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Title Semiparametric Competing Risks Regression under Interval Censoring

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Description Semiparametric regression models on the cumulative incidence function for interval-censored competing risks data as described in Bakoyannis, Yu, & Yiannoutsos (2017) /doi{10.1002/sim.7350} and the models with missing event types as described in Park, Bakoyannis, Zhang, & Yiannoutsos (2021) \doi{10.1093/biostatistics/kxaa052}. The proportional subdistribution hazards model (Fine-Gray model), the proportional odds model, and other models that belong to the class of semiparametric generalized odds rate transformation models.

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Imports alabama, doParallel, foreach, MASS, parallel, splines2, stats, utils

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Contents

`bs.derivs` *Derivative of B-spline*

Description

Generates the derivative of the B-splines basis matrix.

Usage

```
bs.derivs(
  x,
  derivs = 0,
  df = NULL,
  knots = NULL,
  degree = 3,
  intercept = FALSE,
  Boundary.knots = range(x)
)
```

Arguments

`x`	object of B-splines
`derivs`	a number of derivatives
`df`	degrees of freedom of B-splines
`knots`	a vector of internal knots
`degree`	degrees of B-splines
`intercept`	a logical vector
`Boundary.knots`	a vector of boundary knots

Details

The function `bs.derivs` performs derivatives of B-splines

Value

The function `bs.derivs` returns a component:

`resmat`	derivatives of B-spline

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bssmle *B-spline Sieve Maximum Likelihood Estimation*

Description

Routine that performs B-spline sieve maximum likelihood estimation with linear and nonlinear inequality/equality constraints

Usage

```
bssmle(formula, data, alpha, k = 1)
```

Arguments

formula	a formula object relating survival object Surv2(v, u, event) to a set of covariates
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the cause of failure 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the cause of failure 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1

Details

The function bssmle performs B-spline sieve maximum likelihood estimation.

Value

The function bssmle returns a list of components:

beta	a vector of the estimated coefficients for the B-splines
varnames	a vector containing variable names
alpha	a vector of the link function parameters
loglikelihood	a loglikelihood of the fitted model
convergence	an indicator of convegence
tms	a vector of the minimum and maximum observation times
Z	a set of covariates
Tv	a vector of v
Tu	a vector of u
Bv	a list containing the B-splines basis functions evaluated at v
Bu	a list containing the B-splines basis functions evaluated at v

dBv	a list containing the first derivative of the B-splines basis functions evaluated at v
dBu	a list containing the first derivative of the B-splines basis functions evaluated at u
dmat	a matrix of event indicator functions

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bssmle_aipw *B-spline Sieve Maximum Likelihood Estimation for Interval-Censored Competing Risks Data and Missing Cause of Failure*

Description

Routine that performs B-spline sieve maximum likelihood estimation with linear and nonlinear inequality and equality constraints

Usage

```
bssmle_aipw(formula, aux, data, alpha, k)
```

Arguments

formula	a formula object relating survival object Surv2(v, u, event) to a set of covariates
aux	auxiliary variables that may be associated with the missingness and the outcome of interest
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the event type 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the event type 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1

Details

The function bssmle_aipw performs B-spline sieve maximum likelihood estimation.

Value

The function bssmle_aipw returns a list of components:

beta	a vector of the estimated coefficients for the B-splines
varnames	a vector containing variable names
varnames.aux	a vector containing auxiliary variable names
alpha	a vector of the link function parameters
loglikelihood	a loglikelihood of the fitted model
convergence	an indicator of convegence
tms	a vector of the minimum and maximum observation times
Bv	a list containing the B-splines basis functions evaluated at v

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bssmle_lse *Least-Squares Estimator of the Information Matrix*

Description

Performs the least-squares methods to estimate the information matrix for the estimated regression coefficients

Usage

```
bssmle_lse(obj)
```

Arguments

obj	a list of objectives from bssmle

Details

The function bssmle_lse estimates the information matrix for the estimated regression coefficients from the function bssmle using the lease-squares method.

Value

The function bssmle_lse returns a list of components:

Sigma	the estimated variance-covariance matrix for the estimated regression coefficients

Author(s)

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References

Zhang, Y., Hua, L., and Huang, J. (2010), A spline-based semiparametric maximum likelihood estimation method for the Cox model with interval-censoed data. *Scandinavian Journal of Statistics*, **37**:338-354.

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bssmle_lse_lt *Least-Squares Estimator of the Information Matrix*

Description

Performs the least-squares methods to estimate the information matrix for the estimated regression coefficients

Usage

```
bssmle_lse_lt(obj)
```

Arguments

obj	a list of objectives from bssmle_lt

Details

The function bssmle_lse_lt estimates the information matrix for the estimated regression coefficients from the function bssmle_lt using the lease-squares method.

Value

The function bssmle_lse_lt returns a list of components:

Sigma	the estimated information matrix for the estimated regression coefficients

Author(s)

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References

Zhang, Y., Hua, L., and Huang, J. (2010), A spline-based semiparametric maximum likelihood estimation method for the Cox model with interval-censoed data. *Scandinavian Journal of Statistics*, **37**:338-354.

`bssmle_lt` *B-spline Sieve Maximum Likelihood Estimation for Left-Truncated and Interval-Censored Competing Risks Data*

Description

Routine that performs B-spline sieve maximum likelihood estimation with linear and nonlinear inequality/equality constraints

Usage

```
bssmle_lt(formula, data, alpha, k = 1)
```

Arguments

`formula`	a formula object relating survival object `Surv2(w, v, u, event)` to a set of covariates
`data`	a data frame that includes the variables named in the formula argument
`alpha`	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the event type 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the event type 2.
`k`	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1

Details

The function `bssmle_lt` performs B-spline sieve maximum likelihood estimation for left-truncated and interval-censored competing risks data.

