Package 'ConformalSmallest'

October 12, 2022

Title Efficient Tuning-Free Conformal Prediction

Version 1.0

Description An implementation of efficiency first conformal prediction (EFCP) and validity first conformal prediction (VFCP) that demonstrates both validity (coverage guarantee) and efficiency (width guarantee). To learn how to use it, check the vignettes for a quick tutorial. The package is based on the work by Yang Y., Kuchibhotla A.,(2021) <arxiv:2104.13871>.

URL https://github.com/Elsa-Yang98/ConformalSmallest

Imports glmnet, mvtnorm, stats, MASS, quantregForest

License GPL (>= 3)

Encoding UTF-8

RoxygenNote 7.1.1

LazyData true

Suggests testthat (>= 3.0.0), knitr, rmarkdown, ggplot2, repr

Config/testthat/edition 3

Depends R (>= 3.5.0)

VignetteBuilder knitr

NeedsCompilation no

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R topics documented:

`conf_CQR` *Conditional width and coverage for CQR, internal function used inside conf_CQR_conditional*

Description

Conditional width and coverage for CQR, internal function used inside conf_CQR_conditional

Usage

```
conf_CQR(X1, Y1, X2, Y2, beta, mtry, ntree, alpha = 0.1)
```

Arguments

`X1`	training matrix to fit the quantile regression forest
`Y1`	training vector
`X2`	training matrix to compute the conformal scores
`Y2`	training vector to compute the conformal scores
`beta`	nominal quantile level
`mtry`	random forest parameter
`ntree`	random forest parameter
`alpha`	miscoverage level

Value

a function for computing conditional width and coverage

conf_CQR_conditional *Conditional width and coverage for CQR*

Description

Conditional width and coverage for CQR

Usage

```
conf_CQR_conditional(x, y, beta, mtry, ntree, alpha = 0.1)
```

Arguments

x	A N*d training matrix
y	A N*1 training vector
beta	nominal quantile level
mtry	random forest parameter
ntree	random forest parameter
alpha	miscoverage level

Value

a function for computing conditional width and coverage

conf_CQR_prelim *preliminary function for CQR*

Description

preliminary function for CQR

Usage

```
conf_CQR_prelim(X1, Y1, X2, Y2, beta_grid, mtry, ntree, alpha = 0.1)
```

Arguments

X1	A n1*d matrix for training
Y1	A n1*1 vector for training
X2	A n2*d matrix for calibration
Y2	A n2*1 vector for calibration
beta_grid	a grid of beta's
mtry	mtry parameter in random forest
ntree	number of trees parameter in random forest
alpha	miscoverage level

Value

the smallest width and its corresponding beta

`conf_CQR_reg` *EFCP and VFCP for CQR, CQR-m, CQR-r*

Description

EFCP and VFCP for CQR, CQR-m, CQR-r

Usage

```
conf_CQR_reg(
  x,
  y,
  split,
  beta_grid,
  mtry_grid,
  ntree_grid,
  method = "efficient",
  alpha = 0.1
)
```

Arguments

`x`	A N*d training matrix
`y`	A N*1 training vector
`split`	a vector of length 1 for efcp, length 2 for vfcp
`beta_grid`	a grid of beta's
`mtry_grid`	a grid of mtry
`ntree_grid`	a grid of ntree
`method`	"efficient" for efcp; "valid" for vfcp
`alpha`	miscoverage level

Value

the selected cqr method

`conf_CQR_reg_conditional` *Conditional width and coverage for EFCP, VFCP between CQR, CQR-m, CQR-r*

Description

Conditional width and coverage for EFCP, VFCP between CQR, CQR-m, CQR-r

Usage

```
conf_CQR_reg_conditional(
  x,
  y,
  split,
  beta_grid,
  mtry_grid,
  ntree_grid,
  method = "efficient",
  alpha = 0.1
)
```

Arguments

`x`	A N*d training matrix
`y`	A N*1 training vector
`split`	a vector of length 1 for efcp, length 2 for vfcp
`beta_grid`	a grid of beta's
`mtry_grid`	a grid of mtry
`ntree_grid`	a grid of ntree
`method`	"efficient" for efcp; "valid" for vfcp
`alpha`	miscoverage level

