# Package: eBsc (via r-universe)

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**Type** Package

**Title** ``Empirical Bayes Smoothing Splines with Correlated Errors"

**Version** 4.15

**Date** 2022-04-29

**Author** Francisco Rosales, Tatyana Krivobokova, Paulo Serra.

**Description** Presents a statistical method that uses a recursive algorithm for signal extraction. The method handles a non-parametric estimation for the correlation of the errors. See ``Krivobokova", ``Serra", ``Rosales" and ``Klockmann" (2021) <doi:10.48550/arXiv.1812.06948> for details.

**License** GPL-2

**Imports** Brobdingnag, parallel, nlme, Matrix, MASS, splines, Rcpp

**LinkingTo** Rcpp, RcppArmadillo

**NeedsCompilation** yes

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eBsc-package *Empirical Bayes Smoothing Splines with Correlated Errors*

## Description

Empirical Bayes smoothing splines with correlated errors. The method uses a recursive algorithm for signal extraction with a non-parametric estimation of the correlation matrix of the errors.

## Details

| | |
|---|---|
| Package: | eBsc |
| Version: | 4.11 |
| Date: | 2020-08-21 |
| Depends: | Brobdingnag, parallel, nlme, Matrix, MASS |

Index:

| | |
|---|---|
| `eBsc` | `Empirical Bayes smoothing splines with correlated errors` |
| `plot.eBsc` | `Plots fitted curves from the filter` |
| `summary.eBsc` | `Summary information of the error` |

The function `eBsc()` is used to fit the model. Using the resulting `eBsc` object and summary information on the errors can be printed using `summary`.

## Author(s)

Francisco Rosales, Paulo Serra, Tatyana Krivobokova Maintainer: Francisco Rosales <francisco.rosales-marticorena@protonmail.com>

## References

Serra, P. and Krivobokova, T. (2015)
Adaptive Empirical Bayesian Smoothing Splines

## See Also

`stl` (package stats), `HoltWinters` (package stats)

## Examples

```
# simulated data for non-correlated errors
library(eBsc)
n <- 250
sigma <- 0.05
beta <- function(x,p,q){
 gamma(p+q)/(gamma(p)*gamma(q))*x^(p-1)*(1-x)^(q-1)
```

```
}
x <- seq(0, 1, length.out = n)
mu <- (6 * beta(x, 30, 17) + 4 * beta(x, 3, 11))/10;
mu <- (mu - min(mu))/(max(mu) - min(mu))
noise <- rnorm(n)
y <- mu + sigma * noise

# correlation matrix assumed known and equal to the identity
fit.d <- eBsc(y, method = "D", R0 = diag(n))
plot(fit.d, full = FALSE)
```

---

drbasis *Computation of the Demmler-Reinsch basis.*

---

## Description

The Demmler-Reinsch basis is provided for a given smoothness degree in a uniform grid.

## Usage

```
drbasis(nn,qq)
```

## Arguments

| | |
|---|---|
| nn | Number of design points in the uniform grid. |
| qq | Smoothness degree of the basis. |

## Details

The use of large numbers required by the basis is handled by the package Brobdingnag. The method assumes the grid is equidistant. Missing values are not supported.

## Value

A list object containing the following information.

| | |
|---|---|
| eigenvalues | estimadted eigenvalues |
| eigenvectors | estimated eigenvectors |
| eigenvectorsQR | orthonormal eigenvectors |
| x | equidistant grid used to build the basis |

## Author(s)

Francisco Rosales

## References

Rosales F. (2016).
Empirical Bayesian Smoothing Splines for Signals with Correlated Errors: Methods and Applications

Serra, P. and Krivobokova, T. (2015)
Adaptive Empirical Bayesian Smoothing Splines

