Package 'slasso'

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Title S-LASSO Estimator for the Function-on-Function Linear Regression

Version 1.0.0

Description Implements the smooth LASSO estimator for the function-on-function linear regression model described in Centofanti et al. (2020) <arXiv:2007.00529>.

License GPL (>= 3)

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LinkingTo Rcpp, RcppArmadillo

Depends inline

Imports Rcpp, RcppArmadillo, fda, fda.usc, matrixcalc, parallel, matrixStats, MASS, plot3D, methods, cxxfunplus

URL https://github.com/unina-sfere/slasso

BugReports https://github.com/unina-sfere/slasso

SystemRequirements GNU make

Suggests knitr, rmarkdown, testthat

NeedsCompilation yes

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`slasso-package` *Smooth LASSO Estimator for the Function-on-Function Linear Regression Model*

Description

Implements the Smooth LASSO Estimator for the Function-on-Function Linear Regression Model described in Centofanti et al. (2020) <arXiv:2007.00529>.

Details

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Author(s)

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References

Centofanti, F., Fontana, M., Lepore, A., & Vantini, S. (2020). Smooth LASSO Estimator for the Function-on-Function Linear Regression Model. *arXiv preprint arXiv:2007.00529*.

See Also

`slasso.fr`, `slasso.fr_cv`

Examples

```
library(slasso)
data<-simulate_data("Scenario II",n_obs=150)
X_fd=data$X_fd
Y_fd=data$Y_fd
domain=c(0,1)
n_basis_s<-30
```

```
n_basis_t<-30
breaks_s<-seq(0,1,length.out = (n_basis_s-2))
breaks_t<-seq(0,1,length.out = (n_basis_t-2))
basis_s <- fda::create.bspline.basis(domain,breaks=breaks_s)
basis_t <- fda::create.bspline.basis(domain,breaks=breaks_t)

mod_slasso_cv<-slasso.fr_cv(Y_fd = Y_fd,X_fd=X_fd,basis_s=basis_s,basis_t=basis_t,
lambda_L_vec = 10^seq(0,1,by=1),lambda_s_vec = 10^-9,lambda_t_vec = 10^-7,
B0=NULL,max_iterations=10,K=2,invisible=1,ncores=1)
mod_slasso<-slasso.fr(Y_fd = Y_fd,X_fd=X_fd,basis_s=basis_s,basis_t=basis_t,
lambda_L = 10^0.7,lambda_s =10^-5,lambda_t = 10^-6,B0 =NULL,invisible=1,max_iterations=10)

plot(mod_slasso_cv)
plot(mod_slasso)
```

`plot.slasso` *Plot the results of the S-LASSO method*

Description

This function provides plots of the S-LASSO coefficient function estimate when applied to the output of `slasso.fr`, whereas provides the cross-validation plots when applied to the output of `slasso.fr_cv`. In the latter case the first plot displays the CV values as a function of `lambda_L`, `lambda_s` and `lambda_t`, and the second plot displays the CV values as a function of `lambda_L` with `lambda_s` and `lambda_t` fixed at their optimal values.

Usage

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

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

Arguments

`x`	The output of either `slasso.fr_cv` or `slasso.fr`.
`...`	No additional parameters, called for side effects.

Value

No return value, called for side effects.

Examples

```
library(slasso)
data<-simulate_data("Scenario II",n_obs=150)
X_fd=data$X_fd
Y_fd=data$Y_fd
domain=c(0,1)
n_basis_s<-30
n_basis_t<-30
breaks_s<-seq(0,1,length.out = (n_basis_s-2))
breaks_t<-seq(0,1,length.out = (n_basis_t-2))
basis_s <- fda::create.bspline.basis(domain,breaks=breaks_s)
basis_t <- fda::create.bspline.basis(domain,breaks=breaks_t)
mod_slasso<-slasso.fr(Y_fd = Y_fd,X_fd=X_fd,basis_s=basis_s,basis_t=basis_t,
lambda_L = -1.5,lambda_s =-8,lambda_t = -7,B0 =NULL,invisible=1,max_iterations=10)
plot(mod_slasso)
```

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simulate_data *Simulate data through the function-on-function linear regression model*

Description

Generate synthetic data as in the simulation study of Centofanti et al. (2020).

Usage

```
simulate_data(scenario, n_obs = 3000, type_x = "Bspline")
```

Arguments

scenario	A character strings indicating the scenario considered. It could be "Scenario I", "Scenario II", "Scenario III", and "Scenario IV".
n_obs	Number of observations.
type_x	Covariate generating mechanism, either Bspline or Brownian.

Value

A list containing the following arguments:

X: Covariate matrix, where the rows correspond to argument values and columns to replications.

Y: Response matrix, where the rows correspond to argument values and columns to replications.

X_fd: Coavariate functions.

Y_fd: Response functions.

clus: True cluster membership vector.

References

Centofanti, F., Fontana, M., Lepore, A., & Vantini, S. (2020). Smooth LASSO Estimator for the Function-on-Function Linear Regression Model. *arXiv preprint arXiv:2007.00529*.

Examples

```
library(slasso)
data<-simulate_data("Scenario II",n_obs=150)
```

`slasso.fr` *Smooth LASSO estimator for the function-on-function linear regression model*

Description

The smooth LASSO (S-LASSO) method for the function-on-function linear regression model provides interpretable coefficient function estimates that are both locally sparse and smooth (Centofanti et al., 2020).