Value

the selected cqr method

cv.fun *Cross validation conformal prediction for ridge regression*

Description

Cross validation conformal prediction for ridge regression

Usage

```
cv.fun(X, Y, X0, lambda = seq(0, 100, length = 100), nfolds = 10, alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
nfolds	number of folds
alpha	miscoverage level

Value

upper and lower prediction intervals for X0

efcp.fun *Efficiency first conformal prediction for ridge regression*

Description

Efficiency first conformal prediction for ridge regression

Usage

```
efcp.fun(X, Y, X0, lambda = seq(0, 100, length = 100), alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
alpha	miscoverage level

Value

upper and lower prediction intervals for X0.

Examples

```
df=3
d = 5
n=50   #number of training samples
n0=10  #number of prediction points
rho=0.5
Sigma=matrix(rho,d,d)
diag(Sigma)=rep(1,d)
beta=rep(1:5,d/5)
X0=mvtnorm::rmvt(n0,Sigma,df)
X=mvtnorm::rmvt(n,Sigma,df) #multivariate t distribution
eps=rt(n,df)*(1+sqrt(X[,1]^2+X[,2]^2))
Y=X%*%beta+eps
out.efcp=efcp.fun(X,Y,X0)
out.efcp$up
out.efcp$lo
```

`efcp_cqr` *Efficiency first conformal prediction for Conformal Quantile Regression*

Description

Efficiency first conformal prediction for Conformal Quantile Regression

Usage

```
efcp_cqr(x, y, split, beta_grid, params_grid, alpha = 0.1)
```

Arguments

`x`	A N*d training matrix
`y`	A N*1 training vector
`split`	a number between 0 and 1
`beta_grid`	a grid of beta's
`params_grid`	a grid of mtry and ntree
`alpha`	miscoverage level

Value

average prediction width and a function for coverage on some testing points

efcp_ridge *Efficiency first conformal prediction for ridge regression*

Description

Efficiency first conformal prediction for ridge regression

Usage

```
efcp_ridge(X, Y, X0, lambda = seq(0, 100, length = 100), alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
alpha	miscoverage level

Value

upper and lower prediction intervals for X0.

Examples

```
df=3
d = 5
n=50   #number of training samples
n0=10  #number of prediction points
rho=0.5
Sigma=matrix(rho,d,d)
diag(Sigma)=rep(1,d)
beta=rep(1:5,d/5)
X0=mvtnorm::rmvt(n0,Sigma,df)
X=mvtnorm::rmvt(n,Sigma,df) #multivariate t distribution
eps=rt(n,df)*(1+sqrt(X[,1]^2+X[,2]^2))
Y=X%*%beta+eps
out.efcp=efcp.fun(X,Y,X0)
out.efcp$up
out.efcp$lo
```

ginverse.fun *Conformal prediction for linear regression*

Description

Conformal prediction for linear regression

Usage

```
ginverse.fun(x, y, x0, alpha = 0.1)
```

Arguments

x	A N*d training matrix
y	A N*1 training vector
x0	A N0*d testing vector
alpha	miscoverage level

Value

upper and lower prediction intervals for X0

ginverselm.funs *Internal function used for ginverse.fun*

Description

Internal function used for ginverse.fun

Usage

```
ginverselm.funs(intercept = TRUE, lambda = 0)
```

Arguments

intercept	default is TRUE
lambda	a vector

my.ginverselm.funs *Internal function used for ginverse.fun*

Description

Internal function used for ginverse.fun

Usage

```
my.ginverselm.funs
```

Format

An object of class `list` of length 4.

naive.fun *Conformal prediction for linear regression*

Description

Conformal prediction for linear regression

Usage

```
naive.fun(X, Y, X0, alpha = 0.1)
```

Arguments

`X`	A N*d training matrix
`Y`	A N*1 training vector
`X0`	A N0*d testing vector
`alpha`	miscoverage level

Value

upper and lower prediction intervals for X0

pois_n400_reps100 *Outcomes of an example for tuning-free conformalized quantile regression(CQR).*

Description

A dataset containing the experiment results used in the vignettes.

Usage

