Package ‘ahaz’

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Fit semiparametric additive hazards model

Description

Fit a semiparametric additive hazards regression model. Right-censored and left-truncated survival data are supported.

Usage

```
ahaz(surv, x, weights, univariate=FALSE, robust=FALSE)
```

Arguments

- **surv**: Response in the form of a survival object, as returned by the function `Surv()` in the package `survival`. Right-censoring and left-truncation is supported. Tied survival times are not supported.
- **x**: Design matrix. Missing values are not supported.
- **weights**: Optional vector of observation weights. Default is 1 for each observation.
- **univariate**: Fit all univariate models instead of the joint model. Default is `univar = FALSE`.
- **robust**: Robust calculation of variance. Default is `robust = FALSE`.

Details

The semiparametric additive hazards model specifies a hazard function of the form:

\[ h(t) = h_0(t) + \beta' Z_i \]

for \( i = 1, \ldots, n \) where \( Z_i \) is the vector of covariates, \( \beta \) the vector of regression coefficients and \( h_0 \) is an unspecified baseline hazard. The semiparametric additive hazards model can be viewed as an additive analogue of the well-known Cox proportional hazards regression model.

Estimation is based on the estimating equations of Lin & Ying (1994).

The option `univariate` is intended for screening purposes in data sets with a large number of covariates. It is substantially faster than the standard approach of combining `ahaz` with `apply`, see the examples.
Value

An object with S3 class "ahaz".

- **call**: The call that produced this object.
- **nobs**: Number of observations.
- **nvars**: Number of covariates.
- **D**: A nvars x nvars matrix (or vector of length nvars if univar = TRUE).
- **d**: A vector of length nvars; the regression coefficients equal solve(D, d).
- **B**: An nvars x nvars matrix such that \( D^{-1}BD^{-1} \) estimates the covariance matrix of the regression coefficients. If robust=FALSE then B is estimated using an asymptotic approximation; if robust=TRUE then B is estimated from residuals, see residuals.
- **univariate**: Is univariate=TRUE?
- **data**: Formatted version of original data (for internal use).
- **robust**: Is robust=TRUE?

References


See Also

summary.ahaz, predict.ahaz, plot.ahaz. The functions coef, vcov, residuals.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time, sorlie$status)
X <- as.matrix(sorlie[,15:24])

# Fit additive hazards model
fit1 <- ahaz(surv, X)
summary(fit1)

# Univariate models
X <- as.matrix(sorlie[,3:ncol(sorlie)])
fit2 <- ahaz(surv, X, univariate = TRUE)
# Equivalent to the following (slower) solution
beta <- apply(X,2,function(x){coef(ahaz(surv,x))})
plot(beta,coef(fit2))
ahaz.adjust

Adjusted univariate association measures from ahaz

Description

Fast calculation of univariate association measures in the semiparametric additive risk model, adjusted for user-specified covariates

Usage

ahaz.adjust(surv, X, weights, idx, method=c("coef", "z", "crit"))

Arguments

surv Response in the form of a survival object, as returned by the function Surv() in the package survival. Right-censored and counting process format (left-truncation) is supported. Tied survival times are not supported.

X Design matrix. Missing values are not supported.

weights Optional vector of observation weights. Default is 1 for each observation.

idx Vector specifying the indices of the covariates to adjust for.

method The type of adjusted association measure to calculate. See details.

Details

The function is intended mainly for programming use and screening purposes, when a very large number of covariates are considered and direct application of ahaz is unfeasible.

Running this function is equivalent to running ahaz with design matrix cbind(X[,i],X[,idx]) for each column X[,i] in X. By utilizing basic matrix identities, ahaz.adjust runs many times faster.

The following univariate association measures are currently implemented:

- method="z", Z-statistics, obtained from a fitted ahaz model.
- method="coef", regression coefficients, obtained from a fitted ahaz model.
- method="crit", the increase in the natural loss function of the semiparametric additive hazards model when the covariate is included in the model.

Value

A list containing the following elements:

- call The call that produced this object.
- idx A copy of the argument idx.
- adj Adjusted association statistic, as specified by method. Entries with index in idx are set to NA.
ahaz.partial

See Also

ahaz, ahaz.partial, ahazisis.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Adjust for first 10 covariates
idx <- 1:10
a <- ahaz.adjust(surv,X,idx=idx)

# Compare with (slower) solution
b <- apply(X[-idx],2,function(x)(coef(ahaz(surv,cbind(x,X[,idx])))[1]))
plot(b,a$adj[-idx])

ahaz.partial

Partial calculation of estimating quantities used by ahaz

Description

Partial calculation of the quantities used in the estimating equations for ahaz.

Usage

ahaz.partial(surv, X, weights, idx)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>surv</td>
<td>Response in the form of a survival object, as returned by the function Surv() in the package survival. Right-censored and counting process format (left-truncation) is supported. Tied survival times are not supported.</td>
</tr>
<tr>
<td>X</td>
<td>Design matrix. Missing values are not supported.</td>
</tr>
<tr>
<td>weights</td>
<td>Optional vector of observation weights. Default is 1 for each observation.</td>
</tr>
<tr>
<td>idx</td>
<td>Vector of indices of covariates to use in the calculations.</td>
</tr>
</tbody>
</table>
Details

The function is intended mainly for programming use when a very large number of covariates are considered and direct application of `ahaz` is unfeasible.

