Package ‘goftte’

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Omnibus tests to check the proportional regression models assumptions

Description

Let’s denote $Z_i = (Z_{i,k})_{1 \leq k \leq p}$ a matrix of $p$ individual regression covariates, and $\hat{\beta} = (\hat{\beta}_k)_{1 \leq k \leq p}$ the vector of estimated regression coefficients assuming a Cox (1972) proportional hazards (PH) regression model or a Fine & Gray (1999) proportional subdistribution hazards (PSH) regression model. The package implements objective diagnostic tools to assess the key modeling assumptions using cumulative sums of model residuals of the form:

$$U(\hat{\beta}, t, z) = \sum_{i=1}^{n} \int_{0}^{t} f(Z_i)1\{Z_i \leq z\} d\hat{M}_i(u).$$

Here $f(.)$ denotes a smooth function, $z$ the covariates values and $\hat{M}_i(t)$ the model residuals, so-called martingales residuals in Cox regression settings.

To test for PH or PSH assumptions, Lin & al. (1993) and Li & al. (2015) proposed test statistics obtained by letting $f(Z_i) = Z_i$ and $z \to \infty$. In that case, the test statistics reduce to the supremum value of the score process $U(\hat{\beta}, t)$ evaluated at $\beta = \hat{\beta}$ (Kolmogorov-Smirnov type test statistic).

With respect to covariate $k$, the statistic is written as follows:

$$KS = \sup_{t} || U_k(\hat{\beta}, t) ||$$

For checking the functional form of a covariate included in the model, same type of statistics were adopted by considering the process $U(\hat{\beta}, z)$ obtained by letting $f(Z_i) = 1$ and $t \to \infty$.

Null limiting distribution of cumulative sum process are obtained by drawing $R$ independent realizations of an asymptotically equivalent gaussian process (Monte-Carlo simulations). The significance level of KS test statistics were derived from the approximated null distribution.

Our package can be viewed as an extension of the gof package (Holst, 2014) allowing to check the functional form assumptions of covariates in the Cox model and to check Fine and Gray model assumptions. Besides this, it proposes goodness-of-fit tests for PH and PSH based on Cramer-Von Mises (CvM) and Anderson-Darling (AD) type test statistics as recommended by Kvaloy (2004):

$$CvM = \int_{0}^{\infty} U_k(\hat{\beta}, t)^2 dq(t)$$

$$AD = \int_{0}^{\infty} \frac{U_k(\hat{\beta}, t)^2}{q(t)(1-q(t))} dq(t)$$

Where $q(t) = \frac{I_k(\hat{\beta}, t)}{I_k(\hat{\beta}, \infty)}$, and $I(\hat{\beta}, t)$ denotes the consistent sample estimate of the score process covariance matrix.

Author(s)

Patrick Sfumato and Jean-Marie Boher
References


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**fcox.coxph**

Checking the functional form assumption for Cox model

**Description**

Diagnostics for the linear functional form of specific covariate(s) of the Cox model. The method is based on Lin’s approximation of the randomly pertubed sum process (1993). Another approximation method recommended by Liu (2008) is also proposed. P-values are derived for supremum KS test statistics.

**Usage**

```r
## S3 method for class 'coxph'
fcox(model, variable=NULL, type.test=c("Lin"), R=1000, plots=min(R,50),
    seed=NULL,...)
```

**Arguments**

- **model**: Model object (coxph).
- **variable**: Vector corresponding to the labels of each covariate. This is also an output argument.
- **type.test**: Type of approximation. Values are "Lin" or "Liu". Default is "Lin".
- **R**: Generation number used for Monte-Carlo simulations. This is also an output argument.
- **plots**: Realizations number of Monte-Carlo simulations to save for use in the plot-routine.
- **seed**: Random seed.
- **...**: additional arguments.
Details

A `fcov.cph` function accepting models of `cph` type (rms package) is also included in the package, and uses the same arguments as `coxph`. Contrary to `fcov.coxph`, the use of 'x=TRUE' option for covariates design is now required in `cph` model. Strata and cluster options are not supported.

Value

Returns an object of class 'scproc'. The main items of this object are:

- `obs`: 1 x p matrix of unique covariates values for functional form. l is the maximum number of unique observations between the p covariates.
- `W`: The process \( U(\hat{\beta}, z) \).
- `What`: The simulated limiting processes for the R-plots first Monte-Carlo realizations.
- `sdw`: Standard error over covariates values of `What`.
- `cvalues`: R x p matrix whose components are the supremum of the standardized `What` process for each Monte-Carlo realization. The quantiles of this output argument are used to calculate the prediction bands in the plot-routine.

