

Package ‘segclust2d’

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Type Package

Title Bivariate Segmentation/Clustering Methods and Tools

Version 0.3.0

URL <https://github.com/rpatin/segclust2d>

BugReports <https://github.com/rpatin/segclust2d/issues>

Description Provides two methods for segmentation and joint segmentation/clustering of bivariate time-series. Originally intended for ecological segmentation (home-range and behavioural modes) but easily applied on other series, the package also provides tools for analysing outputs from R packages 'moveHMM' and 'marcher'. The segmentation method is a bivariate extension of Lavielle's method available in 'adehabitatLT' (Lavielle, 1999 <[doi:10.1016/S0304-4149\(99\)00023-X](https://doi.org/10.1016/S0304-4149(99)00023-X)> and 2005 <[doi:10.1016/j.sigpro.2005.01.012](https://doi.org/10.1016/j.sigpro.2005.01.012)>). This method rely on dynamic programming for efficient segmentation. The segmentation/clustering method alternates steps of dynamic programming with an Expectation-Maximization algorithm. This is an extension of Picard et al (2007) <[doi:10.1111/j.1541-0420.2006.00729.x](https://doi.org/10.1111/j.1541-0420.2006.00729.x)> method (formerly available in 'cghseg' package) to the bivariate case. The method is fully described in Patin et al (2018) <[doi:10.1101/444794](https://doi.org/10.1101/444794)>.

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LazyData TRUE

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Author Remi Patin [aut, cre],
 Marie-Pierre Etienne [aut],
 Emilie Lebarbier [aut],
 Simon Benhamou [aut]

Maintainer Remi Patin <remi.patin@normale.fr>

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add_covariates *Covariate Calculations*

Description

Add several covariates to movement observations `add_covariates` add several covariates to a data frame with movement information. It adds : distance between location, spatial angle, speed, smoothed speed, persistence and rotation velocity (calculated with spatial angle).

Usage

```
add_covariates(x, ...)

## S3 method for class 'Move'
add_covariates(x, coord.names = c("x", "y"), ...)

## S3 method for class 'ltraj'
add_covariates(x, coord.names = c("x", "y"), ...)

## S3 method for class 'data.frame'
add_covariates(
  x,
  coord.names = c("x", "y"),
  smoothed = FALSE,
  timecol = "dateTime",
  units = "hour",
  radius = NULL,
  ...
)
```

Arguments

<code>x</code>	movement data
<code>...</code>	additional arguments
<code>coord.names</code>	names of coordinates column in <code>x</code>
<code>smoothed</code>	whether speed are smoothed or not
<code>timecol</code>	names of POSIXct time column
<code>units</code>	units for time calculation. Default "hour"
<code>radius</code>	for spatial angle calculations

Value

data.frame with additional covariates

Examples

```
## Not run: add_covariates(move_object, coord.names = c("x","y"), smoothed = T)
## Not run:
data(simulmode)
simple_data <- simulmode[,c("dateTime","x","y")]
full_data <- add_covariates(simple_data, coord.names = c("x","y"),
  timecol = "dateTime",smoothed = TRUE, units ="min")

## End(Not run)
```

angular_speed	<i>Calculate angular speed along a path</i>
---------------	---

Description

angular_speed calculate turning angle between locations, taking a dataframe as input.

Usage

```
angular_speed(x, coord.names = c("x", "y"))
```

Arguments

x	data.frame with locations
coord.names	names of coordinates column in x

Value

vector of turning angle.

Author(s)

Remi Patin, Simon Benhamou.

apply_rowSums	<i>apply_rowSums</i>
---------------	----------------------

Description

Internal function for Expectation-Maximization (EM) algorithm.

Usage

```
apply_rowSums(rupt, x)
```

Arguments

rupt	current estimated breaks in signal
x	bivariate signal

apply_subsampling	<i>Internal function for subsampling</i>
-------------------	--

Description

if subsample = FALSE do nothing.

Usage

```
apply_subsampling(x, is_segclust, subsample, subsample_over, subsample_by)
```

Arguments

x	data.frame to be subsampled
is_segclust	TRUE or FALSE whether the function was called from ‘segclust()’ or ‘segmentation()’
subsample	if FALSE disable subsampling
subsample_over	maximum number of row accepted
subsample_by	subsampling parameters

Details

else if subsample_by is missing, subsample only if nrow(x) > subsample_over, then it subsample with the minimum needed to get a data.frame smaller than subsample_over

if subsample_by is provided, use it to subsample.

Value

a data.frame

argcheck_diag.var *Check for argument 'diag.var'*

Description

Check whether argument 'diag.var' was provided. If not, propose default value.

Usage

```
argcheck_diag.var(diag.var, seg.var)
```

Arguments

diag.var	names of the variables on which statistics are calculated.
seg.var	for behavioral segmentation: names of the variables used for segmentation (either one or two names).

Value

a vector of character string

argcheck_Kmax *Check for argument 'Kmax'*

Description

Check whether argument 'Kmax' was provided and is adequate before subsampling. Propose adequate value if Kmax is not provided.

Usage

```
argcheck_Kmax(Kmax, lmin, datalength)
```

Arguments

Kmax	maximum number of segments.
lmin	minimum length of segments.
datalength	length of data provided

Value

an integer

argcheck_lmin	<i>Check for argument 'lmin'</i>
---------------	----------------------------------

Description

Check whether argument 'lmin' was provided and is adequate before subsampling

Usage

```
argcheck_lmin(lmin, is_segclust)
```

Arguments

lmin	minimum length of segments.
is_segclust	TRUE if function is called from segclust ; FALSE otherwise, if function is called from segmentation .

Value

a NULL object

argcheck_ncluster	<i>Check for argument 'ncluster'</i>
-------------------	--------------------------------------

Description

Check whether argument 'ncluster' was provided and is adequate

Usage

```
argcheck_ncluster(ncluster, Kmax)
```

Arguments

ncluster	number of cluster into which segments should be grouped. Can be a vector if one want to test several number of clusters.
Kmax	maximum number of segments.

Value

a NULL object

argcheck_order.var *Check for argument 'order.var'*

Description

Check whether argument 'order.var' was provided. If not, propose default value.

Usage

```
argcheck_order.var(order.var, diag.var)
```

Arguments

order.var	names of the variable with which states are ordered.
diag.var	names of the variables on which statistics are calculated.