The estimating equations for the semiparametric additive hazards model are of the form $D\beta = d$ with $D$ a quadratic matrix with number of columns equal to the number of covariates. The present function returns $d[idx], D[idx,:], \text{and } B[idx,:];$ the latter a matrix such that $D^{-1}BD^{-1}$ estimates the covariance matrix of the regression coefficients.

Value

A list containing the following elements:

- `call` The call that produced this object.
- `idx` A copy of the argument `idx`.
- `nobs` Number of observations.
- `nvars` Number of covariates.
- `d` Vector of length `length(idx)`.
- `D` Matrix of size `length(idx) x nvars`.
- `B` Matrix of size `length(idx) x nvars`.

See Also

`ahaz`, `ahaz.adjust`.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Get D for the first 10 covariates only
ahaz.partial(surv,X,idx=1:10)
pD1 <- a$D

# Equivalent to the (slower) solution
ahaz(surv,X)

pD2 <- B$D[1:10,]
max(abs(pD1-pD2))
ahaz.tune.control

Tuning controls for regularization

Description
Define the type of tuning method used for regularization. Currently only used by tune.ahazpen.

Usage

# Cross-validation
cv.control(nfolds=5, reps=1, foldid=NULL, trace=FALSE)

# BIC-inspired
bic.control(factor = function(nobs)(log(nobs)))

Arguments

nfolds Number of folds for cross-validation. Default is nfolds=5. Each fold must have size > 1, i.e. nfolds must be less than half the sample size.
reps Number of repetitions of cross-validation with nfolds folds. Default is rep=1. A rep larger than 1 can be useful to reduce variance of cross-validation scores.
foldid An optional vector of values between 1 and nfolds identifying the fold to which each observation belongs. Supercedes nfolds and rep if supplied.
trace Print progress of cross-validation. Default is trace=FALSE.
factor Defines how strongly the number of nonzero penalty parameters penalizes the score in a BIC-type criterion; see the details.

Details

For examples of usage, see tune.ahazpen.

The regression coefficients of the semiparametric additive hazards model are estimated by solving a linear system of estimating equations of the form $D\beta = d$ with respect to $\beta$. The natural loss function for such a linear function is of the least-squares type

$$L(\beta) = \beta' D\beta - 2d' \beta.$$ 

This loss function is used for cross-validation as described by Martinussen & Scheike (2008).

Penalty parameter selection via a BIC-inspired approach was described by Gorst-Rasmussen & Scheike (2011). With $df$ is the degrees of freedom and $n$ the number of observations, we consider a BIC inspired criterion of the form

$$BIC = \kappa L(\beta) + df \cdot \text{factor}(n)$$

where $\kappa$ is a scaling constant included to remove dependency on the time scale and better mimic the behavior of a 'real' (likelihood) BIC. The default factor=function(n)(log(n)) has desirable theoretical properties but may be conservative in practice.
Value

An object with S3 class "ahaz.tune.control".

- **type**: Type of penalty.
- **factor**: Function specified by factor, if applicable
- **getfolds**: A function specifying how folds are calculated, if applicable.
- **rep**: How many repetitions of cross-validation, if applicable.
- **trace**: Print out progress?

References


See Also

tune.ahazpen

ahazisis

Independent screening for the semiparametric additive hazards model

Description

Fast and scalable model selection for the semiparametric additive hazards model via univariate screening combined with penalized regression.

Usage

```
ahazisis(surv, X, weights, standardize=TRUE, nsis=floor(nobs/1.5/log(nobs)), do.isis=TRUE, maxloop=5, penalty=sscad.control(), tune=cv.control(), rank=c("FAST","coef","z","crit"))
```

Arguments

- ** surv**: Response in the form of a survival object, as returned by the function `Surv()` in the package *survival*. Right-censored and counting process format (left-truncation) is supported. Tied survival times are not supported.
- ** X**: Design matrix. Missing values are not supported.
- ** weights**: Optional vector of observation weights. Default is 1 for each observation.
- ** standardize**: Logical flag for variable standardization, prior to model fitting. Estimates are always returned on the original scale. Default is `standardize=TRUE`. 
**nsis**
Number of covariates to recruit initially. If `do.isis=TRUE`, then this is also the maximal number of variables that the algorithm will recruit. Default is `nsis=floor(nobs/log(nobs)/1.5)`.

**do.isis**
Perform iterated independent screening?

**maxloop**
Maximal number of iterations of the algorithm if `do.isis=TRUE`.

**rank**
Method to use for (re)recruitment of variables. See details.

**penalty**
A description of the penalty function to be used for the variable selection part. This can be a character string naming a penalty function (currently "lasso" or stepwise SCAD, "sscad") or a call to the penalty function. Default is `penalty=sscad.control()`. See `ahazpen` and `ahazpen.pen.control` for more options and examples.

**tune**
A description of the tuning method to be used for the variable selection part. This can be a character string naming a tuning control function (currently "cv" or "bic") or a call to the tuning control function. Default is `tune=cv.control()`. See `ahaz.tune.control` for options and examples.

