

# Package ‘flamingos’

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**Type** Package

**Title** Functional Latent Data Models for Clustering Heterogeneous Time-Series ('FLaMingoS')

**Version** 0.1.0

**Description** Provides a variety of original and flexible user-friendly statistical latent variable models for the simultaneous clustering (or classification) and segmentation of heterogeneous functional data (i.e time series or more generally longitudinal data), fitted by unsupervised algorithms, including EM algorithms.

**URL** <https://github.com/fchamroukhi/FLaMingoS>

**BugReports** <https://github.com/fchamroukhi/FLaMingoS/issues>

**License** GPL (>= 3)

**Depends** R (>= 2.10)

**Imports** methods,  
stats,  
Rcpp

**Suggests** knitr,  
rmarkdown

**LinkingTo** Rcpp,  
RcppArmadillo

**Collate** flamingos-package.R  
RcppExports.R  
utils.R  
kmeans.R  
mkStochastic.R  
FData.R  
ParamMixHMM.R  
ParamMixHMMR.R  
ParamMixRHL.P.R  
StatMixHMM.R  
StatMixHMMR.R  
StatMixRHL.P.R  
ModelMixHMMR.R  
ModelMixHMM.R  
ModelMixRHL.P.R  
emMixHMM.R  
emMixHMMR.R

```

emMixRHL.R
cemMixRHL.R
data-toydataset.R

VignetteBuilder knitr
Encoding UTF-8
LazyData true
Roxygen list(markdown = TRUE)
RoxygenNote 6.1.1

```

## R topics documented:

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## Description

flamingos is a toolbox for the simultaneous clustering (or classification) and segmentation of heterogeneous functional data (i.e time-series or more generally longitudinal data), with original and flexible functional latent variable models, fitted by unsupervised algorithms, including EM algorithms.

flamingos contains the following time series segmentation models:

- mixRHL;
- mixHMM;
- mixHMMR.

For the advantages/differences of each of them, the user is referred to our mentioned paper references.

To learn more about flamingos, start with the vignettes: `browseVignettes(package = "flamingos")`

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## References

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## See Also

Useful links:

- <https://github.com/fchamroukhi/FLaMingoS>
- Report bugs at <https://github.com/fchamroukhi/FLaMingoS/issues>

cemMixRHL

*cemMixRHL* is used to fit a MixRHL model.

## Description

`cemMixRHL` is used to fit a MixRHL model. The estimation method is performed by the Classification Expectation-Maximization algorithm (CEM algorithm).

## Usage

```
cemMixRHL(X, Y, K, R, p = 3, q = 1,
           variance_type = c("heteroskedastic", "homoskedastic"),
           init_kmeans = TRUE, n_tries = 1, max_iter = 100,
           threshold = 1e-05, verbose = FALSE, verbose_IRLS = FALSE)
```

## Arguments

X	Numeric vector of length $m$ representing the covariates/inputs $x_1, \dots, x_m$ .
Y	Matrix of size $(n, m)$ representing the observed responses/outputs. Y consists of $n$ functions of X observed at points $1, \dots, m$ .
K	The number of clusters (Number of RHL models).
R	The number of regimes (RHL components) for each cluster.
p	Optional. The order of the polynomial regression. By default, p is set at 3.
q	Optional. The dimension of the logistic regression. For the purpose of segmentation, it must be set to 1 (which is the default value).
variance_type	Optional character indicating if the model is "homoskedastic" or "heteroskedastic". By default the model is "heteroskedastic".
init_kmeans	Optional. A logical indicating whether or not the curve partition should be initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.
n_tries	Optional. Number of runs of the EM algorithm. The solution providing the highest log-likelihood will be returned. If $n\_tries > 1$ , then for the first run, parameters are initialized by uniformly segmenting the data into R segments, and for the next runs, parameters are initialized by randomly segmenting the data into R contiguous segments.
max_iter	Optional. The maximum number of iterations for the EM algorithm.
threshold	Optional. A numeric value specifying the threshold for the relative difference of log-likelihood between two steps of the EM as stopping criteria.
verbose	Optional. A logical value indicating whether or not values of the log-likelihood should be printed during EM iterations.
verbose_IRLS	Optional. A logical value indicating whether or not values of the criterion optimized by IRLS should be printed at each step of the EM algorithm.

## Details

`cemMixRHL` function implements the CEM algorithm. This function starts with an initialization of the parameters done by the method `initParam` of the class `ParamMixRHL`, then it alternates between the E-Step, the C-Step (methods of the class `StatMixRHL`), and the CM-Step (method of the class `ParamMixRHL`) until convergence (until the relative variation of log-likelihood between two steps of the EM algorithm is less than the `threshold` parameter).

**Value**

EM returns an object of class [ModelMixRHL](#).