Value

a vector of character string

argcheck_ordering *Check for argument 'order'*

Description

Check whether argument 'order' was provided for plot.segmentation and segmap. If not, propose default value.

Usage

```
argcheck_ordering(order, seg.type, order.var)
```

Arguments

order	TRUE or FALSE depending on whether cluster be ordered
seg.type	types of the segmentation
order.var	name of the variable to order the cluster

Value

a boolean

argcheck_scale.variable

Check for argument 'scale.variable'

Description

Check whether argument 'scale.variable' was provided. If not, propose default value.

Usage

```
argcheck_scale.variable(scale.variable, is_segclust)
```

Arguments

scale.variable minimum length of segments.
 is_segclust TRUE if function is called from [segclust](#) ; FALSE otherwise, if function is called from [segmentation](#).

Value

a boolean

argcheck_seg.var

Check for argument 'seg.var'

Description

Check whether argument 'seg.var' was adequately provided. If provided, also check for its length (1 or 2) and for the existence of corresponding column names in x. If unprovided, use default value (segmentation only) and tests if column names exists.

Usage

```
argcheck_seg.var(x, seg.var, is_segclust)
```

Arguments

x data used for segmentation. Supported: data.frame, Move object, Itraj object
 seg.var for behavioral segmentation: names of the variables used for segmentation (either one or two names).
 is_segclust TRUE if function is called from [segclust](#) ; FALSE otherwise, if function is called from [segmentation](#).

Value

a list with a data.frame and a vector with two character strings

argcheck_segclust *Check for argument 'ncluster' and 'nseg'*

Description

Check whether argument 'ncluster' and 'nseg' were provided. If not, propose default value based on BIC.

Usage

```
argcheck_segclust(ncluster, nseg, ncluster.BIC, Kopt.BIC)
```

Arguments

ncluster	number of cluster
nseg	number of segment
ncluster.BIC	optimal number of cluster selected by BIC
Kopt.BIC	optimal number of segment selected by BIC for each number of cluster

Value

a list with two integers

argcheck_segmentation *Check for argument 'nseg'*

Description

Check whether argument 'nseg' was provided. If not, propose default value based on Lavielle's criterium

Usage

```
argcheck_segmentation(nseg, Kopt.lavielle)
```

Arguments

nseg	number of segment
Kopt.lavielle	optimal number of segment selected with Lavielle's criterium

Value

an integer

argcheck_type_coord *Check for deprecated 'type' and 'coord.names' argument*

Description

Check whether argument 'type' and 'coord.names' were provided and communicate adequately if need be.

Usage

```
argcheck_type_coord(...)
```

Arguments

... additional parameters transmitted from [segmentation](#) or [segclust](#)

Value

a NULL object

arma_repmat *arma_repmat*

Description

C++ Armadillo version for repmat function. Repeat a matrix in bloc.

Usage

```
arma_repmat(A, n, m)
```

Arguments

A	matrix
n	number of repetition in line
m	number of repetition in column

augment	<i>Generic function for augment</i>
---------	-------------------------------------

Description

see broom::augment for more informations

Usage

```
augment(x, ...)
```

Arguments

x	object to be augmented
...	additional arguments

bisig_plot	<i>bisig_plot draws the plots of the bivariate signal on the same plot (scale free)</i>
------------	---

Description

bisig_plot draws the plots of the bivariate signal on the same plot (scale free)

Usage

```
bisig_plot(x, rupt = NULL, mu = NULL, pop = NULL, merge.seg = FALSE)
```

Arguments

x	the signal to be plotted
rupt	optional, if given add vertical lines at change points (rupt should a vector)
mu	optional the mean of each class of segment,
pop	optional the cluster to whom each segment belongs to,
merge.seg	should segment be merged ?

Value

no value

calc_BIC	<i>Calculate BIC</i>
----------	----------------------

Description

BIC calculates BIC given log-likelihood, number of segment and number of class

Usage

```
calc_BIC(likelihood, ncluster, nseg, n)
```

Arguments

likelihood	log-likelihood
ncluster	number of cluster
nseg	number of segment
n	number of observations

Value

a data.frame with BIC, number of cluster and number of segment

calc_dist	<i>Calculate distance between locations</i>
-----------	---

Description

calc_dist calculate distance between locations, taking a dataframe as input. Distance can also be smoothed over the two steps before and after the each point.

Usage

```
calc_dist(x, coord.names = c("x", "y"), smoothed = FALSE)
```

Arguments

x	data.frame with locations
coord.names	names of coordinates column in x
smoothed	whether distance are smoothed or not

Value

vector of distance

Author(s)

Remi Patin

Examples

```
## Not run: calc_dist(df, coord.names = c("x", "y"), smoothed = T)
```

calc_speed	<i>Calculate speed along a path</i>
------------	-------------------------------------

Description

calc_dist calculate speed between locations, taking a dataframe as input. Speed can also be smoothed over the two steps before and after the each point.

Usage

```
calc_speed(  
  x,  
  coord.names = c("x", "y"),  
  timecol = "dateTime",  
  smoothed = FALSE,  
  units = "hour"  
)
```

Arguments

x	data.frame with locations
coord.names	names of coordinates column in x
timecol	names of POSIXct time column
smoothed	whether speed are smoothed or not
units	units for time calculation. Default "hour"

Value

vector of distance

Author(s)

Remi Patin

Examples

```
## Not run: calc_speed(df, coord.names = c("x", "y"), timecol = "dateTime",  
  smoothed = T)  
## End(Not run)
```

calc_stat_states *Calculate state statistics*

Description

calc_stat_states calculates statistics of a given segmentation : mean and variance of the different states.

Usage

```
calc_stat_states(data, df.segm, diag.var, order.var = NULL)
```

Arguments

data	the data.frame with the different variable
df.segm	output of prep_segm function
diag.var	names of the variables on which statistics are calculated
order.var	names of the variable with which states are ordered

Value

a data.frame with mean and variance of the different states

Examples

```
## Not run: calc_stat_states(data, diag.var = c("dist","angle"),  
order.var='dist', type='hmm',hmm.model=mod1.hmm)  
## End(Not run)
```

check_repetition *Check for repetition in the series*

Description

check_repetition checks whether the series have identical or near-identical repetition larger than lmin. if that is the case, throw an error, the algorithm cannot yet handle these repetition, because variance on the segment would be null.

