

Package ‘discSurv’

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Description Provides data transformations, estimation utilities, predictive evaluation measures and simulation functions for discrete time survival analysis.

Imports functional, mvtnorm, mgcv

Suggests Matrix, matrixcalc, numDeriv, caret, Ecdat, pec, survival, randomForest, nnet, VGAM

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discSurv-package	<i>Discrete Survival Analysis</i>
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Description

Includes functions for data transformations, estimation, evaluation and simulation of discrete survival analysis. Also discrete life table estimates are available. The most important functions are listed below:

- `contToDisc`: Discretizes continuous time variable into a specified grid of censored data for discrete survival analysis.
- `dataLong`: Transform data from short format into long format for discrete survival analysis and right censoring.

- `dataLongCompRisks`: Transforms short data format to long format for discrete survival modelling in the case of competing risks with right censoring.
- `dataLongTimeDep`: Transforms short data format to long format for discrete survival modelling of single event analysis with right censoring.
- `concorIndex`: Calculates the concordance index for discrete survival models (independent measure of time).
- `simCompRisk`: Simulates responses and covariates of discrete competing risk models.

Details

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Author(s)

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References

Gerds T. A. and M. Schumacher, (2006), *Consistent estimation of the expected Brier score in general survival models with right-censored event times*, Biometrical Journal 48(6), 1029-1040

Gerhard Tutz, (2012), *Regression for Categorical Data*, Cambridge University Press

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association

Jerald F. Lawless, (2000), *Statistical Models and Methods for Lifetime Data, 2nd edition*, Wiley series in probability and statistics

Ludwig Fahrmeir, (1997), *Discrete failure time models*, LMU Sonderforschungsbereich 386, Paper 91, <http://epub.ub.uni-muenchen.de/>

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

Roger B. Nelsen, (2006), *An introduction to Copulas*, Springer Science+Business Media, Inc.

Steele Fiona and Goldstein Harvey and Browne William, (2004), *A general multilevel multistate competing risks model for event history data* Statistical Modelling, volume 4, pages 145-159

Tilmann Gneiting and Adrian E. Raftery, (2007), *Strictly proper scoring rules, prediction, and estimation*, Journal of the American Statistical Association 102 (477), 359-376

Van der Laan M. J. and J. M. Robins, (2003), *Unified Methods for Censored Longitudinal Data and Causality*, Springer, New York

W. A. Thompson Jr., (1977), *On the Treatment of Grouped Observations in Life Studies*, *Biometrics*, Vol. 33, No. 3

Wiji Narendranathan and Mark B. Stewart, (1993), *Modelling the probability of leaving unemployment: competing risks models with flexible base-line hazards*, *Applied Statistics*, pages 63-83

William H. Kruskal, (1958), *Ordinal Measures of Association*, *Journal of the American Statistical Association*, Vol. 53, No. 284, pp. 814-861

adjDevResid

Adjusted Deviance Residuals

Description

Calculates the adjusted deviance residuals. This function only supports generalized, linear models. The adjusted deviance residuals should be approximately normal distributed, in the case of a well fitting model.

Usage

```
adjDevResid(dataSet, survModelFormula, censColumn, linkFunc = "logit", idColumn = NULL)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
survModelFormula	Gives the specified relationship of discrete response and covariates. The formula is designed, that the intercepts for the time dependent base line hazards are always included. Therefore only covariates should be given in this formula. This argument is required to be of class "formula".
censColumn	Gives the column name of the event indicator (1=observed, 0=censored). Must be of type "character".
linkFunc	Specifies the desired link function in use of generalized, linear models.
idColumn	Gives the column name of the identification number of each person. The argument must be of type "character". Default NULL means, that each row equals one person (no repeated measurements).

Value

- Output: List with objects:
 - AdjDevResid: Adjusted deviance residuals as numeric vector.
 - GlimFit: Fit object of class (generalized, linear model used in the calculations)
- Input: A list of given argument input values (saved for reference)

Author(s)

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References

Gerhard Tutz, (2012), *Regression for Categorical Data*, Cambridge University Press

See Also

[devResid](#), [brierScore](#), [glm](#), [predErrDiscShort](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]

# Calculate adjusted deviance residuals for the unemployment data subset
adjDevianceResiduals <- adjDevResid (dataSet=UnempDurSubset,
  survModelFormula=spell ~ age + logwage,
  censColumn="censor1", linkFunc="logit", idColumn=NULL)
adjDevianceResiduals

# Exclude outliers
adjDevResidWoOut <- adjDevianceResiduals$Output$AdjDevResid [
  adjDevianceResiduals$Output$AdjDevResid <
  quantile(adjDevianceResiduals$Output$AdjDevResid, prob=0.9) &
  adjDevianceResiduals$Output$AdjDevResid >
  quantile(adjDevianceResiduals$Output$AdjDevResid, prob=0.1)]

# Compare nonparametric density estimate of adjusted deviance residuals
# with adapted normal distribution
plot(density(adjDevResidWoOut), xlim=c(-10,10),
  main="Density comparison: Normal vs nonparametric estimate", lwd=2, las=1, col="red")
dnorm1 <- function(x) {dnorm(x, mean=mean(adjDevResidWoOut), sd=sd(adjDevResidWoOut))}
curve(dnorm1, n=500, add=TRUE, col="black", lwd=2)
legend("topright", legend=c("Normal", "Nonpar"), lty=1, lwd=2, col=c("black", "red"))
```

Description

Calculates the adjusted deviance residuals for arbitrary prediction models. The adjusted deviance residuals should be approximately normal distributed, in the case of a well fitting model.

Usage

```
adjDevResidShort(dataSet, hazards)
```

Arguments

dataSet	Data set in long format. Must be of class "data.frame".
hazards	Estimated hazard rates of the data in long format. Hazard rates are probabilities and therefore restricted to the interval [0, 1]

Value

- Output: List with objects:
 - AdjDevResid: Adjusted deviance residuals as numeric vector
- Input: A list of given argument input values (saved for reference)

Note

The argument *dataSet* must have a response with column name "y". The correct format of the dataset can be augmented by using [dataLong](#).

Author(s)

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References

Gerhard Tutz, (2012), *Regression for Categorical Data*, Cambridge University Press

See Also

[devResidShort](#), [predErrDiscShort](#)

Examples

```
library(survival)

# Transform data to long format
heart[, "stop"] <- ceiling(heart[, "stop"])
set.seed(0)
Indizes <- sample(unique(heart$id), 25)
randSample <- heart[unlist(sapply(1:length(Indizes),
function(x) which(heart$id==Indizes[x]))),)]
heartLong <- dataLongTimeDep(dataSet=randSample,
timeColumn="stop", censColumn="event", idColumn="id", timeAsFactor=FALSE)
```

```
# Fit a generalized, additive model and predict hazard rates on data in long format
library(mgcv)
gamFit <- gam(y ~ timeInt + surgery + transplant + s(age), data=heartLong, family="binomial")
hazPreds <- predict(gamFit, type="response")

# Calculate adjusted deviance residuals
devResiduals <- adjDevResidShort (dataSet=heartLong, hazards=hazPreds)$Output$AdjDevResid
devResiduals
```

aucUno *Area under the Curve Estimation*

Description

Estimates the time dependent area under the curve given calculated true positive rate and false positive rate. Both objects ("tprObj", "fprObj") and must have identical input arguments, e. g. same relationship of discrete response and covariates and supplied data sources. The values should be above 0.5 for a well predicting model, because random guessing would get this score.

Usage

```
aucUno(tprObj, fprObj)
```

Arguments

tprObj Object of class "discSurvTprUno". See function [tprUno](#)
fprObj Object of class "discSurvFprUno". See function [fprUno](#)

Details

The auc is estimated by numerical integration of the ROC curve.

Value

- Output: A list with objects:
 - Output: Named numeric vector with auc value
 - Input: A list of given argument input values (saved for reference)

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References

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association
Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

See Also

[tprUno](#), [fprUno](#)

Examples

```
#####
# Example with cross validation and unemployment data

library(Ecdat)
library(caret)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)
set.seed(7550)
CVfolds <- createFolds (y=UnempDurSubset$spell, returnTrain=TRUE, k=2)

# Estimate true positive rate of time interval 7:
# Correspondes to three and a half month duration (each interval is of length two weeks)
tryTPR <- tprUno (timepoint=7, dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, censModelFormula=censor1 ~ 1,
linkFunc="logit", idColumn=NULL, timeAsFactor=FALSE)
tryTPR
plot(tryTPR)

# Estimate false positive rate of time interval 7:
tryFPR <- fprUno (timepoint=7, dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, censModelFormula=censor1 ~ 1,
linkFunc="logit", idColumn=NULL, timeAsFactor=FALSE)
tryFPR
plot(tryFPR)

# Estimate auc
tryAUC <- aucUno (tprObj=tryTPR, fprObj=tryFPR)
tryAUC
plot(tryAUC)

#####
# Example National Wilm's Tumor Study

library(survival)
head(nwtco)
summary(nwtco$rel)

# Select subset
set.seed(-375)
Indices <- sample(1:dim(nwtco)[1], 500)
```



```

nwtcoSub <- nwtco [Indices, ]

# Convert time range to 30 intervals
intLim <- quantile(nwtcoSub$edrel, prob=seq(0, 1, length.out=30))
intLim [length(intLim)] <- intLim [length(intLim)] + 1
nwtcoSubTemp <- contToDisc(dataSet=nwtcoSub, timeColumn="edrel", intervalLimits=intLim)
nwtcoSubTemp$instit <- factor(nwtcoSubTemp$instit)
nwtcoSubTemp$histol <- factor(nwtcoSubTemp$histol)
nwtcoSubTemp$stage <- factor(nwtcoSubTemp$stage)

# Split in training and test sample
set.seed(-570)
TrainingSample <- sample(1:dim(nwtcoSubTemp)[1], round(dim(nwtcoSubTemp)[1]*0.75))
nwtcoSubTempTrain <- nwtcoSubTemp [TrainingSample, ]
nwtcoSubTempTest <- nwtcoSubTemp [-TrainingSample, ]

# Convert to long format
nwtcoSubTempTrainLong <- dataLong(dataSet=nwtcoSubTempTrain, timeColumn="timeDisc",
censColumn="rel")

# Estimate glm
inputFormula <- y ~ timeInt + histol + instit + stage
glmFit <- glm(formula=inputFormula, data=nwtcoSubTempTrainLong, family=binomial())
linPreds <- predict(glmFit, newdata=cbind(nwtcoSubTempTest,
timeInt=nwtcoSubTempTest$timeDisc))

# Estimate tpr given one training and one test sample at time interval 5
tprFit <- tprUnoShort (timepoint=5, marker=linPreds,
newTime=nwtcoSubTempTest$timeDisc, newEvent=nwtcoSubTempTest$rel,
trainTime=nwtcoSubTempTrain$timeDisc, trainEvent=nwtcoSubTempTrain$rel)

# Estimate fpr given one training and one test sample at time interval 5
fprFit <- fprUnoShort (timepoint=5, marker=linPreds,
newTime=nwtcoSubTempTest$timeDisc, newEvent=nwtcoSubTempTest$rel)

# Estimate auc
tryAUC <- aucUno (tprObj=tprFit, fprObj=fprFit)
tryAUC
plot(tryAUC)

```

brierScore

Brier Score Calculation

Description

Computes the brier score of each person based on a generalized, linear model with cross validation.

