

Package ‘cpss’

August 22, 2022

Title Change-Point Detection by Sample-Splitting Methods

Version 0.0.3

Description Implements multiple change searching algorithms for a variety of frequently considered parametric change-point models. In particular, it integrates a criterion proposed by Zou, Wang and Li (2020) [doi:10.1214/19-AOS1814](https://doi.org/10.1214/19-AOS1814) to select the number of change-points in a data-driven fashion. Moreover, it also provides interfaces for user-customized change-point models with one's own cost function and parameter estimation routine. It is easy to get started with the cpss.* set of functions by accessing their documentation pages (e.g., ?cpss).

License GPL (>= 3)

Encoding UTF-8

LazyData true

RoxygenNote 7.2.0

LinkingTo Rcpp, RcppArmadillo

Imports Rcpp, magrittr, methods, stats, mvtnorm, Rfast, tibble, dplyr, tidy, rlang, ggplot2, gridExtra

Suggests MASS

URL <https://github.com/ghwang-nk/cpss>

BugReports <https://github.com/ghwang-nk/cpss/issues>

Depends R (>= 2.10)

Maintainer Guanghui Wang <ghwang.nk@gmail.com>

NeedsCompilation yes

Author Guanghui Wang [aut, cre],
Changliang Zou [aut]

Repository CRAN

Date/Publication 2022-08-22 09:00:16 UTC

R topics documented:

algo	2
algo_param_dim	3
coef,cpss-method	3
cps	4
cpss	4
cpss-class	5
cpss.custom	5
cpss.em	8
cpss.glm	10
cpss.lm	12
cpss.mean	14
cpss.meanvar	16
cpss.var	17
dat	19
mdl	20
ncps	20
params	21
pelt_pen	21
plot,cpss-method	22
SC	22
SC_vals	23
summary,cpss-method	23
S_vals	24
update,cpss-method	24
update_inputs	25
well	25
Index	26

 algo

Generic functions and methods: algo

Description

Generic functions and methods: algo

Usage

```
algo(x)
```

```
algo(x) <- value
```

```
## S4 method for signature 'cpss'
algo(x)
```

```
## S4 replacement method for signature 'cpss'
algo(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

algo_param_dim	<i>Generic functions and methods: algo_param_dim</i>
----------------	--

Description

Generic functions and methods: algo_param_dim

Usage

```

algo_param_dim(x)

algo_param_dim(x) <- value

## S4 method for signature 'cpss'
algo_param_dim(x)

## S4 replacement method for signature 'cpss'
algo_param_dim(x) <- value

```

Arguments

x	object from cpss
value	value assigned to x

coef, cpss-method	<i>coef method</i>
-------------------	--------------------

Description

coef method

Usage

```

## S4 method for signature 'cpss'
coef(object)

```

Arguments

object	object from cpss
cpss	cpss class

cps *Generic functions and methods: cps*

Description

Generic functions and methods: cps

Usage

```
cps(x)

cps(x) <- value

## S4 method for signature 'cpss'
cps(x)

## S4 replacement method for signature 'cpss'
cps(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

cpss *cpss: Change-Point Detection by Sample-Splitting Methods*

Description

Implements multiple change searching algorithms for a variety of frequently considered parametric change-point models. In particular, it integrates a criterion proposed by Zou, Wang and Li (2020) [doi:10.1214/19-AOS1814](https://doi.org/10.1214/19-AOS1814) to select the number of change-points in a data-driven fashion. Moreover, it also provides interfaces for user-customized change-point models with one's own cost function and parameter estimation routine.

Getting started

Easy to get started with the cpss.* set of functions by accessing their documentation pages

```
library(cpss)
?cpss.mean
?cpss.var
?cpss.meanvar
?cpss.glm
?cpss.lm
?cpss.em
?cpss.custom
```

cpss-class	<i>cpss: an S4 class which collects data and information required for further change-point analyses and summaries</i>
------------	---

Description

cpss: an S4 class which collects data and information required for further change-point analyses and summaries

Slots

dat ANY.
mdl character.
algo character.
algo_param_dim numeric.
SC character.
ncps integer.
pelt_pen numeric.
cps numeric.
params list.
S_vals numeric.
SC_vals matrix.
call list.
update_inputs list.

cpss.custom	<i>Detecting changes in users-customized models</i>
-------------	---

