

Package ‘boostrq’

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Type Package

Title Boosting Regression Quantiles

Version 1.0.0

Description Boosting Regression Quantiles is a component-wise boosting algorithm, that embeds all boosting steps in the well-established framework of quantile regression. It is initialized with the corresponding quantile, uses a quantile-specific learning rate, and uses quantile regression as its base learner. The package implements this algorithm and allows cross-validation and stability selection.

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URL <https://github.com/stefanlinner/boostrq>

BugReports <https://github.com/stefanlinner/boostrq/issues>

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Author Stefan Linner [aut, cre, cph]

Maintainer Stefan Linner <stefan.linner97@gmail.com>

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boostrq	<i>Fitting a boosting regression quantiles model</i>
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Description

Component-wise functional gradient boosting algorithm to fit a quantile regression model.

Usage

```
boostrq(
  formula,
  data,
  mstop = 100,
  nu = NULL,
  tau = 0.5,
  offset = NULL,
  weights = NULL,
  oobweights = NULL,
  risk = "inbag",
  digits = 10,
  exact.fit = FALSE
)
```

Arguments

formula	a symbolic description of the model to be fit.
data	a data frame (or data.table) containing the variables stated in the formula.
mstop	number of iterations, as integer
nu	learning rate, as numeric
tau	quantile parameter, as numeric
offset	a numeric vector used as offset.

<code>weights</code>	(optional) a numeric vector indicating which weights to used in the fitting process (default: all observations are equally weighted, with 1).
<code>oobweights</code>	an additional vector of out-of-bag weights, which is used for the out-of-bag risk.
<code>risk</code>	string indicating how the empirical risk should be computed for each boosting iteration. <code>inbag</code> leads to risks computed for the learning sample (i.e. observations with non-zero weights), <code>oobag</code> to risks based on the out-of-bag (i.e. observations with non-zero <code>oobagweights</code>).
<code>digits</code>	number of digits the slope parameter different from zero to be considered the best-fitting component, as integer.
<code>exact.fit</code>	logical, if set to <code>TRUE</code> the negative gradients of exact fits are set to 0.

Value

A (generalized) additive quantile regression model is fitted using the boosting regression quantiles algorithm, which is a functional component-wise boosting algorithm. The base-learner can be specified via the formula object. `brq` (linear quantile regression) and `brqss` (nonlinear quantile regression) are available base-learner.

Examples

```
boosted.rq <-
boostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

boosted.rq$mstop()

boosted.rq$selection.freqs()

boosted.rq$coef()

boosted.rq$risk()
```

brq

base learner for boosting linear regression quantiles

Description

Base-learner for linear quantile regression.

Usage

```
brq(formula, method = "fn")
```

Arguments

formula	a symbolic description of the base learner.
method	the algorithm used to fit the quantile regression, the default is set to "fn", referring to the Frisch-Newton inferior point method. For more details see the documentation of <code>quantreg::rq</code> .

Value

`brq` returns a string, which is used to specify the formula in the fitting process.

Examples

```
brq(cyl * hp)
```

<code>coef.boostrq</code>	<i>estimated coefficients of boosting regression quantiles</i>
---------------------------	--

Description

estimated coefficients of boosting regression quantiles

Usage

```
## S3 method for class 'boostrq'
coef(object, which = NULL, aggregate = "sum", ...)
```

Arguments

object	object of class <code>boostrq</code>
which	a subset of base-learners
aggregate	a character specifying how to aggregate coefficients of single base learners. The default returns the coefficient for the final number of boosting iterations. "cumsum" returns a list with matrices (one per base-learner) with the cumulative coefficients for all iterations. "none" returns a list of matrices where the <i>j</i> th columns of the respective matrix contains coefficients of the base-learner of the <i>j</i> th boosting iteration. <code>v "sum_aggr" ...</code>
...	additional arguments passed to callies

Value

`coef` extracts the regression coefficients of the fitted `boostrq` model.

