CZIGPMM

Examples

```
x1 <- c(0,35,23,34,8,19,0,0,0,0)
x2 <- c(38,15,0,25,34,0,0,0,0,0)
y <- cbind(x1, x2)
phi0 = 0.5; phi = rep(0.5,2); la = rep(1,2); th = rep(0.1,2)
result <- CZIGPMM(y, phi0, phi, la, th)

summary(result,digits=4)
```

`summary.GaF` *Summary of parameter estimates of a gamma frailty model*

Description

This function returns the result of the `GaFrailtyMM` function

Usage

```
## S3 method for class 'GaF'
summary(object, digits = 4, ...)
```

Arguments

`object`	Output from a call to GaF.
`digits`	The desired number of digits after the decimal point. Default of 4 digits is used.
`...`	Additional arguments

Value

Summary for `GaFrailtyMM` objects.

See Also

`GaFrailtyMM`

Examples

```
library(survival)
result <- GaFrailtyMM(Surv(time, status) ~ age + sex + cluster(id), data=kidney)

summary(result,digits=4)
```

summary.IC2 *Summary of parameter estimates of a IC2 model*

Description

This function returns the result of the IC2MM function

Usage

```
## S3 method for class 'IC2'
summary(object, ...)
```

Arguments

object	Output from a call to IC2.
...	Additional arguments

Value

Summary for IC2MM objects.

See Also

IC2MM

Examples

```
library(survival)
result <- IC2MM(Surv(left, right, type = 'interval2') ~ treatment, bcos)

summary(result)
```

summary.LTN *Summary of parameter estimates of a LTN model*

Description

This function returns the result of the LTNMM function

Usage

```
## S3 method for class 'LTN'
summary(object, digits = 4, ...)
```

Arguments

object	Output from a call to LTN.
digits	The desired number of digits after the decimal point. Default of 4 digits is used.
...	Additional arguments

Value

Summary for LTNMM objects.

See Also

LTNMM

Examples

```
y=c(8.7, 5.4, 8.9, 5.8, 6.2, 9.9, 7.5, 9.5, 6.5, 6.3); a=5
result <- LTNMM(y~1, a=5)

summary(result,digits=4)
```

---

summary.ZIGP *Summary of parameter estimates of a Type I multivariate ZIGP model*

Description

This function returns the result of the ZIGPMM function

Usage

```
## S3 method for class 'ZIGP'
summary(object, digits = 4, ...)
```

Arguments

object	Output from a call to ZIGP.
digits	The desired number of digits after the decimal point. Default of 4 digits is used.
...	Additional arguments

Value

Summary for ZIGPMM objects.

See Also

ZIGPMM

Examples

```
x1 <- c(0, 0, 0,38, 0,19,25, 0,25, 0)
x2 <- c(0, 0, 0,23, 0,51,24, 0,10, 0)
y <- cbind(x1, x2)
phi0 = 0.5; la = rep(1,2); th = rep(0.1,2)
result <- ZIGPMM(y, phi0, la, th)

summary(result,digits=4)
```

---

vijc *Voluntary and involuntary job changes data*

Description

Jung and Winkelmann(1993) provided data on both the numbers of voluntary and involuntary job changes of males during ten period 1974–1984. The samples contain 2124 males who started their working career before or in 1974 and did not retire before 1984.

Usage

```
vijc
```

Format

An object of class `data.frame` with 2124 rows and 2 columns.

Value

Voluntary and involuntary job changes data contains the following fields:

y1	Job changes after experiencing an unemployment spell(assumed to be involuntary)
y2	Direct job to job changes(which are assumed to be voluntary)

References

Huang X.F., Tian G.L., Zhang, C. and Jiang, X.(2017). "Type I multivariate zero-inflated generalized Poisson distribution with applications." *Statistics and its Interface* **10**(2), 291-311.

Jung R.C. and Winkelmann R.(1993). "Two aspects of labor mobility: A bivariate Poisson regression approach." *Empirical Economics* **18**(3), 543–556.

Examples

```
data = data(vijc)
```

`ZIGPMM` *MM algorithm based on the AD method for type I multivariate zero-inflated generalized poisson distribution*

Description

Let $Z \sim Bernoulli(1-\phi)$, $x = (X_1, \cdots, X_m)^T$, $X_i \sim GP(\lambda_i, \theta_i)$, for $i = 1, \cdots, m$, and $(Z, X_1, \cdots, X_m)$ are mutually independent. An m dimensional discrete random vector $y = (Y_1, \cdots, Y_m)^T$ is said to have a Type I multivariate zero-inflated generalized Poisson distribution(ZIGP) distribution if

$$y \overset{\mathrm{d}}{=} Zx = \begin{cases} 0 & \text{with probability } \lambda \\ x & \text{with probability } 1-\lambda \end{cases}$$

where $\lambda \in [0, 1)$, $\lambda = (\lambda_1, \cdots, \lambda_m)^T$, $\theta = (\theta_1, \cdots, \theta_m)^T$, $max(-1, -\lambda_i/q_i) < \theta_i \leqslant 1$ and $q_i \geqslant 4$ is the largest positive integer for each $\lambda_i + \theta_i q_i > 0$ when $\theta_i < 0$. The `ZIGPMM` function is used to calculate the Type I multivariate ZIGP model.

Usage

```
ZIGPMM(data, phi0, la, th, Maxiter = 2000, convergence = 1e-06, ...)
```

Arguments

`data`	Data.frame or Matrix that contains corresponding covariates.
`phi0`	Probability value for the zero-inflated parameter for ZIGP model.
`la`	The scale parameter for Generalized Poisson distribution model.
`th`	The discrete parameter for Generalized Poisson distribution model.
`Maxiter`	The maximum number of iterations is specified by default as 2000.
`convergence`	Specify the convergence criterion, the default is 1e-6.
`...`	Additional arguments

Details

The `ZIGPMM` function is used to calculate Type I multivariate zero-inflated generalized Poisson distribution model using MM algorithms based on AD technology. `data` is provided by user by default, it can be a data frame or a matrix. In addition, the unknown parameters require users to give appropriate initial values, where `0<=phi0<1`, each `th` should satisfy `0<=th<1`, and each `la` should be greater than 0.

Value

An object of class ZIGPMM that contains the following fields: total amount of observations, the number of iterations, convergence rate, the log likelihood value, estimated results for the unknown parameters, the standard deviation of estimate for the unknown parameters, the likelihood-based 95% confidence interval for the unknown parameters, information criterion: AIC value and BIC value.

References

Tian G.L., Huang X.F. and Xu, J.(2019). 'An assembly and decomposition approach for constructing separable minorizing functions in a class of MM algorithms.' *Statistica Sinica* **29**(2), 961-982.

Huang X.F., Tian G.L., Zhang, C. and Jiang, X.(2017). 'Type I multivariate zero-inflated generalized Poisson distribution with applications.' *Statistics and its Interface* **10**(2), 291-311.

Examples

```
x1 <- c(0, 0, 0,38, 0,19,25, 0,25, 0)
x2 <- c(0, 0, 0,23, 0,51,24, 0,10, 0)
y <- cbind(x1, x2)
phi0 = 0.5; la = rep(1,2); th = rep(0.1,2)
ZIGPMM(y, phi0, la, th)
```

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