Description

Detecting changes in users-customized models

Usage

```
cpss.custom(  
  dataset,  
  n,  
  g_subdat,  
  g_param,  
  g_cost,  
  algorithm = "BS",
```

```

dist_min = floor(log(n)),
ncps_max = ceiling(n^0.4),
pelt_pen_val = NULL,
pelt_K = 0,
wbs_nintervals = 500,
criterion = "CV",
times = 2,
model = NULL,
g_smry = NULL,
easy_cost = NULL,
param.opt = NULL
)

```

Arguments

dataset	an ANY object that could be a vector, matrix, tensor, list, etc.
n	an integer indicating the sample size of the data dataset.
g_subdat	a customized R function of two arguments <code>dat</code> and <code>indices</code> , which extracts a subset of data <code>dat</code> according to a collection of time indices <code>indices</code> . The returned object inherits the class from that of <code>dataset</code> . The argument <code>dat</code> inherits the class from that of <code>dataset</code> , and the argument <code>indices</code> is a logical vector with TRUEs indicating extracted indices.
g_param	a customized R function of two arguments <code>dat</code> (cf. <code>dat</code> of <code>g_subdat</code>) and <code>param.opt</code> (cf. <code>param.opt</code> of <code>cpss.custom</code>), which returns estimated parameters based on the data segment <code>dat</code> . It could return a numeric value, vector, matrix, list, etc.
g_cost	a customized R function of two arguments <code>dat</code> (cf. <code>dat</code> of <code>g_subdat</code>) and <code>param</code> , which returns a numeric value of the associated cost for data segment <code>dat</code> with parameters <code>param</code> . The argument <code>param</code> inherits the class from that of the returned object of <code>g_param</code> .
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if <code>algorithm = "PELT"</code> .
pelt_K	a numeric value for pruning adjustment only if <code>algorithm = "PELT"</code> . It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if <code>algorithm = "WBS"</code> , see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").

times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if <code>criterion = "CV"</code> .
model	a character string indicating the considered change model.
g_smry	a customized R function of two arguments <code>dataset</code> (cf. <code>dataset</code> of <code>cpss.custom</code>) and <code>param.opt</code> (cf. <code>param.opt</code> of <code>cpss.custom</code>), which calculates the summary statistics that will be used for cost evaluation. The returned object is a list.
easy_cost	a customized R function of three arguments <code>data_smry</code> , <code>s</code> and <code>e</code> , which evaluates the value of the cost for a date segment from observed time point <code>\$\$</code> to <code>\$e</code> . The argument <code>data_smry</code> inherits the class from that of the returned object of <code>g_smry</code> .
param.opt	an ANY object specifying additional constant parameters needed for parameter estimation or cost evaluation beyond unknown parameters.

Value

`cpss.custom` returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries.

`dat` data set

`mdl` considered change-point model

`algo` change-point searching algorithm

`algo_param_dim` user-specified upper bound of the number of true change-points if `algorithm = "SN"/"BS"/"WBS"`, or user-specified candidate values of the penalty only if `algorithm = "PELT"`

`SC` model selection criterion

`ncps` estimated number of change-points

`pelt_pen` selected value of the penalty only if `algorithm = "PELT"`

`cps` a vector of estimated locations of change-points

`params` a list object, each member is a list containing estimated parameters in the associated data segment

`S_vals` a numeric vector of candidate model dimensions in terms of a sequence of numbers of change-points or values of the penalty

`SC_vals` a numeric matrix, each column records the values of the criterion based on the validation data split under the corresponding model dimension (`S_vals`), and each row represents a splitting at each time

References

- Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500): 1590–1598.
- Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

Examples

```
library("cpss")
g_subdat_l1 <- function(dat, indices) {
  dat[indices]
}
g_param_l1 <- function(dat, param.opt = NULL) {
  return(median(dat))
}
g_cost_l1 <- function(dat, param) {
  return(sum(abs(dat - param)))
}
res <- cpss.custom(
  dataset = well, n = length(well),
  g_subdat = g_subdat_l1, g_param = g_param_l1, g_cost = g_cost_l1,
  ncps_max = 11
)
summary(res)
plot(well)
abline(v = res@cps, col = "red")
```

cpss.em

Detecting changes in exponential family

Description

Detecting changes in exponential family

Usage

```
cpss.em(
  dataset,
  family,
  size = NULL,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2
)
```


