

# Package ‘biomvRCNS’

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**Type** Package

**Title** Copy Number study and Segmentation for multivariate biological data

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**Description** In this package, a Hidden Semi Markov Model (HSMM) and one homogeneous segmentation model are designed and implemented for segmentation genomic data, with the aim of assisting in transcripts detection using high throughput technology like RNA-seq or tiling array, and copy number analysis using aCGH or sequencing.

**License** GPL (>= 2)

**LazyLoad** yes

**Imports** methods, mvtnorm

**Depends** IRanges, GenomicRanges, Gviz

**Suggests** cluster, parallel, GenomicFeatures, dynamicTreeCut, Rsamtools, TxDb.Hsapiens.UCSC.hg19.knownGene

**biocViews** aCGH, CopyNumberVariation, Microarray, Sequencing, Visualization, Genetics

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## Contents

|                           |   |
|---------------------------|---|
| biomvRCNS-class . . . . . | 2 |
| biomvRGviz . . . . .      | 3 |
| biomvRhsmm . . . . .      | 4 |
| biomvRmgmr . . . . .      | 6 |

|                             |    |
|-----------------------------|----|
| biomvRseg . . . . .         | 8  |
| coriell . . . . .           | 10 |
| encodeTP53 . . . . .        | 10 |
| hsmmRun . . . . .           | 11 |
| maxGapminRun . . . . .      | 12 |
| regionSegAlphaNB . . . . .  | 14 |
| regionSegCost . . . . .     | 15 |
| simSegData . . . . .        | 16 |
| sojournAnno . . . . .       | 17 |
| splitFarNeighbour . . . . . | 18 |
| variosm . . . . .           | 19 |

|              |           |
|--------------|-----------|
| <b>Index</b> | <b>20</b> |
|--------------|-----------|

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|                 |                   |
|-----------------|-------------------|
| biomvRCNS-class | Class "biomvRCNS" |
|-----------------|-------------------|

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## Description

The default object class returned by [biomvRhsmm](#), [biomvRseg](#) and [biomvRmgmr](#)

## Objects from the Class

Objects can be created by calls of the form `new("biomvRCNS", ...)`.

## Slots

- x:** Object of class "GRanges", with range information either from real positional data or just indices, with input data matrix stored in the meta columns. Additional meta columns for the estimated states and associated probabilities for each sample will also be appended following the input data matrix when using [biomvRhsmm](#).
- res:** Object of class "GRanges", each range represent one continuous segment identified, with sample name slot 'SAMPLE' and segment mean slot 'MEAN' stored in the meta columns
- param:** Object of class "list", list of all parameters used in the corresponding model.

## Methods

**plot** signature(x = "biomvRCNS", y = "ANY"): ...  
**show** signature(object = "biomvRCNS"): ...

## Examples

```
showClass("biomvRCNS")
```

**Description**

This function could be called to plot segmentation output, together with the input signal and optional annotation. By default resulting image will be printed to file. The plot method for class [biomvRCNS-class](#) also calls this method. See the vignette for a more complete example.

**Usage**

```
biomvRGviz(exprgr, gmgr = NULL, prange = NULL, regionID = NULL, seggr = NULL, plotstrand = "+", eps =
```

**Arguments**

|            |                                                                                                                                                 |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| exprgr     | a GRanges object with one numeric column for the segmentation input signal in its meta DataFrame                                                |
| gmgr       | an optional GRanges object for the annotation, which must have one column named 'TYPE' in its meta DataFrame                                    |
| prange     | an optional vector defining the scope of the plot, the first 3 elements must be formatted as c('seqname', 'start_position', 'end_position')     |
| regionID   | a character for the name of the plotted region or gene name or other identifier, will be used in the title of the plot and the output file name |
| seggr      | a GRanges object for the segmentation output, which must have one column named 'STATE' in its meta DataFrame                                    |
| plotstrand | select which strand to plot, possible values are '+', '-', '**'                                                                                 |
| eps        | whether to output EPS file using postscript, if FALSE then PDF files for each sequence will be generated to the current working folder.         |
| tofile     | whether to output graphics file, if FALSE then will plot on the active device and have the trackList returned.                                  |
| ...        | other arguments for plot, like main, ylab, cex, or height and width for graphic device.                                                         |

**Details**

See the vignette for more details and examples.

**Value**

Plot graph on the active device or output to EPS/PDF file.