```
pois_n400_reps100
```

Format

A list with 10 elements: x_test, n,nrep,width_mat, cov_mat,beta_mat, ntree_mat, cqr_method_mat, evaluations, alpha

x_test test points of x

n number of training samples

nrep number of replications

width_mat a data frame with the first column being the width of the prediction regions

cov_mat a data frame with the first column being the coverage of the prediction regions

beta_mat a data frame with the first column being the beta for CQR used in the final prediction

ntree_mat a data frame with the first column being the number of trees for CQR used in the final prediction

ntree_mat a data frame with the first column being the CQR method (among CQR, CQR-m, CQR-r)used in the final prediction

alpha desired miscoverage level

Source

For details please see the "Example-tuning_free_CQR" vignette:`vignette("Example-tuning_free_CQR", package = "ConformalSmallest")`

`ridge_linear_cov100_t3`

Outcomes of an example for tuning-free conformal prediction with ridge regression.

Description

A dataset containing the experiment results used in the vignettes.

Usage

```
ridge_linear_cov100_t3
```

Format

A list with 7 elements: dim_linear_t3,cov.param_linear_fm_t3, cov.naive_linear_fm_t3, cov.vfcp_linear_fm_t3, cov.star_linear_fm_t3, cov.cv5_linear_fm_t3, cov.efcp_linear_fm_t3

dim dimensions used in the experiment

len.param a matrix with coverages for the prediction regions produced by the parametric method

len.naive a matrix with coverages for the prediction regions produced by naive linear regression method

len.vfcp na matrix with coverages for the prediction regions produced by VFCP

len.star a matrix with coverages for the prediction regions produced by cross validation with the errors

len.cv5 a matrix with coverages for the prediction regions produced by cross-validation with 5 splits

len.efcp a matrix with coverages for the prediction regions produced by efcp

Source

For details please see the "Example-tuning_free_ridge_regression" vignette:`vignette("Example-tuning_free_ridge_reg package = "ConformalSmallest")`

`ridge_linear_cov100_t5`

Outcomes of an example for tuning-free conformal prediction with ridge regression.

Description

A dataset containing the experiment results used in the vignettes.

Usage

```
ridge_linear_cov100_t5
```

Format

A list with 7 elements: dim_linear_t5,cov.param_linear_fm_t5, cov.naive_linear_fm_t5, cov.vfcp_linear_fm_t5, cov.star_linear_fm_t5, cov.cv5_linear_fm_t5, cov.efcp_linear_fm_t5

dim dimensions used in the experiment

cov.param a matrix with coverages for the prediction regions produced by the parametric method

cov.naive a matrix with coverages for the prediction regions produced by naive linear regression method

cov.vfcp na matrix with coverages for the prediction regions produced by VFCP

cov.star a matrix with coverages for the prediction regions produced by cross validation with the errors

cov.cv5 a matrix with coverages for the prediction regions produced by cross-validation with 5 splits

cov.efcp a matrix with coverages for the prediction regions produced by efcp

Source

For details please see the "Example-tuning_free_ridge_regression" vignette:`vignette("Example-tuning_free_ridge_reg package = "ConformalSmallest")`

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ridge_linear_len100_t3

Outcomes of an example for tuning-free conformal prediction with ridge regression.

Description

A dataset containing the experiment results used in the vignettes.

Usage

```
ridge_linear_len100_t3
```

Format

A list with 6 elements: len.param_linear_fm_t3, len.naive_linear_fm_t3, len.vfcp_linear_fm_t3, len.star_linear_fm_t3, len.cv5_linear_fm_t3, len.efcp_linear_fm_t3

len.param a matrix with widths for the prediction regions produced by the parametric method

len.naive a matrix with widths for the prediction regions produced by naive linear regression method

len.vfcp na matrix with widths for the prediction regions produced by VFCP

len.star a matrix with widths for the prediction regions produced by cross validation with the errors

len.cv5 a matrix with widths for the prediction regions produced by cross-validation with 5 splits

len.efcp a matrix with widths for the prediction regions produced by efcp

Source

For details please see the "Example-tuning_free_ridge_regression" vignette:`vignette("Example-tuning_free_ridge_reg package = "ConformalSmallest")`

`ridge_linear_len100_t5` *Outcomes of an example for tuning-free conformal prediction with ridge regression.*

Description

A dataset containing the experiment results used in the vignettes.

Usage