Usage

```
check_repetition(x, lmin, rounding = FALSE, magnitude = 3)
```


Arguments

x	the bivariate series to be tested
lmin	minimum length of segment
rounding	whether or not series are rounded
magnitude	number of magnitude of standard deviation below which values are rounded. i.e if magnitude = 3, difference smaller than one thousandth of the standard deviation are rounded to the same value.

Value

a boolean, TRUE if there is any repetition larger or equal to lmin.

Examples

```
set.seed(42)
dat <- rbind(base::sample(seq(1,10), size= 100, replace = TRUE),
             base::sample(seq(1,10), size= 100, replace = TRUE))
check_repetition(dat, lmin = 3)
check_repetition(dat, lmin = 5)
```

chooseseg_lavielle *Internal Function for choosing optimal number of segment*

Description

Choosing optimal number of segment using Marc Lavielle's method. From Emilie Lebarbier.
Method based on identifying breaks in the slope of the contrast.

Usage

```
chooseseg_lavielle(J, S = 0.75, ...)
```

Arguments

J	likelihood for each number of segment
S	threshold for choosing the number of segment. See adehabitatLT::chooseseg
...	additional arguments

Value

a list with optimal number of segment and full data.frame of the calculus

 choose_kmax

Finding best segmentation with a different threshold S

Description

Choosing optimal number of segment using Marc Lavielle's method. From Emilie Lebarbier. Method based on identifying breaks in the slope of the contrast.

Usage

```
choose_kmax(x, S = 0.75)
```

Arguments

x segmentation-class object
 S threshold for choosing the number of segment. See adehabitatLT::chooseseg

Value

the optimal number of segment given threshold S.

Examples

```
## Not run:
res.seg <- segmentation(df, coord.names = c("x","y"), Kmax = 30, lmin = 10)
# find the optimal number of segment according to Lavielle's criterium with a
# different threshold.
choose_kmax(res.seg, S = 0.60)

## End(Not run)
```

 colsums_sapply

colsums_sapply

Description

Internal function for Expectation-Maximization (EM) algorithm.

Usage

```
colsums_sapply(i, rupt, x, mu, tau)
```

Arguments

i	number of signal
rupt	current estimated breaks in signal
x	bivariate signal
mu	mean parameter for each signal
tau	tau

cumsum_cpp	<i>cumsum_cpp</i>
------------	-------------------

Description

C++ function for cumulative sum (replacing R cumsum)

Usage

```
cumsum_cpp(x)
```

Arguments

x	Numerical Vector
---	------------------

DynProg	<i>DynProg computes the change points given a cost matrix matD and a maximum number of segments Kmax</i>
---------	--

Description

DynProg computes the change points given a cost matrix matD and a maximum number of segments Kmax

Usage

```
DynProg(matD, Kmax)
```

Arguments

matD	the cost Matrix os size n x n
Kmax	the maximal number of segments

Value

a list with J.est a vector with Kmax value, the Kth is the minimum contrast for a model with K segments (-J.est is the log-likelihood) and with t.test a matrix, line K are the coordinates of the change points for a model with K segments

DynProg_algo_cpp	<i>DynProg_algo_cpp</i>
------------------	-------------------------

Description

This function finds the best segmentation given a Cost Matrix using a dynamic programming algorithm. C++ implementation of [DynProg](#)

Usage

```
DynProg_algo_cpp(matD, Kmax)
```

Arguments

matD	Cost Matrix
Kmax	number of segments

EM.algo_simultanee	<i>EM.algo_simultanee calculates the MLE of phi for given change-point instants</i>
--------------------	---

Description

EM.algo_simultanee calculates the MLE of phi for given change-point instants

Usage

```
EM.algo_simultanee(x, rupt, P, phi, eps = 1e-06, sameSigma = FALSE)
```

Arguments

x	bivariate signal
rupt	the sequence of change points
P	number of clusters
phi	starting value for the parameter
eps	eps
sameSigma	TRUE if segments have the same variance

Value

a list with phi, the MLE, tau =(taukj) the probability for segment k to belong to class,lvinc = lvinc,empty = empty,dv = dv

 EM.algo_simultanee_Cpp

EM.algo_simultanee calculates the MLE of phi for given change-point instants and for a fixed number of clusters

Description

EM.algo_simultanee calculates the MLE of phi for given change-point instants and for a fixed number of clusters

Usage

```
EM.algo_simultanee_Cpp(x, rupt, P, phi, eps = 1e-06, sameSigma = FALSE)
```

Arguments

x	bivariate signal
rupt	the sequence of change points
P	number of clusters
phi	starting value for the parameter
eps	eps
sameSigma	TRUE if segments have the same variance

Value

a list with phi, the MLE, tau =(taukj) the probability for segment k to belong to class,lvinc = lvinc,empty = empty,dv = dv

 EM.init_simultanee *EM.init_simultanee proposes an initial value for the EM algorithm based on a hierarchical clustering algorithm (ascending)*

Description

EM.init_simultanee proposes an initial value for the EM algorithm based on a hierarchical clustering algorithm (ascending)

Usage

```
EM.init_simultanee(x, rupt, K, P)
```

Arguments

x	the bivariate signal
rupt	the change point instants, data.frame
K	number of segments
P	number of clusters

Value

phi0 : candidate for the EM algorithm

Estep_simultanee	<i>Estep_simultanee computes posterior probabilities and incomplete-data log-likelihood for mixture models</i>
------------------	--

Description

Estep_simultanee computes posterior probabilities and incomplete-data log-likelihood for mixture models

Usage

```
Estep_simultanee(logdensity, phi, eps = 1e-09)
```

Arguments

logdensity	is a K*P matrix containing the conditional log-densities for each segment
phi	a list containing the parameters of the mixture
eps	eps

Value

a list with tau a K*P matrix, tau kj is the posterior probability for segment k to belong to class j and lvinc, the incomplete log likelihood $P(X=x)$

find_mu_sd	<i>Find mean and standard deviation of segments</i>
------------	---

Description

find_mu_sd calculates statistics of a given segmentation : mean and variance of the different states.

