

Package ‘biospear’

August 11, 2017

Type Package

Title Biomarker Selection in Penalized Regression Models

Version 1.0.1

Author Nils Ternes [aut, cre],
Federico Rotolo [aut], Stefan Michiels [ctr]

Maintainer Nils Ternes <nils.ternes@yahoo.com>

Depends R (>= 2.10), pkgconfig

Description Provides some tools for developing and validating prediction models, estimate expected survival of patients and visualize them graphically. Most of the implemented methods are based on penalized regressions such as: the lasso (Tibshirani R (1996)), the elastic net (Zou H et al. (2005) <doi:10.1111/j.1467-9868.2005.00503.x>), the adaptive lasso (Zou H (2006) <doi:10.1198/016214506000000735>), the stability selection (Meinshausen N et al. (2010) <doi:10.1111/j.1467-9868.2010.00740.x>), some extensions of the lasso (Ternes et al. (2016) <doi:10.1002/sim.6927>), some methods for the interaction setting (Ternes N et al. (2016) <doi:10.1002/bimj.201500234>), or others. A function generating simulated survival data set is also provided.

License GPL-2

Encoding UTF-8

LazyData true

Imports cobs, corpcor, devtools, glmnet, graphics, grplasso, MASS,
Matrix, mboost, parallel, plsRcox, pROC, PRROC, RCurl, stats,
survAUC, survival

NeedsCompilation no

Repository CRAN

Date/Publication 2017-08-11 09:56:11 UTC

R topics documented:

BMsel	2
Breast	6
expSurv	7

predRes	10
selRes	14
simdata	16

Index	18
--------------	-----------

BMsel	<i>Biomarker selection in a Cox regression model</i>
-------	--

Description

This function enables to fit a Cox regression model for a prognostic or a biomarker-by-treatment interaction setting subject to a selection procedure to perform variable selection.

Usage

```
BMsel(data, x, y, z, tt, inter, std.x = TRUE, std.i = FALSE, std.tt = TRUE,
      method = c('alassoL', 'alassoR', 'alassoU', 'enet', 'gboost',
                'glasso', 'lasso', 'lasso-1se', 'lasso-AIC', 'lasso-BIC',
                'lasso-HQIC', 'lasso-pct', 'lasso-pcv1', 'lasso-RIC', 'modCov',
                'PCAlasso', 'PLSlasso', 'ridge', 'ridgelasso', 'stabSel', 'uniFDR'),
      folds = 5, uni.fdr = 0.05, uni.test = 1, ss.rando = F, ss.nsub = 100,
      ss.fsub = 0.5, ss.fwer = 1, ss.thr = 0.6, dfmax = ncol(data) + 1,
      pct.rep = 1, pct.qtl = 0.95, showWarn = TRUE, trace = TRUE)
```

```
## S3 method for class 'resBMsel'
summary(object, show = TRUE, keep = c('tt', 'z', 'x', 'xt'),
        add.ridge = FALSE, ...)
```

Arguments

<code>data</code>	input data.frame . Each row is an observation.
<code>x</code>	colnames or position of the biomarkers in data.
<code>y</code>	colnames or position of the survival outcome in data. The first column must be the time and the second must be the indicator (0/1).
<code>z</code>	colnames or position of the clinical covariates in data, if any.
<code>tt</code>	colname or position of the treatment in data, if any.
<code>inter</code>	logical parameter indicating if biomarker-by-treatment interactions should be computed.
<code>std.x</code>	logical parameter indicating if the biomarkers should be standardized (i.e. subtracting by the mean and dividing by the standard deviation of each biomarker).
<code>std.i</code>	logical parameter indicating if the biomarker-by-treatment interactions should be standardized (i.e. subtracting by the mean and dividing by the standard deviation of each interaction).
<code>std.tt</code>	logical parameter indicating if the treatment should be recoded as +/-0.5.