## Examples

```
oldpar <- par(no.readonly = TRUE)
#plot elements of the basis
library(eBsc)
n <- 100
Basis <- list()
for(i in 1:6){Basis[[i]] <- drbasis( nn = n, qq = i)}

#eigenvalues
par(mfrow = c(3,2), mar = c(4,2,2,2))
for(i in 1:6){
name <- paste("Eigenvalues (q = ",i,")", sep = "")
plot(Basis[[i]]$eigenvalues,
type = 'l', lwd = 2, xlab = "x", ylab = "", main = name)
}
par(oldpar)

#eigenvectors for q = 3
par(mfrow = c(3,2), mar = c(4,2,2,2))
for(i in 1:6){
name <- paste("Eigenvector n. ", i + 3, sep = "")
plot(Basis[[i]]$eigenvectorsQR[, i + 3],
type = 'l', lwd = 2, xlab = "x", ylab = "", main = name)
}
par(oldpar)

#example of a smooth function in the Demmler-Reinsch basis
library(eBsc)
n <- 200
Basis <- list()
for(i in 1:6){Basis[[i]] <- drbasis(nn = n, qq = i)}
coef3 <- c(rep(0,3), (pi*(2:(n-2))) ^ (-3.1)) * (cos(2*(1:n)))
A3 <- Basis[[3]]$eigenvectors
mu <- -A3%*%coef3
mu <- (mu - min(mu)) / (max(mu) - min(mu))
plot(mu, xlab = "x", ylab = "mu", type = 'l', lwd = 2)
par(oldpar)
```

## Description

Empirical Bayes smoothing splines with correlated errors. The method uses a recursive algorithm for signal extraction with a non-parametric estimation of the correlation matrix of the errors.

## Usage

```
eBsc(y, q, method, parallel, R0, zero_range, ARpMAq, trace, tol.lambda, tol.rho, max.iter)
```

## Arguments

| | |
|---|---|
| y | Is a univariate numeric vector without missing values. |
| q | Is the value of q if known. If left empty the method considers all possibles q's between 1 and 6 and selects the best one according to the Tq criteria. q=NULL is the default. |
| method | Is a method used for the fit. It can take the values "D" (deterministic fit), "P" (parametric fit) and "N" (non-parametric fit). For example: i) to fit a model with known correlation matrix R.known one should select method = "D" and R0 = R.known; ii) to fit a model with a nonparametric estimation of the correlation and a starting correlation matrix R.start, one should select method = "N" and R0 = R.start; and iii) to fit a model with an ARMA parametric structure R.ARMA, one should select method="P" and ARpMAq=c(1,0). method = "N" is the default. |
| parallel | Is a logical parameter indicating if parallel computation should be used. parallel=FALSE is the default. |
| R0 | Is the starting correlation matrix. If method = "D" this matrix is not changed by the algorithm. |
| zero_range | Is the interval to look for zeros in the estimating equation for the smoothing parameter (lambda). |
| ARpMAq | Is the desired ARMA structure for the noise process. |
| trace | If true, the process of the algorithm is traced and reported. |
| tol.lambda | Tolerance level for lambda. |
| tol.rho | Tolerance level for rho. |
| max.iter | Maximum number of iterations. |

## Details

The method assumes the data is equidistant.

## Value

A list object of class eBsc containing the following information.

| | |
|---|---|
| q.hat | estimadted q |
| lambda.hat | estimated lambda |
| R.hat | estimated correlation matrix |

| | |
|---|---|
| f.hat | estimated function |
| f.hat | estimated variance |
| etq.hat | estimating equation for q |
| data | data used to fit the model |
| call | Call of eBsc |

## Author(s)

Francisco Rosales, Paulo Serra, Tatyana Krivobokova

## References

Serra, P. and Krivobokova, T. (2015)
Adaptive Empirical Bayesian Smoothing Splines

## See Also

stl (package stats), HoltWinters (package stats)

## Examples

```
library(eBsc)
n <- 250
sigma <- 0.05
beta <- function(x,p,q){
  gamma(p+q)/(gamma(p)*gamma(q))*x^(p-1)*(1-x)^(q-1)
}
x <- seq(0, 1, length.out = n)
mu <- (6 * beta(x, 30, 17) + 4 * beta(x, 3, 11))/10;
mu <- (mu - min(mu))/(max(mu) - min(mu))
noise <- rnorm(n)
y <- mu + sigma * noise

# correlation matrix assumed known and equal to the identity
fit <- eBsc(y,  method = "D", R0 = diag(n))
plot(fit, full=FALSE)
```

---

# plot.eBsc *Plot fitted components*

---

## Description

Plot fitted components and the acf of the errors.