Author(s)

Patrick Sfumato and Jean-Marie Boher.

References


Examples

```r
require(survival)

# Simulating survival data
simcox <- function(n=100, seed=1) {
  if (!is.null(seed))
    set.seed(seed)
  time<-rexp(n); cen<-2*rexp(n);
  status<-(time<cen);
  time[status==0]<-cen[status==0];
  X<-matrix(rnorm(2*n),n,2)
  return(data.frame(time=time, status=status, X))
}
n <- 100; d <- simcox(n);

# Fitting Cox model
fit.coxph <- coxph(Surv(time,status)- X1 + X2, data=d)
```
Checking the covariates functional form assumption

```
f cov(fit. coxph)
```

---

### Description

Diagnostics for the linear functional form of specific covariate(s) of the Fine & Gray model. Similarly to Li (2015), we extend the Lin’s approximation method to take into account competing events. We also provide an adaptation of Liu’s approximation method (2008) for Fine & Gray models. P-values are derived for supremum KS test statistics.

### Usage

```r
## S3 method for class 'crr'
fcov(model, fstatus, ftime, cov1, cencode=0, failcode=1, type.test=c("Lin"), R=1000, plots=min(R,50), seed=NULL, variable=NULL,...)
```

### Arguments

- `model`: Model object (`crr`).
- `fstatus`: Vector corresponding to the failures of the n patients.
- `ftime`: Vector corresponding to the failure times.
- `cov1`: Matrix whose columns consist in the components of the p covariates.
- `cencode`: Censoring code.
- `failcode`: Interest event code. All the failures differing from cencode and faildcode are considered as competing events.
- `type.test`: Type of approximation. Values are "Lin" or "Liu". Default is "Lin".
- `R`: Generation number used for Monte-Carlo simulations. This is also an output argument.
- `plots`: Realizations number of Monte-Carlo simulations to save for use in the plot-routine.
- `seed`: Random seed.
- `variable`: Vector corresponding to the labels of each covariate. This is also an output argument.
- `...`: additional arguments.
Value

Returns an object of class 'scproc'. The main items of this object are:

- **obs**: 1 x p matrix of unique covariates values. l is the maximum number of unique observation between the p covariates.
- **w**: The process \(U(\hat{\beta}, z)\) adapted to Fine & Gray model.
- **what**: The simulated limiting processes for the R-plots first Monte-Carlo realizations.
- **sdw**: Standard error over covariates values of What.
- **cvalues**: R x p matrix whose components are the supremum of the standardized What process for each Monte-Carlo realization. The quantiles of this output argument are used to calculate the prediction bands in the plot-routine.
- **KS**: Vector of the p rejection probabilities using KS type statistic.

Author(s)

Patrick Sfumato and Jean-Marie Boher.

References


Examples

```r
require(cmprsk)

#Simulating survival data with competing events
set.seed(10)
ftime <- rexp(200)
fstatus <- sample(0:2, 200, replace=TRUE)
cov <- matrix(runif(200), nrow=200)

# Fine & Gray regression
fit.crr <- crr(ftime, fstatus, cov)

#Checking the covariates functional form assumption
fcov(model=fit.crr, ftime=ftime, fstatus=fstatus, cov1=cov)
```
Description

Produce a graphical model diagnostic, with the possibility of adding the prediction bands calculated by `predband.scproc`.

Usage

```
## S3 method for class 'scproc'
plot(x, idx=1:length(x$variable), col=c("grey"), ci=FALSE,
     col.ci="darkblue", col.alpha=0.3, lty.ci=0, level=0.95,
     legend=c("type1","type2","none"), xlab=NULL, ylab=NULL,
     ylim=NULL, xlim=NULL, title=NULL, cex.lab=1,cex.main=1,...)
```

Arguments

- `x`: An object of class `scproc`.
- `idx`: The index number of covariates whose the plot is required.
- `col`: Boolean argument controlling for the plot of prediction bands. Values are TRUE or FALSE.
- `ci`: Color of the processes realizations.
- `col.ci`: Color of the prediction bands.
- `col.alpha`: Color intensity of the prediction bands.
- `lty.ci`: Line thickness of the prediction bands border.
- `level`: The required level for prediction bands.
- `legend`: Argument controlling the type of legend on the plot. "type1" for p-values, "type2" for usual type of legends and "none" for no legend.
- `xlab`: Label of the x-axis.
- `ylab`: Label of the y-axis.
- `xlim`: Vector of two components which indicates the extremum values of x-axis.
- `ylim`: Vector of two components which indicates the extremum values of y-axis.
- `title`: Vector of length `idx` whose components are titles of plots.
- `cex.lab`: Magnification of x and y labels relative to `cex`.
- `cex.main`: Magnification of titles relative to `cex`.
- `...`: additional arguments.