Usage

```

brierScore(dataSet, trainIndices, survModelFormula,
linkFunc = "logit", censColumn, idColumn = NULL)

```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
trainIndices	Must be a list of indices used for training data sets. E. g. if a 10-fold cross validation should be conducted, then the list should have length 10 and in each element a integer vector of training indices.
survModelFormula	Gives the specified relationship of discrete response and covariates. The formula is designed, that the intercepts for the time dependent base line hazards are always included. Therefore only covariates should be given in this formula. This argument is required to be of class "formula".
linkFunc	Specifies the desired link function in use of generalized, linear models.
censColumn	Gives the column name of the event indicator (1=observed, 0=censored). Must be of type "character".
idColumn	Gives the column name of the identification number of each person. The argument must be of type "character". Default NULL means, that each row equals one person (no repeated measurements).

Details

At normal circumstances a covariate free model for the censoring weights is sufficient.

Value

Numeric vector of brier scores for each person in the original data.

Note

It is assumed that all time points up to the last interval $[a_q, \text{Inf})$ are available in short format. If not already present, these can be added manually.

Author(s)

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See Also

[adjDevResid](#), [devResid](#), [glm](#), [predErrDiscShort](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
library(caret)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
```

```

set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)
set.seed(7550)
CVfolds <- createFolds (y=UnempDurSubset$spell, returnTrain=TRUE, k=2)

# Calculate brier score
tryBrierScore <- brierScore (dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, linkFunc="logit",
censColumn="censor1", idColumn=NULL)
tryBrierScore

```

concorIndex

Concordance Index

Description

Calculates the concordance index for discrete survival models (independent measure of time). This is the probability that, for a pair of randomly chosen comparable samples, the sample with the higher risk prediction will experience an event before the other sample or belongs to a higher binary class.

Usage

```
concorIndex(aucObj, printTimePoints=FALSE)
```

Arguments

aucObj	Object of class "discSurvAucUno". This object is created using the function aucUno
printTimePoints	Should messages be printed for each calculation of a discrete time interval? (logical scalar) Default is FALSE.

Details

The algorithm extracts all necessary information of the auc object (e. g. marginal probabilities and survival functions).

Value

List with objects

- Output: Concordance index (named numeric vector)
- Input: List with all input arguments (saved for reference)

Note

It is assumed that all time points up to the last interval [a_q, Inf) are available. If not already present, these can be added manually.

Author(s)

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References

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

See Also

[aucUno](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
library(caret)
data(UnempDur)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)
set.seed(7550)
CVfolds <- createFolds (y=UnempDurSubset$spell, returnTrain=TRUE, k=2)

# Estimate true positive rate of time interval 7:
# Correspondes to three and a half month duration (each interval is of length two weeks)
tryTPR <- tprUno (timepoint=7, dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, censModelFormula=censor1 ~ 1,
linkFunc="logit", idColumn=NULL, timeAsFactor=FALSE)
tryTPR
plot(tryTPR)

# Estimate false positive rate of time interval 7:
tryFPR <- fprUno (timepoint=7, dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, censModelFormula=censor1 ~ 1,
linkFunc="logit", idColumn=NULL, timeAsFactor=FALSE)
tryFPR
plot(tryFPR)
```

```

# Estimate false positive rate of time interval 7:
tryAUC <- aucUno (tprObj=tryTPR, fprObj=tryFPR)
tryAUC
plot(tryAUC)

## Not run: # Estimate global concordance index:
tryConcorIndex <- concorIndex (tryAUC)
tryConcorIndex
summary(tryConcorIndex)
## End(Not run)

```

contToDisc

Continuous to Discrete Transformation

Description

Discretizes continuous time variable into a specified grid of censored data for discrete survival analysis. It is a data preprocessing step, before the data can be extended in long format and further analysed with discrete survival models.

Usage

```
contToDisc(dataSet, timeColumn, intervalLimits, equi=FALSE)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
timeColumn	Name of the column with discrete survival times. Must be a scalar character value.
intervalLimits	Numeric vector of the right interval borders, e. g. if the intervals are [0, a ₁), [a ₁ , a ₂), [a ₂ , a _{max}), then intervalLimits = c(a ₁ , a ₂ , a _{max})
equi	Specifies if argument *intervalLimits* should be interpreted as number of equidistant intervals. Logical only TRUE or FALSE is allowed.

Value

Gives the data set expanded with a first column "timeDisc". This column includes the discrete time intervals (ordered factor).

Note

In discrete survival analysis the survival times have to be categorized in time intervals. Therefore this function is required, if there are observed continuous survival times.

Author(s)

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See Also

[dataLong](#), [dataLongTimeDep](#), [dataLongCompRisks](#)

Examples

```
# Example copenhagen stroke study data
library(pec)
data(cost)
head(cost)

# Convert observed times to months
# Right borders of intervals [0, a_1), [a_1, a_2), ... , [a_{\max-1}, a_{\max})
IntBorders <- 1:ceiling(max(cost$time)/30)*30

# Select subsample
subCost <- cost [1:100, ]
CostMonths <- contToDisc (dataSet=subCost, timeColumn="time", intervalLimits=IntBorders)
head(CostMonths)

# Select subsample giving number of equidistant intervals
CostMonths <- contToDisc (dataSet=subCost, timeColumn="time", intervalLimits=10, equi=TRUE)
head(CostMonths)
```

dataCensoring

Data Censoring Transformation

Description

Function for transformation of discrete survival times in censoring encoding. Prior this function the data has to be already transformed to long format. With this new generated variable, the discrete censoring process can be analysed instead of the discrete survival process. In discrete survival analysis this information is used to constructs weights for predictive evaluation measures. It is applicable in single event survival analysis.

Usage

```
dataCensoring(dataSetLong, respColumn, idColumn)
```

Arguments

dataSetLong	Original data in transformed long format .
respColumn	Name of column of discrete survival response as character.
idColumn	Name of column of identification number of persons as character.

Details

The standard procedure is to use functions such as [dataLong](#), [dataLongTimeDep](#), [dataLongCompRisks](#) to augment the data set from short format to long format before using [dataCensoring](#).

Value

Original data set as argument `*dataSetLong*`, but with added censoring process as first variable in column "yCens"

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Ludwig Fahrmeir, (1997), *Discrete failure time models*, LMU Sonderforschungsbereich 386, Paper 91, <http://epub.ub.uni-muenchen.de/>

W. A. Thompson Jr., (1977), *On the Treatment of Grouped Observations in Life Studies*, Biometrics, Vol. 33, No. 3

See Also

[contToDisc](#), [dataLong](#), [dataLongTimeDep](#), [dataLongCompRisks](#)

Examples

```
library(pec)
data(cost)
head(cost)
IntBorders <- 1:ceiling(max(cost$time)/30)*30
subCost <- cost [1:100, ]

# Convert from days to months
CostMonths <- contToDisc (dataSet=subCost, timeColumn="time", intervallLimits=IntBorders)
head(CostMonths)

# Convert to long format based on months
CostMonthsLong <- dataLong (dataSet=CostMonths, timeColumn="timeDisc", censColumn="status")
head(CostMonthsLong, 20)

# Generate censoring process variable
CostMonthsCensor <- dataCensoring (dataSetLong=CostMonthsLong, respColumn="y", idColumn="obj")
head(CostMonthsCensor)
tail(CostMonthsCensor [CostMonthsCensor$obj==1, ], 10)
tail(CostMonthsCensor [CostMonthsCensor$obj==3, ], 10)
```

dataLong

Data Long Transformation

Description

Transform data from short format into long format for discrete survival analysis and right censoring. Data is assumed to include no time varying covariates, e. g. no follow up visits are allowed. It is assumed that the covariates stay constant over time, in which no information is available.

Usage

```
dataLong(dataSet, timeColumn, censColumn, timeAsFactor=TRUE)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
timeColumn	Character giving the column name of the observed times. It is required that the observed times are discrete (integer).
censColumn	Character giving the column name of the event indicator. It is required that this is a binary variable with 1=="event" and 0=="censored".
timeAsFactor	Should the time intervals be coded as factor? Default is to use factor. If the argument is false, the column is coded as numeric.

Details

If the data has continuous survival times, the response may be transformed to discrete intervals using function `contToDisc`. If the data set has time varying covariates the function `dataLongTimeDep` should be used instead. In the case of competing risks and no time varying covariates see function `dataLongCompRisks`.