**Author(s)**

Yang Du

## Examples

```
data(coriell)
x<-coriell[coriell[,2]==1,]
xgr<-GRanges(seqnames=paste('chr', x[,2], sep=' '), IRanges(start=x[,3], width=1, names=x[,1]))
values(xgr)<-DataFrame(x[,4:5], row.names=NULL)
xgr<-xgr[order(xgr)]

J<-2; maxk<-50
# a uniform initial sojourn, not utilizing positional information
soj<-list(J=J, maxk=maxk, type='gamma', d=cbind(dunif(1:maxk, 1, maxk), dunif(1:maxk, 1, maxk)))
soj$d <- sapply(1:J, function(j) rev(cumsum(rev(soj$d[1:maxk,j]))))
sample<-colnames(coriell)[5]
runout<-hsmmRun(matrix(values(xgr)[,sample]), sample, xgr, soj, emis=list(type='norm', mu=quantile(unlist(x), 0.5)))
biomVRGviz(exprgr=xgr, seggr=runout$res, tofile=FALSE)
```

---

biomvRhsmm

*Estimating the most likely state sequence using Hidden Semi Markov Model*

---

## Description

The batch function of building Hidden Semi Markov Model (HSMM) to estimate the most likely state sequences for multiple input data series.

## Usage

```
biomvRhsmm(x, maxk=NULL, maxbp=NULL, J=3, xPos=NULL, xRange=NULL, usePos='start', emis.type='norm')
```

## Arguments

|           |                                                                                                                                           |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------|
| x         | input data matrix, or a GRanges object with input stored in the meta DataFrame, assume ordered.                                           |
| maxk      | maximum length of stay for the sojourn distribution                                                                                       |
| maxbp     | maximum length of stay in bp for the sojourn distribution, given positional information specified in xPos / xRange                        |
| J         | number of states                                                                                                                          |
| xPos      | a vector of positions for each x row                                                                                                      |
| xRange    | a IRanges/GRanges object, same length as x rows                                                                                           |
| usePos    | character value to indicate whether the 'start', 'end' or 'mid' point position should be used to estimate the sojourn distribution        |
| emis.type | type of the emission distribution, only the following types are supported: 'norm', 'mvnorm', 'pois', 'nbinom', 'mvt', 't'                 |
| com.emis  | whether to set a common emission prior across different seqnames. if TRUE, the emission will not be updated during individual runs.       |
| xAnno     | a optional TxD / GRanges / GRangesList / list object used in <a href="#">sojournAnno</a> to infer parameters for the sojourn distribution |
| soj.type  | type of the sojourn distribution, only the following types are supported: 'non-para', 'gamma', 'pois', 'nbinom'                           |

|           |                                                                                                                                                                                                                                                             |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| q.alpha   | a quantile factor controlling the estimated prior for the mean of the emission of each states, <code>seq(from=q.alpha, to=1-q.alpha, length.out=J)</code>                                                                                                   |
| r.var     | a ratio factor controlling the estimated prior for the variance / covariance structure of each states. A value larger than 1 tend to allow larger variation in extreme states; a value smaller than 1 will decrease the probability of having extreme state |
| useMC     | TRUE if <code>mclapply</code> should be used to speed up the calculation, use <code>options(mc.cores=n)</code> to set number of parallel processes                                                                                                          |
| cMethod   | C algorithm used for the most likely state sequence, 'F-B' or 'Viterbi'                                                                                                                                                                                     |
| maxit     | max iteration of the EM run with Forward-Backward algorithm                                                                                                                                                                                                 |
| maxgap    | max distance between neighbouring feature to consider a split                                                                                                                                                                                               |
| tol       | tolerance level of the likelihood change to terminate the EM run                                                                                                                                                                                            |
| grp       | vector of group assignment for each sample, with a length the same as columns in the data matrix, samples within each group would be processed simultaneously if a multivariate emission distribution is available                                          |
| cluster.m | clustering method for prior grouping, possible values are 'ward', 'single', 'complete', 'average', 'mcquitty'                                                                                                                                               |
| avg.m     | method to calculate average value for each segment, 'median' or 'mean' possibly trimmed                                                                                                                                                                     |
| prior.m   | method to select emission prior for each state, 'quantile' uses different levels of quantile; the 'cluster' method uses clara function from cluster                                                                                                         |
| trim      | the fraction (0 to 0.5) of observations to be trimmed from each end of x before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.                                                                                  |
| na.rm     | TRUE if NA value should be ignored                                                                                                                                                                                                                          |