**See Also**

[ModelMixRHL](#), [ParamMixRHL](#), [StatMixRHL](#)

**Examples**

```
data(toydataset)

#' # Let's fit a mixRHL model on a dataset containing 2 clusters:
data <- toydataset[1:190,1:21]

mixrhl <- cemMixRHL(data$x, t(data[,2:ncol(data)]),
K = 2, R = 2, p = 1, verbose = TRUE)

mixrhl$summary()

mixrhl$plot()
```

**emMixHMM**

*emMixHMM* is used to fit a MixHMM model.

**Description**

`emMixHMM` is used to fit a MixHMM model. The estimation method is performed by the Expectation-Maximization algorithm.

**Usage**

```
emMixHMM(Y, K, R, variance_type = c("heteroskedastic", "homoskedastic"),
order_constraint = TRUE, init_kmeans = TRUE, n_tries = 1,
max_iter = 1000, threshold = 1e-06, verbose = FALSE)
```

**Arguments**

<code>Y</code>	Matrix of size $(n, m)$ representing the observed responses/outputs. <code>Y</code> consists of $n$ functions of $X$ observed at points $1, \dots, m$ .
<code>K</code>	The number of clusters (Number of HMM models).
<code>R</code>	The number of regimes (HMM components) for each cluster.
<code>variance_type</code>	Optional character indicating if the model is "homoskedastic" or "heteroskedastic". By default the model is "heteroskedastic".
<code>order_constraint</code>	Optional. A logical indicating whether or not a mask of order one should be applied to the transition matrix of the Markov chain. For the purpose of segmentation, it must be set to TRUE (which is the default value).
<code>init_kmeans</code>	Optional. A logical indicating whether or not the curve partition should be initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.

<code>n_tries</code>	Optional. Number of runs of the EM algorithm. The solution providing the highest log-likelihood will be returned. If <code>n_tries &gt; 1</code> , then for the first run, parameters are initialized by uniformly segmenting the data into K segments, and for the next runs, parameters are initialized by randomly segmenting the data into K contiguous segments.
<code>max_iter</code>	Optional. The maximum number of iterations for the EM algorithm.
<code>threshold</code>	Optional. A numeric value specifying the threshold for the relative difference of log-likelihood between two steps of the EM as stopping criteria.
<code>verbose</code>	Optional. A logical value indicating whether or not values of the log-likelihood should be printed during EM iterations.

## Details

`emMixHMM` function implements the EM algorithm. This function starts with an initialization of the parameters done by the method `initParam` of the class [ParamMixHMM](#), then it alternates between the E-Step (method of the class [StatMixHMM](#)) and the M-Step (method of the class [ParamMixHMM](#)) until convergence (until the relative variation of log-likelihood between two steps of the EM algorithm is less than the `threshold` parameter).

## Value

EM returns an object of class [ModelMixHMM](#).

## See Also

[ModelMixHMM](#), [ParamMixHMM](#), [StatMixHMM](#)

## Examples

```
data(toydataset)

mixhmm <- emMixHMM(t(toydataset[,2:ncol(toydataset)]), K = 3, R = 3, verbose = TRUE)

mixhmm$summary()

mixhmm$plot()
```

`emMixHMMR`

*emMixHMMR is used to fit a MixHMMR model.*

## Description

`emMixHMMR` is used to fit a MixHMMR model. The estimation method is performed by the Expectation-Maximization algorithm.

## Usage

```
emMixHMMR(X, Y, K, R, p = 3, variance_type = c("heteroskedastic",
  "homoskedastic"), order_constraint = TRUE, init_kmeans = TRUE,
  n_tries = 1, max_iter = 1000, threshold = 1e-06, verbose = FALSE)
```

## Arguments

X	Numeric vector of length $m$ representing the covariates/inputs $x_1, \dots, x_m$ .
Y	Matrix of size $(n, m)$ representing the observed responses/outputs. Y consists of $n$ functions of X observed at points $1, \dots, m$ .
K	The number of clusters (Number of HMMR models).
R	The number of regimes (HMMR components) for each cluster.
p	Optional. The order of the polynomial regression. By default, p is set at 3.
variance_type	Optional. character indicating if the model is "homoskedastic" or "heteroskedastic". By default the model is "heteroskedastic".
order_constraint	Optional. A logical indicating whether or not a mask of order one should be applied to the transition matrix of the Markov chain. For the purpose of segmentation, it must be set to TRUE (which is the default value).
init_kmeans	Optional. A logical indicating whether or not the curve partition should be initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.
n_tries	Optional. Number of runs of the EM algorithm. The solution providing the highest log-likelihood will be returned. If n_tries > 1, then for the first run, parameters are initialized by uniformly segmenting the data into K segments, and for the next runs, parameters are initialized by randomly segmenting the data into K contiguous segments.
max_iter	Optional. The maximum number of iterations for the EM algorithm.
threshold	Optional. A numeric value specifying the threshold for the relative difference of log-likelihood between two steps of the EM as stopping criteria.
verbose	Optional. A logical value indicating whether or not values of the log-likelihood should be printed during EM iterations.