method	methods computed to perform variable selection and to estimate the regression coefficients. See the Details section to understand all the implemented methods.
fold	number of folds. <code>fold</code> must be either a value between 3 and the sample size (leave-one-out CV, but not recommended for large datasets), or a vector (same length as the sample size) indicating the fold assignment group of each observation.
<code>uni.fdr</code> , <code>uni.test</code>	specific parameters for the univariate procedure. <code>uni.fdr</code> : threshold false discovery rate (FDR) to control for multiple testing (Benjamini and Hochberg, 1995), <code>uni.test</code> : model comparison approach. 1: p-value of the biomarker effect (i.e. main effect for the prognostic setting, or main effect + interaction for the interaction setting), 2: p-value of the interaction (only available for the interaction setting).
<code>ss.fsub</code> , <code>ss.fwer</code> , <code>ss.nsub</code> , <code>ss.rando</code> , <code>ss.thr</code>	specific parameters for the stability selection. <code>ss.fsub</code> : fraction of samples to use in the sampling process, <code>ss.fwer</code> : parameter to control for the family-wise error rate (FWER, i.e. number of noise variables), <code>ss.nsub</code> : number of subsampling, <code>ss.rando</code> : logical parameter indicating if random weights should be added in the lasso penalty, <code>ss.thr</code> : threshold of the stability probability for filtering variable.
<code>dfmax</code>	limit the maximum number of variables in the model. Useful for very large number of covariates to limit the time computation.
<code>pct.rep</code> , <code>pct.qtl</code>	specific parameters for the percentile lasso. <code>pct.rep</code> : number of replicates, <code>pct.qtl</code> : percentile used to estimate the lambda among its empirical distribution.
<code>showWarn</code>	logical parameter indicating if warnings should be printed.
<code>trace</code>	logical parameter indicating if messages should be printed.
<code>object</code>	object of class 'resBMsel' returned by <code>BMsel</code> .
<code>show</code>	parameter for the <code>summary()</code> indicating if the result should be printed.
<code>keep</code>	parameter for the <code>summary()</code> indicating the type of covariates that should be kept for the summary (<code>tt</code> : treatment covariate, <code>z</code> : clinical covariates, <code>x</code> : biomarker main effects and <code>xt</code> : biomarker-by-treatment interactions).
<code>add.ridge</code>	parameter for the <code>summary()</code> indicating if the ridge penalty should be kept for the summary as no selection is performed.
...	other parameters for plot or summary .

Details

The objects `x`, `y`, `z` (if any) and `tt` (if any) are mandatory for non-simulated data sets.

The `method` parameter specifies the approaches for model selection. Most of these selection methods are based on the lasso penalty (Tibshirani, 1996). The tuning parameter is usually chosen through the cross-validated log-likelihood criterion (`cvl`), except for the empirical extensions of the lasso in which additional penalties to the `cvl` (given with a suffix, e.g. `lasso-pcvl`) are used to estimate the tuning parameter. Other methods based on the lasso are also implemented such as the adaptive lasso (`alassoL`, `alassoR` and `alassoU` for which the last letter indicates the procedure

used to estimate the preliminary weights: "L" for lasso, "R" for ridge and "U" for univariate), the elastic-net (enet) or the stability selection (stabSel). For the interaction setting, specific methods were implemented: to reduce/control the main effects matrix (i.e. ridge (ridgelasso) or dimension reduction (PCALasso or PLSlasso)), to select or discard main effects and interactions simultaneously (i.e. group-lasso (glasso)), or to include only the interaction part in the model (i.e. modCov). Some selection methods not based on penalized regression are also proposed: univariate selection (uniFDR), gradient boosting (gboost). The ridge penalty without selection can also be applied.

For all methods but the uniFDR, tuning parameters are chosen by maximizing the cross-validated log-likelihood (max-cvl). For the elastic-net, the "alpha" parameter (trade-off between ridge and lasso) is investigated among a predefined grid of values (as suggested by the authors, Zou et al. 2005) and the "lambda" is estimated by maximizing the above-mentioned cvl criterion for each of the "alpha" parameter. The combination (alpha; lambda) that maximizes the cvl is finally retained. For the gradient boosting, the number of steps is also estimated by the max-cvl. For the univariate selection, the tuning parameter is the FDR threshold defined by the user to control for multiple testing (using the parameter uni.fdr).