Usage

```
find_mu_sd(df.states, diag.var)
```

Arguments

df.states	a list of data.frame
diag.var	names of the variables on which statistics are calculated

Value

a data.frame with mean and variance of the different states

Gmean_simultanee	<i>Gmean_simultanee calculates the cost matrix for a segmentation model with changes in the mean and variance for all signals</i>
------------------	---

Description

Gmean_simultanee calculates the cost matrix for a segmentation model with changes in the mean and variance for all signals

Usage

```
Gmean_simultanee(Don, lmin, sameVar = FALSE)
```

Arguments

Don	the bivariate signal
lmin	minimum size for a segment, default value is 2
sameVar	whether variance is the same for each segment.

Value

the cost matrix $G(i,j)$ which contains the variance of the data between point $(i+1)$ to point j

Gmixt_algo_cpp	<i>Gmixt_algo_cpp</i>
----------------	-----------------------

Description

Internal C++ algorithm for computing the cost matrix.

Usage

Gmixt_algo_cpp(zi, lgi, P, mvec, wk, svec, prop)

Arguments

zi	vector of observations
lgi	vector of indices
P	number of class
mvec	vector of means for each class
wk	temporary vector for calculations
svec	vector of standard deviations for each class
prop	mixture vector

Gmixt_simultanee	<i>Gmixt_simultanee calculates the cost matrix for a segmentation/clustering model</i>
------------------	--

Description

Gmixt_simultanee calculates the cost matrix for a segmentation/clustering model

Usage

Gmixt_simultanee(Don, lmin, phi)

Arguments

Don	the bivariate signal
lmin	the minimum size for a segment
phi	the parameters of the mixture

Value

a matrix G(i,j), the mixture density for segment between points (i+1) to j $G(i,j) =$

$$\sum_{p=1}^P \log(p_i f(y^{ij}; \theta_p))$$

\sum_{p=1}^P \log(\pi_p f(y_{ij} ; \theta_p)) Rq: this density is factorized in order to avoid numerical zeros in the log

```
Gmixt_simultanee_fullcpp
    Gmixt_simultanee_fullcpp
```

Description

C++ function replacing [Gmixt_simultanee](#)

Usage

```
Gmixt_simultanee_fullcpp(Don, lmin, prop, mu, s)
```

Arguments

Don	Bivariate Signal
lmin	minimum length of segments
prop	mixture parameters
mu	mean parameters
s	standard deviation parameters

```
hybrid_simultanee    hybrid_simultanee performs a simultaneous seg - clustering for bi-
                    variate signals.
```

Description

It is an algorithm which combines dynamic programming and the EM algorithm to calculate the MLE of ϕ and T , which are the mixture parameters and the change point instants. this algorithm is run for a given number of clusters, and estimates the parameters for a segmentation/clustering model with P clusters and $1:K_{max}$ segments

Usage

```
hybrid_simultanee(
    x,
    P,
    Kmax,
    lmin = 3,
    sameSigma = TRUE,
    sameVar.init = FALSE,
    eps = 1e-06,
    lissage = TRUE,
    pureR = FALSE,
    ...
)
```

Arguments

x	the two-dimensional signal, one line per dimension
P	the number of classes
Kmax	the maximal number of segments
lmin	minimum length of segment
sameSigma	should segment have the same variance
sameVar.init	sameVar.init
eps	eps
lissage	should likelihood be smoothed
pureR	should algorithm run in full R or use Rcpp speed improvements
...	additional parameters

Value

a list with Linc, the incomplete loglikelihood =Linc,param=paramtau posterior probability

initialisePhi	<i>initialisePhi is the constructor for a set of parameters for a segclust model</i>
---------------	--

Description

initialisePhi is the constructor for a set of parameters for a segclust model

Usage

```
initialisePhi(P, val = -Inf)
```

Arguments

P	number of classes
val	the value used for initialisation default is -Inf

Value

a set of parameter phi

likelihood	<i>Generic function for likelihood</i>
------------	--

Description

Generic function for likelihood

Usage

```
likelihood(x, ...)
```

Arguments

x	object from which likelihood can be extracted
...	additional parameters

logdens_simultanee_cpp	<i>logdens_simultanee_cpp</i>
------------------------	-------------------------------

Description

Calculate logdensity of a bivariate signal

Usage

```
logdens_simultanee_cpp(xk, mu, sigma, prop)  
logdens_simultanee(xk, phi)
```

Arguments

xk	the bivariate signal
mu	mean parameter for each signal
sigma	standard deviation parameter for each signal
prop	mixture parameter
phi	parameters of the mixture, P components

Value

the value of the log density

map_seg	plot_seg <i>plot segmented movement data on a map.</i>
---------	--

Description

plot_seg plot segmented movement data on a map.

Usage

```
map_seg(
  data,
  output,
  interactive = FALSE,
  html = FALSE,
  scale = 1,
  UTMstring = "+proj=longlat +datum=WGS84 +no_defs",
  width = 400,
  height = 400,
  order = NULL,
  pointsize = 1,
  linesize = 0.5,
  coord.names = c("x", "y"),
  ...
)
```

Arguments

data	the data.frame with the different variable
output	outputs of the segmentation or segclust algorithm for one number of segment
interactive	should graph be interactive with leaflet ?
html	should the graph be incorporated in a markdown file through htmltools::tagList()
scale	for dividing coordinates to have compatibility with leaflet
UTMstring	projection of the coordinates
width	width
height	height
order	should cluster be ordered
pointsize	size of points
linesize	size of lines
coord.names	names of coordinates
...	additional arguments

Value

a ggplot object

Examples

```
## Not run:
#res.seg is a result of the segmentation-only algorithm :
nseg = 10
outputs = res.seg$outputs[[paste(nseg, "segments")]]
map <- map_segm(data=res.seg$data,output=outputs)
#res.segclust is a result of the segmentation-clustering algorithm :
nseg = 10; ncluster = 3
outputs = res.segclust$outputs[[paste(ncluster,"class -",nseg, "segments")]]
map <- map_segm(data=res.seg$data,output=outputs)

## End(Not run)
```

matrixRupt	<i>matrixRupt transforms a vector of change point into a data.frame with start and end of every segment</i>
------------	---

Description

matrixRupt transforms a vector of change point into a data.frame with start and end of every segment

Usage

```
matrixRupt(x, vectorRupt)
```

Arguments

x	the
vectorRupt	the vector containing the change point

Value

the matrix of change point

Mstep_simultanee	<i>Mstep_simultanee computes the MLE within the EM framework</i>
------------------	--