## Details

`emMixHMMR` function implements the EM algorithm. This function starts with an initialization of the parameters done by the method `initParam` of the class `ParamMixHMMR`, then it alternates between the E-Step (method of the class `StatMixHMMR`) and the M-Step (method of the class `ParamMixHMMR`) until convergence (until the relative variation of log-likelihood between two steps of the EM algorithm is less than the threshold parameter).

## Value

EM returns an object of class [ModelMixHMMR](#).

### See Also

ModelMixHMMR, ParamMixHMMR, StatMixHMMR

## Examples

```
data(toydataset)
```

```
mixhmmr$summary()
mixhmmr$plot()
```

**emMixRHL**

*emMixRHL* is used to fit a MixRHL model.

## Description

`emMixRHL` is used to fit a MixRHL model. The estimation method is performed by the Expectation-Maximization algorithm.

## Usage

```
emMixRHL(X, Y, K, R, p = 3, q = 1,
          variance_type = c("heteroskedastic", "homoskedastic"),
          init_kmeans = TRUE, n_tries = 1, max_iter = 1000,
          threshold = 1e-05, verbose = FALSE, verbose_IRLS = FALSE)
```

## Arguments

<code>X</code>	Numeric vector of length $m$ representing the covariates/inputs $x_1, \dots, x_m$ .
<code>Y</code>	Matrix of size $(n, m)$ representing the observed responses/outputs. <code>Y</code> consists of $n$ functions of <code>X</code> observed at points $1, \dots, m$ .
<code>K</code>	The number of clusters (Number of RHL models).
<code>R</code>	The number of regimes (RHL components) for each cluster.
<code>p</code>	Optional. The order of the polynomial regression. By default, <code>p</code> is set at 3.
<code>q</code>	Optional. The dimension of the logistic regression. For the purpose of segmentation, it must be set to 1 (which is the default value).
<code>variance_type</code>	Optional character indicating if the model is "homoskedastic" or "heteroskedastic". By default the model is "heteroskedastic".
<code>init_kmeans</code>	Optional. A logical indicating whether or not the curve partition should be initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.
<code>n_tries</code>	Optional. Number of runs of the EM algorithm. The solution providing the highest log-likelihood will be returned. If <code>n_tries &gt; 1</code> , then for the first run, parameters are initialized by uniformly segmenting the data into <code>R</code> segments, and for the next runs, parameters are initialized by randomly segmenting the data into <code>R</code> contiguous segments.
<code>max_iter</code>	Optional. The maximum number of iterations for the EM algorithm.
<code>threshold</code>	Optional. A numeric value specifying the threshold for the relative difference of log-likelihood between two steps of the EM as stopping criteria.
<code>verbose</code>	Optional. A logical value indicating whether or not values of the log-likelihood should be printed during EM iterations.
<code>verbose_IRLS</code>	Optional. A logical value indicating whether or not values of the criterion optimized by IRLS should be printed at each step of the EM algorithm.

## Details

`emMixRHLP` function implements the EM algorithm. This function starts with an initialization of the parameters done by the method `initParam` of the class `ParamMixRHLP`, then it alternates between the E-Step (method of the class `StatMixRHLP`) and the M-Step (method of the class `ParamMixRHLP`) until convergence (until the relative variation of log-likelihood between two steps of the EM algorithm is less than the `threshold` parameter).

## Value

`EM` returns an object of class `ModelMixRHLP`.

## See Also

`ModelMixRHLP`, `ParamMixRHLP`, `StatMixRHLP`

## Examples

```
data(toydataset)

# Let's fit a mixRHLP model on a dataset containing 2 clusters:
data <- toydataset[1:190,1:21]

mixrhlp <- emMixRHLP(data$x, t(data[,2:ncol(data)]),
                      K = 2, R = 2, p = 1, verbose = TRUE)

mixrhlp$summary()

mixrhlp$plot()
```

## Description

`FData` is a reference class which represents general independent and identically distributed (i.i.d.) functional objects. The data can be ordered by time (functional time series). In the last case, the field `X` represents the time.

## Fields

- `X` Numeric vector of length  $m$  representing the covariates/inputs.
- `Y` Matrix of size  $(n, m)$  representing the observed responses/outputs. `Y` consists of  $n$  functions of `X` observed at points  $1, \dots, m$ .

`mkStochastic`      *mkStochastic ensures that it is a stochastic vector, matrix or array.*

## Description

`mkStochastic` ensures that it is a stochastic vector, matrix or array.

## Usage

```
mkStochastic(M)
```

## Arguments

`M`      A vector, matrix or array to transform.

## Details

`mkStochastic` ensures that the giving argument is a stochastic vector, matrix or array, i.e., that the sum over the last dimension is 1.

## Value

A vector, matrix or array for which the sum over the last dimension is 1.