Usage

```
slasso.fr(
  Y_fd,
  X_fd,
  basis_s,
  basis_t,
  lambda_L,
  lambda_s,
  lambda_t,
  B0 = NULL,
  ...
)
```

Arguments

`Y_fd`	An object of class fd corresponding to the response functions.
`X_fd`	An object of class fd corresponding to the covariate functions.
`basis_s`	B-splines basis along the `s`-direction of class basisfd.
`basis_t`	B-splines basis along the `t`-direction of class basisfd.
`lambda_L`	Regularization parameter of the functional LASSO penalty.
`lambda_s`	Regularization parameter of the smoothness penalty along the `s`-direction.
`lambda_t`	Regularization parameter of the smoothness penalty along the `t`-direction.
`B0`	Initial estimator of the basis coefficients matrix of the coefficient function. Should have dimensions in accordance with the basis dimensions of `basis_s` and `basis_t`.
`...`	Other arguments to be passed to the Orthant-Wise Limited-memory Quasi-Newton optimization function. See the `lbfgs` help page of the package `lbfgs`.

Value

A list containing the following arguments:

- `B`: The basis coefficients matrix estimate of the coefficient function.
- `Beta_hat_fd`: The coefficient function estimate of class bifd.
- `alpha`: The intercept function estimate.
- `lambdas_L`: Regularization parameter of the functional LASSO penalty.
- `lambda_s`: Regularization parameter of the smoothness penalty along the `s`-direction.
- `lambda_t`: Regularization parameter of the smoothness penalty along the `t`-direction.
- `Y_fd`: The response functions.
- `X_fd`: The covariate functions.
- `per_0`: The fraction of domain where the coefficient function is zero.
- `type`: The output type.

References

Centofanti, F., Fontana, M., Lepore, A., & Vantini, S. (2020). Smooth LASSO Estimator for the Function-on-Function Linear Regression Model. *arXiv preprint arXiv:2007.00529*.

See Also

`slasso.fr_cv`

Examples

```
library(slasso)
data<-simulate_data("Scenario II",n_obs=150)
X_fd=data$X_fd
Y_fd=data$Y_fd
domain=c(0,1)
n_basis_s<-30
n_basis_t<-30
breaks_s<-seq(0,1,length.out = (n_basis_s-2))
breaks_t<-seq(0,1,length.out = (n_basis_t-2))
basis_s <- fda::create.bspline.basis(domain,breaks=breaks_s)
basis_t <- fda::create.bspline.basis(domain,breaks=breaks_t)
mod_slasso<-slasso.fr(Y_fd = Y_fd,X_fd=X_fd,basis_s=basis_s,basis_t=basis_t,
lambda_L = -1.5,lambda_s =-8,lambda_t = -7,B0 =NULL,invisible=1,max_iterations=10)
```

slasso.fr_cv *Cross-validation for the S-LASSO estimator*

Description

K-fold cross-validation procedure to choose the tuning parameters for the S-LASSO estimator (Centofanti et al., 2020).

Usage

```
slasso.fr_cv(
  Y_fd,
  X_fd,
  basis_s,
  basis_t,
  K = 10,
  kss_rule_par = 0.5,
  lambda_L_vec = NULL,
  lambda_s_vec = NULL,
  lambda_t_vec = NULL,
  B0 = NULL,
  ncores = 1,
  ...
)
```

Arguments

Y_fd	An object of class fd corresponding to the response functions.
X_fd	An object of class fd corresponding to the covariate functions.
basis_s	B-splines basis along the s-direction of class basisfd.
basis_t	B-splines basis along the t-direction of class basisfd.
K	Number of folds. Default is 10.
kss_rule_par	Parameter of the k-standard error rule. If kss_rule_par=0 the tuning parameters that minimize the estimated prediction error are chosen. Default is 0.5.
lambda_L_vec	Vector of regularization parameters of the functional LASSO penalty.
lambda_s_vec	Vector of regularization parameters of the smoothness penalty along the s-direction.
lambda_t_vec	Vector of regularization parameters of the smoothness penalty along the t-direction.
B0	Initial estimator of the basis coefficients matrix of the coefficient function. Should have dimensions in accordance with the basis dimensions of basis_s and basis_t.
ncores	If ncores>1, then parallel computing is used, with ncores cores. Default is 1.
...	Other arguments to be passed to the Orthant-Wise Limited-memory Quasi-Newton optimization function. See the lbfgs help page of the package lbfgs.

Value

A list containing the following arguments:

- `lambda_opt_vec`: Vector of optimal tuning parameters.
- `CV`: Estimated prediction errors.
- `CV_sd`: Standard errors of the estimated prediction errors.
- `per_0`: The fractions of domain where the coefficient function is zero for all the tuning parameters combinations.
- `comb_list`: The combinations of `lambda_L`,`lambda_s` and `lambda_t` explored.
- `Y_fd`: The response functions.
- `X_fd`: The covariate functions.

References

Centofanti, F., Fontana, M., Lepore, A., & Vantini, S. (2020). Smooth LASSO Estimator for the Function-on-Function Linear Regression Model. *arXiv preprint arXiv:2007.00529*.

See Also

`slasso.fr`

Examples

```
library(slasso)
data<-simulate_data("Scenario II",n_obs=150)
X_fd=data$X_fd
Y_fd=data$Y_fd
domain=c(0,1)
n_basis_s<-60
n_basis_t<-60
breaks_s<-seq(0,1,length.out = (n_basis_s-2))
breaks_t<-seq(0,1,length.out = (n_basis_t-2))
basis_s <- fda::create.bspline.basis(domain,breaks=breaks_s)
basis_t <- fda::create.bspline.basis(domain,breaks=breaks_t)
mod_slasso_cv<-slasso.fr_cv(Y_fd = Y_fd,X_fd=X_fd,basis_s=basis_s,basis_t=basis_t,
lambda_L_vec=seq(0,1,by=1),lambda_s_vec=c(-9),lambda_t_vec=-7,B0=NULL,
max_iterations=10,K=2,invisible=1,ncores=1)
```

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