**Details**

The function is a basic implementation of the iterated sure independent screening method described in Gorst-Rasmussen & Scheike (2011). Briefly, the algorithm does the following:

1. Recruits the `nsis` most relevant covariates by ranking them according to the univariate ranking method described by `rank`.
2. Selects, using `ahazpen` with penalty function described in `penalty`, a model among the top two thirds of the `nsis` most relevant covariates. Call the size of this model `m`.
3. Recruits `nsis` minus `m` new covariates among the non-selected covariates by ranking their relevance according to the univariate ranking method described in `rank`, adjusted for the already selected variables (using an unpenalized semiparametric additive hazards model).

Steps 2-3 are iterated for `maxloop` times, or until `nsis` covariates has been recruited, or until the set of selected covariate is stable between two iterations; whichever comes first.

The following choices of ranking method exist:

- `rank="FAST"` corresponds to ranking, in the initial recruitment step only, by the basic FAST-statistic described in Gorst-Rasmussen & Scheike (2011). If `do.isis=TRUE` then the algorithm sets `rank="z"` for subsequent rankings.
- `rank="coef"` corresponds to ranking by absolute value of (univariate) regression coefficients, obtained via `ahaz`
- `rank="z"` corresponds to ranking by the `|Z|`-statistic of the (univariate) regression coefficients, obtained via `ahaz`
- `rank="crit"` corresponds to ranking by the size of the decrease in the (univariate) natural loss function used for estimation by `ahaz`.

**Value**

An object with S3 class "ahazisis".

**call**
The call that produced this object.
The initial ranking order.

List (of length at most maxloop) listing the covariates selected in each recruitment step.

List (of length at most maxloop) listing the covariates selected in each variable selection step.

List (of length at most maxloop) listing the estimated penalized regression coefficients corresponding to the indices in detail.ISISind.

Indices of covariates selected in the initial recruitment step.

Indices of the final set of covariates selected by the iterated algorithm.

Vector of the penalized regression coefficients of the covariates in ISISind.

The argument nsis.

The argument do.isis.

The argument maxloop.


See Also

`print.ahazisis`, `ahazpen`, `ahaz.adjust`

Examples

data(sorlie)

  # Break ties
  set.seed(10101)
  time <- sorlie$time+runif(nrow(sorlie))*1e-2

  # Survival data + covariates
  surv <- Surv(time,sorlie$status)
  X <- as.matrix(sorlie[,3:ncol(sorlie)]

  # Basic ISIS/SIS with a single step
  set.seed(10101)
  m1 <- ahazisis(surv,X,maxloop=1,rank="coef")
  m1

  # Indices of the variables from the initial recruitment step
  m1$ISISind

  # Indices of selected variables
  m1$ISISind

  # Check fit
  score <- X[,m1$ISISind]%%m1$ISIScoef
  plot(survfit(surv~I(score>median(score))))
ahazpen

Fit penalized semiparametric additive hazards model

Description

Fit a semiparametric additive hazards model via penalized estimating equations using, for example, the lasso penalty. The complete regularization path is computed at a grid of values for the penalty parameter lambda via the method of cyclic coordinate descent.

Usage

ahazpen(surv, X, weights, standardize=TRUE, penalty=lasso.control(),
  nllambda=100, dfmax=nvars, pmax=min(nvars, 2*dfmax),
  lambda.minf=ifelse(nobs < nvars,0.05, 1e-4), lambda,
  penalty.wgt=NULL, keep=NULL, control=list())

Arguments

surv Response in the form of a survival object, as returned by the function Surv() in the package survival. Right-censored and counting process format (left-truncation) is supported. Tied survival times are not supported.

X Design matrix. Missing values are not supported.

weights Optional vector of observation weights. Default is 1 for each observation.

standardize Logical flag for variable standardization, prior to model fitting. Estimates are always returned on the original scale. Default is standardize=TRUE.

penalty A description of the penalty function to be used for model fitting. This can be a character string naming a penalty function (currently "lasso" or stepwise SCAD, "sscad") or a call to the desired penalty function. See ahazpen.pen.control for the available penalty functions and advanced options; see also the examples.

nlambda The number of lambda values. Default is nllambda=100.

dfmax Limit the maximum number of variables in the model. Unless a complete regularization path is needed, it is highly recommended to initially choose a relatively smaller value of dfmax to substantially reduce computation time.

pmax Limit the maximum number of variables to ever be considered by the coordinate descent algorithm.

lambda.minf Smallest value of lambda, as a fraction of lambda.max, the (data-derived) smallest value of lambda for which all regression coefficients are zero. The default depends on the sample size nobs relative to the number of variables nvars. If nobs >= nvars, the default is 0.0001, close to zero. When nobs < nvars, the default is 0.05.

lambda An optional user supplied sequence of penalty parameters. Typical usage is to have the program compute its own lambda sequence based on nllambda and lambda.minf. A user-specified lambda sequence overrides dfmax but not pmax.
penalty.wgt A vector of nonnegative penalty weights for each regression coefficient. This is a number that multiplies \( \lambda \) to allow differential penalization. Can be 0 for some variables, which implies no penalization so that the variable is always included in the model; or \( \text{Inf} \) which implies that the variable is never included in the model. Default is 1 for all variables.

keep A vector of indices of variables which should always be included in the model (no penalization). Equivalent to specifying a penalty.wgt of 0.

control A list of parameters for controlling the model fitting algorithm. The list is passed to ahazpen.fit.control.

Details

Fits the sequence of models implied by the penalty function penalty, the sequence of penalty parameters \( \lambda \) by using the very efficient method of cyclic coordinate descent.