Value

Original data.frame with three additional columns:

- obj: Index of persons as integer vector
- timeInt: Index of time intervals (factor)
- y: Response in long format as binary vector. 1=="event happens in period timeInt" and 0 otherwise

Author(s)

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References

Ludwig Fahrmeir, (1997), *Discrete failure time models*, LMU Sonderforschungsbereich 386, Paper 91, <http://epub.ub.uni-muenchen.de/>

W. A. Thompson Jr., (1977), *On the Treatment of Grouped Observations in Life Studies*, Biometrics, Vol. 33, No. 3

See Also

[contToDisc](#), [dataLongTimeDep](#), [dataLongCompRisks](#)

Examples

```

# Example unemployment data
library(Ecdat)
data(UnempDur)

# Select subsample
subUnempDur <- UnempDur [1:100, ]
head(subUnempDur)

# Convert to long format
UnempLong <- dataLong (dataSet=subUnempDur, timeColumn="spell", censColumn="censor1")
head(UnempLong, 20)

# Is there exactly one observed event of y for each person?
splitUnempLong <- split(UnempLong, UnempLong$obj)
all(sapply(splitUnempLong, function (x) sum(x$y))==subUnempDur$censor1) # TRUE

# Second example: Acute Myelogenous Leukemia survival data
library(survival)
head(leukemia)
leukLong <- dataLong (dataSet=leukemia, timeColumn="time", censColumn="status")
head(leukLong, 30)

# Estimate discrete survival model
estGlm <- glm(formula=y ~ timeInt + x, data=leukLong, family=binomial())
summary(estGlm)

# Estimate survival curves for non-maintained chemotherapy
newDataNonMaintained <- data.frame(timeInt=factor(1:161), x=rep("Nonmaintained"))
predHazNonMain <- predict(estGlm, newdata=newDataNonMaintained, type="response")
predSurvNonMain <- cumprod(1-predHazNonMain)

# Estimate survival curves for maintained chemotherapy
newDataMaintained <- data.frame(timeInt=factor(1:161), x=rep("Maintained"))
predHazMain <- predict(estGlm, newdata=newDataMaintained, type="response")
predSurvMain <- cumprod(1-predHazMain)

# Compare survival curves
plot(x=1:50, y=predSurvMain [1:50], xlab="Time", ylab="S(t)", las=1,
type="l", main="Effect of maintained chemotherapy on survival of leukemia patients")
lines(x=1:161, y=predSurvNonMain, col="red")
legend("topright", legend=c("Maintained chemotherapy", "Non-maintained chemotherapy"),
col=c("black", "red"), lty=rep(1, 2))
# The maintained therapy has clearly a positive effect on survival over the time range

```

Description

Transforms short data format to long format for discrete survival modelling in the case of competing risks with right censoring. It is assumed that the covariates are not time varying.

Usage

```
dataLongCompRisks(dataSet, timeColumn, eventColumns, timeAsFactor=TRUE)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
timeColumn	Character giving the column name of the observed times. It is required that the observed times are discrete (integer).
eventColumns	Character vector giving the column names of the event indicators. It is required that all events are binary and the sum of all event indicators at a given time point, equals one.
timeAsFactor	Should the time intervals be coded as factor? Default is to use factor. If the argument is false, the column is coded as numeric.

Details

It is assumed, that only one event happens at a specific time point (competing risks). Either the observation is censored or one of the possible events takes place.

Value

Original data set in long format with additional columns

- obj: Gives identification number of objects (row index in short format) (integer)
- timeInt: Gives number of discrete time intervals (factor)
- responses: Columns with dimension count of events + 1 (censoring)
 - e0: No event (observation censored in specific interval)
 - e1: Indicator of first event, 1 if event takes place and 0 otherwise
 -
 - ek: Indicator of last k-th event, 1 if event takes place and 0 otherwise

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

- Steele Fiona and Goldstein Harvey and Browne William, (2004), *A general multilevel multistate competing risks model for event history data* Statistical Modelling, volume 4, pages 145-159
- Wiji Narendranathan and Mark B. Stewart, (1993), *Modelling the probability of leaving unemployment: competing risks models with flexible base-line hazards*, Applied Statistics, pages 63-83

See Also

[contToDisc, dataLongTimeDep](#)

Examples

```
# Example with unemployment data
library(Ecdat)
data(UnempDur)

# Select subsample
SubUnempDur <- UnempDur [1:100, ]

# Convert competing risk data to long format
SubUnempDurLong <- dataLongCompRisks (dataSet=SubUnempDur, timeColumn="spell",
eventColumns=c("censor1", "censor2", "censor3", "censor4"))
head(SubUnempDurLong, 20)

# Fit multinomial logit model with VGAM package
# with one coefficient per response
library(VGAM)
multLogitVGM <- vgam(cbind(e0, e1, e2, e3, e4) ~ timeInt + ui + age + logwage,
family=multinomial(refLevel=1),
data = SubUnempDurLong)
coef(multLogitVGM)

# Alternative: Use nnet
# Convert response to factor
rawResponseMat <- SubUnempDurLong[, c("e0", "e1", "e2", "e3", "e4")]
NewFactor <- factor(unnname(apply(rawResponseMat, 1, function(x) which(x == 1))),
labels = colnames(rawResponseMat))

# Include recoded response in data
SubUnempDurLong <- cbind(SubUnempDurLong, NewResp=NewFactor)

# Construct formula of mlogit model
mlogitFormula <- formula(NewResp ~ timeInt + ui + age + logwage)

# Fit multinomial logit model
# with one coefficient per response
library(nnet)
multLogitNNET <- multinom(formula=mlogitFormula, data=SubUnempDurLong)
coef(multLogitNNET)
```

dataLongTimeDep

Data Long Time Dependent Covariates

Description

Transforms short data format to long format for discrete survival modelling of single event analysis with right censoring. Covariates may vary over time.

Usage

```
dataLongTimeDep(dataSet, timeColumn, censColumn, idColumn, timeAsFactor=TRUE)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
timeColumn	Character giving the column name of the observed times. It is required that the observed times are discrete (integer).
censColumn	Character giving the column name of the event indicator. It is required that this is a binary variable with 1=="event" and 0=="censored".
idColumn	Name of column of identification number of persons as character.
timeAsFactor	Should the time intervals be coded as factor? Default is to use factor. If the argument is false, the column is coded as numeric.

Details

There may be some intervals, where no additional information on the covariates is observed (e. g. observed values in interval one and three but two is missing). In this case it is assumed, that the values from the last observation stay constant over time until a new measurement was done.

Value

Original data.frame with three additional columns:

- obj: Index of persons as integer vector
- timeInt: Index of time intervals (factor)
- y: Response in long format as binary vector. 1=="event happens in period timeInt" and 0 otherwise

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Ludwig Fahrmeir, (1997), *Discrete failure time models*, LMU Sonderforschungsbereich 386, Paper 91, <http://epub.ub.uni-muenchen.de/>

W. A. Thompson Jr., (1977), *On the Treatment of Grouped Observations in Life Studies*, Biometrics, Vol. 33, No. 3

See Also

[contToDisc](#), [dataLong](#), [dataLongCompRisks](#)

Examples

```
# Example Primary Biliary Cirrhosis data
library(survival)
dataSet1 <- pbcseq

# Only event death is of interest
dataSet1$status [dataSet1$status==1] <- 0
dataSet1$status [dataSet1$status==2] <- 1
table(dataSet1$status)

# Convert to months
dataSet1$day <- ceiling(dataSet1$day/30)+1
names(dataSet1) [7] <- "month"

# Convert to long format for time varying effects
pbcseqLong <- dataLongTimeDep (dataSet=dataSet1, timeColumn="month",
censColumn="status", idColumn="id")
pbcseqLong [pbcseqLong$obj==1, ]
```

devResid

Deviance Residuals

Description

Computes the root of the deviance residuals for evaluation of performance in discrete survival analysis. A generalized, linear model is used for prediction.

Usage

```
devResid(dataSet, survModelFormula, censColumn, linkFunc = "logit", idColumn = NULL)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
survModelFormula	Gives the specified relationship of discrete response and covariates. The formula is designed, that the intercepts for the time dependent base line hazards are always included. Therefore only covariates should be given in this formula. This argument is required to be of class "formula".
censColumn	Gives the column name of the event indicator (1=observed, 0=censored). Must be of type "character".
linkFunc	Specifies the desired link function in use of generalized, linear models.
idColumn	Gives the column name of the identification number of each person. The argument must be of type "character". Default NULL means, that each row equals one person (no repeated measurements).

Value

- Output: List with objects:
 - DevResid: Square root of deviance residuals as numeric vector.
 - GlmFit: Fit object of class (generalized, linear model used in the calculations)
- Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Gerhard Tutz, (2012), *Regression for Categorical Data*, Cambridge University Press

See Also

[adjDevResid](#), [brierScore](#), [glm](#), [predErrDiscShort](#)

Examples

```
library(Ecdat)
# Example with cross validation and unemployment data
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]

# Calculate deviance residuals for the unemployment data subset
devianceResiduals <- devResid (dataSet=UnempDurSubset, survModelFormula=spell ~ age + logwage,
censColumn="censor1", linkFunc="logit", idColumn=NULL)
devianceResiduals
```

devResidShort

Deviance Residuals

Description

Computes the root of the deviance residuals for evaluation of performance in discrete survival analysis.

Usage

```
devResidShort(dataSet, hazards)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame"
hazards	Estimated hazard rates of the data in long format. Hazard rates are probabilities and therefore restricted to the interval [0, 1]

Value

- Output: List with objects:
 - DevResid: Square root of deviance residuals as numeric vector.
- Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Gerhard Tutz, (2012), *Regression for Categorical Data*, Cambridge University Press

See Also

[adjDevResidShort](#), [predErrDiscShort](#)

Examples

```
library(survival)

# Transform data to long format
heart[, "stop"] <- ceiling(heart[, "stop"])
set.seed(0)
Indizes <- sample(unique(heart$id), 25)
randSample <- heart[unlist(sapply(1:length(Indizes),
function(x) which(heart$id==Indizes[x]))),)]
heartLong <- dataLongTimeDep(dataSet=randSample,
timeColumn="stop", censColumn="event", idColumn="id", timeAsFactor=FALSE)

# Fit a generalized, additive model and predict hazard rates on data in long format
library(mgcv)
gamFit <- gam(y ~ timeInt + surgery + transplant + s(age), data=heartLong, family="binomial")
hazPreds <- predict(gamFit, type="response")

# Calculate the deviance residuals
devResiduals <- devResidShort (dataSet=heartLong, hazards=hazPreds)$Output$DevResid

# Compare with estimated normal distribution
plot(density(devResiduals),
main="Empirical density vs estimated normal distribution",
las=1, ylim=c(0, 0.5))
tempFunc <- function (x) dnorm(x, mean=mean(devResiduals), sd=sd(devResiduals))
curve(tempFunc, xlim=c(-10, 10), add=TRUE, col="red")
```

```
# The empirical density seems like a mixture distribution,  
# but is not too far off in with values greater than 3 and less than 1
```

estMargProb	<i>Estimated Marginal Probabilities</i>
-------------	---

Description

Estimates the marginal probability $P(T=tx)$ based on estimated hazard rates. The hazard rates may or may not depend on covariates. The covariates have to be equal across all estimated hazard rates. Therefore the given hazard rates should only vary over time.