Value

The function `bssmle_lt` returns a list of components:

`beta`	a vector of the estimated coefficients
`varnames`	a vector containing variable names
`alpha`	a vector of the link function parameters
`loglikelihood`	a loglikelihood of the fitted model
`convergence`	an indicator of convegence
`tms`	a vector of the minimum and maximum observation times
`Z`	a design matrix
`Tw`	a vector of `w`
`Tv`	a vector of `v`
`Tu`	a vector of `u`

Bw	a list containing the B-splines basis functions evaluated at w
Bv	a list containing the B-splines basis functions evaluated at v
Bu	a list containing the B-splines basis functions evaluated at u
dBw	a list containing the first derivative of the B-splines basis functions evaluated at w
dBv	a list containing the first derivative of the B-splines basis functions evaluated at v
dBu	a list containing the first derivative of the B-splines basis functions evaluated at u
dmat	a matrix of event indicator functions

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`bssmle_se` *Bootstrap varince-covariance estimation*

Description

Bootstrap varince estimation for the estimated regression coefficients

Usage

```
bssmle_se(formula, data, alpha, k = 1, do.par, nboot, objfun)
```

Arguments

formula	a formula object relating survival object `Surv2(v, u, event)` to a set of covariates
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the cause of failure 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the cause of failure 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1
do.par	using parallel computing for bootstrap calculation. If `do.par = TRUE`, parallel computing will be used during the bootstrap estimation of the variance-covariance matrix for the regression parameter estimates.
nboot	a number of bootstrap samples for estimating variances and covariances of the estimated regression coefficients. If `nboot = 0`, the function `ciregic` does dot perform bootstrap estimation of the variance matrix of the regression parameter estimates and returns `NA` in the place of the estimated variance matrix of the regression parameter estimates.
objfun	an option to select estimating function

Details

The function bssmle_se estimates bootstrap standard errors for the estimated regression coefficients from the function bssmle, bssmle_lt, ro bssmle_ltir.

Value

The function bssmle_se returns a list of components:

notconverged	a list of number of bootstrap samples that did not converge
numboot	a number of bootstrap converged
Sigma	an estimated bootstrap variance-covariance matrix of the estimated regression coefficients

Author(s)

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bssmle_se_aipw *Bootstrap varince-covariance estimation for interval-censored competing risks data and missing cause of failure*

Description

Bootstrap varince estimation for the estimated regression coefficients

Usage

```
bssmle_se_aipw(formula, aux, data, alpha, k, do.par, nboot, w.cores = NULL)
```

Arguments

formula	a formula object relating survival object mSurv(v, u, event) to a set of covariates
aux	auxiliary variables that may be associated with the missingness and the outcome of interest
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the event type 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the event type 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1

do.par	using parallel computing for bootstrap calculation. If do.par = TRUE, parallel computing will be used during the bootstrap estimation of the variance-covariance matrix for the regression parameter estimates.
nboot	a number of bootstrap samples for estimating variances and covariances of the estimated regression coefficients. If nboot = 0, the function ciregic does dot perform bootstrap estimation of the variance matrix of the regression parameter estimates and returns NA in the place of the estimated variance matrix of the regression parameter estimates.
w.cores	a number of cores that are assigned (the default is NULL)

Details

The function bssmle_aipw_se estimates bootstrap standard errors for the estimated regression coefficients from the function bssmle.

Value

The function bssmle_aipw_se returns a list of components:

notconverged	a list of number of bootstrap samples that did not converge
numboot	a number of bootstrap converged
Sigma	an estimated bootstrap variance-covariance matrix of the estimated regression coefficients

Author(s)

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ciregic *Competing Risks Regression with Interval-Censored Data*

Description

The function ciregic performs semiparametric regression on cumulative incidence function with interval-censored competing risks data. It fits the proportional subdistribution hazards model (Fine-Gray model), the proportional odds model, and other models that belong to the class of semiparametric generalized odds rate transformation models. The standard errors for the estimated regression coefficients are estimated by a choice of options: 1) the bootstrapping method or 2) the least-squares method.

Usage

```
ciregic(formula, data, alpha, k = 1, do.par, nboot, ...)
```

Arguments

formula	a formula object relating the survival object Surv2(v, u, event) to a set of covariates
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the cause of failure 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the cause of failure 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1
do.par	an option to use parallel computing for bootstrap. If do.par = TRUE, parallel computing will be used during the bootstrap estimation of the variance-covariance matrix for the regression parameter estimates.
nboot	a number of bootstrap samples for estimating variances and covariances of the estimated regression coefficients. If nboot = 0, the function ciregic provides the variance estimator of the regression parameter estimates using the least-squares method and does not perform the bootstrap method.
...	further arguments

Details

The formula for the model has the form of response ~ predictors. The response in the formula is a Surv2(v, u, event) object where v is the last observation time prior to the failure, u is the first observation time after the failure, and event is the event or censoring indicator. event should include 0, 1 or 2, denoting right-censoring, failure from cause 1 and failure from cause 2, respectively. If event=0 (i.e. right-censored observation) then u is not included in any calculation as it corresponds to ∞. The user can provide any value in u for the right-censored cases, even NA. The function ciregic fits models that belong to the class of generalized odds rate transformation models which includes the proportional subdistribution hazards or the Fine-Gray model and the proportional odds model. The parameter $\alpha = (\alpha 1, \alpha 2)$ defines the link function/model to be fitted for cause of failure 1 and 2, respectively. A value of 0 corresponds to the Fine-Gray model and a value of 1 corresponds to the proportional odds model. For example, if $\alpha = (0, 1)$ then the function ciregic fits the Fine-Gray model for cause 1 and the proportional odds model for cause 2.

Value

The function ciregic provides an object of class ciregic with components:

varnames	a vector containing variable names
coefficients	a vector of the regression coefficient estimates
gamma	a vector of the estimated coefficients for the B-splines
vcov	a variance-covariance matrix of the estimated regression coefficients
alpha	a vector of the link function parameters
loglikelihood	a loglikelihood of the fitted model
convergence	an indicator of convegence

tms	a vector of the minimum and maximum observation times
Bv	a list containing the B-splines basis functions evaluated at v
numboot	a number of converged bootstrap
notconverged	a list of number of bootstrap samples that did not converge
call	a matched call

Author(s)

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References

Bakoyannis, G., Yu, M., and Yiannoutsos C. T. (2017). Semiparametric regression on cumulative incidence function with interval-censored competing risks data. *Statistics in Medicine*, **36**:3683-3707.