```
ridge_linear_len100_t5
```

Format

A list with 6 elements: len.param_linear_fm_t5, len.naive_linear_fm_t5, len.vfcp_linear_fm_t5, len.star_linear_fm_t5, len.cv5_linear_fm_t5, len.efcp_linear_fm_t5

len.param a matrix with widths for the prediction regions produced by the parametric method

len.naive a matrix with widths for the prediction regions produced by naive linear regression method

len.vfcp na matrix with widths for the prediction regions produced by VFCP

len.star a matrix with widths for the prediction regions produced by cross validation with the errors

len.cv5 a matrix with widths for the prediction regions produced by cross-validation with 5 splits

len.efcp a matrix with widths for the prediction regions produced by efcp

Source

For details please see the "Example-tuning_free_ridge_regression" vignette:`vignette("Example-tuning_free_ridge_reg package = "ConformalSmallest")`

star.fun — *Conformal prediction for ridge regression, tuning parameter by minimizing the mean of the residuals*

Description

Conformal prediction for ridge regression, tuning parameter by minimizing the mean of the residuals

Usage

```
star.fun(X, Y, X0, lambda = seq(0, 100, length = 100), alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
alpha	miscoverage level

Value

upper and lower prediction intervals for X0

vfcp.fun — *Validity first conformal prediction for ridge regression*

Description

Validity first conformal prediction for ridge regression

Usage

```
vfcp.fun(X, Y, X0, lambda = seq(0, 100, length = 100), alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
alpha	miscoverage level

Value

upper and lower prediction intervals for X0.

Examples

```
df=3
d = 5
n=50   #number of training samples
n0=10  #number of prediction points
rho=0.5
Sigma=matrix(rho,d,d)
diag(Sigma)=rep(1,d)
beta=rep(1:5,d/5)
X0=mvtnorm::rmvt(n0,Sigma,df)
X=mvtnorm::rmvt(n,Sigma,df) #multivariate t distribution
eps=rt(n,df)*(1+sqrt(X[,1]^2+X[,2]^2))
Y=X%*%beta+eps
out.vfcp=vfcp.fun(X,Y,X0)
out.vfcp$up
out.vfcp$lo
```

---

vfcp_cqr *Validity first conformal prediction for Conformal Quantile Regression*

Description

Validity first conformal prediction for Conformal Quantile Regression

Usage

```
vfcp_cqr(x, y, split, beta_grid, params_grid, alpha = 0.1)
```

Arguments

x	A N*d training matrix
y	A N*1 training vector
split	a number between 0 and 1
beta_grid	a grid of beta's
params_grid	a grid of mtry and ntree
alpha	miscoverage level

Value

average prediction width and a function for coverage on some testing points

vfcp_ridge *Validity first conformal prediction for ridge regression*

Description

Validity first conformal prediction for ridge regression

Usage

```
vfcp_ridge(X, Y, X0, lambda = seq(0, 100, length = 100), alpha = 0.1)
```

Arguments

X	A N*d training matrix
Y	A N*1 training vector
X0	A N0*d testing vector
lambda	a sequence of penalty parameters for ridge regression
alpha	miscoverage level

Value

upper and lower prediction intervals for X0.

Examples

```
df=3
d = 5
n=50   #number of training samples
n0=10  #number of prediction points
rho=0.5
Sigma=matrix(rho,d,d)
diag(Sigma)=rep(1,d)
beta=rep(1:5,d/5)
X0=mvtnorm::rmvt(n0,Sigma,df)
X=mvtnorm::rmvt(n,Sigma,df) #multivariate t distribution
eps=rt(n,df)*(1+sqrt(X[,1]^2+X[,2]^2))
Y=X%*%beta+eps
out.vfcp=vfcp.fun(X,Y,X0)
out.vfcp$up
out.vfcp$lo
```

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