Usage

```
estMargProb(haz)
```

Arguments

haz Numeric vector of estimated hazard rates.

Details

The argument **haz** must be given for the all intervals $[a_0, a_1)$, $[a_1, a_2)$, ..., $[a_{q-1}, a_q)$, $[a_q, \text{Inf})$.

Value

Named vector of estimated marginal probabilities.

Note

It is assumed that all time points up to the last interval $[a_q, \text{Inf})$ are available. If not already present, these can be added manually.

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[estSurv](#)

Examples

```

# Example unemployment data
library(Ecdat)
data(UnempDur)

# Select subsample
subUnempDur <- UnempDur [1:100, ]

# Convert to long format
UnempLong <- dataLong (dataSet=subUnempDur, timeColumn="spell", censColumn="censor1")
head(UnempLong)

# Estimate binomial model with logit link
Fit <- glm(formula=y ~ timeInt + age + logwage, data=UnempLong, family=binomial())

# Estimate discrete survival function given age, logwage of first person
hazard <- predict(Fit, newdata=subset(UnempLong, obj==1), type="response")

# Estimate marginal probabilities given age, logwage of first person
MarginalProbCondX <- estMargProb (hazard)
MarginalProbCondX
sum(MarginalProbCondX)==1 # TRUE: Marginal probabilities must sum to 1!

```

 estSurv

Estimated Survival Function

Description

Estimates the survival function $S(T=tx)$ based on estimated hazard rates. The hazard rates may or may not depend on covariates. The covariates have to be equal across all estimated hazard rates. Therefore the given hazard rates should only vary over time.

Usage

```
estSurv(haz)
```

Arguments

haz Numeric vector of estimated hazard rates.

Details

The argument **haz** must be given for the all intervals $[a_0, a_1)$, $[a_1, a_2)$, ..., $[a_{q-1}, a_q)$, $[a_q, \text{Inf})$.

Value

Named vector of estimated probabilities of survival.

Note

It is assumed that all time points up to the last interval [a_q, Inf) are available. If not already present, these can be added manually.

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[estMargProb](#)

Examples

```
# Example unemployment data
library(Ecdat)
data(UnempDur)

# Select subsample
subUnempDur <- UnempDur [1:100, ]

# Convert to long format
UnempLong <- dataLong (dataSet=subUnempDur, timeColumn="spell", censColumn="censor1")
head(UnempLong)

# Estimate binomial model with logit link
Fit <- glm(formula=y ~ timeInt + age + logwage, data=UnempLong, family=binomial())

# Estimate discrete survival function given age, logwage of first person
hazard <- predict(Fit, newdata=subset(UnempLong, obj==1), type="response")
SurvivalFuncCondX <- estSurv(hazard)
SurvivalFuncCondX
```

fprUno

False Positive Rate Uno

Description

Estimates the predictive false positive rate (fpr) based on cross validation and generalized, linear models (see [glm](#)). The concept was suggested by Uno et al. (see references)

Usage

```
fprUno(timepoint, dataSet, trainIndices, survModelFormula,
censModelFormula, linkFunc = "logit", idColumn = NULL, timeAsFactor=TRUE)
```

Arguments

timepoint	Discrete time interval given that the false positive rate is evaluated (integer scalar)
dataSet	Original data in short format. Should be of class "data.frame".
trainIndices	List of Indices from original data used for training (list of integer vectors). The length of the list is equal to the number of cross validation samples.
survModelFormula	Formula of the discrete survival model. It is used in a generalized, linear model.
censModelFormula	Formula of the censoring model. It is used in a generalized, linear model. Usually this is done without covariates.
linkFunc	Link function of the generalized, linear model.
idColumn	Name of the column with identification numbers of persons. Default NULL means, that each row equals one person (no repeated measurements).
timeAsFactor	Should the time intervals be coded as factor? Default is to use factor. If the argument is false, the column is coded as numeric.

Value

- Output: List with objects:
 - Output: Data frame with two columns: "cutoff" gives the different marker values and "fpr" the false positive rates
 - Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

References

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

See Also

[tprUno](#), [tprUnoShort](#), [aucUno](#), [concorIndex](#), [createFolds](#), [glm](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
library(caret)
data(UnempDur)
```

```
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)
set.seed(7550)
CVfolds <- createFolds (y=UnempDurSubset$spell, returnTrain=TRUE, k=2)

# Estimate false positive rate of time interval 7:
tryFPR <- fprUno (timepoint=7, dataSet=UnempDurSubset, trainIndices=CVfolds,
survModelFormula=spell ~ age + logwage, censModelFormula=censor1 ~ 1,
linkFunc="logit", idColumn=NULL, timeAsFactor=FALSE)
tryFPR
plot(tryFPR)
```

fprUnoShort

False Positive Rate for arbitrary prediction models

Description

Estimates the false positive rate (based on concept of Uno, et al.) for an arbitrary discrete survival prediction model on one test data set.

Usage

```
fprUnoShort(timepoint, marker, newTime, newEvent)
```

Arguments

timepoint	Gives the discrete time interval of which the fpr is evaluated (numeric scalar).
marker	Gives the predicted values of the linear predictor of a regression model (numeric vector). May also be on the response scale.
newTime	New time intervals in the test data (integer vector).
newEvent	New event indicators in the test data (integer binary vector).

Details

This function is useful, if other models than generalized, linear models (glm) should be used for prediction. In the case of glm better use the cross validation version [fprUno](#).

Value

- Output: A list with objects:
 - Output: Data frame with two columns: "cutoff" gives the different marker values and "fpr" the false positive rates
 - Input: A list of given argument input values (saved for reference)

Note

It is assumed that all time points up to the last interval [a_q, Inf) are available in short format. If not already present, these can be added manually.

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

References

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

See Also

[tprUno](#), [tprUnoShort](#), [aucUno](#), [concorIndex](#), [createFolds](#), [glm](#)

Examples

```
#####
# Example with unemployment data and prior fitting

library(Ecdat)
library(caret)
library(mgcv)
data(UnempDur)
summary(UnempDur$spell)
# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
set.seed(-570)
TrainingSample <- sample(1:100, 75)
UnempDurSubsetTrain <- UnempDurSubset [TrainingSample, ]
UnempDurSubsetTest <- UnempDurSubset [-TrainingSample, ]

# Convert to long format
UnempDurSubsetTrainLong <- dataLong(dataSet=UnempDurSubsetTrain,
timeColumn="spell", censColumn="censor1")

# Estimate gam with smooth baseline
gamFit <- gam(formula=y ~ s(I(as.numeric(as.character(timeInt)))) +
s(age) + s(logwage), data=UnempDurSubsetTrainLong, family=binomial())
gamFitPreds <- predict(gamFit, newdata=cbind(UnempDurSubsetTest, timeInt=UnempDurSubsetTest$spell))

# Estimate false positive rate
fprGamFit <- fprUnoShort (timepoint=1, marker=gamFitPreds,
newTime=UnempDurSubsetTest$spell, newEvent=UnempDurSubsetTest$censor1)
```

```

plot(fprGamFit)

#####
# Example National Wilm's Tumor Study

library(survival)
head(nwtco)
summary(nwtco$rel)

# Select subset
set.seed(-375)
Indices <- sample(1:dim(nwtco)[1], 500)
nwtcoSub <- nwtco [Indices, ]

# Convert time range to 30 intervals
intLim <- quantile(nwtcoSub$edrel, prob=seq(0, 1, length.out=30))
intLim [length(intLim)] <- intLim [length(intLim)] + 1
nwtcoSubTemp <- contToDisc(dataSet=nwtcoSub, timeColumn="edrel", intervalLimits=intLim)
nwtcoSubTemp$instit <- factor(nwtcoSubTemp$instit)
nwtcoSubTemp$histol <- factor(nwtcoSubTemp$histol)
nwtcoSubTemp$stage <- factor(nwtcoSubTemp$stage)

# Split in training and test sample
set.seed(-570)
TrainingSample <- sample(1:dim(nwtcoSubTemp)[1], round(dim(nwtcoSubTemp)[1]*0.75))
nwtcoSubTempTrain <- nwtcoSubTemp [TrainingSample, ]
nwtcoSubTempTest <- nwtcoSubTemp [-TrainingSample, ]

# Convert to long format
nwtcoSubTempTrainLong <- dataLong(dataSet=nwtcoSubTempTrain,
timeColumn="timeDisc", censColumn="rel")

# Estimate glm
inputFormula <- y ~ timeInt + histol + instit + stage
glmFit <- glm(formula=inputFormula, data=nwtcoSubTempTrainLong, family=binomial())
linPreds <- predict(glmFit, newdata=cbind(nwtcoSubTempTest,
timeInt=nwtcoSubTempTest$timeDisc))

# Estimate tpr given one training and one test sample at time interval 10
fprFit <- fprUnoShort (timepoint=10, marker=linPreds,
newTime=nwtcoSubTempTest$timeDisc, newEvent=nwtcoSubTempTest$rel)
plot(fprFit)

```

gumbel

Gumbel Link Function

Description

Constructs the link function with gumbel distribution in appropriate format for use in generalized, linear models

Usage