## Details

This is the batch function of building Hidden Semi Markov Model (HSMM) to estimating the most likely state sequences for multiple input data series. The function will sequentially process each region identified by the distinctive seqnames in `x` or in `xRange` if available, or assuming all data from the same region. A second layer of stratification is introduced by the argument `grp`, which could be used to reflect experimental design. The assumption is that profiles from the same group could be considered homogeneous, thus processed together if `emis.type` is compatible (currently only with 'mvnorm'). Argument for the sojourn density will be initialized as flat prior or estimated from other data before calling the work horse function `hsmmRun`. Then for each batch run results will be combined and eventually a `biomvRCNS-class` object will be returned. See the vignette for more details and examples.

## Value

A `biomvRCNS-class` object:

|        |                                                                                                                                                                                                                                                                                                                      |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x:     | Object of class "GRanges", with range information either from real positional data or just indices, with input data matrix stored in the meta columns. Additional meta columns for the estimated states and associated probabilities for each sample or group will also be appended following the input data matrix. |
| res:   | Object of class "GRanges", each range represent one continuous segment identified, with sample name slot 'SAMPLE', estimated state slot 'STATE' and segment mean slot 'MEAN' stored in the meta columns                                                                                                              |
| param: | Object of class "list", list of all parameters used in the model run, plus the re-estimated emission and sojourn parameters.                                                                                                                                                                                         |

**Author(s)**

Yang Du

**References**

Guedon, Y. (2003). Estimating hidden semi-Markov chains from discrete sequences. *Journal of Computational and Graphical Statistics*, 12(3), 604-639.

**See Also**[biomvRseg](#)**Examples**

```
data(coriell)
xgr<-GRanges(seqnames=paste('chr', coriell[,2], sep=' '), IRanges(start=coriell[,3], width=1, names=coriell[,4]),
values(xgr)<-DataFrame(coriell[,4:5], row.names=NULL))
xgr<-sort(xgr)
reshsmm<-biomvRhsmm(x=xgr, maxbp=4E4, J=3, soj.type='gamma', emis.type='norm', grp=c(1,2))

## access model parameters
reshsmm@param$soj.par
reshsmm@param$emis.par

## states assigned and associated probabilities
mcols(reshsmm@x)[,-(1:2)]
```

biomvRmgmr

*Batch process multiple sequences and samples using max-gap-min-run algorithm for 2 states segmentation*

**Description**

This is a wrapper function for batch processing multiple sequences and samples using max-gap-min-run algorithm for 2 states segmentation

**Usage**

```
biomvRmgmr(x, xPos=NULL, xRange=NULL, usePos='start', cutoff=NULL, q=0.9, high=TRUE, minrun=5, maxgap=1000000)
```

**Arguments**

|        |                                                                                                 |
|--------|-------------------------------------------------------------------------------------------------|
| x      | input data matrix, or a GRanges object with input stored in the meta DataFrame, assume ordered. |
| xPos   | a vector of positions for each x row                                                            |
| xRange | a IRanges/GRanges object, same length as x rows                                                 |
| usePos | character value to indicate whether the 'start', 'end' or 'mid' point position should be used   |
| cutoff | threshold level above which is considered extreme                                               |
| q      | relative quantile threshold level instead of absolute value for the cutoff                      |

|           |                                                                                                                                                                                                                    |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| high      | TRUE if the cutoff or q here is the lower bound and values greater than the threshold are considered                                                                                                               |
| minrun    | minimum run length for the resulting segments                                                                                                                                                                      |
| maxgap    | maximum genomic distance below which two adjacent qualified tiles can be joined                                                                                                                                    |
| splitLen  | numeric value, maximum length of segments, split if too long                                                                                                                                                       |
| poolGrp   | TRUE if samples within the same group should be pooled using median for each feature                                                                                                                               |
| grp       | vector of group assignment for each sample, with a length the same as columns in the data matrix, samples within each group would be processed simultaneously if a multivariate emission distribution is available |
| cluster.m | clustering method for prior grouping, possible values are 'ward', 'single', 'complete', 'average', 'mcquitty'                                                                                                      |
| avg.m     | method to calculate average value for each segment, 'median' or 'mean' possibly trimmed                                                                                                                            |
| trim      | the fraction (0 to 0.5) of observations to be trimmed from each end of x before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.                                         |
| na.rm     | TRUE if NA value should be ignored                                                                                                                                                                                 |

## Details

This is the batch function to apply [maxGapminRun](#) multiple sequence.

