Package 'StepSignalMargiLike'

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Type Package

Title Step-Wise Signal Extraction via Marginal Likelihood

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Description Provides function to estimate multiple change points
using marginal likelihood method. See the Manual file in data folder for
a detailed description of all functions, and a walk through tutorial.
For more information of the method, please see Du, Kao and Kou (2016)
<doi:10.1080/01621459.2015.1006365>.

License GPL (>= 2)

Imports Rcpp (>= 0.11.3)

LinkingTo Rcpp

SystemRequirements C++11

NeedsCompilation yes

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R topics documented:

`StepSignalMargiLike-package`

Estimating Change Points Using Marginal Likelihood

Description

(See the Manual.pdf file in data folder for a detail description of all functions, and a walkthrough tutorial.)

This packages provides function to estimate multiple change points using marginal likelihood method proposed by Du, Kao and Kou (2015), which we would denoted as DKK2015 afterward. `est.changepoints` estimates change-points. `PlotChangePoints` plots. Other functions are for the normal and Poisson examples in DKK2015.

Details

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Author(s)

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References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2016), "Stepwise Signal Extraction via Marginal Likelihood"

Examples

```
n <- 5
```

```
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.t <- 1:(5*n)

prior <- prior.norm.A(data.x)
max.segs <- 10

index.ChPT <- est.changepoints(data.x, mode="normal", prior)
est.mean <- est.mean.norm(data.x, index.ChPT, prior)
PlotChangePoints(data.x, data.t, index.ChPT, est.mean)

PlotChangePoints(data.x, data.t, index.ChPT, est.mean, type.data="p",
  col.data="green", col.est="black", main="Stepwise Signal Estimation",
  sub="Using Marginal Likelihood", xlab="time", ylab="value")
```

ChangePointAnalyzeNorm

ChangePointAnalyzeNorm

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
ChangePointAnalyzeNorm
```

Examples

```
n <- 5
max.segs <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.t <- 1:(5*n)

prior <- prior.norm.A(data.x)

ChangePointAnalyzeNorm(data.x, n, max.segs, prior)
```

ChangePointAnalyzeNormUnRes

ChangePointAnalyzeNormUnRes

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
ChangePointAnalyzeNormUnRes
```

Examples

```
n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.t <- 1:(5*n)

prior <- prior.norm.A(data.x)

ChangePointAnalyzeNormUnRes(data.x, n, prior)
```

ChangePointAnalyzePoiss

ChangePointAnalyzePoiss

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
ChangePointAnalyzePoiss
```

Examples

```
n <- 20
max.segs <- 5

data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
```

```
data.x <- c(data.x, rpois(n, 80))

prior <- prior.pois(data.x)

ChangePointAnalyzePoiss(data.x, n, max.segs, prior)
```

ChangePointAnalyzePoissUnRes *ChangePointAnalyzePoissUnRes*

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
ChangePointAnalyzePoissUnRes
```

Examples

```
n <- 20

data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
data.x <- c(data.x, rpois(n, 80))

prior <- prior.pois(data.x)

ChangePointAnalyzePoissUnRes(data.x, n, prior)
```

`est.changepoints` *est.changepoints*

Description

This function estimates multiple change points using marginal likelihood method proposed by Du, Kao and Kou (2015), which we would denoted as DKK2015 afterward.

Usage

```
est.changepoints(data.x, model, prior, max.segs, logH, logMD)
```

Arguments

`data.x`	Observed data in vector or matrix form. When the data is in matrix form, each column should represent a single observation.
`model`	The specified distributional assumption. Currently we have implemented two arguments: "normal" (data follows one dimensional Normal distribution with unknown mean and variance) and "poisson" (data follows Poisson distribution with unknown intensity). A third argument "user" is also accepted, given that the prior and the log marginal likelihood function are specified in the parameter prior and logMD.
`prior`	The prespecified prior parameters in consistent with the form used in `logMD`. For the proposed priors in DKK2015, use the corresponding `prior` function provided.
`max.segs`	(Opt.) The maximum number of segments allowed, which is the value M in DKK2015. Must be a positive integer greater then 1. If missing, the function would process using the algorihtm by Jackson et al.(2005).
`logH`	(Opt.) A Boolean algebra determine whether to report the log H matrix in DKK2015. Default is FALSE.
`logMD`	(Opt.) The log marginal likelihood function (which is the log of D function in DKK2015). The function must be in the form of `logMD(data.x, prior)`.

Details

See Manual.pdf in "data" folder.

Value

If `logH` is FALSE, the function returns the set of estimated change-points by the index of the data, where each index is the end point of a segment. If the result is no change-points, the function returns `NULL`.

If `logH` is TRUE, then the function returns a list with three components: `changePTs` is the set of estimated change-points, `log.H` is the log value for the H matrix used in the algorithm, where $log.H(m,i) = logH(x1, x2, ..., xi|m)$, and `max.j` records the j that maximizes the marginal likelihood in each step. See the manual in data folder for more details.