Fine, J. P. and Gray, R. J. (1999). A proportional hazards model for the subdistribution of a competing risk. *Journal of the American Statistical Association*, **94**:496-509.

See Also

summary.ciregic for the summarized results and predict.ciregic for value of the predicted cumulative incidence functions. coef and vcov are the generic functions. dataprep for reshaping data from a long format to a suitable format to be used in the function ciregic.

Examples

```
## Not run:
## Set seed in order to have reproducibility of the bootstrap standard error estimate
set.seed(1234)

## Reshaping data from a long format to a suitable format
newdata <- dataprep(data = longdata, ID = id, time = t,
                    event = c, Z = c(z1, z2))
## Estimation of regression parameters only. No bootstrap variance estimation.
## with 'newdata'
fit <- ciregic(formula = Surv2(v = v, u = u, event = c) ~ z1 + z2, data = newdata,
               alpha = c(1, 1), nboot = 0, do.par = FALSE)
fit

## Bootstrap variance estimation based on 50 replications
fit <- ciregic(formula = Surv2(v = v, u = u, event = c) ~ z1 + z2, data = newdata,
               alpha = c(1, 1), nboot = 50, do.par = FALSE)

## End(Not run)
## Note that the user can use parallel computing to decrease
## the computation time of the bootstrap variance-covariance
## estimation (e.g. nboot = 50)
```

```
## Summarize semiparametric regression model
summary(fit)

## Predict and draw plot the cumulative incidence function evaluated at z1 = 1 and z2 = 0.5
t <- seq(from = 0, to = 2.8, by = 2.8 / 99)
pred <- predict(object = fit, covp = c(1, 0.5), times = t)
pred
plot(pred$t, pred$cif1, type = "l", ylim = c(0, 1))
points(pred$t, pred$cif2, type = "l", col = 2)
```

`ciregic_aipw` *Competing Risks Regression with Interval-Censored Data and Missing Cause of Failure*

Description

The function `ciregic_aipw` performs semiparametric regression on cumulative incidence function with interval-censored competing risks data in the presence of missing cause of failure. It fits the proportional subdistribution hazards model (Fine-Gray model), the proportional odds model, and other models that belong to the class of semiparametric generalized odds rate transformation models. The estimates have double robustness property, which means that the estimators are consistent even if either the model for the probability of missingness or the model for the probability of the cause of failure is misspecified under the missing at random assumption.

Usage

```
ciregic_aipw(
  formula,
  aux = NULL,
  data,
  alpha,
  k = 1,
  do.par,
  nboot,
  w.cores = NULL,
  ...
)
```

Arguments

`formula`	a formula object relating the survival object `Surv2(v, u, event)` to a set of covariates
`aux`	auxiliary variable(s) that may be associated with the missingness and the outcome of interest
`data`	a data frame that includes the variables named in the formula argument

alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the event type 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the event type 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1
do.par	an option to use parallel computing for bootstrap. If do.par = TRUE, parallel computing will be used during the bootstrap estimation of the variance-covariance matrix for the regression parameter estimates.
nboot	a number of bootstrap samples for estimating variances and covariances of the estimated regression coefficients. If nboot = 0, the function ciregic_aipw does not perform bootstrap estimation of the variance-covariance matrix of the regression parameter estimates and returns NA in the place of the estimated variance-covariance matrix of the regression parameter estimates.
w.cores	a number of cores that are assigned (the default is NULL)
...	further arguments

Details

The formula for the model has the form of response ~ predictors. The response in the formula is a Surv2(v, u, event) object where v is the last observation time prior to the event, u is the first observation time after the event, and event is the event or censoring indicator. event should include 0, 1 or 2, denoting right-censoring, event type 1 and 2, respectively. If event=0 (i.e. right-censored observation) then u is not included in any calculation as it corresponds to ∞. The user can provide any value in u for the right-censored cases, even NA. The function ciregic_aipw fits models that belong to the class of generalized odds rate transformation models which includes the proportional subdistribution hazards or the Fine-Gray model and the proportional odds model. The parameter $\alpha = (\alpha 1, \alpha 2)$ defines the link function/model to be fitted for event 1 and 2, respectively. A value of 0 corresponds to the Fine-Gray model and a value of 1 corresponds to the proportional odds model. For example, if $\alpha = (0, 1)$ then the function ciregic_aipw fits the Fine-Gray model for the event type 1 and the proportional odds model for the event type 2.

Value

The function ciregic_aipw provides an object of class ciregic_aipw with components:

varnames	a vector containing variable names
varnames.aux	a vector containing auxiliary variable names
coefficients	a vector of the regression coefficient estimates
gamma	a vector of the estimated coefficients for the B-splines
vcov	a variance-covariance matrix of the estimated regression coefficients
alpha	a vector of the link function parameters
loglikelihood	a loglikelihood of the fitted model
convergence	an indicator of convegence
tms	a vector of the minimum and maximum observation times

Bv	a list containing the B-splines basis functions evaluated at v
numboot	a number of converged bootstrap
notconverged	a list of number of bootstrap samples that did not converge
call	a matched call

Author(s)

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References

Bakoyannis, G., Yu, M., and Yiannoutsos C. T. (2017). Semiparametric regression on cumulative incidence function with interval-censored competing risks data. *Statistics in Medicine*, **36**:3683-3707.

Fine, J. P. and Gray, R. J. (1999). A proportional hazards model for the subdistribution of a competing risk. *Journal of the American Statistical Association*, **94**:496-509.

See Also

summary.ciregic_aipw for the summarized results and predict.ciregic_aipw for value of the predicted cumulative incidence functions. coef and vcov are the generic functions. dataprep function for reshaping data from a long format to a suitable format to be used in the function ciregic_aipw.