We have included the possibility to adjust for clinical covariates (z) for all methods. For penalized regressions, these covariates are considered as unpenalized. For the gradient boosting, a model with clinical covariates is preliminary implemented and regression coefficients are fixed as offset in the boosting approach. For the univariate selection, clinical covariates are forced as adjustment variables in the model and the FDR is calculated on the Wald p-values of the coefficient associated with the biomarker in such models.

Value

An object of class 'resBMsel' containing the list of the selected biomarkers and their estimated regression coefficients for the chosen methods.

Author(s)

Nils Ternes, Federico Rotolo, and Stefan Michiels
Maintainer: Nils Ternes <nils.ternes@yahoo.com>

References

Ternes N, Rotolo F and Michiels S. Empirical extensions of the lasso penalty to reduce the false discovery rate in high-dimensional Cox regression models. *Statistics in Medicine* 2016;35(15):2561-2573. doi:[10.1002/sim.6927](https://doi.org/10.1002/sim.6927)

Ternes N, Rotolo F, Heinze G and Michiels S. Identification of biomarker-by-treatment interactions in randomized clinical trials with survival outcomes and high-dimensional spaces. *Biometrical journal*. In press. doi:[10.1002/bimj.201500234](https://doi.org/10.1002/bimj.201500234)

Tibshirani R. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society, Ser B* 1996;58:267-288.

Examples

```
#####
# Simulated data set
#####
```

```

## Low calculation time
set.seed(654321)
sdata <- simdata(
  n = 500, p = 20, q.main = 3, q.inter = 0,
  prob.tt = 0.5, alpha.tt = 0,
  beta.main = -0.8,
  b.corr = 0.6, b.corr.by = 4,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1)

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = FALSE,
  folds = 5)

summary(resBM)

## Not run:
## Moderate calculation time
set.seed(123456)
sdata <- simdata(
  n = 500, p = 100, q.main = 5, q.inter = 5,
  prob.tt = 0.5, alpha.tt = -0.5,
  beta.main = c(-0.5, -0.2), beta.inter = c(-0.7, -0.4),
  b.corr = 0.6, b.corr.by = 10,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1,
  active.inter = c("bm003", "bm021", "bm044", "bm049", "bm097"))

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = TRUE,
  folds = 5)

summary(resBM)
summary(resBM, keep = "xt")

## End(Not run)

#####
# Breast cancer data set
#####

## Not run:
data(Breast)
dim(Breast)

set.seed(123456)
resBM <- BMsel(
  data = Breast,
  x = 4:ncol(Breast),

```

```

y = 2:1,
tt = 3,
inter = FALSE,
std.x = TRUE,
folds = 5,
method = c("lasso", "lasso-pcv1"))

summary(resBM)

## End(Not run)

#####
#####

```

Breast

Early breast cancer data

Description

Breast contains clinical and genomic data of 614 early breast cancer patients.

Usage

```
data(Breast)
```

Format

A dataframe with variables:

time Distant-relapse free survival time (in years).

status Distant-relapse free survival indicator (0 = censored, 1 = event).

treat Treatment arm (Anthracycline-based adjuvant chemotherapy with (treat = +0.5) or without (treat = -0.5) taxane).

... All other covariates (p=1689) are gene expression values.

References

Desmedt C, Di Leo A, de Azambuja E, Larsimont D, Haibe-Kains B et al. Multifactorial approach to predicting resistance to anthracyclines *Journal of Clinical Oncology* 2011;29:1578-86. doi:[10.1200/JCO.2010.31.2231](https://doi.org/10.1200/JCO.2010.31.2231)

Hatzis C, Pusztai L, Valero V, Booser DJ, Esserman L et al. A genomic predictor of response and survival following taxane-anthracycline chemotherapy for invasive breast cancer. *Journal of the American Medical Association* 2011;305:1873-1881. doi:[10.1001/jama.2011.593](https://doi.org/10.1001/jama.2011.593)