`ModelMixHMM-class`      *A Reference Class which represents a fitted MixHMM model.*

## Description

`ModelMixHMM` represents an estimated MixHMM model.

## Fields

`param` A [ParamMixHMM](#) object. It contains the estimated values of the parameters.

`stat` A [StatMixHMM](#) object. It contains all the statistics associated to the MixHMM model.

## Methods

`plot(what = c("clustered", "smoothed", "loglikelihood"), ...)` Plot method

`what` The type of graph requested:

- "clustered" = Clustered curves (field `klas` of class [StatMixHMM](#)).
- "smoothed" = Smoothed signal (field `smoothed` of class [StatMixHMM](#)).
- "loglikelihood" = Value of the log-likelihood for each iteration (field `stored_loglik` of class [StatMixHMM](#)).

`...` Other graphics parameters.

`summary(digits =getOption("digits"))` Summary method.

`digits` The number of significant digits to use when printing.

**See Also**

[ParamMixHMM](#), [StatMixHMM](#)

**Examples**

```
data(toydataset)

mixhmm <- emMixHMM(t(toydataset[,2:ncol(toydataset)]), K = 3, R = 3, verbose = TRUE)

# mixhmm is a ModelMixHMM object. It contains some methods such as 'summary' and 'plot'
mixhmm$summary()
mixhmm$plot()

# mixhmm has also two fields, stat and param which are reference classes as well

# Log-likelihood:
mixhmm$stat$loglik

# Means
mixhmm$param$mu
```

**ModelMixHMMR-class**

*A Reference Class which represents a fitted MixHMMR model.*

**Description**

ModelMixHMMR represents an estimated MixHMMR model.

**Fields**

**param** A [ParamMixHMMR](#) object. It contains the estimated values of the parameters.

**stat** A [StatMixHMMR](#) object. It contains all the statistics associated to the MixHMMR model.

**Methods**

**plot(what = c("clustered", "smoothed", "loglikelihood"), ...)** Plot method

**what** The type of graph requested:

- "clustered" = Clustered curves (field klas of class [StatMixHMMR](#)).
- "smoothed" = Smoothed signal (field smoothed of class [StatMixHMMR](#)).
- "loglikelihood" = Value of the log-likelihood for each iteration (field stored\_loglik of class [StatMixHMMR](#)).

... Other graphics parameters.

**summary(digits =getOption("digits"))** Summary method.

**digits** The number of significant digits to use when printing.

**See Also**

[ParamMixHMMR](#), [StatMixHMMR](#)

## Examples

```

data(toydataset)

mixhmmr <- emMixHMMR(toydataset$x, t(toydataset[,2:ncol(toydataset)]),
                      K = 3, R = 3, p = 1, verbose = TRUE)

# mixhmmr is a ModelMixHMMR object. It contains some methods such as 'summary' and 'plot'
mixhmmr$summary()
mixhmmr$plot()

# mixhmmr has also two fields, stat and param which are reference classes as well

# Log-likelihood:
mixhmmr$stat$loglik

# Parameters of the polynomial regressions:
mixhmmr$param$beta

```

## ModelMixRHP-class

*A Reference Class which represents a fitted MixRHP model.*

## Description

ModelMixRHP represents an estimated MixRHP model.

## Fields

`param` A [ParamMixRHP](#) object. It contains the estimated values of the parameters.

`stat` A [StatMixRHP](#) object. It contains all the statistics associated to the MixRHP model.

## Methods

`plot(what = c("estimatedsignal", "regressors", "loglikelihood"), ...)` Plot method.

`what` The type of graph requested:

- `"estimatedsignal"` = Estimated signal (field `Ex` of class [StatMixRHP](#)).
- `"regressors"` = Polynomial regression components (fields `polynomials` and `pi_jgk` of class [StatMixRHP](#)).
- `"loglikelihood"` = Value of the log-likelihood for each iteration (field `stored_loglik` of class [StatMixRHP](#)).

`...` Other graphics parameters.

By default, all the above graphs are produced.

`summary(digits = getOption("digits"))` Summary method.

`digits` The number of significant digits to use when printing.

## See Also

[ParamMixRHP](#), [StatMixRHP](#)

## Examples

```

data(toydataset)

# Let's fit a mixRHLP model on a dataset containing 2 clusters:
data <- toydataset[1:190,1:21]

mixrhlp <- cemMixRHLP(data$x, t(data[,2:ncol(data)]),
                        K = 2, R = 2, p = 1, verbose = TRUE)

# mixrhlp is a ModelMixRHLP object. It contains some methods such as 'summary' and 'plot'
mixrhlp$summary()
mixrhlp$plot()

# mixrhlp has also two fields, stat and param which are reference classes as well

# Log-likelihood:
mixrhlp$stat$loglik

# Parameters of the polynomial regressions:
mixrhlp$param$beta

```

**ParamMixHMM-class**

*A Reference Class which contains parameters of a MixHMM model.*

## Description

ParamMixHMM contains all the parameters of a MixHMM model.