Examples

```
## Not run:
## Set seed in order to have reproducibility of the bootstrap standard error estimate
set.seed(1234)

## Estimation of regression parameters only. No bootstrap variance estimation.
## with 'simdata_aipw'
data(simdata_aipw)
fit_aipw <- ciregic_aipw(formula = Surv2(v = v, u = u, event = c) ~ z1 + z2, aux = a,
                         data = simdata_aipw, alpha = c(1, 1), nboot = 0,
                         do.par = FALSE)
fit_aipw
## Bootstrap variance estimation based on 50 replications
fit_aipw <- ciregic_aipw(formula = Surv2(v = v, u = u, event = c) ~ z1 + z2, aux = a,
                         data = simdata_aipw, alpha = c(1, 1), k = 1, nboot = 50,
                         do.par = FALSE)

## End(Not run)
## Note that the user can use parallel computing to decrease
## the computation time of the bootstrap variance-covariance
## estimation (e.g. nboot = 50)

## Summarize semiparametric regression model
summary(fit_aipw)
```

```
## Predict and draw plot the cumulative incidence function evaluated at z1 = 1 and z2 = 0.5
t <- seq(from = 0, to = 2.8, by = 2.8 / 99)
pred <- predict(object = fit_aipw, covp = c(1, 0.5), times = t)
pred
plot(pred$t, pred$cif1, type = "l", ylim = c(0, 1))
points(pred$t, pred$cif2, type = "l", col = 2)
```

---

ciregic_lt *Competing Risks Regression with Left-truncated and Interval-Censored Data*

Description

The function ciregic_lt performs semiparametric regression on cumulative incidence function with left-truncated and interval-censored competing risks data. It fits the proportional subdistribution hazards model (Fine-Gray model), the proportional odds model, and other models that belong to the class of semiparametric generalized odds rate transformation models. The least-square method is implemented to estimate the standard error of the regression coefficients.

Usage

```
ciregic_lt(formula, data, alpha, k = 1, do.par, nboot, ...)
```

Arguments

formula	a formula object relating the survival object Surv2(v, u, w, event) to a set of covariates
data	a data frame that includes the variables named in the formula argument
alpha	$\alpha = (\alpha 1, \alpha 2)$ contains parameters that define the link functions from class of generalized odds-rate transformation models. The components $\alpha 1$ and $\alpha 2$ should both be ≥ 0. If $\alpha 1 = 0$, the user assumes the proportional subdistribution hazards model or the Fine-Gray model for the cause of failure 1. If $\alpha 2 = 1$, the user assumes the proportional odds model for the cause of failure 2.
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1
do.par	an option to use parallel computing for bootstrap. If do.par = TRUE, parallel computing will be used during the bootstrap estimation of the variance-covariance matrix for the regression parameter estimates.
nboot	a number of bootstrap samples for estimating variances and covariances of the estimated regression coefficients. If nboot = 0, the function ciregic_lt returns a closed-form variance estimator using the least-squares method and does not perform bootstrap estimation of the variance-covariance matrix of the regression parameter estimates. For nboot ≥ 1, the function ciregic_lt returns the boostrap variance estimator of the regression parameter estimates.
...	further arguments

Details

The function `ciregic_lt` is capable of analyzing left-truncated and interval-censored competing risks data. A triplet of time points `(w, v, u)` is required if an observation is left-truncated and interval-censored. A part of left-truncation is also allowed by defining `w = 0` for interval-censored only observation. The formula for the model has the form of `response ~ predictors`. The response in the formula is a `Surv2(v, u, w, event)` object where `w` is a left-truncation time, `v` is the last observation time prior to the failure, `u` is the first observation time after the failure, and `event` is the event or censoring indicator. `event` should include 0, 1 or 2, denoting right-censoring, failure from cause 1 and failure from cause 2, respectively. If `event=0` (i.e. right-censored observation) then `u` is not included in any calculation as it corresponds to ∞. The user can provide any value in `u` for the right-censored cases, even `NA`. The function `ciregic_lt` fits models that belong to the class of generalized odds rate transformation models which includes the proportional subdistribution hazards or the Fine-Gray model and the proportional odds model. The parameter $\alpha = (\alpha 1, \alpha 2)$ defines the link function/model to be fitted for cause of failure 1 and 2, respectively. A value of `0` corresponds to the Fine-Gray model and a value of `1` corresponds to the proportional odds model. For example, if $\alpha = (0, 1)$ then the function `ciregic_lt` fits the Fine-Gray model for cause 1 and the proportional odds model for cause 2.

Value

The function `ciregic_lt` provides an object of class `ciregic_lt` with components:

`varnames`	a vector containing variable names
`coefficients`	a vector of the regression coefficient estimates
`gamma`	a vector of the estimated coefficients for the B-splines
`vcov`	a variance-covariance matrix of the estimated regression coefficients
`alpha`	a vector of the link function parameters
`loglikelihood`	a loglikelihood of the fitted model
`convergence`	an indicator of convegence
`tms`	a vector of the minimum and maximum observation times
`Bv`	a list containing the B-splines basis functions evaluated at `v`
`numboot`	a number of converged bootstrap
`notconverged`	a list of number of bootstrap samples that did not converge
`call`	a matched call

Author(s)

Jun Park, <jun.park@alumni.iu.edu>

Giorgos Bakoyannis, <gbakogia@iu.edu>

References

Bakoyannis, G., Yu, M., and Yiannoutsos C. T. (2017). Semiparametric regression on cumulative incidence function with interval-censored competing risks data. *Statistics in Medicine*, **36**:3683-3707.

Fine, J. P. and Gray, R. J. (1999). A proportional hazards model for the subdistribution of a competing risk. *Journal of the American Statistical Association*, **94**:496-509.

See Also

summary.ciregic_lt for the summarized results and predict.ciregic_lt for value of the predicted cumulative incidence functions. coef and vcov are the generic functions. dataprep for reshaping data from a long format to a suitable format to be used in the function ciregic_lt.