Details

This function is derived from `plot.cumres` of gof package.
Author(s)

Patrick Sfumato and Jean-Marie Boher.

References


Examples

```r
require(cmprsk)

# Simulating survival data with competing events
set.seed(10)
ftime <- rexp(200)
fstatus <- sample(0:2, 200, replace=TRUE)
cov <- matrix(runif(200), nrow=200)

# Fine & Gray regression
fit.crr <- crr(ftime, fstatus, cov)

# Checking the covariates functional form assumption
k <- fcov(model=fit.crr, ftime=ftime, fstatus=fstatus, cov1=cov)

# Plotting a graphical model diagnostic
plot(k)
```

Description

Calculates the prediction bands under the null hypothesis.

Usage

```r
## S3 method for class 'scproc'
predband(x, idx=1:length(x$variable), level=0.95, cval=0, ...)
```

Arguments

- **x**: An object of class `scproc`.
- **idx**: The index number of covariates whose the prediction band is calculated.
- **level**: The required level for prediction bands.
- **cval**: Parameter used to calculate the symmetric prediction bands defined by the standard error multiplied by `cval`.
- **...**: Additional arguments.
Details

This function is derived from confint.cumres of gof package.

Value

t
Ordered values of the variable used: unique times for proportionality and unique observations of covariates for functional form.

yu
Upper simultaneous confidence limit.

Author(s)

Patrick Sfumato and Jean-Marie Boher.

References


Examples

require(cmprsk)

#Simulating survival data with competing events
set.seed(10)
ftime <- rexp(200)
fstatus <- sample(0:2,200,replace=TRUE)
cov <- matrix(runif(200),nrow=200)

# Fine & Gray regression
fit.crr <- crr(ftime,fstatus,cov)

#Checking the covariates functional form assumption
k <- fcov(model=fit.crr, ftime=ftime,fstatus=fstatus,cov1=cov)

#Prediction bands
predband(k)

print.scproc

Printing method for 'scproc' objects

Description

Produces a printed summary of assumption diagnostics.

Usage

## S3 method for class 'scproc'
print(x, idx=NULL, ...)

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## S3 method for class 'scproc'
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print.scproc

Printing method for 'scproc' objects

Description

Produces a printed summary of assumption diagnostics.

Usage

## S3 method for class 'scproc'
print(x, idx=NULL, ...)
Arguments

x An object of class scproc.
idx The index number of covariates whose print is required.
... additional arguments.

Details

This function is derived from print.cumres of gof package.

Author(s)

Patrick Sfumato and Jean-Marie Boher.

References


Examples

require(cmprsk)

#Simulating survival data with competing events
set.seed(10)
ftime <- rexp(200)
fstatus <- sample(0:2,200,replace=TRUE)
cov <- matrix(runif(200),nrow=200)

# Fine & Gray regression
fit.crr <- crr(ftime,fstatus,cov)

#Checking the covariates functional form assumption
k<-fcov(model=fit.crr, ftime=ftime,fstatus=fstatus,cov1=cov)

#Summary of covariates functional form assumption diagnostics
print(k)

---

prop.coxph Checking proportional hazards assumption for Cox model

Description

Diagnostics for proportional hazards of specific covariate(s) of the Cox model. The limiting null distribution of the score process is approximated using either Lin’s method (1993) or Liu’s (2008). P-values are derived for KS, CvM and AD statistics.
prop.coxph

Usage

## S3 method for class 'coxph'
prop(model, variable=FALSE, type.test=c("Lin"), R=1000, plots=min(R,50), seed=NULL,...)

Arguments

- **model**: Model object (coxph).
- **variable**: Vector corresponding to the labels of each covariate. This is also an output argument.
- **type.test**: Type of approximation. Values are "Lin" or "Liu". Default is "Lin".
- **R**: Generation number used for Monte-Carlo simulations. This is also an output argument.
- **plots**: Realizations number of Monte-Carlo simulations to save for use in the plot-routine.
- **seed**: Random seed.
- **...**: Additional arguments.