```
gumbel()
```

Details

Insert this function into a binary regression model

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

See Also

[glm](#)

Examples

```
# Example with copenhagen stroke study
library(pec)
data(cost)
head(cost)

# Take subsample and convert time to months
costSub <- cost [1:50, ]
costSub$time <- ceiling(costSub$time/30)
costLong <- dataLong(dataSet=costSub, timeColumn="time", censColumn="status")
gumbelModel <- glm(formula=y ~ timeInt + diabetes, data=costLong, family=binomial(link=gumbel()))

# Estimate hazard given prevStroke nad no prevStroke
hazPrevStroke <- predict(gumbelModel, newdata=data.frame(timeInt=factor(1:143),
diabetes=factor(rep("yes", 143), levels=c("no", "yes"))), type="response")
hazWoPrevStroke <- predict(gumbelModel, newdata=data.frame(timeInt=factor(1:143),
diabetes=factor(rep("no", 143), levels=c("no", "yes"))), type="response")

# Estimate survival function
SurvPrevStroke <- cumprod(1-hazPrevStroke)
SurvWoPrevStroke <- cumprod(1-hazWoPrevStroke)

# Example graphics of survival curves with and without diabetes
plot(x=1:143, y=SurvWoPrevStroke, type="l", xlab="Months",
ylab="S (t|x)", las=1, lwd=2, ylim=c(0,1))
lines(x=1:143, y=SurvPrevStroke, col="red", lwd=2)
legend("topright", legend=c("Without diabetes", "Diabetes"),
lty=1, lwd=2, col=c("black", "red"))
```

intPredErrDisc *Integrated Prediction Error Curve*

Description

Estimates the integrated prediction error curve based on previous estimation of the prediction error curve. This measure is time invariant and is based on the weighted quadratic differences of estimated and observed survival functions.

Usage

```
intPredErrDisc(predErrObj, tmax=NULL)
```

Arguments

predErrObj	Object of class "discSurvPredErrDisc" generated by function predErrDiscShort
tmax	Gives the maximum time interval for which prediction errors are calculated. It must be smaller than the maximum observed time in the training data of the object produced by function predErrDiscShort ! Default=NULL means, that all observed intervals are generated.

Value

Named vector with integrated prediction error per time interval.

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Tilmann Gneiting and Adrian E. Raftery, (2007), *Strictly proper scoring rules, prediction, and estimation*, Journal of the American Statistical Association 102 (477), 359-376

See Also

[predErrDiscShort](#)

Examples

```
#####
# Example with cross validation and unemployment data

library(Ecdat)
library(mgcv)
data(UnempDur)
summary(UnempDur$spell)
```



```

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)

# Generate training and test data
set.seed(7550)
TrainIndices <- sample (x=1:dim(UnempDurSubset) [1], size=75)
TrainUnempDur <- UnempDurSubset [TrainIndices, ]
TestUnempDur <- UnempDurSubset [-TrainIndices, ]

# Convert to long format
LongTrain <- dataLong(dataSet=TrainUnempDur, timeColumn="spell", censColumn="censor1")
LongTest <- dataLong(dataSet=TestUnempDur, timeColumn="spell", censColumn="censor1")
# Convert factor to numeric for smoothing
LongTrain$timeInt <- as.numeric(as.character(LongTrain$timeInt))
LongTest$timeInt <- as.numeric(as.character(LongTest$timeInt))

# Estimate, for example, a generalized, additive model in discrete survival analysis
gamFit <- gam (formula=y ~ s(timeInt) + age + logwage, data=LongTrain, family=binomial())

# Estimate survival function of each person in the test data
oneMinusPredHaz <- 1 - predict(gamFit, newdata=LongTest, type="response")
predSurv <- aggregate(formula=oneMinusPredHaz ~ obj, data=LongTest, FUN=cumprod)

# Prediction error in first and second interval
tryPredErrDisc1 <- predErrDiscShort (timepoints=1,
estSurvList=predSurv [[2]], newTime=TestUnempDur$spell,
newEvent=TestUnempDur$censor1, trainTime=TrainUnempDur$spell,
trainEvent=TrainUnempDur$censor1)

# Estimate integrated prediction error
tryIntPredErrDisc <- intPredErrDisc (tryPredErrDisc1)
tryIntPredErrDisc

# Example up to interval 3 (higher intervals are truncated)
tryIntPredErrDisc2 <- intPredErrDisc (tryPredErrDisc1, tmax=3)
tryIntPredErrDisc2

#####
# Example with cancer data

library(survival)
head(cancer)

# Data preparation and conversion to 30 intervals
cancerPrep <- cancer
cancerPrep$status <- cancerPrep$status-1
intLim <- quantile(cancerPrep$time, prob=seq(0, 1, length.out=30))
intLim [length(intLim)] <- intLim [length(intLim)] + 1

```

```

# Cut discrete time in smaller number of intervals
cancerPrep <- contToDisc(dataSet=cancerPrep, timeColumn="time", intervalLimits=intLim)

# Generate training and test data
set.seed(753)
TrainIndices <- sample (x=1:dim(cancerPrep) [1], size=dim(cancerPrep) [1]*0.75)
TrainCancer <- cancerPrep [TrainIndices, ]
TestCancer <- cancerPrep [-TrainIndices, ]
TrainCancer$timeDisc <- as.numeric(as.character(TrainCancer$timeDisc))
TestCancer$timeDisc <- as.numeric(as.character(TestCancer$timeDisc))

# Convert to long format
LongTrain <- dataLong(dataSet=TrainCancer, timeColumn="timeDisc", censColumn="status")
LongTest <- dataLong(dataSet=TestCancer, timeColumn="timeDisc", censColumn="status")
# Convert factors
LongTrain$timeInt <- as.numeric(as.character(LongTrain$timeInt))
LongTest$timeInt <- as.numeric(as.character(LongTest$timeInt))
LongTrain$sex <- factor(LongTrain$sex)
LongTest$sex <- factor(LongTest$sex)

# Estimate, for example, a generalized, additive model in discrete survival analysis
gamFit <- gam (formula=y ~ s(timeInt) + s(age) + sex + ph.ecog, data=LongTrain, family=binomial())
summary(gamFit)

# Estimate survival function of each person in the test data
oneMinusPredHaz <- 1 - predict(gamFit, newdata=LongTest, type="response")
predSurv <- aggregate(formula=oneMinusPredHaz ~ obj, data=LongTest, FUN=cumprod)

# One survival curve is missing: Replace the missing values,
# with average value of other survival curves
predSurvTemp <- predSurv [[2]]
for(i in 1:length(predSurv [[2]])) {
  lenTemp <- length(predSurv [[2]] [[i]])
  if(lenTemp < 32) {
    predSurvTemp [[i]] <- c(predSurv [[2]] [[i]], rep(NA, 30-lenTemp))
  }
}
# Calculate average survival curve
avgSurv <- rowMeans(do.call(cbind, predSurvTemp), na.rm=TRUE) [1:4]
# Insert into predicted survival curves
predSurvTemp <- predSurv [[2]]
for(i in 3:(length(predSurvTemp)+1)) {
  if(i==3) {
    predSurvTemp [[i]] <- avgSurv
  }
  else {
    predSurvTemp [[i]] <- predSurv [[2]] [[i-1]]
  }
}
# Check if the length of all survival curves is equal to the observed
# time intervals in test data
all(sapply(1:length(predSurvTemp), function (x) length(predSurvTemp [[x]]))==
as.numeric(as.character(TestCancer$timeDisc))) # TRUE

```

```
# Prediction error second interval
tryPredErrDisc1 <- predErrDiscShort (timepoints=2,
estSurvList=predSurvTemp, newTime=TestCancer$timeDisc,
newEvent=TestCancer$status, trainTime=TrainCancer$timeDisc,
trainEvent=TrainCancer$status)

# Calculate integrated prediction error
tryIntPredErrDisc <- intPredErrDisc (tryPredErrDisc1)
tryIntPredErrDisc
```

lifeTable

Life Table Construction and Estimates

Description

Constructs a life table and estimates discrete hazard rates, survival functions, cumulative hazard rates and their standard errors without covariates.

Usage

```
lifeTable(dataSet, timeColumn, censColumn, intervalBorders = NULL)
```

Arguments

dataSet	Original data in short format. Must be of class "data.frame".
timeColumn	Name of the column with discrete survival times. Must be a scalar character vector.
censColumn	Gives the column name of the event indicator (1=observed, 0=censored). Must be of type "character".
intervalBorders	Optional names of the intervals for each row, e. g. [a ₀ , a ₁), [a ₁ , a ₂), ..., [a _{q-1} , a _q)

Value

List containing an object of class "data.frame" with following columns

- n: Number of individuals at risk in a given time interval (integer)
- events: Observed number of events in a given time interval (integer)
- dropouts: Observed number of dropouts in a given time interval (integer)
- atRisk: Estimated number of individuals at risk, corrected by dropouts (numeric)
- hazard: Estimated risk of death (without covariates) in a given time interval
- seHazard: Estimated standard deviation of estimated hazard
- S: Estimated survival curve
- seS: Estimated standard deviation of estimated survival function
- cumHazard: Estimated cumulative hazard function
- seCumHazard: Estimated standard deviation of the estimated cumulative hazard function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

References

Jerald F. Lawless, (2000), *Statistical Models and Methods for Lifetime Data*, 2nd edition, Wiley series in probability and statistics

Examples

```
# Example with unemployment data
library(Ecdat)
data(UnempDur)

# Extract subset of all persons smaller or equal the median of age
UnempDurSubset <- subset(UnempDur, age<=median(UnempDur$age))
LifeTabUnempDur <- lifeTable (dataSet=UnempDurSubset, timeColumn="spell", censColumn="censor1")
LifeTabUnempDur