Examples

```
## Not run:
## Set seed in order to have reproducibility of the bootstrap standard error estimate
set.seed(1234)

## Reshaping data from a long format to a suitable format
newdata <- dataprep_lt(data = longdata_lt, ID = id, time = t, W = w,
                       event = c, Z = c(z1, z2))
## Estimation of regression parameters only. No bootstrap variance estimation.
## with 'newdata'
fit_lt <- ciregic_lt(formula = Surv2(v = v, u = u, w = w, event = c) ~ z1 + z2, data = newdata,
                     alpha = c(1, 1), nboot = 0, do.par = FALSE)
fit_lt

## Bootstrap variance estimation based on 50 replications
fit_lt <- ciregic_lt(formula = Surv2(v = v, u = u, w = w, event = c) ~ z1 + z2, data = newdata,
                     alpha = c(1, 1), nboot = 50, do.par = FALSE)

## End(Not run)
## Note that the user can use parallel computing to decrease
## the computation time of the bootstrap variance-covariance
## estimation (e.g. nboot = 50)

## Summarize semiparametric regression model
summary(fit_lt)

## Predict and draw plot the cumulative incidence function evaluated at z1 = 1 and z2 = 0.5
mint <- fit_lt$tms[1]
maxt <- fit_lt$tms[2]
pred <- predict(object = fit_lt, covp = c(1, 0.5),
                times = seq(mint, maxt, by = (maxt - mint) / 99))
pred
plot(pred$t, pred$cif1, type = "l", ylim = c(0, 1))
points(pred$t, pred$cif2, type = "l", col = 2)
```

---

dataprep *Data manipulation*

Description

The function dataprep reshapes data from a long format to a ready-to-use format to be used directly in the function ciregic.

Usage

```
dataprep(data, ID, time, event, Z)
```

Arguments

data	a data frame that includes the variables named in the ID, time, event, and z arguments
ID	a variable indicating individuals' ID
time	a variable indicating observed time points
event	a vector of event indicator. If an observation is righ-censored, event = 0; otherwise, event = 1 or event = 2, where 1 represents the first cause of failure, and 2 represents the second cause of failure. The current version of package only allows two causes of failure.
Z	a vector of variables indicating name of covariates

Details

The function dataprep provides a ready-to-use data format that can be directly used in the function ciregic. The returned data frame consists of id, v, u, c, and covariates as columns. The v and u indicate time window with the last observation time before the event and the first observation after the event. The c represents a type of event, for example, c = 1 for the first cause of failure, c = 2 for the second cause of failure, and c = 0 for the right-censored. For individuals having one time record with the event, the lower bound v will be replaced by zero, for example (0, v]. For individuals having one time record without the event, the upper bound u will be replaced by Inf, for example (v, Inf].

Value

a data frame

Author(s)

Jun Park, <jun.park@alumni.iu.edu>

Giorgos Bakoyannis, <gbakogia@iu.edu>

Examples

```
library(intccr)
dataprep(data = longdata, ID = id, time = t, event = c, Z = c(z1, z2))
```

dataprep_lt *Data preparation*

Description

The function dataprep_lt reshapes data from a long format to a ready-to-use format to be used directly in the function ciregic_lt.

Usage

```
dataprep_lt(data, ID, W, time, event, Z)
```

Arguments

data	a data frame that includes the variables named in the ID, time, event, and z arguments
ID	a variable indicating individuals' ID
W	a vector of left-truncated time points
time	a variable indicating observed time points
event	a vector of event indicator. If an observation is righ-censored, event = 0; otherwise, event = 1 or event = 2, where 1 represents the first cause of failure, and 2 represents the second cause of failure. The current version of package only allows two causes of failure.
Z	a vector of variables indicating name of covariates

Details

The function dataprep_lt provides a ready-to-use data format that can be directly used in the function ciregic_lt. The returned data frame consists of id, v, u, c, and covariates as columns. The v and u indicate time window with the last observation time before the event and the first observation after the event. The c represents a type of event, for example, c = 1 for the first cause of failure, c = 2 for the second cause of failure, and c = 0 for the right-censored. For individuals having one time record with the event, the lower bound v will be replaced by zero, for example (0, v]. For individuals having one time record without the event, the upper bound u will be replaced by Inf, for example (v, Inf].

Value

a data frame

Author(s)

Jun Park, <jun.park@alumni.iu.edu>

Giorgos Bakoyannis, <gbakogia@iu.edu>

dbs *Derivative of B-spline*

Description

Generates the derivative of the B-splines basis matrix.

Usage

```
dbs(
  x,
  derivs = 1L,
  df = NULL,
  knots = NULL,
  degree = 3L,
  intercept = FALSE,
  Boundary.knots = range(x, na.rm = TRUE)
)
```

Arguments

x	object of B-splines
derivs	a number of derivatives
df	degrees of freedom of B-splines
knots	a vector of internal knots
degree	degrees of B-splines
intercept	a logical vector
Boundary.knots	a vector of boundary knots

Details

The function dbs performs derivatives of B-splines

Value

The function dbs returns a component:

dMat	B-spline matrix

Author(s)

Jun Park, <jun.park@alumni.iu.edu>

Giorgos Bakoyannis, <gbakogia@iu.edu>

fit *Output of* ciregic

Description

Object contains the output of the function ciregic. Standard errors were estimated by the least-squares method.

Usage

```
fit
```

Format

A list of components.

Examples

```
fit
```

fit_aipw *Output of* ciregic_aipw

Description

A list of outputs containing the last time prior to the event, the first time after the event, cause of failure with 50% of missingness, and covariates.

Usage

```
fit_aipw
```

Format

A list of 14:

call a matched call

varnames a vector containing variable names

varnames.aux a vector containing auxiliary variable names

coefficients a vector of the regression coefficient estimates

gamma a vector of the estimated coefficients for the B-splines

vcov a variance-covariance matrix of the estimated regression coefficients

alpha a vector of the link function parameters

k a parameter that controls the number of knots in the B-spline

loglikelihood a loglikelihood of the fitted model

convergence an indicator of convegence

tms a vector of the minimum and maximum observation times

Bv a list containing the B-splines basis functions evaluated at v

notconverged a list of number of bootstrap samples not converged

Examples

```
fit_aipw
```

`fit_lt` *Output of* `ciregic_lt`

Description

Object contains the output of the function `ciregic_lt`. Standard errors were estimated by the least-squares method.

Usage

```
fit_lt
```

Format

A list of components.