Examples

```

boosted.rq <-
boostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

coef(boosted.rq, aggregate = "cumsum")

```

cvrisk.boostrq

Crossvalidation for boostrq

Description

Crossvalidation for boostrq

Usage

```

## S3 method for class 'boostrq'
cvrisk(
  object,
  folds = mboost::cv(object$weights, type = "kfold"),
  grid = 0:mstop(object),
  papply = parallel::mclapply,
  mc.preschedule = FALSE,
  fun = NULL,
  ...
)

```

Arguments

object	a boostrq object
folds	a matrix indicating the weights for the k resampling iterations
grid	a vector of stopping parameters the empirical quantile risk is to be evaluated for.
papply	(parallel) apply function, defaults to mclapply. To run sequentially (i.e. not in parallel), one can use lapply.
mc.preschedule	preschedule tasks if are parallelized using mclapply (default: FALSE)? For details see mclapply.
fun	if fun is NULL, the out-of-sample risk is returned. fun, as a function of object, may extract any other characteristic of the cross-validated models. These are returned as is.
...	additional arguments passed to callies

Value

Cross-validated Boosting regression quantiles

Examples

```

boosted.rq <-
boostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

set.seed(101)

cvk.out <-
cvrisk(
  boosted.rq,
  grid = 0:mstop(boosted.rq),
  folds = mboost::cv(boosted.rq$weights, type = "kfold", B = 5)
)

cvk.out

plot(cvk.out)

mstop(cvk.out)

boosted.rq[mstop(cvk.out)]

```

fitted.boostrq

fitted values of boosting regression quantiles

Description

fitted values of boosting regression quantiles

Usage

```

## S3 method for class 'boostrq'
fitted(object, ...)

```

Arguments

object	object of class boostrq
...	additional arguments passed to callies

Value

fitted returns the fitted values of the fitted boostrq model.

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
fitted(boosted.rq)
```

mstop.boostrq	<i>Current number of iterations of boostrq</i>
---------------	--

Description

Current number of iterations of boostrq

Usage

```
## S3 method for class 'boostrq'  
mstop(object, ...)
```

Arguments

object	a boostrq object
...	additional arguments passed to callies

Value

current number of boosting iterations

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)
```

```
mstop(boosted.rq)
```

```
predict.bostrq      Model predictions for boosting regression quantiles
```

Description

Model predictions for boosting regression quantiles

Usage

```
## S3 method for class 'bostrq'
predict(object, newdata = NULL, which = NULL, aggregate = "sum", ...)
```

Arguments

object	a bostrq object
newdata	a data.frame (or data.table) including all covariates contained in the baselearners
which	a subset of base-learners
aggregate	a character specifying how to aggregate coefficients of single base learners. The default returns the coefficient for the final number of boosting iterations. "cumsum" returns a list with matrices (one per base-learner) with the cumulative coefficients for all iterations. "none" returns a list of matrices where the jth columns of the respective matrix contains coefficients of the base-learner of the jth boosting iteration.
...	additional arguments passed to callies

Value

predictions for the new data

Examples

```
boosted.rq <-
bostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

predict.data <- data.frame(hp = 165, cyl = 6, am = 1, wt = 3.125)

predict(boosted.rq, newdata = predict.data)
```

print.boostrq	<i>printing boosting regression quantiles</i>
---------------	---

Description

printing boosting regression quantiles

Usage

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

Arguments

x	object of class boostrq
...	additional arguments passed to callies

Value

print shows a dense representation of the boostrq model fit.

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
boosted.rq
```

print.summary.boostrq	<i>Print result summaries for a boostrq object</i>
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Description

Print result summaries for a boostrq object

Usage

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

Arguments

x a summary.bostrq object
 ... additional arguments passed to callies

Value

printing the result summaries for a bostrq object including the print-information, estimated coefficients, and selection frequencies

Examples

```
boosted.rq <-
bostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

summary(boosted.rq)
```

residuals.bostrq *residuals of boosting regression quantiles*

Description

residuals of boosting regression quantiles

Usage

```
## S3 method for class 'bostrq'
residuals(object, ...)
```

Arguments

object object of class bostrq
 ... additional arguments passed to callies

Value

residuals returns the residuals of the fitted bostrq model.

Examples

```
boosted.rq <-  
bostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
residuals(boosted.rq)
```

risk.bostrq	<i>Empirical Quantile Risk of bostrq Object</i>
-------------	---

Description

Empirical Quantile Risk of bostrq Object

Usage

```
## S3 method for class 'bostrq'  
risk(object, ...)
```

Arguments

object	a bostrq object
...	additional arguments passed to callies

Value

numeric vector containing the respective empirical quantile risk of the different boosting iterations.

Examples

```
boosted.rq <-  
bostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
risk(boosted.rq)
```

selected.boostrq *Extract indices of selected base learners*

Description

Extract indices of selected base learners

Usage