# Example with monoclonal gammopathy data
library(survival)
head(mgus)
# Extract subset of mgus
subMgus <- mgus [mgus$futime<=median(mgus$futime), ]
# Transform time in days to intervals [0, 1), [1, 2), [2, 3), ... , [12460, 12461)
mgusInt <- subMgus
mgusInt$futime <- mgusInt$futime + 1
LifeTabGamma <- lifeTable (dataSet=mgusInt, timeColumn="futime", censColumn="death")
head(LifeTabGamma$Output, 25)
plot(x=1:dim(LifeTabGamma$Output)[1], y=LifeTabGamma$Output$hazard, type="l",
     xlab="Time interval", ylab="Hazard", las=1,
     main="Life table estimated marginal hazard rates")
```

martingaleResid

Martingale Residuals

Description

Estimates the martingale residuals of a generalized, linear model.

Usage

```
martingaleResid(dataSet, survModelFormula, censColumn,
               linkFunc = "logit", idColumn = NULL)
```

Arguments

dataSet	Original data in short format. Should be of class "data.frame".
survModelFormula	Formula of the discrete survival model. It is used in a generalized, linear model.
censColumn	Formula of the censoring model. It is used in a generalized, linear model. Usually this is done without covariates.
linkFunc	Link function of the generalized, linear model.
idColumn	Name of the column with identification numbers of persons. Default NULL means, that each row equals one person (no repeated measurements).

Value

- Output: List with objects:
 - MartingaleResid: Square root of deviance residuals as numeric vector.
 - GlmFit: Fit object of class (generalized, linear model used in the calculations)
- Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Terry M. Therneau and Patricia M. Grambsch and Thomas R. Fleming, (1990), *Martingale-Based Residuals for Survival Models*, Biometrika, Vol. 77, No. 1, 147-160

See Also

[tprUno](#), [tprUnoShort](#), [aucUno](#), [concorIndex](#), [glm](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]

# Calculate martingale residuals for the unemployment data subset
MartResid <- martingaleResid (dataSet=UnempDurSubset,
survModelFormula=spell ~ age + logwage, censColumn="censor1",
linkFunc="logit", idColumn=NULL)
MartResid
sum(MartResid$Output$MartingaleResid)
```

```
# Plot martingale residuals vs each covariate in the event interval
# Dotted line is a loess estimate
plot(MartResid)
```

```
plot.discSurvAdjDevResid
```

Plot method of class "discSurvAdjDevResid"

Description

Is called implicitly by using standard plot function on an object of class "discSurvAdjDevResid". It plots a qqplot against the normal distribution. If the model fits the data well, it should be approximately normal distributed.

Usage

```
## S3 method for class 'discSurvAdjDevResid'
plot(x, ...)
```

Arguments

x	Object of class "discSurvAdjDevResid"
...	Additional arguments to plot function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[adjDevResid](#)

```
plot.discSurvAucUno
```

Plot method of class "discSurvAucUno"

Description

Plots and ROC curve for discrete survival models. On the x-axis the false positive rate and on the y-axis the true positive rate is shown.

Usage

```
## S3 method for class 'discSurvAucUno'
plot(x, ...)
```

Arguments

x Object of class "discSurvAucUno"
... Additional arguments to the plot function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[aucUno](#)

`plot.discSurvFprUno` *Plot method of class "discSurvFprUno"*

Description

Plots the cutoff values (x-axis) against the false positive rate (y-axis).

Usage

```
## S3 method for class 'discSurvFprUno'  
plot(x, ...)
```

Arguments

x Object of class "discSurvFprUno"
... Additional arguments to the plot function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[fprUno](#)

```
plot.discSurvMartingaleResid
```

Plot method of class "discSurvMartingaleResid"

Description

Gives a different plot of each marginal covariate against the martingale residuals. Additionally a nonparametric [loess](#) estimation is done.

Usage

```
## S3 method for class 'discSurvMartingaleResid'  
plot(x, ...)
```

Arguments

x	Object of class "discSurvMartingaleResid"
...	Additional arguments to the plot function

Author(s)

Thomas Welchowski

See Also

[martingaleResid](#)

```
plot.discSurvTprUno
```

Plot method of class "discSurvTprUno"

Description

Plots the cutoff values (x-axis) against the true positive rate (y-axis).

Usage

```
## S3 method for class 'discSurvTprUno'  
plot(x, ...)
```

Arguments

x	Object of class "discSurvTprUno"
...	Additional arguments to the plot function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[tprUno](#)

predErrDiscShort *Prediction Error Curves for arbitrary prediction models*

Description

Estimates prediction error curves of arbitrary prediction models. In prediction error curves the estimated and observed survival functions are compared adjusted by weights at given timepoints.

Usage

```
predErrDiscShort(timepoints, estSurvList, newTime, newEvent, trainTime, trainEvent)
```

Arguments

timepoints	Vector of the number of discrete time intervals. Must be of type integer.
estSurvList	List of persons in the test data. Each element contains a numeric vector of estimated survival functions of all given time points.
newTime	Numeric vector of discrete survival times in the test data.
newEvent	Integer vector of univariate event indicator in the test data.
trainTime	Numeric vector of discrete survival times in the training data.
trainEvent	Integer vector of univariate event indicator in the training data.

Details

The prediction error curves should be smaller than 0.25 for all time points, because this is equivalent to a random assignment error.

Value

- List: List with objects:
 - Output: List with two components
 - * predErr: Numeric vector with estimated prediction error values. Names give the evaluation time point.
 - * weights: List of weights used in the estimation. Each list component gives the weights of a person in the test data.
 - Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Van der Laan M. J. and J. M. Robins, (2003), *Unified Methods for Censored Longitudinal Data and Causality*, Springer, New York

Gerds T. A. and M. Schumacher, (2006), *Consistent estimation of the expected Brier score in general survival models with right-censored event times*, Biometrical Journal 48(6), 1029-1040

See Also

[aucUno](#), [gam](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
library(mgcv)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)

# Generate training and test data
set.seed(7550)
TrainIndices <- sample (x=1:dim(UnempDurSubset) [1], size=75)
TrainUnempDur <- UnempDurSubset [TrainIndices, ]
TestUnempDur <- UnempDurSubset [-TrainIndices, ]

# Convert to long format
LongTrain <- dataLong(dataSet=TrainUnempDur, timeColumn="spell", censColumn="censor1")
LongTest <- dataLong(dataSet=TestUnempDur, timeColumn="spell", censColumn="censor1")
# Convert factor to numeric for smoothing
LongTrain$timeInt <- as.numeric(as.character(LongTrain$timeInt))
LongTest$timeInt <- as.numeric(as.character(LongTest$timeInt))

#####
# Estimate a generalized, additive model in discrete survival analysis

gamFit <- gam (formula=y ~ s(timeInt) + age + logwage, data=LongTrain, family=binomial())

# Estimate survival function of each person in the test data
oneMinusPredHaz <- 1 - predict(gamFit, newdata=LongTest, type="response")
predSurv <- aggregate(formula=oneMinusPredHaz ~ obj, data=LongTest, FUN=cumprod)
```

```

# Prediction error in first interval
tryPredErrDisc1 <- predErrDiscShort (timepoints=1,
estSurvList=predSurv [[2]], newTime=TestUnempDur$spell,
newEvent=TestUnempDur$ensor1, trainTime=TrainUnempDur$spell,
  trainEvent=TrainUnempDur$ensor1)
tryPredErrDisc1
summary(tryPredErrDisc1)

# Prediction error of the 2. to 10. interval
tryPredErrDisc2 <- predErrDiscShort (timepoints=2:10,
estSurvList=predSurv [[2]], newTime=TestUnempDur$spell,
newEvent=TestUnempDur$ensor1, trainTime=TrainUnempDur$spell,
  trainEvent=TrainUnempDur$ensor1)
tryPredErrDisc2
summary(tryPredErrDisc2)

#####
# Fit a random discrete survival forest

library(randomForest)
LongTrainRF <- LongTrain
LongTrainRF$y <- factor(LongTrainRF$y)
rffit <- randomForest (formula=y ~ timeInt + age + logwage, data=LongTrainRF)

# Estimate survival function of each person in the test data
oneMinusPredHaz <- 1 - predict(rffit, newdata=LongTest, type="prob") [, 2]
predSurv <- aggregate(formula=oneMinusPredHaz ~ obj, data=LongTest, FUN=cumprod)

# Prediction error in first interval
tryPredErrDisc1 <- predErrDiscShort (timepoints=1,
estSurvList=predSurv [[2]], newTime=TestUnempDur$spell,
newEvent=TestUnempDur$ensor1, trainTime=TrainUnempDur$spell,
  trainEvent=TrainUnempDur$ensor1)
tryPredErrDisc1
summary(tryPredErrDisc1)

# Prediction error of the 2. to 10. interval
tryPredErrDisc2 <- predErrDiscShort (timepoints=2:10,
estSurvList=predSurv [[2]], newTime=TestUnempDur$spell,
newEvent=TestUnempDur$ensor1, trainTime=TrainUnempDur$spell,
  trainEvent=TrainUnempDur$ensor1)
tryPredErrDisc2
summary(tryPredErrDisc2)

```

```
print.discSurvAdjDevResid
```

Print method of class "discSurvAdjDevResid"

Description

Prints the adjusted deviance residuals rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvAdjDevResid'  
print(x, ...)
```

Arguments

x	Object of class "discSurvAdjDevResid"
...	Additional arguments to default print

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[adjDevResid](#)

`print.discSurvAucUno` *Print method of class "discSurvAucUno"*

Description

Prints the auc value rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvAucUno'  
print(x, ...)
```

Arguments

x	Object of class "discSurvAdjDevResid"
...	Additional arguments to default print

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[aucUno](#)

```
print.discSurvConcorIndex
    Print method of class "discSurvConcorIndex"
```

Description

Displays the concordance index rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvConcorIndex'
print(x, ...)
```

Arguments

x	Object of class "discSurvConcorIndex"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[concorIndex](#)

```
print.discSurvDevResid
    Print method of class "discSurvDevResid"
```

Description

Displays the deviance residuals rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvDevResid'
print(x, ...)
```

Arguments

x	Object of class "discSurvDevResid"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[devResid](#)

print.discSurvFprUno *Print method of class "discSurvFprUno"*

Description

Displays the cutoff values and false positive rates rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvFprUno'  
print(x, ...)
```