## Fields

**fData** [FData](#) object representing the sample (covariates/inputs X and observed responses/outputs Y).

**K** The number of clusters (Number of HMM models).

**R** The number of regimes (HMM components) for each cluster.

**variance\_type** Character indicating if the model is homoskedastic (`variance_type = "homoskedastic"`) or heteroskedastic (`variance_type = "heteroskedastic"`). By default the model is heteroskedastic.

**order\_constraint** A logical indicating whether or not a mask of order one should be applied to the transition matrix of the Markov chain. For the purpose of segmentation, it must be set to `TRUE` (which is the default value).

**alpha** Cluster weights. Matrix of dimension  $(K, 1)$ .

**prior** The prior probabilities of the Markov chains. `prior` is a matrix of dimension  $(R, K)$ . The k-th column represents the prior distribution of the Markov chain associated to the cluster k.

**trans\_mat** The transition matrices of the Markov chains. `trans_mat` is an array of dimension  $(R, R, K)$ .

**mask** Mask applied to the transition matrices `trans_mat`. By default, a mask of order one is applied.

**mu** Means. Matrix of dimension  $(R, K)$ . The k-th column gives represents the k-th cluster and gives the means for the R regimes.

`sigma2` The variances for the K clusters. If MixHMM model is heteroskedastic (`variance_type = "heteroskedastic"`) then `sigma2` is a matrix of size  $(R, K)$  (otherwise MixHMM model is homoskedastic (`variance_type = "homoskedastic"`) and `sigma2` is a matrix of size  $(1, K)$ ).  
`nu` The degree of freedom of the MixHMM model representing the complexity of the model.

## Methods

`initGaussParamHmm(Y, k, R, variance_type, try_algo)` Initialize the means `mu` and `sigma2` for the cluster `k`.  
`initParam(init_kmeans = TRUE, try_algo = 1)` Method to initialize parameters `alpha`, `prior`, `trans_mat`, `mu` and `sigma2`.  
If `init_kmeans = TRUE` then the curve partition is initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.  
If `try_algo = 1` then `mu` and `sigma2` are initialized by segmenting the time series `Y` uniformly into `R` contiguous segments. Otherwise, `mu` and `sigma2` are initialized by segmenting randomly the time series `Y` into `R` segments.  
`MStep(statMixHMM)` Method which implements the M-step of the EM algorithm to learn the parameters of the MixHMM model based on statistics provided by the object `statMixHMM` of class `StatMixHMM` (which contains the E-step).

ParamMixHMMR-class     *A Reference Class which contains parameters of a MixHMMR model.*

## Description

ParamMixHMMR contains all the parameters of a MixHMMR model.

## Fields

`fData` `FData` object representing the sample (covariates/inputs `X` and observed responses/outputs `Y`).  
`K` The number of clusters (Number of HMMR models).  
`R` The number of regimes (HMMR components) for each cluster.  
`p` The order of the polynomial regression.  
`variance_type` Character indicating if the model is homoskedastic (`variance_type = "homoskedastic"`) or heteroskedastic (`variance_type = "heteroskedastic"`). By default the model is heteroskedastic.  
`order_constraint` A logical indicating whether or not a mask of order one should be applied to the transition matrix of the Markov chain. For the purpose of segmentation, it must be set to `TRUE` (which is the default value).  
`alpha` Cluster weights. Matrix of dimension  $(K, 1)$ .  
`prior` The prior probabilities of the Markov chains. `prior` is a matrix of dimension  $(R, K)$ . The `k`-th column represents the prior distribution of the Markov chain associated to the cluster `k`.  
`trans_mat` The transition matrices of the Markov chains. `trans_mat` is an array of dimension  $(R, R, K)$ .  
`mask` Mask applied to the transition matrices `trans_mat`. By default, a mask of order one is applied.

**beta** Parameters of the polynomial regressions. **beta** is an array of dimension  $(p + 1, R, K)$ , with  $p$  the order of the polynomial regression.  $p$  is fixed to 3 by default.

**sigma2** The variances for the  $K$  clusters. If MixHMMR model is heteroskedastic (**variance\_type** = "heteroskedastic") then **sigma2** is a matrix of size  $(R, K)$  (otherwise MixHMMR model is homoskedastic (**variance\_type** = "homoskedastic") and **sigma2** is a matrix of size  $(1, R, K)$ ).