Description

Mstep_simultanee computes the MLE within the EM framework

Usage

```
Mstep_simultanee(x, rupt, tau, phi, sameSigma = TRUE)
```

Arguments

x	the bivariate signal
rupt	the rupture dataframe
tau	the K*P matrix containing posterior probabilities of membership to clusters
phi	the parameters of the mixture
sameSigma	TRUE if all segment have the same variance

Value

phi the updated value of the parameters

`Mstep_simultanee_cpp` *Mstep_simultanee computes the MLE within the EM framework*

Description

`Mstep_simultanee` computes the MLE within the EM framework

Usage

```
Mstep_simultanee_cpp(x, rupt, tau, phi, sameSigma = TRUE)
```

Arguments

x	the bivariate signal
rupt	the rupture dataframe
tau	the K*P matrix containing posterior probabilities of membership to clusters
phi	the parameters of the mixture
sameSigma	whether segments have the same variance

Value

phi the updated value of the parameters

neighborsbis	<i>neighbors tests whether neighbors of point k,P can be used to re-initialize the EM algorithm and to improve the log-likelihood.</i>
--------------	--

Description

neighbors tests whether neighbors of point k,P can be used to re-initialize the EM algorithm and to improve the log-likelihood.

Usage

```
neighborsbis(  
  kv.hull,  
  x,  
  L,  
  k,  
  param,  
  P,  
  lmin,  
  eps,  
  sameSigma = TRUE,  
  pureR = FALSE  
)
```

Arguments

kv.hull	convex hull of likelihood
x	the initial dataset
L	the likelihood
k	the points of interest
param	param outputs of segmentation
P	the number of class
lmin	minimal size of the segment to be implemented
eps	eps
sameSigma	should segments have same variance ?
pureR	should algorithm use only R functions or benefit from Rcpp faster algorithm

Value

smoothing likelihood

plot_seg *Plot segmentation on time-series*

Description

plot_seg plot segmented time serie.

Usage

```
plot_seg(
  data,
  output,
  interactive = FALSE,
  diag.var,
  x_col = "expectTime",
  html = FALSE,
  order = FALSE,
  stationarity = FALSE
)
```

Arguments

data	the data.frame with the different variable
output	outputs of the segmentation or segclust algorithm for one number of segment
interactive	should graph be interactive through leaflet ?
diag.var	names of the variables on which statistics are calculated
x_col	column name for time
html	should the graph be incorporated in a markdown file through htmltools::tagList()
order	should cluster be ordered
stationarity	if TRUE, cut each segment in three and plot each part with its own mean to assess stationarity of each segment

Value

a graph

Examples

```
## Not run:
#res.segclust is the results of the segmentation-clustering algorithm
ncluster = 3
nseg = 10
g <- plot_seg(data = res.segclust$data, output =
  res.segclust$outputs[[paste(ncluster,"class -",nseg, "segments")]],
  diag.var = x$`Diagnostic variables`,x_col = 'dateTime')
#res.seg is the results of the segmentation-only algorithm
```



```
nseg = 10
g <- plot_segm(data = res.segclust$data,
output = res.segclust$outputs[[paste(nseg, "segments")]],
diag.var = x$`Diagnostic variables`,x_col = 'dateTime')

## End(Not run)
```

plot_states

Plot states statistics

Description

plot_states plot states statistics

Usage

```
plot_states(outputs, diag.var, position_width = 0.3, order = FALSE)
```

Arguments

outputs	outputs of the segmentation or segclust algorithm for one number of segment
diag.var	names of the variables on which statistics are calculated
position_width	width between different model if several models are compared
order	should cluster be ordered

Value

a graph

Examples

```
## Not run:
#res.segclust is the results of the segmentation-clustering algorithm
ncluster = 3
nseg = 10
g <- plot_states(output = res.segclust$outputs[[
paste(ncluster,"class -",nseg, "segments")
]],
diag.var = c("dist","angle2"))
#res.seg is the results of the segmentation-only algorithm
nseg = 10
g <- plot_states(output = res.segclust$outputs[[paste(nseg, "segments")]],
diag.var = c("dist","angle2"))

## End(Not run)
```

```
prepare_HMM
```

Prepare HMM output for proper comparison plots

Description

```
prepare_HMM
```

Usage

```
prepare_HMM(data, hmm.model = NULL, diag.var, order.var = diag.var[1])
```

Arguments

data	data
hmm.model	hmm.model
diag.var	diag.var
order.var	order.var

Examples

```
## Not run:
# Example taken from moveHMM package.
# 1. simulate data
# define all the arguments of simData
nbAnimals <- 1
nbStates <- 2
nbCovs <- 2
mu<-c(15,50)
sigma<-c(10,20)
angleMean <- c(pi,0)
kappa <- c(0.7,1.5)
stepPar <- c(mu,sigma)
anglePar <- c(angleMean,kappa)
stepDist <- "gamma"
angleDist <- "vm"
zeroInflation <- FALSE
obsPerAnimal <- c(50,100)

data <- moveHMM::simData(nbAnimals=nbAnimals,nbStates=nbStates,
                        stepDist=stepDist,angleDist=angleDist,
                        stepPar=stepPar,anglePar=anglePar,nbCovs=nbCovs,
                        zeroInflation=zeroInflation,
                        obsPerAnimal=obsPerAnimal)

### 2. fit the model to the simulated data
# define initial values for the parameters
mu0 <- c(20,70)
sigma0 <- c(10,30)
kappa0 <- c(1,1)
```

```

stepPar0 <- c(mu0,sigma0) # no zero-inflation, so no zero-mass included
anglePar0 <- kappa0 # the angle mean is not estimated,
# so only the concentration parameter is needed
formula <- ~cov1+cos(cov2)
m <- moveHMM::fitHMM(data=data,nbStates=nbStates,stepPar0=stepPar0,
                    anglePar0=anglePar0,formula=formula,
                    stepDist=stepDist,angleDist=angleDist,angleMean=angleMean)

### 3. Transform into a segmentation-class object
res.hmm <- prepare_HMM(data=data,
hmm.model = m, diag.var = c("step","angle"))
### 4. you can now apply the same function than for segclust2d outputs
plot(res.hmm)
segmap(res.hmm)

## End(Not run)

```

```
prepare_shiftfit
```

Prepare shiftfit output for proper comparison plots

Description

```
prepare_shiftfit
```

Usage

```

prepare_shiftfit(
  data,
  shiftfit.model = NULL,
  diag.var,
  order.var = diag.var[1]
)