For data sets with a very large number of covariates, it is recommended to only calculate partial paths by specifying a smallish value of \( d_{\max} \).

The sequence \( \lambda \) is computed automatically by the algorithm but can also be set (semi)manually by specifying nlambda or \( \lambda \). The stability and efficiency of the algorithm is highly dependent on the grid \( \lambda \) values being reasonably dense, and \( \lambda \) (and nlambda) should be specified accordingly. In particular, it is not recommended to specify a single or a few lambda values. Instead, a partial regularization path should be calculated and the functions predict.ahazpen or coef.ahazpen should be used to extract coefficient estimates at specific lambda values.

Value

An object with S3 class "ahazpen".

call The call that produced this object

beta An \( nvars \times \text{length}(\lambda) \) matrix (in sparse column format, class dgCMatrix) of penalized regression coefficients.

lambda The sequence of actual \( \lambda \) values used.

df The number of nonzero coefficients for each value of \( \lambda \).

nobs Number of observations.

nvars Number of covariates.

surv A copy of the argument survival.

npasses Total number of passes by the fitting algorithm over the data, for all \( \lambda \) values.

penalty.wgt The actually used penalty.wgt.

penalty An object of class ahaz.pen.control, as specified by penalty.

dfmax A copy of dfmax.

penalty A copy of pmax.
References


See Also

print.ahazpen, predict.ahazpen, coef.ahazpen, plot.ahazpen, tune.ahazpen.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time, sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Fit additive hazards regression model
fit1 <- ahazpen(surv, X, penalty="lasso", dfmax=30)
plot(fit1)

# Extend the grid to contain exactly 100 lambda values
lrange <- range(fit1$lambda)
fit2 <- ahazpen(surv, X, penalty="lasso", lambda=exp(seq(log(lrange[1]), log(lrange[2]), length = 100))
plot(fit2)

# User-specified lambda sequence
lambda <- exp(seq(log(0.30), log(0.1), length = 100))
fit2 <- ahazpen(surv, X, penalty="lasso", lambda = lambda)
plot(fit2)

# Advanced usage - specify details of the penalty function
fit4 <- ahazpen(surv, X, penalty=sscad.control(nsteps=2))
fit4
fit5 <- ahazpen(surv, X, penalty=lasso.control(alpha=0.1))
plot(fit5)
ahazpen.fit.control  Controls for ahazpen fitting algorithm

Description

Controls the numerical algorithm for fitting the penalized semiparametric additive hazards model. This is typically only used in a call to ahazpen.

Usage

ahazpen.fit.control(thresh=1e-5, maxit=100000, ...)

Arguments

thresh Declare convergence when the maximal relative change from the last iteration is less than thresh. Default is thresh=1e-5.
maxit Maximal number passes by the algorithm over the data for all values of the regularization parameter lambda. Default is maxit=100000.
...

For future methods.

Value

A list with elements named as the arguments.

See Also

ahazpen

ahazpen.pen.control  Penalty controls for ahazpen

Description

Describe the penalty function to be used in the penalized semiparametric additive hazards model. Typically only used in a call to ahazpen or tune.ahazpen.

Usage

# (Adaptive) lasso/elasticnet
lasso.control(alpha=1, ada.wgt=NULL)

# Stepwise SCAD
sscad.control(a=3.7, nsteps=1, init.sol=NULL, c=NULL)
Arguments

alpha

Elasticnet penalty parameter with default alpha=1 corresponding to the standard lasso; see details.

ada.wgt

Optional covariate weights used for fitting the adaptive lasso. Default is not to use weights, i.e. fit the standard lasso. A user-specified init.sol can be a nonnegative vector of length corresponding to the number of covariates in the model.

For advanced use it may also be specified as a function with arguments surv, X and weights precisely; see the details.

a

Parameter of the stepwise SCAD penalty, see details. Default is a=3.7

nsteps

Number of steps in stepwise SCAD. Default is nsteps=1.

init.sol

Optional initial solution for stepwise SCAD consisting of a numerical vector of length corresponding to the number of covariates in the model. Default is a vector of regression coefficients obtained from ahaz if there are more observations than covariates, zero otherwise. For advanced use, initsol it can also be specified as a function with arguments surv, X and weights precisely; see the details.

c

Optional scaling factor for stepwise SCAD. Usually it is not necessary to change supply this; see the details.

Details

The lasso/elasticnet penalty function takes the form

\[ p_\lambda(\beta) = \lambda((1 - \alpha)\|\beta\|_2 + \alpha\|\beta\|_1) \]

where \(0 < \alpha \leq 1\). Choosing \(\alpha < 1\) encourages joint selection of correlated covariates and may improve the fit when there are substantial correlations among covariates.

The stepwise SCAD penalty function takes the form

\[ p_\lambda(\beta) = w_\lambda(c|b_1|)|\beta_1| + \ldots + w_\lambda(c|b_{nvars}|)|\beta_{nvars}| \]

where \(b\) is some initial estimate, \(c\) is a scaling factor, and for \(I\) the indicator function

\[ w_\lambda(x) = \lambda I(x \leq \lambda) + \frac{(a\lambda - x)_+}{a - 1} I(x > \lambda) \]

The scaling factor \(c\) controls how ‘different’ the stepwise SCAD penalty is from the standard lasso penalty (and is also used to remove dependency of the penalty on the scaling of the time axis).