Arguments

dataset	a numeric matrix of dimension $n \times d$, where each row represents an observation and each column stands for a variable. A numeric vector is also acceptable for univariate observations.
family	a character string specifying the underlying distribution. In the current version, detecting changes in binomial ("binom"), multinomial ("multinom"), Poisson ("pois"), exponential ("exp"), geometric ("geom"), Dirichlet ("diri"), gamma ("gamma"), beta ("beta"), chi-square ("chisq") and inverse gaussian ("invgauss") distributions are supported.
size	an integer indicating the number of trials only if family = "binom" or family = "multinom".
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").
times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if criterion = "CV".

Value

cpss.em returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

- Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500):1590–1598.
- Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.meanvar](#) [cpss.mean](#) [cpss.var](#)

Examples

```

library("cpss")
set.seed(666)
n <- 1000
tau <- c(100, 300, 700, 900)
tau_ext <- c(0, tau, n)
theta <- c(1, 0.2, 1, 0.2, 1)
seg_len <- diff(c(0, tau, n))
y <- unlist(lapply(seq(1, length(tau) + 1), function(k) {
  rexp(seg_len[k], theta[k])
})))
res <- cpss.em(
  y, family = "exp", algorithm = "WBS", ncps_max = 10,
  criterion = "MS", times = 10
)
cps(res)
# [1] 100 299 705 901

```

cpss.glm

*Detecting changes in GLMs***Description**

Detecting changes in GLMs

Usage

```

cpss.glm(
  formula,
  family,
  data = NULL,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2
)

```

Arguments

formula	a formula object specifying the GLM with change-points.
family	a description of the error distribution and link function to be used in the model, which can be a character string naming a family function or a family function.
data	an optional data frame containing the variables in the model.

algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").
times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if criterion = "CV".

Value

cpss.glm returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500):1590–1598.

Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.lm](#)

Examples

```
library("cpss")
set.seed(666)
n <- 200
size <- rpois(n, 20 - 1) + 1
tau <- c(75, 100, 175)
tau_ext <- c(0, tau, n)
be <- list(c(0, 0.5), c(0, -0.5), c(0.5, -0.5), c(-0.5, -0.5))
seg_len <- diff(c(0, tau, n))
x <- rnorm(n)
eta <- lapply(seq(1, length(tau) + 1), function(k) {
  be[[k]][1] + be[[k]][2] * x[(tau_ext[k] + 1):tau_ext[k + 1]]
})
```

```

eta <- do.call(c, eta)
p <- 1 / (1 + exp(-eta))
y <- rbinom(n, size = size, prob = p)

pelt_pen_val <- (log(n))^seq(0.5, 2, by = 0.1)
res <- cpss.glm(
  formula = cbind(y, size - y) ~ x, family = binomial(),
  algorithm = "PELT", pelt_pen_val = pelt_pen_val, ncps_max = 10
)
summary(res)
# 75 105 175
coef(res)
# [1,] 0.02540872 0.08389551 0.5284425 -0.4980768
# [2,] 0.57222684 -0.45430385 -0.5203319 -0.4581678

```

cpss.lm

Detecting changes in linear models

Description

Detecting changes in linear models

Usage

```

cpss.lm(
  formula,
  data = NULL,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2
)

```

Arguments

formula	a formula object specifying the GLM with change-points.
data	an optional data frame containing the variables in the model.
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).

npcs_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").
times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if criterion = "CV".

Value

cpss.lm returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

- Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500):1590–1598.
- Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.glm](#)

Examples

```
library("cpss")
set.seed(666)
n <- 400
tau <- c(80, 200, 300)
tau_ext <- c(0, tau, n)
be <- list(c(0, 1), c(1, 0.5), c(0, 1), c(-1, 0.5))
seg_len <- diff(c(0, tau, n))
x <- rnorm(n)
mu <- lapply(seq(1, length(tau) + 1), function(k) {
  be[[k]][1] + be[[k]][2] * x[(tau_ext[k] + 1):tau_ext[k + 1]]
})
mu <- do.call(c, mu)
sig <- unlist(lapply(seq(1, length(tau) + 1), function(k) {
  rep(be[[k]][2], seg_len[k])
})))
y <- rnorm(n, mu, sig)
res <- cpss.lm(
  formula = y ~ x,
```

```

  algorithm = "BS", ncps_max = 10
)
summary(res)
# 80 202 291
coef(res)
# $coef
#           [,1]      [,2]      [,3]      [,4]
# [1,] -0.00188792  1.0457718 -0.03963209 -0.9444813
# [2,]  0.91061557  0.6291965  1.20694409  0.4410036
#
# $sigma
# [1] 0.8732233 0.4753216 0.9566516 0.4782329