Ternes N, Rotolo F, Heinze G and Michiels S. Identification of biomarker-by-treatment interactions in randomized clinical trials with survival outcomes and high-dimensional spaces. *Biometrical journal*. In press. doi:[10.1002/bimj.201500234](https://doi.org/10.1002/bimj.201500234)

Examples

```

library(survival)
data(Breast)
dim(Breast)

km <- survfit(Surv(time, status) ~ treat, data = Breast)
km
plot(km, col = c("black", "red"), lwd = 2, xlim = c(0, 5), xaxt = "n", yaxt = "n")
legend("bottomleft", legend = c("Control", "Experimental"), col = 1:2,
      lty = 1, lwd = 2, cex = 1.5)
axis(1, cex.axis = 1.3)
axis(2, las = 2, cex.axis = 1.3)
mtext("Distant-recurrence free survival", side = 2, line = 3.2, cex = 1.5)
mtext("Time (in years)", side = 1, line = 2.5, cex = 1.5)

```

expSurv

Computation of expected survival based on a prediction model

Description

Based on a prediction model, this function computes expected survival for patients with associated confidence intervals. The returned object can be plotted to obtain a meaningful graphical visualization.

Usage

```
expSurv(res, traingroup, method, ci.level = .95, boot = FALSE, nboot, smooth = TRUE,
       pct.group = 4, time, trace = TRUE, ncores = 1)
```

```
## S3 method for class 'resexpSurv'
predict(object, newdata, ...)
```

```
## S3 method for class 'resexpSurv'
plot(x, method, pr.group, print.ci = TRUE,
     xlim, ylim, xlab, ylab, ...)
```

Arguments

res	an object of class 'resBMscl' generated by BMscl .
traingroup	the data.frame used to compute the res object (training set).
method	selection method to compute. If missing, all methods contained in res are computed.
ci.level	the nominal level for the two-sided confidence interval (CI) of the survival probability.
boot	logical value: TRUE = bootstrapped CI, FALSE = analytical CI.
nboot	number of bootstrap replicates (only used when boot=TRUE).

smooth	logical value indicating if smoothed B-splines should be computed.
pct.group	number or percentile of the prognostic-risk groups. If a single number is provided, all the groups must be defined according to Cox (1957). If percentiles are provided, the sum must be 1 (e.g. 0.164, 0.336, 0.336, 0.164).
time	single time point to estimate the expected survival probabilities.
trace	logical parameter indicating if messages should be printed.
ncores	number of CPUs used (for the bootstrap CI).
object, x	an object of class 'reexpSurv' generated by <code>expSurv</code> .
newdata	<code>data.frame</code> containing new patients data. <code>newdata</code> must have the same variables as <code>traindata</code> .
pr.group	parameter for the <code>plot()</code> indicating the number of the prognostic-risk group for which the plot will be printed.
print.ci	logical parameter for the <code>plot()</code> indicating if CI will be printed.
xlim, ylim, xlab, ylab	usual parameters for <code>plot</code> .
...	other paramaters for <code>predict</code> or <code>plot</code> .

Details

Using an object of class 'resBMsel' generated by `BMsel`, `expSurv` computes expected survival at a given time and constructs confidence intervals thereof either with an analytical (`boot = FALSE`) or non-parametric bootstrap approach (`boot = TRUE`). Smoothed B-splines (logical option `smooth`) and categorization of the prognostic score into risk groups (using the option `pct.group`) may be used to obtain a meaningful graphical visualization. Predictions for new patients (`newdata` data frame) can be computed using `predict()`. Graphical visualization can be obtained using `plot()`.

Value

A list of length three containing the expected survival (`surv`) and their corresponding confidence intervals (lower and upper). Each element of the list contains a matrix of dimension number of patients x number of implemented methods.