**nu** The degree of freedom of the MixHMMR model representing the complexity of the model.

**phi** A list giving the regression design matrices for the polynomial and the logistic regressions.

## Methods

**initParam(init\_kmeans = TRUE, try\_algo = 1)** Method to initialize parameters **alpha**, **prior**, **trans\_mat**, **beta** and **sigma2**.  
 If **init\_kmeans** = TRUE then the curve partition is initialized by the K-means algorithm. Otherwise the curve partition is initialized randomly.  
 If **try\_algo** = 1 then **beta** and **sigma2** are initialized by segmenting the time series **Y** uniformly into **R** contiguous segments. Otherwise, **beta** and **sigma2** are initialized by segmenting randomly the time series **Y** into **R** segments.

**initRegressionParam(Y, k, R, phi, variance\_type, try\_algo)** Initialize **beta** and **sigma2** for the cluster **k**.

**MStep(statMixHMMR)** Method which implements the M-step of the EM algorithm to learn the parameters of the MixHMMR model based on statistics provided by the object **statMixHMMR** of class **StatMixHMMR** (which contains the E-step).

## ParamMixRHLP-class

*A Reference Class which contains parameters of a MixRHLP model.*

## Description

ParamMixRHLP contains all the parameters of a MixRHLP model.

## Fields

**fData** **FData** object representing the sample (covariates/inputs **X** and observed responses/outputs **Y**).  
**K** The number of clusters (Number of RHLP models).  
**R** The number of regimes (RHLP components) for each cluster.  
**p** The order of the polynomial regression.  
**q** The dimension of the logistic regression. For the purpose of segmentation, it must be set to 1.  
**variance\_type** Character indicating if the model is homoskedastic (**variance\_type** = "homoskedastic") or heteroskedastic (**variance\_type** = "heteroskedastic"). By default the model is heteroskedastic.  
**alpha** Cluster weights. Matrix of dimension  $(1, K)$ .  
**W** Parameters of the logistic process.  $\mathbf{W} = (\mathbf{w}_1, \dots, \mathbf{w}_K)$  is an array of dimension  $(q + 1, R - 1, K)$ , with  $\mathbf{w}_g = (\mathbf{w}_{g,1}, \dots, \mathbf{w}_{g,R-1})$ ,  $g = 1, \dots, K$ , and **q** the order of the logistic regression. **q** is fixed to 1 by default.  
**beta** Parameters of the polynomial regressions.  $\boldsymbol{\beta} = (\boldsymbol{\beta}_1, \dots, \boldsymbol{\beta}_K)$  is an array of dimension  $(p + 1, R, K)$ , with  $\boldsymbol{\beta}_g = (\boldsymbol{\beta}_{g,1}, \dots, \boldsymbol{\beta}_{g,R})$ ,  $g = 1, \dots, K$ ,  $p$  the order of the polynomial regression.  $p$  is fixed to 3 by default.

**sigma2** The variances for the K clusters. If MixRHLP model is heteroskedastic (`variance_type = "heteroskedastic"`) then `sigma2` is a matrix of size  $(R, K)$  (otherwise MixRHLP model is homoskedastic (`variance_type = "homoskedastic"`) and `sigma2` is a matrix of size  $(K, 1)$ ).  
**nu** The degree of freedom of the MixRHLP model representing the complexity of the model.  
**phi** A list giving the regression design matrices for the polynomial and the logistic regressions.

## Methods

**CMStep(statMixRHLP, verbose\_IRLS = FALSE)** Method which implements the M-step of the CEM algorithm to learn the parameters of the MixRHLP model based on statistics provided by the object `statMixRHLP` of class `StatMixRHLP` (which contains the E-step and the C-step).

**initParam(init\_kmeans = TRUE, try\_algo = 1)** Method to initialize parameters `alpha`, `W`, `beta` and `sigma2`.  
If `init_kmeans = TRUE` then the curve partition is initialized by the R-means algorithm. Otherwise the curve partition is initialized randomly.  
If `try_algo = 1` then `beta` and `sigma2` are initialized by segmenting the time series  $Y$  uniformly into  $R$  contiguous segments. Otherwise, `W`, `beta` and `sigma2` are initialized by segmenting randomly the time series  $Y$  into  $R$  segments.

**initRegressionParam(Xg, g, try\_algo = 1)** Initialize the matrix of polynomial regression coefficients `beta_g` for the cluster  $g$ .

**MStep(statMixRHLP, verbose\_IRLS = FALSE)** Method which implements the M-step of the EM algorithm to learn the parameters of the MixRHLP model based on statistics provided by the object `statMixRHLP` of class `StatMixRHLP` (which contains the E-step).

## StatMixHMM-class

*A Reference Class which contains statistics of a MixHMM model.*

## Description

StatMixHMM contains all the statistics associated to a `MixHMM` model.