The one-step SCAD method of Zou & Li (2008) corresponds to taking \(b\) equal to the estimator derived from \texttt{ahaz}. See Gorst-Rasmussen & Scheike (2011) for details. By iterating such one-step SCAD and updating the initial solution \(b\) accordingly, the algorithm approximates the solution obtained using full SCAD. Note that calculating the full SCAD solution generally leads to a non-convex optimization problem: multiple solutions and erratic behavior of solution paths can be an issue.

The arguments \texttt{ada.wgt} and \texttt{init.sol} can be specified as functions of the observations. This is convenient, for example, when using cross-validation for tuning parameter selection. Such a
function **must** be specified precisely with the arguments `surv`, `X` and `weights` and **must** output a numeric vector of length corresponding to the number of covariates. `ahazpen` will take care of scaling so the function should produce output on the original scale. See the examples here as well as the examples for `tune.ahazpen` for usage of this feature in practice.

**Value**

An object with S3 class "ahaz.pen.control".

- **type**: Type of penalty.
- **init.sol**: Function specifying the initial solution, if applicable.
- **alpha**: Value of alpha, if applicable.
- **nsteps**: Number of steps for stepwise SCAD penalty, if applicable.
- **a**: Parameter for stepwise SCAD penalty, if applicable.
- **c**: Scaling factor for stepwise SCAD penalty, if applicable.
- **ada.wgt**: Function specifying the weights for the adaptive lasso penalty, if applicable.

**References**


**See Also**

`ahazpen`, `tune.ahazpen`

**Examples**

```r
data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Fit additive hazards regression model with elasticnet penalty
model <- ahazpen(surv,X,penalty=lasso.control(alpha=0.1),dfmax=30)
plot(model)
```
# Adaptive lasso with weights $1/|\beta_i|^{0.5}$. Note that, although
# we do not use 'weights', it MUST be included as an argument
adafun <- function(surv,X,weights)
  return(1/abs(coef(ahaz(surv,X)))^0.5)
model <- ahazpen(surv,X[,1:50],penalty=lasso.control(ada.wgt=adafun))
plot(model)

# One-step SCAD with initial solution derived from univariate regressions
scadfun <- function(surv,X,weights){
  fit <- ahaz(surv,X,univariate=TRUE)
  return(coef(fit))
}
set.seed(10101)
model.ssc <- tune.ahazpen(surv,X,dfmax=30,penalty=sscad.control(init.sol=scadfun))
plot(model.ssc)

---

**plot.ahaz**

Plot an ahaz object

**Description**

Plot method for a fitted semiparametric additive hazards model; plots the Breslow estimate of underlying cumulative hazard function.

**Usage**

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

**Arguments**

- `x` The result of an ahaz fit.
- `...` Additional graphical arguments passed to the plot function.

**Details**

Calling plot.ahaz is equivalent to first calling ahaz, then calling predict with type="cumhaz", and finally calling plot.

**See Also**

ahaz, predict.ahaz, plot.cumahaz
Examples

data(sorlie)

# Break ties
set.seed(100101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,15:24])

# Fit additive hazards model
fit <- ahaz(surv, X)
plot(fit)

---

plot.ahazpen

Plot an ahazpen object

Description

Plots regularization paths for fitted penalized semiparametric additive hazards model.

Usage

## S3 method for class 'ahazpen'
plot(x, xvar=c("norm","lambda"), labels=FALSE, df=TRUE,
     ylab="Regression coefficients", xlab=xname,...)

Arguments

x

The result of an ahazpen fit.

xvar

Scaling for first axis. Options are the $L^1$ norm of the vector of regression coefficients ("norm") or the penalty parameter on a log scale ("lambda").

labels

Try to display indices for the regression coefficients in the right-hand margin. Default is labels=FALSE.

df

Display number of nonzero parameters in top margin. Default is df=TRUE.

ylab

Label for y-axis.

xlab

Label for x-axis. The default is either "L1 norm" or $\lambda$, depending on xvar.

... Additional graphical arguments passed to the plot function.

See Also

ahazpen, print.ahazpen, predict.ahazpen, coef.ahazpen.
Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Fit additive hazards regression model
fit <- ahazpen(surv, X, dfmax=50)
par(mfrow=c(1,2)); plot(fit); plot(fit,xvar="lambda")

# With labels only
plot(fit,labels=TRUE,df=FALSE)

---

plot.cumahaz

Plot a cumahaz object

Description

Plots the Breslow estimate of cumulative hazard function, as obtained from the predict.ahaz

Usage

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

Arguments

x

Result of a call to the predict.ahaz function with option type="cumhaz".

...

Additional graphical arguments passed to the plot function.

See Also

predict.ahaz,predict.ahazpen

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,15:24])

# Fit additive hazards regression model
fit <- ahaz(surv, X)

# Cumulative hazard
cumhaz <- predict(fit, type="cumhaz")
plot(cumhaz)

plot.tune.ahazpen  

Plot a tune.ahazpen object

Description

Plot, as a function of the penalty parameter, the curve of tuning scores produced when tuning a
penalized semiparametric additive hazards model.

Usage

## S3 method for class 'tune.ahazpen'
plot(x, df = TRUE, ...)

Arguments

x  The result of a call to tune.ahazpen.

df Display number of nonzero parameters in top margin. Default is df=TRUE.

... Additional graphical arguments passed to the plot function.