## Value

A [biomvRCNS-class](#) object:

|        |                                                                                                                                                                           |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x:     | Object of class "GRanges", with range information either from real positional data or just indices, with input data matrix stored in the meta columns.                    |
| res:   | Object of class "GRanges", each range represent one continuous segment identified, with sample name slot 'SAMPLE' and segment mean slot 'MEAN' stored in the meta columns |
| param: | Object of class "list", list of all parameters used in the model run.                                                                                                     |

## Author(s)

Yang Du

## See Also

[biomvRhsmm](#) [maxGapminRun](#)

## Examples

```
data(coriell)
xgr<-GRanges(seqnames=paste('chr', coriell[,2], sep=''), IRanges(start=coriell[,3], width=1, names=coriell[,4]),
values(xgr)<-DataFrame(coriell[,4:5], row.names=NULL)
xgr<-xgr[order(xgr)]
resseg<-biomvRmgmr(x=xgr, minrun=3000, maxgap=1500, q=0.9, grp=c(1,2))
```

biomvRseg

*Homogeneous segmentation of multi-sample genomic data***Description**

The function will perform a two stage segmentation on multi-sample genomic data from array experiment or high throughput sequencing data.

**Usage**

```
biomvRseg(x, maxk=NULL, maxbp=NULL, maxseg=NULL, xPos=NULL, xRange=NULL, usePos='start', family='n
```

**Arguments**

|           |                                                                                                                                                                                                                    |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x         | input data matrix, or a GRanges object with input stored in the meta DataFrame                                                                                                                                     |
| maxk      | maximum length of a segment                                                                                                                                                                                        |
| maxbp     | maximum length of a segment in bp, given positional information specified in xPos / xRange / or x                                                                                                                  |
| maxseg    | maximum number of segment the function will try                                                                                                                                                                    |
| xPos      | a vector of positions for each x row                                                                                                                                                                               |
| xRange    | a IRanges/GRanges object, same length as x rows                                                                                                                                                                    |
| usePos    | character value to indicate whether the 'start', 'end' or 'mid' point position should be used                                                                                                                      |
| family    | family of x distribution, only the following types are supported: 'norm', 'nbinom', 'pois'                                                                                                                         |
| penalty   | penalty method used for determining the optimal number of segment using likelihood, possible values are 'none', 'AIC', 'AICc', 'BIC', 'SIC', 'HQIC', 'mBIC'                                                        |
| twoStep   | TRUE if a second stage merging will be performed after the initial group segmentation                                                                                                                              |
| segDisp   | TRUE if a segment-wise estimation of dispersion parameter rather than using a overall estimation                                                                                                                   |
| useMC     | TRUE if <a href="#">mclapply</a> should be used to speed up the calculation for nbinom dispersion estimation                                                                                                       |
| useSum    | TRUE if using grand sum across sample / x columns, like in the <code>tilingArray</code> solution                                                                                                                   |
| comVar    | TRUE if assuming common variance across samples (x columns)                                                                                                                                                        |
| maxgap    | max distance between neighbouring feature to consider a split                                                                                                                                                      |
| tol       | tolerance level of the likelihood change to determining the termination of the EM run                                                                                                                              |
| grp       | vector of group assignment for each sample, with a length the same as columns in the data matrix, samples within each group would be processed simultaneously if a multivariate emission distribution is available |
| cluster.m | clustering method for prior grouping, possible values are 'ward', 'single', 'complete', 'average', 'mcquitty'                                                                                                      |
| avg.m     | method to calculate average value for each segment, 'median' or 'mean' possibly trimmed                                                                                                                            |

|                    |                                                                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>trim</code>  | the fraction (0 to 0.5) of observations to be trimmed from each end of <code>x</code> before the mean is computed. Values of <code>trim</code> outside that range are taken as the nearest endpoint. |
| <code>na.rm</code> | TRUE if NA value should be ignored                                                                                                                                                                   |

## Details

A homogeneous segmentation algorithm, using dynamic programming like in `tilingArray`; however capable of handling count data from sequencing.