```

Arguments

data	data
shiftfit.model	shiftfit.model
diag.var	diag.var
order.var	order.var

Examples

```

## Not run:
data(simulshift)
# 1. subsample to a reasonable size
subdata <- simulshift[seq(1,30000,by = 100),]
# 2. use algorithm from marcher package
MWN.fit <- with(subdata,

```

```

marcher::estimate_shift(T=indice, X=x, Y=y,n.clust = 3))
# 3. convert output
MWN.segm <- prepare_shiftfit(subdata,MWN.fit,diag.var = c("x","y"))
# 4. use segclust2d functions
plot(MWN.segm)
plot(MWN.segm,stationarity = TRUE)
segmap(MWN.segm)

## End(Not run)

```

```
prep_seg
```

Find segment and states for a Picard model

Description

prep_seg find the different segment and states of a given HMM model

Usage

```
prep_seg(data, param, seg.type = NULL, nseg = NULL)
```

Arguments

data	the data.frame with the different variable
param	the param output of the segmentation
seg.type	either 'hybrid' or 'dynprog'
nseg	number of segment chosen

Value

a data.frame with states of the different segments

```
prep_seg_HMM
```

Internal function for HMM

Description

prep_seg_HMM

Usage

```
prep_seg_HMM(data, hmm.model)
```

Arguments

data	data
hmm.model	hmm.model

```
prep_segshiftfit      Internal function for HMM
```

Description

```
prep_segshiftfit
```

Usage

```
prep_segshiftfit(data, shiftfit.model)
```

Arguments

```
data          data
shiftfit.model shiftfit.model
```

```
relabel_states      Relabel states of a segmentation/clustering output
```

Description

relabel_states relabel the states of a segmentation/clustering output. This allows merging different states into the same if for instance several of the model states represent the same behavioural states.

Usage

```
relabel_states(mode.segclust, newlabel, ncluster, nseg, order = TRUE)
```

Arguments

```
mode.segclust  segclust output
newlabel       a vector with the new names ordered, corresponding to state_ordered
ncluster       the number of cluster for which you want relabeling
nseg           the number of segment for which you want relabeling
order          boolean, whether this changes the ordered states or not. FALSE value obsolete
               for now
```

Value

a segmentation object with state names changed for the segmentation specified by ncluster and nseg

repmat	<i>repmat repeats a matrix</i>
--------	--------------------------------

Description

repmat repeats a matrix

Usage

repmat(a, n, m)

Arguments

a	the base matrix
n	number of repetition in lines
m	number of repetition in columns

Value

a matrix with n repeats of a in lines et m in columns

ruptAsMat	<i>ruptAsMat is an internal function to transform a vector giving the change point to matrix 2 columns matrix in which each line gives the beginning and the end of a segment</i>
-----------	---

Description

ruptAsMat is an internal function to transform a vector giving the change point to matrix 2 columns matrix in which each line gives the beginning and the end of a segment

Usage

ruptAsMat(vectRupt)

Arguments

vectRupt	the vector of change point
----------	----------------------------

Value

the matrix containing the segments

`segclust`*Segmentation/Clustering of movement data - Generic function*

Description

Joint Segmentation/Clustering of movement data. Method available for `data.frame`, `move` and `ltraj` objects. The algorithm finds the optimal segmentation for a given number of cluster and segments using an iterated alternation of a Dynamic Programming algorithm and an Expectation-Maximization algorithm. Among the different segmentation found, the best one can be chosen using the maximum of a BIC penalized likelihood.

Usage

```
segclust(x, ...)  
  
## S3 method for class 'data.frame'  
segclust(x, ...)  
  
## S3 method for class 'Move'  
segclust(x, ...)  
  
## S3 method for class 'ltraj'  
segclust(x, ...)
```

Arguments

<code>x</code>	data.frame with observations
<code>...</code>	additional parameters given to segclust_internal .

Value

a [segmentation-class](#) object

Examples

```
## @examples  
df <- test_data()$data  
## # data is a data.frame with column 'x' and 'y'  
## Simple segmentation with automatic subsampling  
## if data has more than 1000 rows:  
res <- segclust(df,  
  Kmax = 15, lmin = 10, ncluster = 2:4,  
  seg.var = c("x", "y"))  
## Plot results  
plot(res)  
segmap(res, coord.names = c("x", "y"))  
## check penalized likelihood of  
## alternative number of segment possible.
```

```

# There should be a clear break if the segmentation is good
plot_BIC(res)
## Not run:
# Advanced options:
# Run with automatic subsampling if df has more than 500 rows:
res <- segclust(df, Kmax = 30, lmin = 10, ncluster = 2:4,
               seg.var = c("x", "y"), subsample_over = 500)
# Run with subsampling by 2:
res <- segclust(df, Kmax = 30, lmin = 10, ncluster = 2:4,
               seg.var = c("x", "y"), subsample_by = 2)
# Disable subsampling:
res <- segclust(df, Kmax = 30, lmin = 10,
               ncluster = 2:4, seg.var = c("x", "y"), subsample = FALSE)
# Disabling automatic scaling of variables for segmentation (standardizing
# the variables) :
res <- segclust(df, Kmax = 30, lmin = 10,
               seg.var = c("dist", "angle"), scale.variable = FALSE)

## End(Not run)

```

segclust2d

segclust2d: tools for segmentation of animal GPS movement data

Description

Provides two methods for segmentation and joint segmentation/clustering of bivariate time-series. Originally intended for ecological segmentation (home-range and behavioural modes) but easily applied on other series, the package also provides tools for analysing outputs from R packages `moveHMM` and `marcher`.

Details

The segmentation method is a bivariate extension of Lavielle's method available in `adehabitatLT` (Lavielle 1999; and 2005). This method rely on dynamic programming for efficient segmentation.

The segmentation/clustering method alternates steps of dynamic programming with an Expectation-Maximization algorithm. This is an extension of Picard et al (2007) method (formerly available in `cghseg` package) to the bivariate case.

The full description of the method is published in Patin et al. (2020).

References:

Lavielle, M. (1999) Detection of multiple changes in a sequence of dependent variables. *Stochastic Processes and their Applications*, **83**: 79–102.

Lavielle, M. (2005) Using penalized contrasts for the change-point problem. Report number 5339, Institut national de recherche en informatique et en automatique.