Details

A plot is produced displaying the tuning score for each value of penalty parameter (alongside upper
and lower standard deviation curves, if cross-validation has been used). The value of lambda which
minimizes the estimated tuning score is indicated with a dashed vertical line.

See Also

ahazpen, tune.ahazpen, print.tune.ahazpen.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time, sorlie$status)
predict.ahaz

\[
X <- \text{as.matrix(sorlie[,3:ncol(sorlie)])}
\]

# Do 10 fold cross-validation
set.seed(10101)
tune.fit <- tune.ahazpen(surv, X, penalty="lasso",
  dfmax=50, tune = cv.control(nfolds=10))
plot(tune.fit)

---

predict.ahaz  
**Prediction methods for ahaz**

### Description

Compute regression coefficients, linear predictor, cumulative hazard function, or integrated martingale residuals for a fitted semiparametric additive hazards model.

### Usage

```r
## S3 method for class 'ahaz'
predict(object, newX, type=c("coef", "lp",
  "residuals", "cumhaz"), beta=NULL, ...)
## S3 method for class 'ahaz'
coef(object, ...)
## S3 method for class 'ahaz'
vcov(object, ...)
## S3 method for class 'ahaz'
residuals(object, ...)
```

### Arguments

- **object**  
The result of an ahaz fit.
- **newX**  
Optional new matrix of covariates at which to do predictions. Currently only supported for type="lp".
- **type**  
Type of prediction. Options are the regression coefficients ("coef"), the linear predictor ("lp"), the martingale residuals ("residuals"), or the cumulative hazard ("cumhaz"). See the details.
- **beta**  
Optional vector of regression coefficients. If unspecified, the regression coefficients derived from object are used.
- **...**  
For future methods.

### Details

The Breslow estimator of the baseline cumulative hazard is described in Lin & Ying (1994).
The regression coefficients $\beta_0$ in the semiparametric additive hazards model are obtained as the solution $\hat{\beta}$ to a quadratic system of linear equations $D\hat{\beta} = d$. The (integrated) martingale residuals $\epsilon_i$ for $i = 1, \ldots, n$ are vectors, of length corresponding to the number of covariates, so that

$$D(\hat{\beta} - \beta_0) - d \approx \epsilon_1 + \cdots + \epsilon_n$$

The residuals estimate integrated martingales and are asymptotically distributed as mean-zero IID multivariate Gaussian. They can be used to derive a sandwich-type variance estimator for regression coefficients (implemented in \texttt{summary.ahaz} when \texttt{robust=TRUE} is specified). They can moreover be used for implementing consistent standard error estimation under clustering; or for implementing resampling-based inferential methods.

See Martinussen & Scheike (2006), Chapter 5.4 for details.

**Value**

For `type="coef"` and `type="lp"`, a vector of predictions.

For `type="coef"`, a matrix of (integrated) martingale residuals, with number of columns corresponding to the number of covariates.

For `type="cumhaz"`, an object with S3 class "cumahaz" consisting of:

- `time` Jump times for the cumulative hazard estimate.
- `cumhaz` The cumulative hazard estimate.
- `event` Status at jump times (1 corresponds to death, 0 corresponds to entry/exit).

**References**


**See Also**

\texttt{ahaz, summary.ahaz, plot.cumahaz}.

**Examples**

```r
data(sorlie)
set.seed(10101)

# Break ties
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time, sorlie$status)
X <- as.matrix(sorlie[,15:24])

# Fit additive hazards regression model
fit <- ahaz(surv, X)

# Parameter estimates
```
predict.ahazpen

Description

Compute regression coefficient estimates, linear predictor, cumulative hazard function, or integrated martingale residuals for a fitted penalized semiparametric additive hazards model.

Usage

```r
## S3 method for class 'ahazpen'
predict(object, newX, type=c("coef","lp","residuals","cumhaz"),
        lambda=NULL, ...)
## S3 method for class 'ahazpen'
coef(object, ...)
```

Arguments

- `object`: The result of an ahazpen fit.
- `newX`: New matrix of covariates at which to do predictions. Required unless `type="coef"`. 
lambda  Value of lambda for at which predictions are to be made. This argument is required for type="residuals" and type="cumhaz". Since predictions rely on interpolations between lambda values, it is recommended not to use a lambda-value smaller than the minimum of object$lambda.

type  The type of prediction. Options are the regression coefficients ("coef"), the linear predictors ("lp"), the (integrated) martingale residuals ("residuals"), or the cumulative hazard ("cumhaz")

...  For future methods.

Details
See the details in `predict.ahaz` for information on the different types of predictions.

Value
For type="coef" and type="lp", a matrix of regression coefficients, respectively linear predictions for each value of the penalty parameter.
For type="residuals", a matrix of (integrated) martingale residuals associated with the nonzero penalized regression coefficients for a regularization parameter equal to lambda.
For type="cumhaz", an object with S3 class "cumhaz" based on the regression coefficients estimated for a regularization parameter equal to lambda, the object containing:

time  Jump times for the cumulative hazard estimate.
cumhaz  The cumulative hazard estimate.
event  Status at jump times (1 corresponds to death, 0 corresponds to entry/exit).

See Also
`ahazpen`, `print.ahazpen`, `plot.ahazpen`, `predict.ahaz`, `plot.cumhaz`.