```

cpss.mean

Detecting changes in mean

Description

Detecting changes in mean

Usage

```

cpss.mean(
  dataset,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2,
  Sigma = NULL
)

```

Arguments

dataset	a numeric matrix of dimension $n \times d$, where each row represents an observation and each column stands for a variable. A numeric vector is also acceptable for univariate observations.
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.

pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").
times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if criterion = "CV".
Sigma	if a numeric matrix (or constant) is supplied, it will be taken as the value of the common covariance (or variance). By default it is NULL, and the covariance is estimated by

$$\hat{\Sigma} = \frac{1}{2(n-1)} \sum_{i=1}^{n-1} (Y_i - Y_{i+1})(Y_i - Y_{i+1})'$$

Value

cpss.mean returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500): 1590–1598.
 Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.meanvar](#) [cpss.var](#)

Examples

```
library("cpss")
set.seed(666)
n <- 2048
tau <- c(205, 267, 308, 472, 512, 820, 902, 1332, 1557, 1598, 1659)
seg_len <- diff(c(0, tau, n))
mu <- rep(c(0, 14.64, -3.66, 7.32, -7.32, 10.98, -4.39, 3.29, 19.03, 7.68, 15.37, 0), seg_len)
ep <- 7 * rnorm(n)
y <- mu + ep

res <- cpss.mean(y, algorithm = "SN", ncps_max = 20)
summary(res)
# 205 267 307 471 512 820 897 1332 1557 1601 1659
plot(res, type = "scatter")
```

```

plot(res, type = "path")
out <- update(res, dim_update = 12)
out@cps
# 205 267 307 471 512 820 897 1332 1557 1601 1659 1769
# coef(out)

```

cpss.meanvar

Detecting changes in mean and (co)variance

Description

Detecting changes in mean and (co)variance

Usage

```

cpss.meanvar(
  dataset,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2
)

```

Arguments

dataset	a numeric matrix of dimension $n \times d$, where each row represents an observation and each column stands for a variable. A numeric vector is also acceptable for univariate observations.
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).

criterion a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").

times an integer specifying how many times of sample-splitting should be performed; It should be 2 if `criterion = "CV"`.

Value

`cpss.meanvar` returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500):1590–1598.

Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.mean](#) [cpss.var](#)

Examples

```
library("cpss")
if (!requireNamespace("MASS", quietly = TRUE)) {
  stop("Please install the package \"MASS\".")
}
set.seed(666)
n <- 1000
tau <- c(200, 400, 600, 800)
mu <- list(rep(0, 2), rep(1, 2), rep(1, 2), rep(0, 2), rep(0, 2))
Sigma <- list(diag(2), diag(2), matrix(c(1,-1,-1, 4), 2), matrix(c(1, 0.5, 0.5, 1), 2), diag(2))
seg_len <- diff(c(0, tau, n))
y <- lapply(seq(1, length(tau) + 1), function(k) {
  MASS::mvrnorm(n = seg_len[k], mu = mu[[k]], Sigma = Sigma[[k]])
})
y <- do.call(rbind, y)
res <- cpss.meanvar(y, algorithm = "BS", dist_min = 20)
cps(res)
# [1] 211 402 598 804
plot(res, type = "coef")
```

cpss.var

Detecting changes in (co)variance

Description

Detecting changes in (co)variance

Usage

```
cpss.var(
  dataset,
  algorithm = "BS",
  dist_min = floor(log(n)),
  ncps_max = ceiling(n^0.4),
  pelt_pen_val = NULL,
  pelt_K = 0,
  wbs_nintervals = 500,
  criterion = "CV",
  times = 2,
  mu = NULL
)
```