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
```

```
data.x <- c(data.x, rnorm(n, 1,1))

prior <- prior.norm.A(data.x)
max.segs <- 10

est.changepoints(data.x=data.x, model="normal", prior=prior)
est.changepoints(data.x=data.x, model="normal", prior=prior, max.segs=max.segs)
est.changepoints(data.x=data.x, model="normal", prior=prior, max.segs=max.segs,logH=TRUE)
```

`est.mean.norm` *est.mean.norm*

Description

This function estimates the posterior mean for each segments under the normal assumption with conjugate prior. The variance σ^2 is assumed to be drawn from an inverse Gamma distribution with shape parameter $\nu 0$ and scale parameter $\sigma 0^2$, while mean is assumed to be drawn from a normal distribution with mean $\mu 0$ and variance $\sigma^2/\kappa 0$.

Usage

```
est.mean.norm(data.x, index.ChPT, prior)
```

Arguments

`data.x`	Observed data in vector form where each element represents a single observation.
`index.ChPT`	The set of the index of change points in a vector. Must be in accending order. This could be obtained by `est.changepoints`.
`prior`	Vector contatining prior parameters in the order of $(\mu 0, \kappa 0, \nu 0, \sigma 0^2)$.

Details

See Manual.pdf in "data" folder.

Value

Vector containing estimated mean for each segments.

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))

prior <- prior.norm.A(data.x)
index.ChPT <- c(n,2*n,3*n,4*n)
est.mean.norm(data.x, index.ChPT, prior)
```

`est.mean.pois` *est.mean.pois*

Description

This function estimates the posterior mean for each segments under the Poisson assumption with conjugate prior. The data is assumed to follow Poisson(λ), where λ is assumed to have Beta prior with shape parameters α and β.

Usage

```
est.mean.pois(data.x, index.ChPT, prior)
```

Arguments

`data.x`	Observed data in vector form where each element represents a single observation.
`index.ChPT`	The set of the index of change points in a vector. Must be in accending order. This could be obtained by `est.changepoints`.
`prior`	Vector contatining prior parameters in the order of (α, β).

Details

See Manual.pdf in "data" folder.

Value

Vector containing estimated mean for each segments.

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 20
data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
data.x <- c(data.x, rpois(n, 80))
data.x <- matrix(data.x,1)

prior <- c(1,2)
index.ChangePTs <- c(n, 2*n, 3*n, 4*n)
est.mean.pois(data.x, index.ChangePTs, prior)
```

PlotChangePoints *PlotChangePoints*

Description

This function plots the data and the estimated stepwise signal given the estimated change points and means. The function only applies to one dimensional data.

Usage

```
PlotChangePoints(data.x, data.t, index.ChPT, est.mean, type.data, col.data,
  col.est, main.plot, sub.plot, xlab.plot, ylab.plot)
```

Arguments

`data.x`	Observed data in vector form where each element represents a single observation.
`data.t`	The one-dimensional time or seqeuential labeling for the data.
`index.ChPT`	The set of the index of change points in a vector. Must be in accending order. This could be obtained by `est.changepoints`.
`est.mean`	The estimated mean in each segments in a vector. The length must be one plus the length of `index.ChPT`. For normal and Poisson cases as in DKK2013, apply `est.mean.norm` and `est.mean.pois` respectively.
`type.data`	(Opt.) The line type for the data. Options are the same as in plot() argument. Default is "l".
`col.data`	(Opt.) The line color for the data. Options are the same as in plot() argument. Default is "red".
`col.est`	(Opt.) The line color for the estimated stepwise signal. Options are the same as in plot() arguent. Default is "blue".

main.plot	(Opt.) The overall title used in the plot, which is like the main in plot(). Default is NULL.
sub.plot	(Opt.) The sub title used in the plot, which is like the main in plot(). Default is NULL.
xlab.plot	(Opt.) The title for the x axis used in the plot, which is like the main in plot(). Default is "data.t".
ylab.plot	(Opt.) The title for the y axis used in the plot, which is like the main in plot(). Default is "data.x".

Details

See Manual.pdf in "data" folder.

Value

Plot for the data and the estimated change-points. Note that this function only apply to one-dimensional observation.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.x <- matrix(data.x, 1)
data.t <- 1:(5*n)

index.ChPT <- c(n,2*n,3*n,4*n)
est.mean <- c(1,10,2,10,2)
PlotChangePoints(data.x, data.t, index.ChPT, est.mean)

PlotChangePoints(data.x, data.t, index.ChPT, est.mean, type.data="p",
  col.data="green", col.est="black", main="Stepwise Signal Estimation",
  sub="Using Marginal Likelihood", xlab="time", ylab="value")
```

---

prior.norm.A *prior.norm.A*

Description

This function computes the Norm-A prior proposed in Du, Kao and Kou (2015), which is used under conjugate normal assumption. The variance σ^2 is assumed to be drawn from an inverse Gamma distribution with shape parameter $\nu 0$ and scale parameter $\sigma 0^2$, while mean is assumed to be drawn from a normal distribution with mean $\mu 0$ and variance $\sigma^2/\kappa 0$.