Patin, R., Etienne, M. P., Lebarbier, E., Chamailly'e-Jammes, S., & Benhamou, S. (2020). Identifying stationary phases in multivariate time series for highlighting behavioural modes and home range settlements. *Journal of Animal Ecology*, 89(1), 44-56.

Picard, F., Robin, S., Lebarbier, E. and Daudin, J.-J. (2007), A Segmentation/Clustering Model for the Analysis of Array CGH Data. *Biometrics*, 63: 758-766. doi:10.1111/j.1541-0420.2006.00729.x

segclust_internal *Internal segmentation/clustering function*

Description

Internal segmentation/clustering function

Usage

```
segclust_internal(  
  x,  
  seg.var,  
  diag.var,  
  order.var,  
  Kmax,  
  ncluster,  
  lmin,  
  scale.variable,  
  sameSigma = FALSE,  
  ...  
)
```

Arguments

x	data.frame with observations
seg.var	names of the variables used for segmentation (either one or two names).
diag.var	names of the variables on which statistics are calculated.
order.var	names of the variable with which states are ordered.
Kmax	maximum number of segments.
ncluster	number of cluster into which segments should be grouped. Can be a vector if one want to test several number of clusters.
lmin	minimum length of segments.
scale.variable	TRUE or FALSE for automatic scaling of variables (reduction and centering)
sameSigma	does segments have same variance ?
...	additional arguments given to chooseseg_lavielle

segmap_list	segmap_list create maps with a list of object of segmentation class
-------------	---

Description

segmap_list create maps with a list of object of segmentation class

Usage

```
segmap_list(
  x_list,
  ncluster_list = NULL,
  nseg_list = NULL,
  pointsize = 1,
  linesize = 0.5,
  coord.names = c("x", "y")
)
```

Arguments

x_list	list of segmentation objects for different individuals or path
ncluster_list	list of number of cluster to be selected for each individual. If empty, the function takes the default one
nseg_list	list of number of segment to be selected for each individual. If empty, the function takes the default one
pointsize	size of points
linesize	size of lines
coord.names	names of coordinates

Value

a ggplot2 graph

segmentation	Segmentation of movement data - Generic function
--------------	--

Description

Segmentation of movement data. No clustering. Method available for data.frame, move and ltraj object. The algorithm finds for each number of segment the optimal segmentation using a Dynamic Programming approach. The number of segment is then chosen using Lavielle's (2005) procedure based on locating rupture in the penalized likelihood.

Usage

```

segmentation(x, ...)

## S3 method for class 'data.frame'
segmentation(x, ...)

## S3 method for class 'Move'
segmentation(x, ...)

## S3 method for class 'ltraj'
segmentation(x, ...)

segmentation_internal(
  x,
  seg.var,
  diag.var,
  order.var,
  lmin,
  Kmax,
  scale.variable,
  sameSigma = FALSE,
  ...
)

```

Arguments

x	data.frame with observations
...	additional parameters given to chooseseg_lavielle
seg.var	names of the variables used for segmentation (either one or two names).
diag.var	names of the variables on which statistics are calculated.
order.var	names of the variable with which states are ordered.
lmin	minimum length of segments.
Kmax	maximum number of segments.
scale.variable	TRUE or FALSE for automatic scaling of variables (reduction and centering)
sameSigma	does segments have same variance ?

Value

a [segmentation-class](#) object

Examples

```

df <- test_data()$data
#' # data is a data.frame with column 'x' and 'y'
# Simple segmentation with automatic subsampling
# if data has more than 1000 rows:
res <- segmentation(df, Kmax = 30, lmin = 10, seg.var = c("x","y"))

```

```

# Plot results
plot(res)
segmap(res)
# check likelihood of alternative number of segment possible. There should
# be a clear break if the segmentation is good
plot_likelihood(res)
## Not run:
# Advanced options:
# Run with automatic subsampling if df has more than 500 rows:
res <- segmentation(df, Kmax = 30, lmin = 10,
  seg.var = c("x","y"), subsample_over = 500)

# Run with subsampling by 2:
res <- segmentation(df, Kmax = 30, lmin = 10,
  seg.var = c("x","y"), subsample_by = 2)

# Disable subsampling:
res <- segmentation(df, Kmax = 30, lmin = 10,
  seg.var = c("x","y"), subsample = FALSE)

# Run on other kind of variables :
res <- segmentation(df, Kmax = 30, lmin = 10, seg.var = c("dist","angle"))

# Automatic scaling of variables for segmentation
(set a mean of 0 and a standard deviation of 1 for both variables)

res <- segmentation(df, Kmax = 30, lmin = 10,
  seg.var = c("dist","angle"), scale.variable = TRUE)

## End(Not run)

```

segmentation-class	<i>segmentation class description</i>
--------------------	---------------------------------------

Description

segmentation class description

print.segmentation prints object of segmentation class

plot.segmentation plot object of segmentation class - wrapper for [plot_seg](#)

likelihood.segmentation deprecated function for plotting likelihood estimates of segmentation object. Now use [plot_likelihood](#).

plot_likelihood plot likelihood estimates of a segmentation object - works only for picard segmentation.

get_likelihood returns likelihood estimates of a segmentation object. Deprecated, now use [logLik.segmentation](#).

logLik.segmentation returns log-likelihood estimates of a segmentation object

`plot_BIC` plot BIC estimates of a segmentation object - works only for `segclust` algorithm.
`BIC` returns BIC-based penalized log-likelihood estimates of a segmentation object when segmentation/clustering has been run.
`stateplot` plot state distribution of a segmentation object
`states` return `data.frame` with states statistics a segmentation object
`segment` return `data.frame` with segment information of a segmentation object
`augment.segmentation` return `data.frame` with original data and state information of a segmentation object
`segmap` create maps with object of segmentation class (interpreting latitude/longitude)

Usage

```
## S3 method for class 'segmentation'
print(x, max.level = 1, ...)

## S3 method for class 'segmentation'
plot(x, nseg, ncluster, interactive = FALSE, xcol = "indice", order, ...)

## S3 method for class 'segmentation'
likelihood(x, ...)

plot_likelihood(x)

get_likelihood(x)

## S3 method for class 'segmentation'
logLik(object, ...)

plot_BIC(x)

## S3 method for class 'segmentation'
BIC(object, ...)

stateplot(x, nseg, ncluster, order)

states(x, nseg, ncluster)

segment(x, nseg, ncluster)

## S3 method for class 'segmentation'
augment(x, nseg, ncluster, colname_state = "state", ...)

segmap(
  x,
  interactive = FALSE,
  nseg,
  ncluster,
```

```

    html = FALSE,
    scale = 1,
    width = 400,
    height = 400,
    order,
    pointsize = 1,
    linesize = 0.5,
    ...
)

