

Package ‘adass’

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Type Package

Title Adaptive Smoothing Spline (AdaSS) Estimator for the
Function-on-Function Linear Regression

Version 1.0.1

Description Implements the adaptive smoothing spline estimator for the function-on-
function linear regression model described in Centofanti et al. (2023) <[doi:10.1007/s00180-022-01223-6](https://doi.org/10.1007/s00180-022-01223-6)>.

License GPL (>= 3)

Encoding UTF-8

Imports fda, parallel, matrixcalc, SparseM, mvtnorm, Rfast, plot3D

URL <https://github.com/unina-sfere/adass>

BugReports <https://github.com/unina-sfere/adass>

SystemRequirements GNU make

Suggests knitr, rmarkdown, testthat

RoxygenNote 7.2.3

NeedsCompilation no

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adass-package	<i>Adaptive smoothing spline estimator for the function-on-function linear regression model</i>
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Description

Implements the adaptive smoothing spline estimator for the function-on-function linear regression model described in Centofanti et al. (2023) [doi:10.1007/s00180022012236](https://doi.org/10.1007/s00180022012236).

Details

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Author(s)

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References

Centofanti, F., Lepore, A., Menafoglio, A., Palumbo, B., Vantini, S. (2023). Adaptive Smoothing Spline Estimator for the Function-on-Function Linear Regression Model. *Computational Statistics* 38(1), 191–216.

See Also

[adass.fr](#), [adass.fr_eaass](#)

Examples

```
library(adass)
data<-simulate_data("Scenario HAT",n_obs=100)
X_fd=data$X_fd
Y_fd=data$Y_fd
basis_s <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
basis_t <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
mod_smooth <-adass.fr(Y_fd,X_fd,basis_s = basis_s,basis_t = basis_t,tun_par=c(10^-6,10^-6,0,0,0,0))
grid_s<-seq(0,1,length.out = 10)
grid_t<-seq(0,1,length.out = 10)
beta_der_eval_s<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,sLfdoobj = 2)
beta_der_eval_t<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,tLfdoobj = 2)
```

```

mod_adsm<-adass.fr_eaass(Y_fd,X_fd,basis_s,basis_t,
                        beta_ders=beta_der_eval_s, beta_dert=beta_der_eval_t,
                        rand_search_par=list(c(-8,4),c(-8,4),c(0,0.1),c(0,4),c(0,0.1),c(0,4)),
                        grid_eval_ders=grid_s, grid_eval_dert=grid_t,
                        popul_size = 2,ncores=1,iter_num=1)

mod_opt <-adass.fr(Y_fd, X_fd, basis_s = basis_s, basis_t = basis_t,
                  tun_par=mod_adsm$tun_par_opt,beta_ders = beta_der_eval_s,
                  beta_dert = beta_der_eval_t,grid_eval_ders=grid_s,grid_eval_dert=grid_t )
plot(mod_opt)

```

adass.fr	<i>Adaptive smoothing spline estimator for the function-on-function linear regression model</i>
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Description

The adaptive smoothing spline (AdaSS) estimator for the function-on-function linear regression proposed in Centofanti et al., 2020.

Usage

```

adass.fr(
  Y_fd,
  X_fd,
  basis_s,
  basis_t,
  beta_ders = NULL,
  beta_dert = NULL,
  grid_eval_ders = NULL,
  grid_eval_dert = NULL,
  tun_par = c(lambda_s = 10^4, lambda_t = 10^4, delta_s = 0, gamma_s = 1, delta_t = 0,
              delta_t = 1),
  CV = FALSE,
  K = 10,
  X_fd_test = NULL,
  Y_fd_test = NULL
)

```

Arguments

<code>Y_fd</code>	An object of class <code>fd</code> corresponding to the response functions.
<code>X_fd</code>	An object of class <code>fd</code> corresponding to the covariate functions.
<code>basis_s</code>	B-splines basis along the <i>s</i> -direction of class <code>basisfd</code> .
<code>basis_t</code>	B-splines basis along the <i>t</i> -direction of class <code>basisfd</code> .