Arguments

dataset	a numeric matrix of dimension $n \times d$, where each row represents an observation and each column stands for a variable. A numeric vector is also acceptable for univariate observations.
algorithm	a character string specifying the change-point searching algorithm, one of the following choices: "SN" (segment neighborhood), "BS" (binary segmentation), "WBS" (wild binary segmentation) and "PELT" (pruned exact linear time) algorithms.
dist_min	an integer specifying minimum searching distance (length of feasible segments).
ncps_max	an integer specifying an upper bound of the number of true change-points.
pelt_pen_val	a numeric vector specifying candidate values of the penalty only if algorithm = "PELT".
pelt_K	a numeric value for pruning adjustment only if algorithm = "PELT". It is usually taken to be 0 if the negative log-likelihood is used as a cost, see Killick et al. (2012).
wbs_nintervals	an integer specifying the number of random intervals drawn only if algorithm = "WBS", see Fryzlewicz (2014).
criterion	a character string specifying the model selection criterion, "CV" ("cross-validation") or "MS" ("multiple-splitting").
times	an integer specifying how many times of sample-splitting should be performed; It should be 2 if criterion = "CV".
mu	If a numeric vector or constant is supplied, it will be taken as the value of the common mean. By default it is NULL, and the mean is estimated by the sample mean.

Value

cpss.var returns an object of an S4 class, called "cpss", which collects data and information required for further change-point analyses and summaries. See [cpss.custom](#).

References

Killick, R., Fearnhead, P., and Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association*, 107(500): 1590–1598.

Fryzlewicz, P. (2014). Wild binary segmentation for multiple change-point detection. *The Annals of Statistics*, 42(6): 2243–2281.

See Also

[cpss.meanvar](#) [cpss.mean](#)

Examples

```
library("cpss")
if (!requireNamespace("MASS", quietly = TRUE)) {
  stop("Please install the package \"MASS\".")
}
set.seed(666)
n <- 1000
tau <- c(200, 500, 750)
mu <- list(rep(0, 2), rep(0, 2), rep(0, 2), rep(0, 2))
Sigma <- list(diag(2), matrix(c(1, 0, 0, 4), 2), matrix(c(1, -0.5, -0.5, 4), 2), diag(2))
seg_len <- diff(c(0, tau, n))
y <- lapply(seq(1, length(tau) + 1), function(k) {
  MASS::mvrnorm(n = seg_len[k], mu = mu[[k]], Sigma = Sigma[[k]])
})
y <- do.call(rbind, y)
res <- cpss.var(y, algorithm = "BS", dist_min = 20)
cps(res)
# [1] 215 515 751
```

 dat

Generic functions and methods: dat

Description

Generic functions and methods: dat

Usage

```
dat(x)
```

```
dat(x) <- value
```

```
## S4 method for signature 'cpss'
dat(x)
```

```
## S4 replacement method for signature 'cpss'
dat(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x
cpss	cpss class

mdl	<i>Generic functions and methods: mdl</i>
-----	---

Description

Generic functions and methods: mdl

Usage

```
mdl(x)

mdl(x) <- value

## S4 method for signature 'cpss'
mdl(x)

## S4 replacement method for signature 'cpss'
mdl(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

ncps	<i>Generic functions and methods: ncps</i>
------	--

Description

Generic functions and methods: ncps

Usage

```
ncps(x)

ncps(x) <- value

## S4 method for signature 'cpss'
ncps(x)

## S4 replacement method for signature 'cpss'
ncps(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

params	<i>Generic functions and methods: params</i>
--------	--

Description

Generic functions and methods: params

Usage

```
params(x)

params(x) <- value

## S4 method for signature 'cpss'
params(x)

## S4 replacement method for signature 'cpss'
params(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

pelt_pen	<i>Generic functions and methods: pelt_pen</i>
----------	--

Description

Generic functions and methods: pelt_pen

Usage

```
pelt_pen(x)

pelt_pen(x) <- value

## S4 method for signature 'cpss'
pelt_pen(x)

## S4 replacement method for signature 'cpss'
pelt_pen(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

plot, cpss-method	<i>plot method</i>
-------------------	--------------------

Description

plot method

Usage

```
## S4 method for signature 'cpss'
plot(obj, type, x = c(), y = c(), ...)
```

Arguments

obj	object from cpss
type	type of visualization
x	x
y	y
...	...
cpss	cpss class

SC	<i>Generic functions and methods: SC</i>
----	--

Description

Generic functions and methods: SC

Usage

```
SC(x)