## Fields

**tau\_ik** Matrix of size  $(n, K)$  giving the posterior probabilities that the curve  $Y_i$  originates from the  $k$ -th HMM model.  
**gamma\_ikjr** Array of size  $(nm, R, K)$  giving the posterior probabilities that the observation  $Y_{ij}$  originates from the  $r$ -th regime of the  $k$ -th HMM model.  
**loglik** Numeric. Log-likelihood of the MixHMM model.  
**stored\_loglik** Numeric vector. Stored values of the log-likelihood at each iteration of the EM algorithm.  
**klas** Row matrix of the labels issued from `tau_ik`. Its elements are  $klas(i) = k$ ,  $i = 1, \dots, n$ .  
**z\_ik** Hard segmentation logical matrix of dimension  $(n, K)$  obtained by the Maximum a posteriori (MAP) rule:  $z_{ik} = 1$  if  $z_{ik} = \arg \max_s P(z_{is} = 1 | Y_i; \Psi) = tau_{ik}$ ; 0 otherwise,  $k = 1, \dots, K$ .  
**smoothed** Matrix of size  $(m, K)$  giving the estimated mean series. The  $k$ -th column gives the estimated mean series of cluster  $k$ .  
**mean\_curve** To define.

BIC Numeric. Value of BIC (Bayesian Information Criterion).  
AIC Numeric. Value of AIC (Akaike Information Criterion).  
ICL1 Numeric. Value of ICL (Integrated Completed Likelihood Criterion).  
log\_w\_k\_fyi Private. Only defined for calculations.  
exp\_num\_trans Private. Only defined for calculations.  
exp\_num\_trans\_from\_1 Private. Only defined for calculations.

## Methods

computeStats(paramMixHMM) Method used in the EM algorithm to compute statistics based on parameters provided by the object paramMixHMM of class [ParamMixHMM](#).  
EStep(paramMixHMM) Method used in the EM algorithm to update statistics based on parameters provided by the object paramMixHMM of class [ParamMixHMM](#) (prior and posterior probabilities).  
MAP() MAP calculates values of the fields z\_ik and klas by applying the Maximum A Posteriori Bayes allocation rule.  
 $z_{ik} = 1 \text{ if } z_{ik} = \arg \max_s P(z_{is} = 1 | \mathbf{Y}_i; \Psi) = tau_{tk}; 0 \text{ otherwise, } k = 1, \dots, K.$

## See Also

[ParamMixHMM](#)

StatMixHMMR-class      *A Reference Class which contains statistics of a MixHMMR model.*

## Description

StatMixHMMR contains all the statistics associated to a [MixHMMR](#) model.

## Fields

tau\_ik Matrix of size  $(n, K)$  giving the posterior probabilities that the curve  $Y_i$  originates from the  $k$ -th HMMR model.  
gamma\_ikjr Array of size  $(nm, R, K)$  giving the posterior probabilities that the observation  $Y_{ij}$  originates from the  $r$ -th regime of the  $k$ -th HMM model.  
loglik Numeric. Log-likelihood of the MixHMMR model.  
stored\_loglik Numeric vector. Stored values of the log-likelihood at each iteration of the EM algorithm.  
klas Row matrix of the labels issued from tau\_ik. Its elements are  $klas(i) = k, i = 1, \dots, n$ .  
z\_ik Hard segmentation logical matrix of dimension  $(n, K)$  obtained by the Maximum a posteriori (MAP) rule:  $z_{ik} = 1 \text{ if } z_{ik} = \arg \max_s P(z_{is} = 1 | \mathbf{Y}_i; \Psi) = tau_{tk}; 0 \text{ otherwise, } k = 1, \dots, K$ .  
smoothed Matrix of size  $(m, K)$  giving the estimated mean series. The  $k$ -th column gives the estimated mean series of cluster  $k$ .  
mean\_curve To define.  
BIC Numeric. Value of BIC (Bayesian Information Criterion).

AIC Numeric. Value of AIC (Akaike Information Criterion).  
 ICL1 Numeric. Value of ICL (Integrated Completed Likelihood Criterion).  
 log\_w\_k\_fyi Private. Only defined for calculations.  
 exp\_num\_trans Private. Only defined for calculations.  
 exp\_num\_trans\_from\_1 Private. Only defined for calculations.

## Methods

computeStats(paramMixHMMR) Method used in the EM algorithm to compute statistics based on parameters provided by the object paramMixHMMR of class [ParamMixHMMR](#).  
 EStep(paramMixHMMR) Method used in the EM algorithm to update statistics based on parameters provided by the object paramMixHMMR of class [ParamMixHMMR](#) (prior and posterior probabilities).  
 MAP() MAP calculates values of the fields z\_ik and klas by applying the Maximum A Posteriori Bayes allocation rule.  

$$z_{ik} = 1 \text{ if } z_{ik} = \arg \max_s P(z_{is} = 1 | \mathbf{Y}_i; \Psi) = \tau_{tk}; 0 \text{ otherwise}$$

## See Also

[ParamMixHMMR](#)

StatMixRHP-class      *A Reference Class which contains statistics of a MixRHP model.*

## Description

StatMixRHP contains all the statistics associated to a [MixRHP](#) model.