<code>beta_ders</code>	Initial estimate of the partial derivative of the coefficient function along the s-direction. Either a matrix or a class <code>basisfd</code> object. If <code>NULL</code> no adaptive penalty is used along the s-direction.
<code>beta_dert</code>	Initial estimate of the partial derivative of the coefficient function along the t-direction. Either a matrix or a class <code>basisfd</code> object. If <code>NULL</code> no adaptive penalty is used along the t-direction.
<code>grid_eval_ders</code>	Grid of evaluation of the partial derivatives along the s-direction.
<code>grid_eval_dert</code>	Grid of evaluation of the partial derivatives along the t-direction.
<code>tun_par</code>	Vector of tuning parameters.
<code>CV</code>	If <code>TRUE</code> the K-fold cross-validation prediction error is calculated. Default is <code>FALSE</code> . If <code>X_fd_test</code> and <code>Y_fd_test</code> are both provided the prediction error on the test set is calculated in place of the cross-validation prediction error when <code>CV</code> is <code>TRUE</code> .
<code>K</code>	Number of folds. Default is 10.
<code>X_fd_test</code>	Test set covariate functions. Default is <code>NULL</code> .
<code>Y_fd_test</code>	Test set response functions. Default is <code>NULL</code> .

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.
- `tun_par`: Vector of tuning parameters.
- `CV`: Estimated prediction error.
- `CV_sd`: Standard error of the estimated prediction error.
- `Y_fd`: The response functions.
- `X_fd`: The covariate functions.

References

Centofanti, F., Lepore, A., Menafoglio, A., Palumbo, B., Vantini, S. (2023). Adaptive Smoothing Spline Estimator for the Function-on-Function Linear Regression Model. *Computational Statistics* 38(1), 191–216.

See Also

[adass.fr_eaass](#)

Examples

```
library(adass)
data<-simulate_data("Scenario HAT",n_obs=100)
X_fd=data$X_fd
Y_fd=data$Y_fd
basis_s <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
basis_t <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
mod_smooth <-adass.fr(Y_fd,X_fd,basis_s = basis_s,basis_t = basis_t,tun_par=c(10^-6,10^-6,0,0,0,0))
grid_s<-seq(0,1,length.out = 10)
grid_t<-seq(0,1,length.out = 10)
beta_der_eval_s<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,sLfdoobj = 2)
beta_der_eval_t<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,tLfdoobj = 2)
mod_adass <-adass.fr(Y_fd, X_fd, basis_s = basis_s, basis_t = basis_t,
                    tun_par=c(10^-6,10^-6,0,1,0,1),beta_ders = beta_der_eval_s,
                    beta_dert = beta_der_eval_t,grid_eval_ders=grid_s,grid_eval_dert=grid_t )
```

adass.fr_eaass	<i>Evolutionary algorithm for the adaptive smoothing spline estimator (EAASS).</i>
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Description

EAASS algorithm to choose the tuning parameters for the AdaSS estimator (Centofanti et al., 2020).

Usage

```
adass.fr_eaass(
  Y_fd,
  X_fd,
  basis_s,
  basis_t,
  beta_ders = NULL,
  beta_dert = NULL,
  grid_eval_ders = NULL,
  grid_eval_dert = NULL,
  rand_search_par = list(c(-4, 4), c(-4, 4), c(0, 1, 5, 10, 15), c(0, 1, 2, 3, 4), c(0,
    1, 5, 10, 15), c(0, 1, 2, 3, 4)),
  popul_size = 12,
  iter_num = 10,
  r = 0.2,
  pert_vec = c(0.8, 1.2),
  X_fd_test = NULL,
  Y_fd_test = NULL,
  progress = TRUE,
  ncores = 1,
  K = 10
)
```

Arguments

<code>Y_fd</code>	An object of class <code>fd</code> corresponding to the response functions.
<code>X_fd</code>	An object of class <code>fd</code> corresponding to the covariate functions.
<code>basis_s</code>	B-splines basis along the <i>s</i> -direction of class <code>basisfd</code> .
<code>basis_t</code>	B-splines basis along the <i>t</i> -direction of class <code>basisfd</code> .
<code>beta_ders</code>	Initial estimate of the partial derivative of the coefficient function along the <i>s</i> -direction. Either a matrix or a class <code>basisfd</code> object. If <code>NULL</code> no adaptive penalty is used along the <i>s</i> -direction.
<code>beta_dert</code>	Initial estimate of the partial derivative of the coefficient function along the <i>t</i> -direction. Either a matrix or a class <code>basisfd</code> object. If <code>NULL</code> no adaptive penalty is used along the <i>t</i> -direction.
<code>grid_eval_ders</code>	Grid of evaluation of the partial derivatives along the <i>s</i> -direction.
<code>grid_eval_dert</code>	Grid of evaluation of the partial derivatives along the <i>t</i> -direction.
<code>rand_search_par</code>	List containing the initial population ranges for the tuning parameters.
<code>popul_size</code>	Initial population size.
<code>iter_num</code>	Algorithm iterations.
<code>r</code>	Truncation parameter in the exploitation phase.
<code>pert_vec</code>	Perturbation parameters in the exploration phase.
<code>X_fd_test</code>	Test set covariate functions. Default is <code>NULL</code> . If <code>X_fd_test</code> and <code>Y_fd_test</code> are both provided the prediction error on the test set is used as performance metric in place of the cross-validation prediction error.
<code>Y_fd_test</code>	Test set response functions. Default is <code>NULL</code> . If <code>X_fd_test</code> and <code>Y_fd_test</code> are both provided the prediction error on the test set is used as performance metric in place of the cross-validation prediction error.
<code>progress</code>	If <code>TRUE</code> a progress bar is printed. Default is <code>TRUE</code> .
<code>ncores</code>	If <code>ncores > 1</code> , then parallel computing is used, with <code>ncores</code> cores. Default is 1.
<code>K</code>	Number of folds. Default is 10.