SC(x) <- value

## S4 method for signature 'cpss'
SC(x)

## S4 replacement method for signature 'cpss'
SC(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

SC_vals	<i>Generic functions and methods: SC_vals</i>
---------	---

Description

Generic functions and methods: SC_vals

Usage

```
SC_vals(x)

SC_vals(x) <- value

## S4 method for signature 'cpss'
SC_vals(x)

## S4 replacement method for signature 'cpss'
SC_vals(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

summary,cpss-method	<i>summary method</i>
---------------------	-----------------------

Description

summary method

Usage

```
## S4 method for signature 'cpss'
summary(object)
```

Arguments

object	object from cpss
cpss	cpss class

S_vals

Generic functions and methods: S_vals

Description

Generic functions and methods: S_vals

Usage

```
S_vals(x)

S_vals(x) <- value

## S4 method for signature 'cpss'
S_vals(x)

## S4 replacement method for signature 'cpss'
S_vals(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

update, cpss-method *update method*

Description

update method

Usage

```
## S4 method for signature 'cpss'
update(object, dim_update)
```

Arguments

object	object from cpss
dim_update	model dimension to update
cpss	cpss class

update_inputs	<i>Generic functions and methods: update_inputs</i>
---------------	---

Description

Generic functions and methods: update_inputs

Usage

```
update_inputs(x)
update_inputs(x) <- value
## S4 method for signature 'cpss'
update_inputs(x)
## S4 replacement method for signature 'cpss'
update_inputs(x) <- value
```

Arguments

x	object from cpss
value	value assigned to x

well	<i>Well-log data</i>
------	----------------------

Description

Measurements of the nuclear magnetic response of underground rocks.

Usage

```
well
```

Format

A vector of 4,050 measurements:

well Measurements.

Source

[doi:10.1111/14679868.00421](https://doi.org/10.1111/14679868.00421)

Index

- * **datasets**
 - well, 25

- algo, 2
- algo, cpss-method (algo), 2
- algo<- (algo), 2
- algo<- , cpss-method (algo), 2
- algo_param_dim, 3
- algo_param_dim, cpss-method (algo_param_dim), 3
- algo_param_dim<- (algo_param_dim), 3
- algo_param_dim<- , cpss-method (algo_param_dim), 3

- coef, cpss-method, 3
- cps, 4
- cps, cpss-method (cps), 4
- cps<- (cps), 4
- cps<- , cpss-method (cps), 4
- cpss, 4
- cpss-class, 5
- cpss.custom, 5, 9, 11, 13, 15, 17, 18
- cpss.em, 8
- cpss.glm, 10, 13
- cpss.lm, 11, 12
- cpss.mean, 9, 14, 17, 19
- cpss.meanvar, 9, 15, 16, 19
- cpss.var, 9, 15, 17, 17

- dat, 19
- dat, cpss-method (dat), 19
- dat<- (dat), 19
- dat<- , cpss-method (dat), 19

- mdl, 20
- mdl, cpss-method (mdl), 20
- mdl<- (mdl), 20
- mdl<- , cpss-method (mdl), 20

- ncps, 20
- ncps, cpss-method (ncps), 20

- ncps<- (ncps), 20
- ncps<- , cpss-method (ncps), 20

- params, 21
- params, cpss-method (params), 21
- params<- (params), 21
- params<- , cpss-method (params), 21
- pelt_pen, 21
- pelt_pen, cpss-method (pelt_pen), 21
- pelt_pen<- (pelt_pen), 21
- pelt_pen<- , cpss-method (pelt_pen), 21
- plot, cpss-method, 22

- S_vals, 24
- S_vals, cpss-method (S_vals), 24
- S_vals<- (S_vals), 24
- S_vals<- , cpss-method (S_vals), 24
- SC, 22
- SC, cpss-method (SC), 22
- SC<- (SC), 22
- SC<- , cpss-method (SC), 22
- SC_vals, 23
- SC_vals, cpss-method (SC_vals), 23
- SC_vals<- (SC_vals), 23
- SC_vals<- , cpss-method (SC_vals), 23
- summary, cpss-method, 23

- update, cpss-method, 24
- update_inputs, 25
- update_inputs, cpss-method (update_inputs), 25
- update_inputs<- (update_inputs), 25
- update_inputs<- , cpss-method (update_inputs), 25

- well, 25