```
## S3 method for class 'boostrq'  
selected(object, ...)
```

Arguments

object a boostrq object
... additional arguments passed to callies

Value

an index vector indicating the selected base learner in each iteration

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
selected(boosted.rq)
```

stabsel.boostrq *Stability Selection for boosting regression quantiles*

Description

Stability Selection for boosting regression quantiles

Usage

```
## S3 method for class 'boostrq'
stabsel(
  x,
  cutoff,
  q,
  PFER,
  grid = 0:mstop(x),
  folds = stabs::subsample(x$weights, B = B),
  B = ifelse(sampling.type == "MB", 100, 50),
  assumption = "unimodal",
  sampling.type = "SS",
  papply = parallel::mclapply,
  verbose = TRUE,
  ...
)
```

Arguments

x	a fitted model of class "boostrq"
cutoff	cutoff between 0.5 and 1. Preferably a value between 0.6 and 0.9 should be used
q	number of (unique) selected components (base-learners) that are selected in each subsample.
PFER	upper bound for the per-family error rate. This specifies the amount of falsely selected base-learners, which is tolerated.
grid	a numeric vector of the form 0:m.
folds	a weight matrix with number of rows equal to the number of observations. Usually one should not change the default here as subsampling with a fraction of 1/2 is needed for the error bounds to hold.
B	number of subsampling replicates. Per default, we use 50 complementary pairs for the error bounds of Shah & Samworth (2013) and 100 for the error bound derived in Meinshausen & Buehlmann (2010). As we use B complementary pairs in the former case this leads to 2B subsamples.
assumption	Defines the type of assumptions on the distributions of the selection probabilities and simultaneous selection probabilities. Only applicable for sampling.type = "SS". For sampling.type = "MB" we always use code "none".
sampling.type	use sampling scheme of Shah & Samworth (2013), i.e., with complementary pairs (sampling.type = "SS"), or the original sampling scheme of Meinshausen & Buehlmann (2010).
papply	(parallel) apply function, defaults to mclapply. To run sequentially (i.e. not in parallel), one can use lapply.
verbose	logical (default: TRUE) that determines whether warnings should be issued.
...	additional arguments passed to callies

Value

An object of class stabsel.

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl) + brq(hp) + brq(am) + brq(wt) + brq(drat),  
  data = mtcars,  
  mstop = 600,  
  nu = 0.1,  
  tau = 0.5  
)  
  
stabsel_parameters(  
  q = 3,  
  PFER = 1,  
  p = 5,  
  sampling.type = "SS",  
  assumption = "unimodal"  
)  
  
set.seed(100)  
brq.stabs <-  
stabsel(  
  x = boosted.rq,  
  q = 3,  
  PFER = 1,  
  sampling.type = "SS",  
  assumption = "unimodal"  
)  
  
brq.stabs
```

summary.boostrq

Result summaries for a boostrq object

Description

Result summaries for a boostrq object

Usage

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

Arguments

object a bostrq object
 ... additional arguments passed to callies

Value

result summaries for a bostrq object including the print-information, estimated coefficients, and selection frequencies

Examples

```
boosted.rq <-
bostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

summary(boosted.rq)
```

update.bostrq *Update and Re-fit a bostrq model*

Description

Update and Re-fit a bostrq model

Usage

```
## S3 method for class 'bostrq'
update(object, weights, oobweights, risk, ...)
```

Arguments

object a bostrq object
 weights (optional) a numeric vector indicating which weights to used in the fitting process (default: all observations are equally weighted, with 1).
 oobweights an additional vector of out-of-bag weights, which is used for the out-of-bag risk.
 risk string indicating how the empirical risk should be computed for each boosting iteration. inbag leads to risks computed for the learning sample (i.e. observations with non-zero weights), oobag to risks based on the out-of-bag (i.e. observations with non-zero oobagweights).
 ... additional arguments passed to callies

Value

a re-fitted boostrq model

Examples

```
boosted.rq <-
boostrq(
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),
  data = mtcars,
  mstop = 200,
  nu = 0.1,
  tau = 0.5
)

update(
  boosted.rq,
  weights = c(rep(1, 30), 0, 0),
  oobweights = c(rep(0, 30), 1,1),
  risk = "oobag"
)
```

[.boostrq

Updating number of iterations

Description

Updating number of iterations

Usage

```
## S3 method for class 'boostrq'
x[i, return = TRUE, ...]
```

Arguments

x	a boostrq object
i	desired number of boosting iterations
return	TRUE, if the result should be returned
...	additional arguments passed to callies

Value

a boostrq object with the updated number of iterations

Examples

```
boosted.rq <-  
boostrq(  
  formula = mpg ~ brq(cyl * hp) + brq(am + wt),  
  data = mtcars,  
  mstop = 200,  
  nu = 0.1,  
  tau = 0.5  
)  
  
boosted.rq[500]
```

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