Author(s)

Nils Ternes, Federico Rotolo, and Stefan Michiels
 Maintainer: Nils Ternes <nils.ternes@yahoo.com>

Examples

```
#####
# Simulated data set
#####

## Low calculation time
set.seed(654321)
sdata <- simdata(
  n = 500, p = 20, q.main = 3, q.inter = 0,
```



```

    prob.tt = 0.5, alpha.tt = 0,
    beta.main = -0.8,
    b.corr = 0.6, b.corr.by = 4,
    m0 = 5, wei.shape = 1, recr = 4, fu = 2,
    timefactor = 1)

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = FALSE,
  folds = 5)

esurv <- expSurv(
  res = resBM,
  traindata = sdata,
  boot = FALSE,
  time = 5,
  trace = TRUE)
plot(esurv, method = "lasso-pcvl")

## Not run:
## Moderate calculation time
set.seed(123456)
sdata <- simdata(
  n = 500, p = 100, q.main = 5, q.inter = 5,
  prob.tt = 0.5, alpha.tt = -0.5,
  beta.main = c(-0.5, -0.2), beta.inter = c(-0.7, -0.4),
  b.corr = 0.6, b.corr.by = 10,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1,
  active.inter = c("bm003", "bm021", "bm044", "bm049", "bm097"))

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = TRUE,
  folds = 5)

esurv <- expSurv(
  res = resBM,
  traindata = sdata,
  boot = TRUE,
  nboot = 100,
  smooth = TRUE,
  pct.group = 4,
  time = 5,
  ncores = 5)
plot(esurv, method = "lasso", pr.group = 3)

## End(Not run)

#####
# Breast cancer data set

```

```
#####

## Not run:
data(Breast)
dim(Breast)

set.seed(123456)
resBM <- BMsel(
  data = Breast,
  x = 4:ncol(Breast),
  y = 2:1,
  tt = 3,
  inter = FALSE,
  std.x = TRUE,
  folds = 5,
  method = c("lasso", "lasso-pcv1"))

esurv <- expSurv(
  res = resBM,
  traindata = Breast,
  boot = FALSE,
  smooth = TRUE,
  time = 4,
  trace = TRUE
)
plot(esurv, method = "lasso")

## End(Not run)

#####
#####
```

predRes

Evaluation of the prediction accuracy of a prediction model

Description

This function computes several criteria to assess the prediction accuracy of a prediction model.

Usage

```
predRes(res, method, traindata, newdata, int.cv, int.cv.nfold = 5, time,
  trace = TRUE, ncores = 1)
```

```
## S3 method for class 'predRes'
plot(x, method, crit = c("C", "PE", "dC"),
  xlim, ylim, xlab, ylab, col,...)
```

Arguments

<code>res</code>	an object of class 'resBMsel' generated by <code>BMsel</code> .
<code>method</code>	methods for which prediction criteria are computed. If missing, all methods contained in <code>res</code> are computed.
<code>traindata</code>	input <code>data.frame</code> used to compute the <code>res</code> object. This object is mandatory.
<code>newdata</code>	input <code>data.frame</code> not used to compute the <code>res</code> object. This object is not mandatory (see Details section).
<code>int.cv</code>	logical parameter indicating if a double cross-validation process (2CV) should be performed to mimick an external validation set.
<code>int.cv.nfold</code>	number of folds for the double cross-validation. Considering a large value for <code>int.cv.nfold</code> should provide extremely large computation time. <code>int.cv.nfold</code> must not be considered when <code>int.cv = FALSE</code> .
<code>time</code>	time points to compute the prediction criteria.
<code>trace</code>	logical parameter indicating if messages should be printed.
<code>ncores</code>	number of CPUs used (for the double cross-validation).
<code>x</code>	an object of class 'predRes' generated from <code>predRes</code> .
<code>crit</code>	parameter indicating the criterion for which the results will be printed (C: concordance via Uno's C-statistic, PE: prediction error via integrated Brier score and dC: delta Uno's C-statistic (for the interaction setting only)).
<code>xlim, ylim, xlab, ylab, col</code>	usual parameters for <code>plot</code> .
<code>...</code>	other paramaters for <code>plot</code> .