Value

A list containing the following arguments:

- `tun_par_opt`: Vector of optimal tuning parameters.
- `CV`: Estimated prediction errors.
- `CV_sd`: Standard errors of the estimated prediction errors.
- `comb_list`: The combinations of tuning parameters explored.
- `Y_fd`: The response functions.
- `X_fd`: The covariate functions.

References

Centofanti, F., Lepore, A., Menafoglio, A., Palumbo, B., Vantini, S. (2023). Adaptive Smoothing Spline Estimator for the Function-on-Function Linear Regression Model. *Computational Statistics* 38(1), 191–216.

See Also

[adass.fr_eaass](#)

Examples

```
library(adass)
data<-simulate_data("Scenario HAT",n_obs=100)
X_fd=data$X_fd
Y_fd=data$Y_fd
basis_s <- fda::create.bspline.basis(c(0,1),nbasis = 5,norder = 4)
basis_t <- fda::create.bspline.basis(c(0,1),nbasis = 5,norder = 4)
mod_smooth <-adass.fr(Y_fd,X_fd,basis_s = basis_s,basis_t = basis_t,tun_par=c(10^-6,10^-6,0,0,0,0))
grid_s<-seq(0,1,length.out = 5)
grid_t<-seq(0,1,length.out = 5)
beta_der_eval_s<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,sLfdoobj = 2)
beta_der_eval_t<-fda::eval.bifd(grid_s,grid_t,mod_smooth$Beta_hat_fd,tLfdoobj = 2)
mod_adsm<-adass.fr_eaass(Y_fd,X_fd,basis_s,basis_t,
                        beta_ders=beta_der_eval_s, beta_dert=beta_der_eval_t,
                        rand_search_par=list(c(-8,4),c(-8,4),c(0,0.1),c(0,4),c(0,0.1),c(0,4)),
                        grid_eval_ders=grid_s, grid_eval_dert=grid_t,
                        popul_size = 1,ncores=1,iter_num=1)
```

plot.adass

Plot the results of the AdaSS method

Description

This function provides plots of the AdaSS coefficient function estimate when applied to the output of `adass.fr`.

Usage

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

Arguments

<code>x</code>	The output of <code>adass.fr</code> .
<code>...</code>	No additional parameters, called for side effects.

Value

No return value, called for side effects.

Examples

```
library(adass)
data<-simulate_data("Scenario HAT",n_obs=100)
X_fd=data$X_fd
Y_fd=data$Y_fd
basis_s <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
basis_t <- fda::create.bspline.basis(c(0,1),nbasis = 10,norder = 4)
mod_adass <- adass.fr(Y_fd,X_fd,basis_s = basis_s, basis_t = basis_t,
  tun_par=c(10^-6,10^-6,0,0,0,0))
plot(mod_adass)
```

simulate_data	<i>Simulate data through the function-on-function linear regression model</i>
---------------	---

Description

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

Usage

```
simulate_data(scenario, n_obs = 3000)
```

Arguments

scenario	A character strings indicating the scenario considered. It could be "Scenario HAT", "Scenario DAMP", or "Scenario RCHANGE".
n_obs	Number of observations.

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: Coivariate functions.

Y_fd: Response functions.

Beta_vero_fd: The true coefficient function.

References

Centofanti, F., Lepore, A., Menafoglio, A., Palumbo, B., Vantini, S. (2023). Adaptive Smoothing Spline Estimator for the Function-on-Function Linear Regression Model. *Computational Statistics* 38(1), 191–216.

Examples

```
library(adass)
data<-simulate_data("Scenario HAT",n_obs=100)
```

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