Examples

```
fit_lt
```

`longdata` *Simulated interval-censored competing risks data - long format*

Description

The data containing the subject id, series of time points, cause of failure, and covariates with 200 observations.

Usage

```
longdata
```

Format

A data frame with 868 rows and 5 variables.

Examples

```
library(intccr)
data(longdata)
```

`longdata_lt` *Simulated left-truncated and interval-censored competing risks data - long format*

Description

Data containing observation time points, a left-truncation time, cause of failure, and baseline covariates with 275 observations.

Usage

```
longdata_lt
```

Format

A data frame with 275 unique individuals and 6 variables.

Examples

```
library(intccr)
data(longdata_lt)
```

`naive_b` *Initial values for the sieve maximum likelihood estimation*

Description

The function `naive_b` provides a vector of initial values for the B-spline sieve maximum likelihood estimation.

Usage

```
naive_b(data, w = NULL, v, u, c, q, k = 1)
```

Arguments

data	a data frame that includes the variables named in each argument
w	a left-truncation time (default is w = NULL.)
v	the last observation time prior to the failure
u	the first observation time after the failure
c	an indicator of cause of failure, for example, if an observation is righ-censored, event = 0; otherwise, event = 1 or event = 2, where 1 represents the first cause of failure, and 2 represents the second cause of failure. The current version of package only allows for two causes of failure.
q	a number of parameters in design matrix
k	a parameter that controls the number of knots in the B-spline with $0.5 \leq$k≤ 1

Details

The function naive_b provides initial values for the optimization procedure.

Value

Initial values of B-spline estimation

b	a vector of the initial values to be used in the optimization process

Author(s)

Giorgos Bakoyannis, <gbakogia@iu.edu>

Jun Park, <jun.park@alumni.iu.edu>

Examples

```
attach(simdata)
intccr:::naive_b(data = simdata, v = v, u = u, c = c, q = 2)
```

---

predict.ciregic *Covariate-Specific Cumulative Incidence Prediction*

Description

predict method for class ciregic. It provides the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Usage

```
## S3 method for class 'ciregic'
predict(object, covp, times, ...)
```

Arguments

object	an object of class ciregic, which is a result of a call to ciregic
covp	a desired values for covariates
times	time points that user wants to predict value of cumulative incidence function
...	further arguments

Details

predict.ciregic returns the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Value

The function predict.ciregic returns a list of predicted values of the model from object.

t	time points
cif1	the predicted value of cumulative incidence function for the event type 1
cif2	the predicted value of cumulative incidence function for the event type 2

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic and summary of the fitted semiparametric regression model summary.ciregic

Examples

```
## Continuing the ciregic(...) example
pfit <- predict(object = fit, covp = c(1, 0.5), times = c(0.1, 0.15, 0.5, 0.7))
pfit
mint <- fit$tms[1]
maxt <- fit$tms[2]
pfit1 <- predict(object = fit, covp = c(1, 0.5),
                 times = seq(mint, maxt, by = (maxt-mint)/99))
plot(pfit1$t, pfit1$cif1, ylim = c(0, 1), type = "l")
lines(pfit1$t, pfit1$cif2, ylim = c(0, 1), lty = 2, col = 2)
```

---

predict.ciregic_aipw *Covariate-Specific Cumulative Incidence Prediction*

Description

predict method for class ciregic_aipw. It provides the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Usage

```
## S3 method for class 'ciregic_aipw'
predict(object, covp, times, ...)
```

Arguments

object	an object of class ciregic_aipw, which is a result of a call to ciregic_aipw
covp	a desired values for covariates
times	time points that user wants to predict value of cumulative incidence function
...	further arguments

Details

predict.ciregic_aipw returns the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Value

The function predict.ciregic_aipw returns a list of predicted values of the model from object.

t	time points
cif1	the predicted value of cumulative incidence function for the event type 1
cif2	the predicted value of cumulative incidence function for the event type 2

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic_aipw and summary of the fitted semiparametric regression model summary.ciregic_aipw

Examples

```
## Continuing the ciregic_aipw(...) example
pfit <- predict(object = fit_aipw, covp = c(1, 0.5), times = c(0.1, 0.15, 0.5, 0.7))
pfit
mint <- fit_aipw$tms[1]
maxt <- fit_aipw$tms[2]
pfit1 <- predict(object = fit_aipw, covp = c(1, 0.5),
                 times = seq(mint, maxt, by = (maxt - mint) / 99))
plot(pfit1$t, pfit1$cif1, ylim = c(0, 1), type = "l")
lines(pfit1$t, pfit1$cif2, ylim = c(0, 1), lty = 2, col = 2)
```

---

predict.ciregic_lt *Covariate-Specific Cumulative Incidence Prediction*

Description

predict method for class ciregic_lt. It provides the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Usage

```
## S3 method for class 'ciregic_lt'
predict(object, covp, times, ...)
```

Arguments

object	an object of class ciregic_lt, which is a result of a call to ciregic_lt
covp	a desired values for covariates
times	time points that user wants to predict value of cumulative incidence function
...	further arguments

Details

predict.ciregic_lt returns the predicted cumulative incidence function for a given covariate pattern and timepoint(s).

Value

The function predict.ciregic_lt returns a list of predicted values of the model from object.

t	time points
cif1	the predicted value of cumulative incidence function for the event type 1
cif2	the predicted value of cumulative incidence function for the event type 2

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic_lt and summary of the fitted semiparametric regression model summary.ciregic_lt

Examples

```
## Continuing the ciregic_lt(...) example
pfit <- predict(object = fit_lt, covp = c(1, 0.5), times = c(0.1, 0.15, 0.5, 0.7))
pfit
mint <- fit_lt$tms[1]
maxt <- fit_lt$tms[2]
pfit1 <- predict(object = fit_lt, covp = c(1, 0.5),
                 times = seq(mint, maxt, by = (maxt - mint) / 99))
plot(pfit1$t, pfit1$cif1, ylim = c(0, 1), type = "l")
lines(pfit1$t, pfit1$cif2, ylim = c(0, 1), lty = 2, col = 2)
```

---

predict.dbs *Prediction of derivative of B-spline*

Description

Evaluates the derivative of the B-splines basis matrix at given values.