Details

To evaluate the accuracy of the selected models, three predictive accuracy measures are implemented:

- the integrated Brier score (PE) to measure the overall prediction error of the prediction model. The time-dependent Brier score is a quadratic score based on the predicted time-dependent survival probability.
- the Uno's C-statistic (C) to evaluate the discrimination of the prediction model. It's one of the least biased concordance statistic estimator in the presence of censoring (Uno et al., 2011).
- the absolute difference of the treatment-specific Uno's C-statistics (dC) to evaluate the interaction strength of the prediction model (Ternes et al., 2016).

For simulated datasets, the predictive accuracy metrics are also computed for the "oracle model" that is the unpenalized Cox proportional hazards model fitted to the active biomarkers only.

Value

A list of the same length of the `time` considered. Each element of the list contains between 1 and 3 sublists depending on the chosen validation (i.e. training set [always computed], internal validation through double cross-validation (2CV) [if `int.cv = TRUE`] and/or external validation [if `newdata` is provided]). Each sublist is a matrix containing the predictive accuracy metrics of the implemented methods.

Author(s)

Nils Ternes, Federico Rotolo, and Stefan Michiels
 Maintainer: Nils Ternes <nils.ternes@yahoo.com>

References

Ternes N, Rotolo F and Michiels S. Empirical extensions of the lasso penalty to reduce the false discovery rate in high-dimensional Cox regression models. *Statistics in Medicine* 2016;35(15):2561-2573. doi:[10.1002/sim.6927](https://doi.org/10.1002/sim.6927)

Ternes N, Rotolo F, Heinze G and Michiels S. Identification of biomarker-by-treatment interactions in randomized clinical trials with survival outcomes and high-dimensional spaces. *Biometrical journal*. In press. doi:[10.1002/bimj.201500234](https://doi.org/10.1002/bimj.201500234)

Uno H, Cai T, Pencina MJ, D'Agostino RB and Wei LJ. On the C-statistics for evaluating overall adequacy of risk prediction procedures with censored survival data. *Statistics in Medicine* 2011;30:1105-1117. doi:[10.1002/sim.4154](https://doi.org/10.1002/sim.4154)

Examples

```
#####
# Simulated data set
#####

## Low calculation time
set.seed(654321)
sdata <- simdata(
  n = 500, p = 20, q.main = 3, q.inter = 0,
  prob.tt = 0.5, alpha.tt = 0,
  beta.main = -0.8,
  b.corr = 0.6, b.corr.by = 4,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1)

newdata <- simdataV(
  traindata = sdata,
  Nvalid = 500
)

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = FALSE,
  folds = 5)

predAcc <- predRes(
  res = resBM,
  traindata = sdata,
  newdata = newdata,
  time = 1:5)

plot(predAcc, crit = "C")
```

```

## Not run:
## Moderate calculation time
set.seed(123456)
sdata <- simdata(
  n = 500, p = 100, q.main = 5, q.inter = 5,
  prob.tt = 0.5, alpha.tt = -0.5,
  beta.main = c(-0.5, -0.2), beta.inter = c(-0.7, -0.4),
  b.corr = 0.6, b.corr.by = 10,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1,
  active.inter = c("bm003", "bm021", "bm044", "bm049", "bm097"))

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcv1"),
  inter = TRUE,
  folds = 5)

predAcc <- predRes(
  res = resBM,
  traindata = sdata,
  int.cv = TRUE,
  time = 1:5,
  ncores = 5)
plot(predAcc, crit = "dC")

## End(Not run)

#####
# Breast cancer data set
#####

## Not run:
data(Breast)
dim(Breast)

set.seed(123456)
resBM <- BMsel(
  data = Breast,
  x = 4:ncol(Breast),
  y = 2:1,
  tt = 3,
  inter = FALSE,
  std.x = TRUE,
  folds = 5,
  method = c("lasso", "lasso-pcv1"))

summary(resBM)

predAcc <- predRes(
  res = resBM,
  traindata = Breast,
  time = 1:4,

```

```

    trace = TRUE)
  plot(predAcc, crit = "C")

## End(Not run)

#####
#####

```

 selRes

Evaluation of the selection accuracy of a prediction model

Description

This function computes several criteria to assess the selection accuracy of a prediction model. Of note, this function is only available for simulated data sets for which true biomarkers are known.