Details

- The same type of function was proposed in gof package (cumres.coxph) at the difference that the authors only used Lin’s method to approximate the limiting null distribution of the score process.
- A prop.cph function accepting models of cph type (rms package) is also included in the package, and uses the same arguments as prop.coxph. Contrary to prop.coxph, the use of `x=TRUE` option for covariates design is now required in cph model. Strata and cluster options are not supported.

Value

Returns an object of class 'scproc'. The main items of this object are:

- **obs**: m x p matrix of unique times. m is the length of unique times.
- **W**: The process $U(\hat{\beta}, t)$.
- **What**: The simulated limiting processes for the R-plots first Monte-Carlo realizations.
- **sdw**: Standard error over time of What.
- **cvalues**: R x p matrix whose components are the supremum of the standardized What process for each Monte-Carlo realization. The quantiles of this output argument are used to calculate the prediction bands in the plot-routine.
- **KS**: Vector of the p rejection probabilities using KS type statistic.
- **CvM**: Vector of the p rejection probabilities using CvM type statistic.
- **AD**: Vector of the p rejection probabilities using AD type statistic.

Author(s)

Patrick Sfumato and Jean-Marie Boher.
References


Examples

```r
require(survival)
Csimulating survival data
simcox <- function(n=100, seed=1) {
  if (!is.null(seed))
    set.seed(seed)
  time<-rexp(n); cen<-2*rexp(n);
  status<-floor(time<cen);
  time[status==8]<-cen[status==0];
  X<-matrix(rnorm(2*n),n,2)
  return(data.frame(time=time, status=status, X))
}
n <- 100; d <- simcox(n);

#Fitting Cox's model
fit.coxph <- coxph(Surv(time,status)~ X1 + X2, data=d)

#Checking the proportional hazards assumption
prop(fit.coxph)
```

---

**prop.crr**

Checking proportional subdistribution hazard assumption for Fine & Gray model

Description

Diagnostics for the proportional subdistribution hazards of specific covariate(s) of the Fine & Gray model. Similarly to Li (2015), the limiting null distribution of the score process is approximated by extending Lin’s method (1993) to take into account competing events. An adaptation of Liu’s approximation method (2008) for Fine & Gray model is also provided. P-values are derived for KS, CvM and AD statistics.

Usage

```r
## S3 method for class 'crr'
prop(model, fstatus, ftime, cov1, cencode=0, failcode=1, variable=NULL, type.test=c("Liu"), R=1000, plots=min(R,50), seed=NULL,...)
```
Arguments

- **model**: Model object (**crr**).
- **fstatus**: Vector corresponding to the failures of the n patients.
- **ftime**: Vector corresponding to the failure times.
- **cov1**: Matrix whose columns consist in the components of the p covariates.
- **cencode**: Censoring code.
- **failcode**: Interest event code. All the failures differing from cencode and failcode are considered as competing events.
- **type.test**: Type of approximation. Values are "Lin" or "Liu". Default is "Liu".
- **r**: Generation number used for Monte-Carlo simulations. This is also an output argument.
- **plots**: Realizations number of Monte-Carlo simulations to save for use in the plot-routine.
- **seed**: Random seed.
- **variable**: Vector corresponding to the labels of each covariate. This is also an output argument.
- ... additional arguments.

Value

Returns an object of class 'scproc'. The main items of this object are:

- **obs**: m x p matrix of unique times. m is the length of unique times.
- **W**: The process $U(\hat{\beta}, t)$ adapted to Fine & Gray model.
- **What**: The simulated limiting processes for the R-plots first Monte-Carlo realizations.
- **sdw**: Standard error over time of What.
- **cvalues**: R x p matrix whose components are the supremum of the standardized What process for each Monte-Carlo realization. The quantiles of this output argument are used to calculate the prediction bands in the plot-routine.
- **KS**: Vector of the p rejection probabilities using KS type statistic.
- **CvM**: Vector of the p rejection probabilities using CvM type statistic.
- **AD**: Vector of the p rejection probabilities using AD type statistic.

Author(s)

Patrick Sfumato and Jean-Marie Boher.

References

Examples

```r
require(cmprsk)

# Simulating survival data with competing events
set.seed(10)
ftime <- rexp(200)
status <- sample(0:2, 200, replace=TRUE)
cov <- matrix(runif(200), nrow=200)

# Fine & Gray regression
fit.crr <- crr(ftime, status, cov)

# Checking the proportional subdistribution hazards assumption
prop(model=fit.crr, ftime=ftime, status=status, cov1=cov)
```
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