```

Arguments

x	a segmentation object generated by segmentation
max.level	argument to be passed to <code>utils::str()</code>
...	additional arguments
nseg	number of segment chosen
ncluster	number of classes chosen
interactive	whether plot are interactive (dygraphs/leaflet) or not (ggplot2)
xcol	column for x axis. can be POSIXct
order	should cluster be ordered
object	a segmentation-class object, created by <code>segclust</code> .
colname_state	column name for the added state column
html	whether <code>htmltools::tagList</code> should be applied on the returned object object for integrating in html pages
scale	for dividing coordinates to have compatibility with leaflet
width	width
height	height
pointsize	size of points
linesize	size of lines

Examples

```

## Not run:
plot(res.segclust)
plot(res.segclust, nseg = 10, ncluster = 3)

## End(Not run)

## Not run:
plot_likelihood(res.seg)

## End(Not run)

## Not run:
logLik(res.seg)

```

```
## End(Not run)

## Not run:
plot_BIC(res.segclust)

## End(Not run)

## Not run:
plot_BIC(res.segclust)

## End(Not run)

## Not run:
stateplot(res.segclust)
stateplot(res.seg)

## End(Not run)
## Not run:
states(res.segclust)
states(res.seg)

## End(Not run)

## Not run:
segment(res.segclust)
segment(res.segclust, ncluster = 3, nseg = 30)
segment(res.seg)
segment(res.seg, nseg = 4)

## End(Not run)
## Not run:
augment(res.segclust)
augment(res.segclust, ncluster = 3, nseg = 30)
augment(res.seg)
augment(res.seg, nseg = 4)

## End(Not run)
## Not run:
segmap(res.segclust, coord.names = c("x", "y"))
segmap(res.segclust, ncluster = 3, nseg = 30)
segmap(res.seg)
segmap(res.seg, nseg = 4)

## End(Not run)
```

simulmode

Simulations of behavioural mode

Description

A dataset containing a simulation of 3 different behavioural mode

Usage

simulmode

Format

A data frame with 302 rows and 10 variables:

indice index of position

x x coordinates

y y coordinates

speed smoothed speed

spatial_angle angle at constant step length

dist raw speed

angle angular speed

vit_p persistence speed

vit_r rotation speed

vit_p_spa persistence speed calculated with spatial angles

vit_r_spa rotation speed calculated with spatial angles

dateTime arbitrary date in POSIXct format

simulshift

Simulations of home-range shift

Description

A dataset containing a simulation of home-range shift

Usage

simulshift

Format

A data frame with 53940 rows and 10 variables:

indice index of position

x x coordinates

y y coordinates

dateTime arbitrary date in POSIXct format

spatial_angle	<i>Calculate spatial angle along a path</i>
---------------	---

Description

spatial_angle calculate spatial angle between locations, taking a dataframe as input. Spatial angle is considered as the angle between the focus point, the first location entering a given circle and the last location inside.

Usage

```
spatial_angle(x, coord.names = c("x", "y"), radius = NULL)
```

Arguments

x	data.frame with locations
coord.names	names of coordinates column in x
radius	for angle calculation. Default is median of step length.

Value

vector of spatial angle.

Author(s)

Remi Patin, Simon Benhamou.

Examples

```
## Not run:  
data(simulmode)  
spatial_angle(simulmode)  
  
## End(Not run)
```

stat_segm	<i>Calculate statistics on a given segmentation</i>
-----------	---

Description

stat_segm calculates statistics of a given segmentation : mean and variance of the different states. it also creates standard objects for plot.

Usage

```
stat_segm(
  data,
  diag.var,
  order.var = NULL,
  param = NULL,
  seg.type = NULL,
  nseg
)
```

Arguments

data	the data.frame with the different variable
diag.var	names of the variables on which statistics are calculated
order.var	names of the variable with which states are ordered
param	parameters of output segmentation
seg.type	either 'hybrid' or 'dynprog'
nseg	number of segment chosen

Value

a list which first element is a data.frame with states of the different segments and which second element is a data.frame with mean and variance of the different states

Examples

```
## Not run:
#res.segclust is a result of a segmentation-clustering algorithm
param <- res.segclust$param[["3 class"]]
nseg = 10
out <- stat_segm(data, diag.var = c("dist","angle"),
  order.var = "dist", param = param, nseg=nseg, seg.type = "segclust")

## End(Not run)
```

stat_seg_HMM

Get segment statistic for HMM model

Description

stat_seg_HMM

Usage

```
stat_seg_HMM(data, hmm.model = NULL, diag.var, order.var = NULL)
```

Arguments

data	data
hmm.model	hmm.model
diag.var	diag.var
order.var	order.var

stat_segshiftfit	<i>Get segment statistic for shiftfit model</i>
------------------	---

Description

stat_segshiftfit

Usage

```
stat_segshiftfit(data, shiftfit.model = NULL, diag.var, order.var = NULL)
```

Arguments

data	data
shiftfit.model	shiftfit.model
diag.var	diag.var
order.var	order.var

subsample_rename	<i>Internal function for subsampling</i>
------------------	--

Description

merge subsampled data.frame df with fulldata to add segmentation information on the full data.frame

Usage

```
subsample_rename(df, fulldata, colname)
```

Arguments

df	subsampled data.frame with additional information on segmentation
fulldata	full data.frame
colname	column name

test_data	<i>Test function generating fake data</i>
-----------	---

Description

Test function generating fake data

Usage

test_data()

wrap_dynprog_cpp	<i>DynProg Rcpp DynProg computes the change points given a cost matrix matD and a maximum number of segments Kmax</i>
------------------	---

Description

DynProg Rcpp DynProg computes the change points given a cost matrix matD and a maximum number of segments Kmax

Usage

wrap_dynprog_cpp(G, K)

Arguments

G	the cost Matrix os size n x n
K	the number of segments considered

Value

a list with J.est a vector with Kmax value, the Kth is the minimum contrast for a model with K segments (-J.est is the log-likelihood) and with t.test a matrix, line K are the coordinates of the change points for a model with K segments

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