Usage

```
prior.norm.A(data.x)
```

Arguments

data.x	Observed data in vector form where each element represents a single observation.

Details

See Manual.pdf in "data" folder.

Value

Vector for prior parameters in the order of $(\mu 0, \kappa 0, \nu 0, \sigma 0^2)$

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))

prior.norm.A(data.x)
```

---

prior.norm.B *prior.norm.B*

Description

This function computes the Norm-B prior proposed in Du, Kao and Kou (2015), which is used under conjugate normal assumption. The variance σ^2 is assumed to be drawn from an inverse Gamma distribution with shape parameter $\nu 0$ and scale parameter $\sigma 0^2$, while mean is assumed to be drawn from a normal distribution with mean $\mu 0$ and variance $\sigma^2/\kappa 0$.

Usage

```
prior.norm.B(data.x)
```

Arguments

data.x	Observed data in vector form where each element represents a single observation.

Details

See Manual.pdf in "data" folder.

Value

Vector for prior parameters in the order of $(\mu 0, \kappa 0, \nu 0, \sigma 0^2)$

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))

prior.norm.B(data.x)
```

---

prior.norm.C *prior.norm.C*

Description

This function computes the Norm-C prior proposed in Du, Kao and Kou (2015), which is used under conjugate normal assumption. The variance σ^2 is assumed to be drawn from an inverse Gamma distribution with shape parameter $\nu 0$ and scale parameter $\sigma 0^2$, while mean is assumed to be drawn from a normal distribution with mean $\mu 0$ and variance $\sigma^2/\kappa 0$.

Usage

```
prior.norm.C(data.x)
```

Arguments

data.x	Observed data in vector form where each element represents a single observation.

Details

See Manual.pdf in "data" folder.

Value

Vector for prior parameters in the order of $(\mu 0, \kappa 0, \nu 0, \sigma 0^2)$

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
library(StepSignalMargiLike)

n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))

prior.norm.C(data.x)
```

`prior.pois` *prior.pois*

Description

This function computes the Pois prior proposed in Du, Kao and Kou (2015), which is used under the Poisson assumption with conjugate prior. The data is assumed to follow Poisson(λ), where λ is assumed to have Beta prior with shape parameters α and β.

Usage

```
prior.pois(data.x)
```

Arguments

`data.x`	Observed data in vector form where each element represents a single observation.

Details

See Manual.pdf in "data" folder.

Value

Vector for prior parameters in the order of (α, β)

References

Chao Du, Chu-Lan Michael Kao and S. C. Kou (2015), "Stepwise Signal Extraction via Marginal Likelihood". Forthcoming in Journal of American Statistical Association.

Examples

```
n <- 20

data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
data.x <- c(data.x, rpois(n, 80))

prior.pois(data.x)
```

StepSignalMargiLike_ChangePointAnalyzeNorm

StepSignalMargiLike_ChangePointAnalyzeNorm

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
StepSignalMargiLike_ChangePointAnalyzeNorm
```

Examples

```
n <- 5
max.segs <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.t <- 1:(5*n)

prior <- prior.norm.A(data.x)

ChangePointAnalyzeNorm(data.x, n, max.segs, prior)
```

StepSignalMargiLike_ChangePointAnalyzeNormUnRes *StepSignalMargiLike_ChangePointAnalyzeNormUnRes*

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
StepSignalMargiLike_ChangePointAnalyzeNormUnRes
```

Examples

```
n <- 5
data.x <- rnorm(n, 1, 1)
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 2,1))
data.x <- c(data.x, rnorm(n, 10,1))
data.x <- c(data.x, rnorm(n, 1,1))
data.t <- 1:(5*n)

prior <- prior.norm.A(data.x)

ChangePointAnalyzeNormUnRes(data.x, n, prior)
```

StepSignalMargiLike_ChangePointAnalyzePoiss *StepSignalMargiLike_ChangePointAnalyzePoiss*

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
StepSignalMargiLike_ChangePointAnalyzePoiss
```

Examples

```
n <- 20
max.segs <- 20

data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
```

```
data.x <- c(data.x, rpois(n, 80))

prior <- prior.pois(data.x)

ChangePointAnalyzePoiss(data.x, n, max.segs, prior)
```

`StepSignalMargiLike_ChangePointAnalyzePoissUnRes` *StepSignalMargiLike_ChangePointAnalyzePoissUnRes*

Description

Supported C++ function used in function `est.changepoints`.

Usage

```
StepSignalMargiLike_ChangePointAnalyzePoissUnRes
```

Examples

```
n <- 20

data.x <- rpois(n, 1)
data.x <- c(data.x, rpois(n, 10))
data.x <- c(data.x, rpois(n, 50))
data.x <- c(data.x, rpois(n, 20))
data.x <- c(data.x, rpois(n, 80))

prior <- prior.pois(data.x)

ChangePointAnalyzePoissUnRes(data.x, n, prior)
```

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