Arguments

x	Object of class "discSurvFprUno"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[fprUno](#)

print.discSurvLifeTable
Print method of class "discSurvLifeTable"

Description

Prints the discrete life table estimates rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvLifeTable'  
print(x, ...)
```

Arguments

x Object of class "discSurvLifeTable"
... Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[lifeTable](#)

`print.discSurvMartingaleResid`
Print method of class "discSurvMartingaleResid"

Description

Displays martingale residuals rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvMartingaleResid'  
print(x, ...)
```

Arguments

x Object of class "discSurvMartingaleResid"
... Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[martingaleResid](#)

```
print.discSurvPredErrDisc
    Print method of class "discSurvPredErrDisc"
```

Description

Displays prediction error rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvPredErrDisc'
print(x, ...)
```

Arguments

x	Object of class "discSurvPredErrDisc"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[predErrDiscShort](#)

```
print.discSurvSimCompRisk
    Print method of class "discSurvSimCompRisk"
```

Description

Displays the simulated data set.

Usage

```
## S3 method for class 'discSurvSimCompRisk'
print(x, ...)
```

Arguments

x	Object of class "discSurvSimCompRisk"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

See Also

[simCompRisk](#)

print.discSurvTprUno *Print method of class "discSurvTprUno"*

Description

Displays the true positive rate rounded to 4 digits.

Usage

```
## S3 method for class 'discSurvTprUno'  
print(x, ...)
```

Arguments

x	Object of class "discSurvTprUno"
...	Additional arguments to the print function

Author(s)

Thomas Welchowski

See Also

[tprUno](#)

simCompRisk *Simulation of Competing Risks data*

Description

Simulates responses and covariates of discrete competing risk models. Responses and covariates are modelled separately by gaussian copulas given kendalls tau. This data can further be analysed with discrete competing risk models.

Usage

```
simCompRisk(responseCorr, covariateCorr, sampleSize, covariateSeed = NULL,  
covariateQuantFunc, covariateArgs, intercept = TRUE, trueCoef, responseSeed,  
responseQuantFunc, responseFixArgs, responseLinPredArgs, censorRN, censorArgs, censorSeed)
```

Arguments

responseCorr	Regulates correlation between event survival times. Numeric Matrix with kendalls tau version b rank correlations. Each cell is restricted to be between -1 and 1. Diagonal elements are always 1.
covariateCorr	Regulates correlation between event covariates. Numeric Matrix with kendalls tau version b rank correlations (each cell is restricted to be between -1 and 1). Diagonal elements are always 1. Uses singular, value decomposition for inversion of covariance matrices.
sampleSize	Integer scalar specifying the number of rows of the data frame.
covariateSeed	Integer scalar, specifying seed of covariate random number generation.
covariateQuantFunc	Character vector, giving the marginal quantile functions of all covariates
covariateArgs	List of Arguments for each quantile function of the marginal distributions. Each list element should be a named numeric vector (names giving the arguments)
intercept	Logical vector, giving if intercept is given in true coefficients for each Event (Default all TRUE)
trueCoef	List of numeric vectors containing the beta of true coefficients, e. g. linear predictor $\eta = X$
responseSeed	Integer scalar, specifying seed of response random number generation
responseQuantFunc	Character vector, giving the marginal quantile functions of all survival
responseFixArgs	List of Arguments for each quantile function of the marginal distributions. Each list element should be a named numeric vector.
responseLinPredArgs	List of lists, specifying the relationship of linear predictor and parameters of the marginal distributions. Each list element is a list of all functional relationships between linear predictor and parameters of one marginal distribution. Each list element is a function giving the functional relationship between linear predictor and one parameter.
censorRN	Integer scalar, specifying seed of censoring random number generation
censorArgs	Named numeric vector, giving all arguments of the marginal censoring distribution
censorSeed	Integer scalar, specifying seed of censoring random number generation

Value

List with following components

- Data: Simulated data of class "data.frame"
- covariateCorr: Original input rank correlation structure of covariates
- samleSize: Sample size
- covariateSeed: Covariate seed
- ... (all arguments specified in Input are saved other the corresponding names)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

Wiji Narendranathan and Mark B. Stewart, (1993), *Modelling the probability of leaving unemployment: competing risks models with flexible base-line hazards*, Applied Statistics, pages 63-83

Roger B. Nelsen, (2006), *An introduction to Copulas*, Springer Science+Business Media, Inc.

Steele Fiona and Goldstein Harvey and Browne William, (2004), *A general multilevel multistate competing risks model for event history data* Statistical Modelling, volume 4, pages 145-159

See Also

[dataLongCompRisks](#), [vgam](#)

Examples

```
library(Matrix)
library(matrixcalc)

#####
# Design of Simulation

# Monte carlo samples for each design = 10
# SampleSize = 100 in each replicate

# Responses:
# R1 i.n.d. ~ Weibull (shape=0.5, scale=exp(eta))
# E(R1) = gamma (3)*exp(eta)
# R2 i.n.d. ~ Weibull (shape=1, scale=exp(eta))
# E(R2) = gamma (2)*exp(eta)
# R3 i.n.d. ~ Weibull (shape=2, scale=exp(eta))
# E(R3) = gamma (1.5)*exp(eta)

# Random Censoring
# Z = 2/3 * (gamma (3) + gamma (2) + gamma (1.5)) = 2.590818
# Independent of survival times C_i i.i.d ~ Exp (lambda=Z)

# Correlation structure of survival times:
# Specify with kendalls tau -> spearmans rho
# Kendalls tau matrix:
# R1  R2  R3
# R1  1   0.3  0.4
# R2  0.3  1   0.5
# R3  0.4  0.5  1

# Covariates:
# V1: Binary variable ~ Bin (n=2, pi=0.5) -> E (V1) = 1
# V2: Continuous positive variable ~ Gamma (shape=1, scale=1) -> E (V2) = 1
# V3: Continuous variable ~ Normal (mu=0, sigma^2=1) -> E (V5) = 0
```

```

# True linear predictor:
# eta = X %*% beta
# beta_1 = c(-0.5, 1, 0.5)
# beta_2 = c(1, -1, 1)
# beta_3 = c(-0.5, -0.5, 2)

# Correlation Structure in Covariates:
# Specify with kendalls tau -> pearsons rho
# V1    V2    V3
# V1     1 -0.25  0
# V2  -0.25  1  0.25
# V3     0  0.25  1

# Design Correlation Matrix of covariates
DesignCovariateCor <- diag(3)
DesignCovariateCor [lower.tri(DesignCovariateCor)] <- c(-0.25, 0, 0.25)
DesignCovariateCor [upper.tri(DesignCovariateCor)] <- c(-0.25, 0, 0.25)

# Check if correlation matrix is symmetric
sum(DesignCovariateCor-t(DesignCovariateCor))==0 # TRUE -> ok
# Check if correlation matrix is positive definite
is.positive.definite (DesignCovariateCor) # TRUE -> ok
# Check if correlation matrix is transformed pearson matrix is positive, definite
is.positive.definite (apply(DesignCovariateCor, c(1,2), tauToPearson)) # TRUE -> ok

# Design Correlation Matrix positive definite after transformation
DesignResponseCor <- diag(3)
DesignResponseCor [lower.tri(DesignResponseCor)] <- c(0.3, 0.4, 0.5)
DesignResponseCor [upper.tri(DesignResponseCor)] <- c(0.3, 0.4, 0.5)

# Check if response correlation matrix is symmetric
sum(DesignResponseCor-t(DesignResponseCor))==0
# Check if response correlation matrix is positive definite
is.positive.definite (DesignResponseCor)
# Check if response correlation matrix is transformed pearson matrix is positive, definite
is.positive.definite (apply(DesignResponseCor, c(1,2), tauToPearson))

# Simulate raw data
DesignSampleSize <- 100
MonteCarloSamples <- 10
SimOutput <- vector("list", MonteCarloSamples)
for(j in 1:MonteCarloSamples) {
  SimOutput [[j]] <- simCompRisk (responseCorr=DesignResponseCor, covariateCorr=DesignCovariateCor,
    covariateSeed=NULL, sampleSize=100, covariateQuantFunc=c("qbinom", "qgamma", "qnorm"),
    covariateArgs=list(c(size=2, prob=0.5), c(shape=1, scale=1), c(mean=0, sd=1)),
    intercept=c(FALSE, FALSE, FALSE),
    trueCoef=list(c(-0.5, 1, 0.5), c(1, -1, 1), c(-0.5, -0.5, 2)),
    responseSeed=NULL, responseQuantFunc=c("qweibull", "qweibull", "qweibull"),
    responseFixArgs=list(c(shape=0.5), c(shape=1), c(shape=2)),
    responseLinPredArgs=list(list(scale=function (x) {exp(x)}),
    list(scale=function (x) {exp(x)}),
    list(scale=function (x) {exp(x)})), censorRN="rexp",
    censorArgs=c(rate=2/3 * (gamma (3) + gamma (2) + gamma (1.5))), censorSeed=NULL)
}

```

```
}
SimOutput [[1]]
SimOutput [[5]]

OverviewData <- data.frame(Min=rep(NA, MonteCarloSamples),
Max=rep(NA, MonteCarloSamples), Censrate=rep(NA, MonteCarloSamples))
for(j in 1:MonteCarloSamples) {

  # Calculate Range of observed time
  OverviewData [j, 1:2] <- range (SimOutput [[j]]$Data [, "Time"])

  # Calculate censoring rate
  OverviewData [j, "Censrate"] <- mean(SimOutput [[j]]$Data [, "Censor"])

}
OverviewData
```

summary.discSurvConcorIndex

Summary method of class "discSurvConcorIndex"

Description

Displays the concordance index, auc values over all time points, survival function and marginal probabilities each rounded to 4 digits.

Usage

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

Arguments

object	Object of class "discSurvConcorIndex"
...	Additional arguments to generic summary function

Author(s)

Thomas Welchowski

See Also

[concorIndex](#)