## Fields

pi\_jgk Array of size  $(nm, R, K)$  representing the logistic proportion for cluster g.  
 h\_ig Matrix of size  $(n, K)$  giving the posterior probabilities (fuzzy segmentation matrix) that the curve  $Y_i$  originates from the  $g$ -th RHP model.  
 c\_ig Hard segmentation logical matrix of dimension  $(n, K)$  obtained by the Maximum a posteriori (MAP) rule:  $c_{ig} = 1$  if  $c_{ig} = \arg \max_s h_{is}$ ; 0 otherwise,  $g = 1, \dots, K$ .  
 klas Column matrix of the labels issued from c\_ig. Its elements are  $klas(i) = g$ ,  $i = 1, \dots, n$ .  
 tau\_ijgk Array of size  $(nm, R, K)$  giving the posterior probabilities that the observation  $Y_{ij}$  originates from the  $R$ -th regime of the  $g$ -th RHP model.  
 polynomials Array of size  $(m, R, K)$  giving the values of the estimated polynomial regression components.  
 weighted\_polynomials Array of size  $(m, R, K)$  giving the values of the estimated polynomial regression components weighted by the prior probabilities pi\_jgk.  
 Ex Matrix of size  $(m, K)$ . Ex is the curve expectation (estimated signal): sum of the polynomial components weighted by the logistic probabilities pi\_jgk.  
 loglik Numeric. Observed-data log-likelihood of the MixRHP model.  
 com\_loglik Numeric. Complete-data log-likelihood of the MixRHP model.

`stored_loglik` Numeric vector. Stored values of the log-likelihood at each EM iteration.  
`stored_com_loglik` Numeric vector. Stored values of the Complete log-likelihood at each EM iteration.  
`BIC` Numeric. Value of BIC (Bayesian Information Criterion).  
`ICL` Numeric. Value of ICL (Integrated Completed Likelihood).  
`AIC` Numeric. Value of AIC (Akaike Information Criterion).  
`log_fg_xij` Matrix of size  $(n, K)$  giving the values of the probability density function  $f(y_i|h_{ig} = 1, \mathbf{x}, \boldsymbol{\Psi})$ ,  $i = 1, \dots, n$ .  
`log_alphag_fg_xij` Matrix of size  $(n, K)$  giving the values of the logarithm of the joint probability density function  $f(y_i, h_i = g|\mathbf{x}, \boldsymbol{\Psi})$ ,  $i = 1, \dots, n$ .  
`log_tau_ijgk` Array of size  $(nm, R, K)$  giving the logarithm of `tau_ijgk`.

## Methods

`computeStats(paramMixRHP)` Method used in the EM algorithm to compute statistics based on parameters provided by the object `paramMixRHP` of class [ParamMixRHP](#).  
`CStep(reg_irls)` Method used in the CEM algorithm to update statistics.  
`EStep(paramMixRHP)` Method used in the EM algorithm to update statistics based on parameters provided by the object `paramMixRHP` of class [ParamMixRHP](#) (prior and posterior probabilities).  
`MAP()` MAP calculates values of the fields `c_ig` and `k1as` by applying the Maximum A Posteriori Bayes allocation rule.  
 $c_{ig} = 1$  if  $c_{ig} = \arg \max_s h_{is}$ ; 0 otherwise,  $g = 1, \dots, K$ .

## See Also

[ParamMixRHP](#)

`toydataset`

*A dataset composed of simulated time series with regime changes.*

## Description

A dataset composed of 30 simulated time series with regime changes.

## Usage

`toydataset`

## Format

A data frame with 350 rows and 31 variables:

- x** The covariate variable which is the time in that case.
- y1** Times series with a wave form shape and for which a normally distributed random noise has been added.
- y2** Same as y1.
- y3** Same as y1.

**y4** Same as y1.

**y5** Same as y1.

**y6** Same as y1.

**y7** Same as y1.

**y8** Same as y1.

**y9** Same as y1.

**y10** Same as y1.

**y11** Time series generated as follows:

- First regime: 120 values of Normally distributed random numbers with mean 5.
- Second regime: 70 values of Normally distributed random numbers with mean 7.
- Third regime: 160 values of Normally distributed random numbers with mean 5.

**y12** Same as y11.

**y13** Same as y11.

**y14** Same as y11.

**y15** Same as y11.

**y16** Same as y11.

**y17** Same as y11.

**y18** Same as y11.

**y19** Same as y11.

**y20** Same as y11.

**y21** Time series generated as follows:

- First regime: 80 values of Normally distributed random numbers with mean 7.
- Second regime: 130 values of Normally distributed random numbers with mean 5.
- Third regime: 140 values of Normally distributed random numbers with mean 4.

**y22** Same as y21.

**y23** Same as y21.

**y24** Same as y21.

**y25** Same as y21.

**y26** Same as y21.

**y27** Same as y21.

**y28** Same as y21.

**y29** Same as y21.

**y30** Same as y21.

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