Examples

data(sorlie)

set.seed(10101)

# Break ties
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Fit additive hazards regression model w/lasso penalty
fit <- ahazpen(surv, X, dfmax=100)

# Coefficients
beta <- predict(fit,X,lambda=0.08,type="coef")
barplot(as.numeric(beta))
# Linear predictions
linpred <- predict(fit, X, lambda=0.1, type="lp")
riskgrp <- factor(linpred < median(linpred))
plot(survfit(surv~riskgrp))

# Residuals
resid <- predict(fit, X, lambda=0.1, type = "residuals")
par(mfrow = c(1,2))
hist(resid[,1],main=colnames(resid)[1])
hist(resid[,2],main=colnames(resid)[2])

# Cumulative hazard
cumhaz <- predict(fit,X,lambda=0.1,type="cumhaz")
plot(cumhaz)

---

**predict.tune.ahazpen**  
*Prediction methods for tune.ahazpen*

**Description**

Compute regression coefficient estimates, linear predictor, cumulative hazard function, or integrated martingale residuals for a fitted and tuned penalized semiparametric additive hazards model.

**Usage**

```r
## S3 method for class 'tune.ahazpen'
predict(object, newX, lambda="lambda.min", ...)
## S3 method for class 'tune.ahazpen'
coef(object, ...)
```

**Arguments**

- `object`: The result of an ahazpen fit.
- `newX`: New matrix of covariates at which to do predictions. Required for some types of predictions, see `predict.ahazpen`.
- `lambda`: Value of lambda at which predictions are to be made. Required for some types of predictions, see `predict.ahazpen`. Default is the optimal lambda value saved in object.
- `...`: Additional arguments to be passed to `predict.ahazpen` (usually the type of prediction required).

**Details**

See the details in `predict.ahazpen` for information on the available types of predictions.
Value
The object returned depends on the details in the argument ... passed to predict.ahazpen.

See Also
predict.ahazpen, ahazpen, print.ahazpen, plot.ahazpen, predict.ahaz, plot.cumahaz.

Examples

data(sorlie)

set.seed(10101)

# Break ties
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Fit additive hazards regression model w/lasso penalty
cv.fit <- tune.ahazpen(surv, X, dfmax=100, tune="cv")

# Predict coefficients at cv.fit$lambda.min
coef(cv.fit)

# Predict risk score at cv.fit$lambda.min
predict(cv.fit,newX=X,type="lp")
Details

The call that produced x is printed, alongside the number of covariates initially recruited, the number of covariates finally recruited (if applicable) and the number of iterations (if applicable).

See Also

ahazisis

print.ahazpen

Print an ahazpen object

Description

Print method for fitted penalized semiparametric additive hazards model.

Usage

## S3 method for class 'ahazpen'
print(x, digits=max(3, getOption("digits") - 3), ...)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Fitted ahazpen object.</td>
</tr>
<tr>
<td>digits</td>
<td>Significant digits to print.</td>
</tr>
<tr>
<td>...</td>
<td>For future methods.</td>
</tr>
</tbody>
</table>

Details

The call that produced x is printed, alongside the number of observations, the number of covariates, and details on the sequence of penalty parameters.

See Also

ahazpen, predict.ahazpen, coef.ahazpen.
print.summary.ahaz \hspace{1cm} \textit{Print a summary.ahaz object}

\section*{Description}

Produces a printed summary of a fitted semiparametric additive hazards model.

\section*{Usage}

\begin{verbatim}
## S3 method for class 'summary.ahaz'
print(x, digits=max(getOption("digits") - 3, 3),
    signif.stars=getOption("show.signif.stars"), ...)
\end{verbatim}

\section*{Arguments}

\begin{itemize}
  \item \textbf{x} \hspace{1cm} The result of a call to \texttt{summary.ahaz}.
  \item \textbf{digits} \hspace{1cm} Significant digits to print.
  \item \textbf{signif.stars} \hspace{1cm} Show stars to highlight small p-values.
  \item \textbf{...} \hspace{1cm} For future methods.
\end{itemize}

\section*{See Also}

\texttt{summary.ahaz, ahaz, plot.ahaz}.

---

\section*{print.tune.ahazpen \hspace{1cm} \textit{Print a tune.ahazpen object}}

\section*{Description}

Print method for \texttt{tune.ahazpen} objects.

\section*{Usage}

\begin{verbatim}
## S3 method for class 'tune.ahazpen'
print(x, digits=max(3, getOption("digits") - 3), ...)
\end{verbatim}

\section*{Arguments}

\begin{itemize}
  \item \textbf{x} \hspace{1cm} The result of a call to \texttt{tune.ahazpen}.
  \item \textbf{digits} \hspace{1cm} Significant digits in printout.
  \item \textbf{...} \hspace{1cm} Additional print arguments.
\end{itemize}
Details

The call that produced `x` is printed, alongside the number of penalty parameters used, the value of the optimal penalty and the number of non-zero regression coefficients at the optimal penalty parameter.

See Also

`ahazpen`, `tune.ahazpen`, `plot.tune.ahazpen`.

---

sorlie  

Sorlie gene expressions

Description

Dataset containing 549 gene expression measurement, exit time and exit status in a study of breast cancer among 115 women.

Usage

data(sorlie)

Format

- `time`  Time to exit.
- `status`  Status at exit (censoring = 0, event = 1).
- `X1,...,X549`  Gene expression measurements.