Usage

```
## S3 method for class 'dbs'
predict(object, newx)
```

Arguments

object	returned object of B-splines
newx	a vector of points

Details

The function predict is a generic function of bs.derivs

Value

The function predict returns a predicted B-splies.

Author(s)

Giorgos Bakoyannis, <gbakogia@iu.edu>

Jun Park, <jp84@alumni.iu.edu>

---

pseudo.HIV.long *Artificial HIV dataset*

Description

Artificial dataset that was simulated to resemble the HIV study on loss to HIV care and death in sub-Saharan Africa, that was presented in Bakoyannis, Yu, & Yiannoutsos (2017). It contains subject id, observation times, cause of failure, and covariates.

Usage

```
pseudo.HIV.long
```

Format

A data frame with 22710 rows and 6 variables.

References

Bakoyannis, G., Yu, M., and Yiannoutsos C. T. (2017). Semiparametric regression on cumulative incidence function with interval-censored competing risks data. *Statistics in Medicine*, **36**:3683-3707.

Examples

```
head(pseudo.HIV.long, n = 20)
```

simdata — *Simulated interval-censored competing risks data with 2 covariates - wide format*

Description

The data containing the idividual identification number, the last time point prior to the event, the first time point after the event, cause of failure, and covariates with 200 observations.

Usage

```
simdata
```

Format

A data frame with 200 rows and 6 variables.

id subject id

v the last observation time prior to the event

u the first observation time after the event

c cause of failure with missing

z1 binary variable

z2 continuous variable

Examples

```
library(intccr)
data(simdata)
```

simdata_aipw — *Simulated interval censored data with 2 covariates in the presence of* 50% *of missing cause of failure - wide format*

Description

The dataset containing the individual identification number, the last time prior to the event, the first time after the event, cause of failure with 50% of missingness, and covariates.

Usage

```
simdata_aipw
```

Format

A data frame with 200 rows and 7 variables:

id subject id

v the last observation time prior to the event

u the first observation time after the event

c cause of failure with missing

z1 binary variable

z2 continuous variable

a auxiliary variable

Examples

```
library(intccr)
data(simdata_aipw)
```

`simdata_lt` *Simulated left-truncated and interval-censored competing risks data with 2 covariates - wide format*

Description

The data containing the individual identification number, the left-truncated time, the last and first observation time prior to the event and after the event, cause of failure, and baseline covariates with 275 observations.

Usage

```
simdata_lt
```

Format

A data frame with 275 unique individuals and 7 variables.

id subject id

w the left truncation time

v the last observation time prior to the event

u the first observation time after the event

c cause of failure with missing

z1 binary variable

z2 continuous variable

Examples

```
library(intccr)
data(simdata_lt)
```

summary.ciregic *Summary of* ciregic

Description

summary method for class ciregic

Usage

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

Arguments

object	an object of class ciregic, which is a result of a call to ciregic
...	further arguments

Details

The function summary.ciregic returns the coefficients, bootstrap standard errors, and etc. Additionally, 'significance star' is included.

Value

The function summary.ciregic returns a list of summary statistics of the model from object.

varnames	a vector containing variable names
coefficients	a vector of the regression coefficient estimates
se	a bootstrap standard error of the coefficients
z	z value of the estimated coefficients
p	p value of the estimated coefficients
call	a matched call

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic and values of the predicted cumulative incidence functions predict.ciregic

Examples

```
## Continuing the ciregic(...) example
sfit <- summary(fit)
sfit
```

summary.ciregic_aipw *Summary of* ciregic_aipw

Description

summary method for class ciregic_aipw

Usage

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

Arguments

object	an object of class ciregic_aipw, which is a result of a call to ciregic_aipw
...	further arguments

Details

The function summary.ciregic_aipw returns the coefficients, bootstrap standard errors, and etc. Additionally, 'significance star' is included.

Value

The function summary.ciregic_aipw returns a list of summary statistics of the model from object.

varnames	a vector containing variable names
coefficients	a vector of the regression coefficient estimates
se	a bootstrap standard error of the coefficients
z	z value of the estimated coefficients
p	p value of the estimated coefficients
call	a matched call

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic_aipw and values of the predicted cumulative incidence functions predict.ciregic_aipw

Examples

```
## Continuing the ciregic_aipw(...) example
sfit <- summary(fit_aipw)
sfit
```

summary.ciregic_lt *Summary of* ciregic_lt

Description

summary method for class ciregic_lt

Usage

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

Arguments

object	an object of class ciregic_lt, which is a result of a call to ciregic_lt
...	further arguments

Details

The function summary.ciregic_lt returns the coefficients, bootstrap standard errors, and etc. Additionally, 'significance star' is included.

Value

The function summary.ciregic_lt returns a list of summary statistics of the model from object.

varnames	a vector containing variable names
coefficients	a vector of the regression coefficient estimates
se	a bootstrap standard error of the coefficients
z	z value of the estimated coefficients
p	p value of the estimated coefficients
call	a matched call

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic_lt and values of the predicted cumulative incidence functions predict.ciregic_lt

Examples

```
## Continuing the ciregic_lt(...) example
sfit_lt <- summary(fit_lt)
sfit_lt
```

Surv2 *Creating data frame*

Description

The function Surv2 generates the survival object to be treated as the response from ciregic.

Usage

```
Surv2(v, u, w = NULL, sub = NULL, event)
```

Arguments

v	the last observation time prior to the failure; $0 \leq v \leq u$
u	the first observation time after the failure; $u \geq 0$
w	a left truncation time or delayed entry time. The default setting is w = NULL for non left-truncated data.
sub	an indicator variable in the data set. It is an optional argument for interval-censored competing risks data and missing cause of failure, and the default is NULL. sub = 1 for the observations that are subject to missingness and sub = 0 elsewhere.
event	an indicator of cause of failure. If an observation is righ-censored, event = 0; otherwise, event = 1 or event = 2, where 1 represents the first cause of failure, and 2 represents the second cause of failure. The current version of package only allows for two causes of failure.