Usage

```
selRes(res)
```

Arguments

`res` an object of class 'resBMsel' generated by [BMsel](#) with data simulated using [simdata](#).

Details

Based on the 2x2 contingency table (active vs. inactive / selected vs. unselected), four selection criteria are provided:

- the false discovery rate (FDR) that is the proportion of inactive biomarkers among the selected ones,
 - the false non-discovery rate (FNDR) that is the proportion of active biomarkers among the unselected ones,
 - the false negative rate (FNR) that is the proportion of unselected biomarkers among the active ones,
 - the false positive rate (FPR) that is the proportion of selected biomarkers among the inactive ones.
- These four criteria are between 0 and 1, and must be minimized.

We also provided two discrimination criteria, translating the ability to discard inactive biomarkers more likely than active ones independently of the tuning parameters:

- the area under the ROC curve (AUC) depending on the sensitivity [1 - FNR] and specificity [1 - FPR],
- the area under the precision-recall curve (AUPRC) depending on the FNR and FDR (Davis and Goadrich, 2006).

Of note, the AUPRC is more meaningful than the AUC when there are many more inactive than active biomarkers. These two criteria are between 0 and 1, and must be maximized.

Value

A matrix of dimension 6 x the number of methods used to fit `res`.

Author(s)

Nils Ternes, Federico Rotolo, and Stefan Michiels
 Maintainer: Nils Ternes <nils.ternes@yahoo.com>

References

Davis J and Goadrich M. The relationship between Precision-Recall and ROC curves. *Proceedings of the 23rd International Conference on Machine Learning*. ACM, Pittsburgh PA, 233-240.

Ternes N, Rotolo F and Michiels S. Empirical extensions of the lasso penalty to reduce the false discovery rate in high-dimensional Cox regression models. *Statistics in Medicine* 2016;35(15):2561-2573. doi:[10.1002/sim.6927](https://doi.org/10.1002/sim.6927)

Ternes N, Rotolo F, Heinze G and Michiels S. Identification of biomarker-by-treatment interactions in randomized clinical trials with survival outcomes and high-dimensional spaces. *Biometrical journal*. In press. doi:[10.1002/bimj.201500234](https://doi.org/10.1002/bimj.201500234)

Examples

```
#####
# Simulated data set
#####

## Low calculation time
set.seed(654321)
sdata <- simdata(
  n = 500, p = 20, q.main = 3, q.inter = 0,
  prob.tt = 0.5, alpha.tt = 0,
  beta.main = -0.8,
  b.corr = 0.6, b.corr.by = 4,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1)

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcvl"),
  inter = FALSE,
  folds = 5)

selAcc <- selRes(resBM)

## Not run:
## Moderate calculation time
set.seed(123456)
sdata <- simdata(
  n = 500, p = 100, q.main = 5, q.inter = 5,
  prob.tt = 0.5, alpha.tt = -0.5,
  beta.main = c(-0.5, -0.2), beta.inter = c(-0.7, -0.4),
  b.corr = 0.6, b.corr.by = 10,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1,
  active.inter = c("bm003", "bm021", "bm044", "bm049", "bm097"))
```

```

resBM <- BMsel(
  data = sdata,
  method = c("lasso", "lasso-pcv1"),
  inter = TRUE,
  folds = 5)

selAcc <- selRes(resBM)

## End(Not run)

```

simdata

Generation of data sets with survival outcome

Description

This function simulates a data set with survival outcome with given active biomarkers (prognostic and/or interacting with the treatment).

Usage

```

simdata(n, p, q.main, q.inter, prob.tt, m0, alpha.tt, beta.main,
  beta.inter, b.corr, b.corr.by, wei.shape, recr, fu, timefactor,
  active.main, active.inter)

simdataV(traindata, Nvalid)

```

Arguments

n	the sample size.
p	the number of biomarkers.
q.main	the number of true prognostic biomarkers.
q.inter	the number of true biomarkers interacting with the treatment.
prob.tt	the treatment assignment probability.
m0	the baseline median survival time.
alpha.tt	the effect of the treatment (in log-scale).
beta.main	the effect of the prognostic biomarkers (in log-scale).
beta.inter	the effect of the biomarkers interacting with the treatment (in log-scale).
b.corr	the correlation between biomarker blocks.
b.corr.by	the size of the blocks of correlated biomarkers.
wei.shape	the shape parameter of the Weibull distribution.
recr	the recruitment period duration.
fu	the follow-up period duration.
timefactor	the scale multiplicative factor for times (i.e. 1 = times in years).