References


Examples

data(sorlie)
summary.ahaz

Summarize an ahaz object

Description

Produces a summary of a fitted semiparametric additive hazards model.

Usage

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

Arguments

- **object**: The result of an ahaz fit.
- **...**: For future methods.

Value

An object with S3 class "summary.ahaz".

- **call**: The call that produced this object.
- **coefficients**: Vector of regression coefficients.
- **cov**: Estimated covariance matrix of regression coefficients.
- **nobs**: Number of observations.
- **nvars**: Number of covariates
- **waldtest**: Vector of quantities from a Wald test.
- **univar**: Logical: summarizing univariate regressions (option univariate in ahaz)?

See Also

ahaz, plot.ahaz

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time, sorlie$status)
X <- as.matrix(sorlie[,15:25])

# Fit additive hazards model
fit1 <- ahaz(surv, X)
summary(fit1)
**tune.ahazpen**  
*Choice of penalty parameter in ahazpen*

**Description**

Tuning of penalty parameters for the penalized semiparametric additive hazards model via cross-validation - or via non-stochastic procedures, akin to BIC for likelihood-based models.

**Usage**

```r
tune.ahazpen(surv, X, weights, standardize=TRUE, penalty=lasso.control(),
             tune=cv.control(), dfmax=nvars, lambda, ...)
```

**Arguments**

- **surv**
  Response in the form of a survival object, as returned by the function `Surv()` in the package `survival`. Right-censored and counting process format (left-truncation) is supported. Tied survival times are not supported.

- **X**
  Design matrix. Missing values are not supported.

- **weights**
  Optional vector of observation weights. Default is 1 for each observation.

- **standardize**
  Logical flag for variable standardization, prior to model fitting. Parameter estimates are always returned on the original scale. Default is `standardize=TRUE`.

- **penalty**
  A description of the penalty function to be used for model fitting. This can be a character string naming a penalty function (currently "lasso" or step-wise SCAD, "sscad") or it can be a call to the penalty function. Default is `penalty=lasso.control()`. See `ahazpen.pen.control` for the available penalty functions and advanced options; see also the examples.

- **dfmax**
  Limit the maximum number of covariates included in the model. Default is `dfmax=nvars-1`. Unless a complete regularization path is needed, it is highly recommended to initially choose a relatively smaller value of `dfmax` to reduce computation time and memory usage.

- **lambda**
  An optional user supplied sequence of penalty parameters. Typical usage is to have the program compute its own lambda sequence based on `nlambda` and `lambda.min`.

- **tune**
  A description of the tuning method to be used. This can be a character string naming a tuning control function (currently "cv" or "bic") or a call to the tuning control function. Default is 5-fold cross-validation, `tune=cv.control()`, see `ahaz.tune.control` for more options. See also the examples.

- **...**
  Additional arguments to be passed to `ahazpen`, see `ahazpen` for options.

**Details**

The function performs an initial penalized fit based on the penalty supplied in `penalty` to obtain a sequence of penalty parameters. Subsequently, it selects among these an optimal penalty parameter based on the tuning control function described in `tune`, see `ahaz.tune.control`. 
Value

An object with S3 class "tune.ahazpen".

call The call that produced this object.
lambda The actual sequence of lambda values used.
tunem The tuning score for each value of lambda (mean cross-validated error, if tune=cv_control()).
tunemsd Estimate of the cross-validated standard error, if tune=cv_control().
tunelo Lower curve = tunem-tunemsd, if tune=cv_control().
tuneup Upper curve = tunem+tunemsd, if tune=cv_control().
lambda.min Value of lambda for which tunem is minimized.
df Number of non-zero coefficients at each value of lambda.
tune The selected tune of S3 class "ahaz.tune.control".
penalty The selected penalty of S3 class "ahazpen.pen.control".
foldsused Folds actually used, if tune=cv_control().

References


See Also

ahaz.tune.control, plot.tune.ahazpen, ahazpen.

Examples

data(sorlie)

# Break ties
set.seed(10101)
time <- sorlie$time+runif(nrow(sorlie))*1e-2

# Survival data + covariates
surv <- Surv(time,sorlie$status)
X <- as.matrix(sorlie[,3:ncol(sorlie)])

# Training/test data
set.seed(20202)
train <- sample(1:nrow(sorlie),76)
test <- setdiff(1:nrow(sorlie),train)

# Run cross validation on training data
set.seed(10101)

CV.las <- tune.ahazpen(surv[train,, X[train,, dfmax=30])
plot(CV.las)

# Check fit on the test data
```r
testrisk <- predict(cv.las.X[test,], type="lp")
plot(survfit(surv[test,]~I(testrisk<median(testrisk))), main="Low versus high risk")

# Advanced example, cross-validation of one-step SCAD
# With initial solution derived from univariate models.
# Since init.sol is specified as a function, it is
# automatically cross-validated as well.
scadfun <- function(surv, X, weights)(coef(ahaz(surv, X, univariate=TRUE)))
set.seed(10101)
cv.ssc <- tune.ahazpen(surv[train,] X[train,],
              penalty=sscad.control(init.sol=scadfun),
              tune=cv.control(rep=5), dfmax=30)
# Check fit on test data

testrisk <- predict(cv.ssc, X[test,], type="lp")
plot(survfit(surv[test,]~I(testrisk<median(testrisk))), main="Low versus high risk")
```

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