## Usage

```
## S3 method for class 'eBsc'
plot(x,full=FALSE,...)
```

## Arguments

| | |
|---|---|
| x | eBsc object. |
| full | plot option. If TRUE graphial details of the estimation are provided. If FALSE a simple plot of the estimation and its confidence bands is provided. |
| ... | further arguments to be passed to plot(). |

## Details

if the eBsc plots the fits and the acf of the errors.

## Value

The function returns the selected plots.

## Author(s)

Francisco Rosales, Paulo Serra, Tatyana Krivobokova.

## References

Serra, P. and Krivobokova, T. (2015)
Adaptive Empirical Bayesian Smoothing Splines

## Examples

```
library(eBsc)
n <- 250
sigma <- 0.05
Basis <- list()
for(i in 1:6) Basis[[i]] <- drbasis(nn = n, qq = i)
coef3 <- c(rep(0,3),(pi*(2:(n-2)))^(-3.1))*(cos(2*(1:n)))
A3 <- Basis[[3]]$eigenvectors
mu <- A3%*%coef3
mu <- (mu-min(mu))/(max(mu)-min(mu))
noise <- rnorm(n)
y <- mu + sigma * noise

#correlation assumed known and equal to the identity
fit.d <- eBsc(y, method = "D", R0 = diag(n))

#simple plot by
plot(fit.d, full = FALSE)
```

RcppArmadillo-Functions

*Set of functions in example RcppArmadillo package*

## Description

These four functions are created when `RcppArmadillo.package.skeleton()` is invoked to create a skeleton packages.

## Usage

```
rcpparma_hello_world()
rcpparma_outerproduct(x)
rcpparma_innerproduct(x)
rcpparma_bothproducts(x)
```

## Arguments

| | |
|---|---|
| `x` | a numeric vector |

## Details

These are example functions which should be largely self-explanatory. Their main benefit is to demonstrate how to write a function using the Armadillo C++ classes, and to have to such a function accessible from R.

## Value

`rcpparma_hello_world()` does not return a value, but displays a message to the console.

`rcpparma_outerproduct()` returns a numeric matrix computed as the outer (vector) product of `x`.

`rcpparma_innerproduct()` returns a double computer as the inner (vector) product of `x`.

`rcpparma_bothproducts()` returns a list with both the outer and inner products.

## Author(s)

Dirk Eddelbuettel

## References

See the documentation for Armadillo, and RcppArmadillo, for more details.

## Examples

```
x <- sqrt(1:4)
rcpparma_innerproduct(x)
rcpparma_outerproduct(x)
```

summary.eBsc *eBsc Summary*

## Description

Takes an eBsc object produced by eBsc and summarizes the information of the errors.

## Usage

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

## Arguments

| | |
|---|---|
| object | eBsc object. |
| ... | further arguments to be passed to summary(). |

## Value

The function gives basic statistics of the error from applying eBsc.

## Author(s)

Francisco Rosales, Paulo Serra, Tatyana Krivobokova

## References

Serra, P. and Krivobokova, T. (2015)
Adaptive Empirical Bayesian Smoothing Splines

## See Also

plot.eBsc (package eBsc),

## Examples

```
# simulated data
library(eBsc)
n <- 250
sigma <- 0.05

Basis <- list()
for(i in 1:6){Basis[[i]] <- drbasis(nn = n, qq = i)}
coef3 <- c(rep(0,3),(pi*(2:(n-2)))^(-3.1)) * (cos(2*(1:n)))
A3 <- Basis[[3]]$eigenvectors
mu <- - A3%*%coef3
mu <- (mu - min(mu))/(max(mu) - min(mu))
noise <- rnorm(n)
y <- mu + sigma * noise
```

```
# correlation matrix assumed known and equal to the identity
fit <- eBsc(y, method = "D", R0 = diag(n))

summary(fit)
```

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