<code>active.main</code>	the list of the prognostic biomarkers (not mandatory).
<code>active.inter</code>	the list of the biomarkers interacting with the treatment (not mandatory).
<code>traindata</code>	the training set returned by <code>simdata</code> , used to generate the new validation data set with the same characteristics.
<code>Nvalid</code>	the sample size of the new validation data set.

Details

The `simdata` function generates p Gaussian unit-variance ($\sigma = 1$) biomarkers including autoregressive correlation ($\sigma_{ij} = b.corr^{|i-j|}$) within `b.corr.by`-biomarker blocks. The number of active biomarkers and their effect sizes (in log-scale) can be specified using `q.main` and `beta.main` for the true prognostic biomarkers and using `q.inter` and `beta.inter` for the true treatment-effect modifiers. A total of n patients is generated and randomly assigned to the experimental (coded as $+0.5$, with probability `prob.tt`) and control treatment (coded as -0.5). The treatment effect is specified using `alpha.tt` (in log-scale). Survival times are generated using a Weibull with shape `wei.shape` (i.e. $1 =$ exponential distribution) and patient-specific scale depending on the baseline median survival time `m0` and the biomarkers values of the patient. Censor status is generated by considering independent censoring from a $U(fu, fu + recr)$ distribution, reflecting a trial with `recr` years of accrual and `fu` years of follow-up. Another data set with the same characteristics as the one generated by `simdata` can be obtained by using the `simdataV` function.

Value

A simulated `data.frame` object.

Author(s)

Nils Ternes, Federico Rotolo, and Stefan Michiels
 Maintainer: Nils Ternes <nils.ternes@yahoo.com>

Examples

```
set.seed(123456)
sdata <- simdata(
  n = 500, p = 100, q.main = 5, q.inter = 5,
  prob.tt = 0.5, alpha.tt = -0.5,
  beta.main = c(-0.5, -0.2), beta.inter = c(-0.7, -0.4),
  b.corr = 0.6, b.corr.by = 10,
  m0 = 5, wei.shape = 1, recr = 4, fu = 2,
  timefactor = 1,
  active.inter = c("bm003", "bm021", "bm044", "bm049", "bm097"))

newdata <- simdataV(
  traindata = sdata,
  Nvalid = 500)
```

Index

- *Topic **biomarker selection**
 - BMsel, 2
 - *Topic **breast**
 - Breast, 6
 - *Topic **cancer**
 - Breast, 6
 - *Topic **confidence intervals**
 - expSurv, 7
 - *Topic **dataset**
 - Breast, 6
 - *Topic **data**
 - simdata, 16
 - *Topic **estimations**
 - expSurv, 7
 - *Topic **interactions**
 - BMsel, 2
 - *Topic **prediction**
 - predRes, 10
 - *Topic **prognostic**
 - BMsel, 2
 - *Topic **selection**
 - selRes, 14
 - *Topic **simulation**
 - simdata, 16
 - *Topic **surrogate**
 - Breast, 6
 - *Topic **survival**
 - BMsel, 2
 - expSurv, 7
- BMsel, 2, 7, 8, 11, 14
- Breast, 6
- data.frame, 2, 8, 11
- expSurv, 7, 8
- plot, 3, 8, 11
- plot.predRes (predRes), 10
- plot.resexpSurv (expSurv), 7
- predict, 8
- predict.resexpSurv (expSurv), 7
- predRes, 10, 11
- selRes, 14
- simdata, 14, 16
- simdataV (simdata), 16
- summary, 3
- summary.resBMsel (BMsel), 2