Details

The function Surv2 provides a response data frame which is used in the function ciregic and ciregic_lt. For interval-censored competing risks data, the function Surv2 must use three parameters (v, u, c). For left-truncated and interval censored competing risks data, the function Surv2 must use four parameters (v, u, w, c). If data are partially left-truncated, but all interval-censored, w = 0 for only interval-censored competing risks data.

Value

data frame

Author(s)

Jun Park, <jun.park@alumni.iu.edu>

Giorgos Bakoyannis, <gbakogia@iu.edu>

Examples

```
attach(simdata)
Surv2(v = v, u = u, event = c)
attach(simdata_lt)
Surv2(v = v, u = u, w = w, event = c)
```

---

vcov.ciregic *Variance-covariance matrix of* ciregic

Description

vcov method for class ciregic

Usage

```
## S3 method for class 'ciregic'
vcov(object, ...)
```

Arguments

object	an object of class ciregic, which is a result of a call to ciregic
...	further arguments

Details

The function vcov returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic, summary of the fitted semiparametric regression model summary.ciregic, and values of predicted cumulative incidence functions predict.ciregic

Examples

```
## Continuing the ciregic(...) example
vcov(fit)
```

`vcov.ciregic_aipw` *Variance-covariance matrix of* `ciregic_aipw`

Description

`vcov` method for class `ciregic_aipw`

Usage

```
## S3 method for class 'ciregic_aipw'
vcov(object, ...)
```

Arguments

`object`	an object of class `ciregic_aipw`, which is a result of a call to `ciregic_aipw`
`...`	further arguments

Details

The function `vcov` returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data `ciregic_aipw`, summary of the fitted semiparametric regression model `summary.ciregic_aipw`, and values of predicted cumulative incidence functions `predict.ciregic_aipw`

Examples

```
## Continuing the ciregic_aipw(...) example
vcov(fit_aipw)
```

`vcov.ciregic_lt` *Variance-covariance matrix of* `ciregic_lt`

Description

`vcov` method for class `ciregic_lt`

Usage

```
## S3 method for class 'ciregic_lt'
vcov(object, ...)
```

Arguments

`object`	an object of class `ciregic_lt`, which is a result of a call to `ciregic_lt`
`...`	further arguments

Details

The function `vcov` returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data `ciregic_lt`, summary of the fitted semiparametric regression model `summary.ciregic_lt`, and values of predicted cumulative incidence functions `predict.ciregic_lt`

Examples

```
## Continuing the ciregic_lt(...) example
vcov(fit_lt)
```

`vcov.summary.ciregic` *Variance-covariance matrix of* `summary.ciregic`

Description

`vcov` method for class `summary.ciregic`

Usage

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

Arguments

`object`	an object of class `summary.ciregic`, which is a result of a call to `ciregic`
`...`	further arguments

Details

The `vcov` returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data `ciregic`, summary of the fitted semiparametric regression model `summary.ciregic`, and values of the predicted cumulative incidence functions `predict.ciregic`

Examples

```
## Continuing the ciregic(...) example
vcov(summary(fit))
```

vcov.summary.ciregic_aipw *Variance-covariance matrix of* summary.ciregic_aipw

Description

vcov method for class summary.ciregic_aipw

Usage

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

Arguments

object	an object of class summary.ciregic_aipw, which is a result of a call to ciregic_aipw
...	further arguments

Details

The vcov returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic_aipw, summary of the fitted semiparametric regression model summary.ciregic_aipw, and values of the predicted cumulative incidence functions predict.ciregic_aipw

Examples

```
## Continuing the ciregic_aipw(...) example
vcov(summary(fit_aipw))
```

`vcov.summary.ciregic_lt` *Variance-covariance matrix of* `summary.ciregic_lt`

Description

vcov method for class `summary.ciregic_lt`

Usage

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

Arguments

`object`	an object of class `summary.ciregic_lt`, which is a result of a call to `ciregic_lt`
`...`	further arguments

Details

The vcov returns the variance-covariance matrix of the fitted semiparametric regression model.

Value

The estimated bootstrap variance-covariance matrix

See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data `ciregic_lt`, summary of the fitted semiparametric regression model `summary.ciregic_lt`, and values of the predicted cumulative incidence functions `predict.ciregic_lt`

Examples

```
## Continuing the ciregic_lt(...) example
vcov(summary(fit_lt))
```

waldtest *Wald test for* ciregic *and* ciregic_lt

Description

waldtest for class ciregic or ciregic_lt. This provides the result of Wald test for the fitted model from the function ciregic or ciregic_lt.

Usage

```
waldtest(obj1, obj2 = NULL, ...)
```

Arguments

obj1	an object of the fitted model in ciregic or ciregic_lt
obj2	an object of the fitted model in ciregic or ciregic_lt, the default is NULL
...	further arguments

Details

The function waldtest.ciregic returns a result of Wald test.

Value

The function waldtest returns an output table of Wald test of the model from object.

varnames.full	a variable name of a vector of variables names in the full model
varnames.nested	a variable name of a vector of variables names in the nested model
vcov	the estimated bootstrap variance-covariance matrix for overall Wald test
vcov.event1	the estimated bootstrap variance-covariance matrix for cause-specific Wald test (event type 1)
vcov.event2	the estimated bootstrap variance-covariance matrix for cause-specific Wald test (event type 2)
table	a table including test statistic, degrees of freedom, and p-value

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See Also

The fitted semiparametric regression on cumulative incidence function with interval-censored competing risks data ciregic and left-truncated and interval-censored competing risks data ciregic_lt

Examples

```
## Continuing the ciregic(...) example
library(intccr)
waldtest(obj1 = fit)
set.seed(12345)
newdata <- dataprep(data = longdata, ID = id, time = t,
                    event = c, Z = c(z1, z2))
fit.nested <- ciregic(formula = Surv2(v = v, u = u, event = c) ~ z2, data = newdata,
                      alpha = c(1, 1), nboot = 0, do.par = FALSE)
waldtest(obj1 = fit, obj2 = fit.nested)
```

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