```
summary.discSurvPredErrDisc
```

Summary method of class "discSurvPredErrDisc"

Description

Prints the prediction errors and corresponding weights given by the survival function of the censoring process. All values are rounded to 4 digits.

Usage

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

Arguments

object	Object of class "discSurvPredErrDisc"
...	Additional arguments to generic summary function

Author(s)

Thomas Welchowski

See Also

[predErrDiscShort](#)

```
tauToPearson
```

Transformation of Tau to Pearson correlation

Description

If the two variables are bivariate normal distributed, this formula maps kendalls tau to bravais pearson correlation coefficient rho.

Usage

```
tauToPearson(Tau)
```

Arguments

Tau	Numeric vector in the interval [-1, 1]
-----	--

Details

This relationship holds only in the case if the two random variables are jointly normal distributed.

Value

Vector of bravais pearson correlation coefficient rho

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

References

William H. Kruskal, (1958), *Ordinal Measures of Association*, Journal of the American Statistical Association, Vol. 53, No. 284, pp. 814-861

See Also

[simCompRisk](#)

Examples

```
# Plot of relation between kendalls tau and pearson correlation
MaxDisc1 <- nlm(bf(start=0.5, objective=function(x) -abs(tauToPearson(x)-x))
MaxDisc2 <- nlm(bf(start=-0.5, objective=function(x) -abs(tauToPearson(x)-x))
plot(x=seq(-1,1,length.out=500), y=tauToPearson(seq(-1,1,length.out=500)),
xlab=expression(tau), ylab=expression(rho), type="l", las=1,
main="Relationship between tau and pearson correlation (bivariate normal)", lwd=2)
lines(x=seq(-1,1,length.out=500), y=seq(-1,1,length.out=500), lty=2)
segments(x0=0, y0=-1.25, x1=0, y1=0, lty=2)
segments(x0=-1.25, y0=0, x1=0, y1=0, lty=2)
segments(x0=MaxDisc1$par, y0=-1.25, x1=MaxDisc1$par, y1=tauToPearson(MaxDisc1$par), lty=2)
segments(x0=MaxDisc2$par, y0=-1.25, x1=MaxDisc2$par, y1=tauToPearson(MaxDisc2$par), lty=2)

# The maximum discrepancy between pearson and spearman is at
# a kendalls tau value about 0.56 and -0.56
```

tprUno

True positive Rate Uno

Description

Estimates the true positive rate based on Uno et al. to evaluate the predictive accuracy of discrete generalized, linear survival models by cross validation.

Usage

```
tprUno(timepoint, dataSet, trainIndices, survModelFormula,
censModelFormula, linkFunc = "logit", idColumn = NULL, timeAsFactor=TRUE)
```

Arguments

timepoint	Discrete time interval given that the false positive rate is evaluated (integer scalar)
dataSet	Original data in short format. Should be of class "data.frame".
trainIndices	List of Indices from original data used for training (list of integer vectors). The length of the list is equal to the number of cross validation samples.
survModelFormula	Formula of the discrete survival model. It is used in a generalized, linear model.
censModelFormula	Formula of the censoring model. It is used in a generalized, linear model. Usually this is done without covariates.
linkFunc	Link function of the generalized, linear model.
idColumn	Name of the column with identification numbers of persons. Default NULL means, that each row equals one person (no repeated measurements).
timeAsFactor	Should the time intervals be coded as factor? Default is to use factor. If the argument is false, the column is coded as numeric.

Details

The formula `survModelFormula` must be in a specific structure: The response on the left side of the formula is the time of the short data format. On the right side are the covariates without time, e. g. `Time ~ X1 + X2` if there are only two covariates. The time will be added automatically.

The next formula `survModelFormula` has similar structure. The difference is the left side of the formula: This must be the

Value

List with objects

- Output: Data frame with two columns: "cutoff" gives the different marker values and "tpr" the true positive rates
- Input: A list of given argument input values (saved for reference)

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

References

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, *Biometrics* 61, 92-105

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, *Journal of the American Statistical Association*

See Also

[tprUnoShort](#), [fprUno](#), [fprUnoShort](#), [aucUno](#), [concorIndex](#), [createFolds](#), [glm](#)

Examples

```
# Example with cross validation and unemployment data
library(Ecdat)
library(caret)
data(UnempDur)
summary(UnempDur$spell)

# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
head(UnempDurSubset)
range(UnempDurSubset$spell)
set.seed(7550)
CVfolds <- createFolds (y=UnempDurSubset$spell, returnTrain=TRUE, k=2)

# Estimate true positive rate of time interval 7:
# Correspondes to three and a half month duration (each interval is of length two weeks)
tryTPR <- tprUno (timepoint=7, dataSet=UnempDurSubset,
trainIndices=CVfolds, survModelFormula=spell ~ age + logwage,
censModelFormula=censor1 ~ 1, linkFunc="logit", idColumn=NULL)
tryTPR
plot(tryTPR)
```

tprUnoShort

True Positive Rate for arbitrary prediction models

Description

Estimates the true positive rate (based on concept of Uno, et al.) for an arbitrary discrete survival prediction model on one test data set.

Usage

```
tprUnoShort(timepoint, marker, newTime, newEvent, trainTime, trainEvent)
```

Arguments

timepoint	Gives the discrete time interval of which the tpr is evaluated (numeric scalar).
marker	Gives the predicted values of the linear predictor of a regression model (numeric vector). May also be on the response scale.
newTime	New time intervals in the test data (integer vector).
newEvent	New event indicators in the test data (integer vector with 0 or 1).
trainTime	Time intervals in the training data (integer vector).
trainEvent	Event indicators in the training data (integer vector with 0 or 1).

Details

This function is useful, if other models than generalized, linear models (glm) should be used for prediction. In the case of glm better use the cross validation version [tprUno](#).

Value

List with objects

- Output Data frame with two columns: "cutoff" gives the different marker values and "fpr" the false positive rates
- Input A list of given argument input values (saved for reference)

Note

It is assumed that all time points up to the last interval [a_q, Inf) are available in short format. If not already present, these can be added manually.

Author(s)

Thomas Welchowski <welchow@imbie.meb.uni-bonn.de>

Matthias Schmid <matthias.schmid@imbie.uni-bonn.de>

References

Hajime Uno and Tianxi Cai and Lu Tian and L. J. Wei, (2007), *Evaluating Prediction Rules for t-Year Survivors With Censored Regression Models*, Journal of the American Statistical Association

Patrick J. Heagerty and Yingye Zheng, (2005), *Survival Model Predictive Accuracy and ROC Curves*, Biometrics 61, 92-105

See Also

[tprUno](#), [aucUno](#), [concorIndex](#), [createFolds](#), [glm](#)

Examples

```
#####
# Example with unemployment data and prior fitting

library(Ecdat)
library(caret)
library(mgcv)
data(UnempDur)
summary(UnempDur$spell)
# Extract subset of data
set.seed(635)
IDsample <- sample(1:dim(UnempDur)[1], 100)
UnempDurSubset <- UnempDur [IDsample, ]
set.seed(-570)
TrainingSample <- sample(1:100, 75)
UnempDurSubsetTrain <- UnempDurSubset [TrainingSample, ]
```

```

UnempDurSubsetTest <- UnempDurSubset [-TrainingSample, ]

# Convert to long format
UnempDurSubsetTrainLong <- dataLong(dataSet=UnempDurSubsetTrain,
timeColumn="spell", censColumn="censor1")

# Estimate gam with smooth baseline
gamFit <- gam(formula=y ~ s(I(as.numeric(as.character(timeInt)))) +
s(age) + s(logwage), data=UnempDurSubsetTrainLong, family=binomial())
gamFitPreds <- predict(gamFit, newdata=cbind(UnempDurSubsetTest,
timeInt=UnempDurSubsetTest$spell))

# Estimate tpr given one training and one test sample
tprGamFit <- tprUnoShort (timepoint=1, marker=gamFitPreds,
newTime=UnempDurSubsetTest$spell, newEvent=UnempDurSubsetTest$censor1,
trainTime=UnempDurSubsetTrain$spell, trainEvent=UnempDurSubsetTrain$censor1)
plot(tprGamFit)

#####
# Example National Wilm's Tumor Study

library(survival)
head(nwtco)
summary(nwtco$rel)

# Select subset
set.seed(-375)
Indices <- sample(1:dim(nwtco)[1], 500)
nwtcoSub <- nwtco [Indices, ]

# Convert time range to 30 intervals
intLim <- quantile(nwtcoSub$edrel, prob=seq(0, 1, length.out=30))
intLim [length(intLim)] <- intLim [length(intLim)] + 1
nwtcoSubTemp <- contToDisc(dataSet=nwtcoSub, timeColumn="edrel", intervalLimits=intLim)
nwtcoSubTemp$instit <- factor(nwtcoSubTemp$instit)
nwtcoSubTemp$histol <- factor(nwtcoSubTemp$histol)
nwtcoSubTemp$stage <- factor(nwtcoSubTemp$stage)

# Split in training and test sample
set.seed(-570)
TrainingSample <- sample(1:dim(nwtcoSubTemp)[1], round(dim(nwtcoSubTemp)[1]*0.75))
nwtcoSubTempTrain <- nwtcoSubTemp [TrainingSample, ]
nwtcoSubTempTest <- nwtcoSubTemp [-TrainingSample, ]

# Convert to long format
nwtcoSubTempTrainLong <- dataLong(dataSet=nwtcoSubTempTrain,
timeColumn="timeDisc", censColumn="rel")

# Estimate glm
inputFormula <- y ~ timeInt + histol + instit + stage
glmFit <- glm(formula=inputFormula, data=nwtcoSubTempTrainLong, family=binomial())
linPreds <- predict(glmFit, newdata=cbind(nwtcoSubTempTest,
timeInt=nwtcoSubTempTest$timeDisc))

```

```
# Estimate tpr given one training and one test sample at time interval 10
tprFit <- tprUnoShort (timepoint=10, marker=linPreds,
newTime=nwtcoSubTempTest$timeDisc, newEvent=nwtcoSubTempTest$rel,
trainTime=nwtcoSubTempTrain$timeDisc, trainEvent=nwtcoSubTempTrain$rel)
plot(tprFit)
```

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