## Value

A `biomvRCNS-class` object:

|                      |                                                                                                                                                                           |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code> :     | Object of class "GRanges", with range information either from real positional data or just indices, with input data matrix stored in the meta columns.                    |
| <code>res</code> :   | Object of class "GRanges", each range represent one continuous segment identified, with sample name slot 'SAMPLE' and segment mean slot 'MEAN' stored in the meta columns |
| <code>param</code> : | Object of class "list", list of all parameters used in the model run.                                                                                                     |

## References

- Piegorsch, W. W. (1990). Maximum likelihood estimation for the negative binomial dispersion parameter. *Biometrics*, 863-867.
- Picard, F. et al. (2005) A statistical approach for array CGH data analysis. *BMC Bioinformatics*, 6, 27.
- Huber, W. et al. (2006) Transcript mapping with high density oligonucleotide tiling arrays. *Bioinformatics*, 22, 1963-1970. .
- Zhang, N. R. and Siegmund, D. O. (2007). A Modified Bayes Information Criterion with Applications to the Analysis of Comparative Genomic Hybridization Data. *Biometrics* 63 22-32.
- Robinson MD and Smyth GK (2008). Small-sample estimation of negative binomial dispersion, with applications to SAGE data. *Biostatistics*, 9, 321-332

## See Also

[biomvRhsmm](#)

## Examples

```
data(coriell)
xgr<-GRanges(seqnames=paste('chr', coriell[,2], sep=''), IRanges(start=coriell[,3], width=1, names=coriell[,4]),
values(xgr)<-DataFrame(coriell[,4:5], row.names=NULL))
xgr<-xgr[order(xgr)]
resseg<-biomvRseg(x=xgr, maxbp=4E4, maxseg=10, family='norm', grp=c(1,2))
```

---

coriell

---

*Array CGH data set of Coriell cell lines*


---

### Description

These are two data array CGH studies sets of Corriell cell lines taken from the reference below.

### Format

A data frame containing five variables: first is clone name, second is clone chromosome, third is clone position, fourth and fifth are log2ratio for two cell lines.

### References

<http://www.nature.com/ng/journal/v29/n3/supinfo/ng754\%5BS1.html>

Snijders et al., Assembly of microarrays for genome-wide measurement of DNA copy number, Nature Genetics, 2001

---

encodeTP53

---

*mapped RNA-seq data from ENCODE*


---

### Description

The data contains gene expression and transcript annotations in the region of the human TP53 gene (region (chr17:7,560,001-7,610,000 from the Human February 2009 (GRCh37/hg19) genome assembly), which is part of the long RNA-seq data generated by ENCODE/Cold Spring Harbor Lab, containing 2 cell types (GM12878 and K562) with 2 replicates each.

The alignment files were pulled from UCSC (<http://hgdownload.cse.ucsc.edu/goldenPath/hg19/encodeDCC/wgEncodeC> And subsequently reads were counted in each non-overlapping 25bp window for the region (chr17:7,560,001-7,610,000). The example code to generate this count GRanges is available in the vignette.

The regional annotation of TP53 RNAs isoforms were derived from the ENCODE Gene Annotations (GENCODE), sub-setted to only isoforms of TP53 gene. <http://hgdownload.cse.ucsc.edu/goldenPath/hg19/encodeDCC/wgEncodeGencodeV4/wgEncodeGencodeManualV4.gtf.gz>.

This dataset is used in the package vignette to illustrate a use case of transcript detection.

### Format

Containing two GRanges objects, one for the sample count and one for the regional annotation of gene TP53

### References

<http://dx.doi.org/10.1371/journal.pbio.1001046> The ENCODE Project Consortium (2011) A User's Guide to the Encyclopedia of DNA Elements (ENCODE). PLoS Biol 9(4): e1001046. doi:10.1371/journal.pbio.1001046

---

|         |                                                                                 |
|---------|---------------------------------------------------------------------------------|
| hsmmRun | <i>Estimating the most likely state sequence using Hidden Semi Markov Model</i> |
|---------|---------------------------------------------------------------------------------|

---

## Description

This is the working horse of the biomvRhsmm

## Usage

```
hsmmRun(x, xid="sampleid", xRange, soj, emis, cMethod='F-B', maxit=1, maxgap=Inf, tol=1e-06, avg.m=
```

## Arguments

|          |                                                                                                                                                                            |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x        | input data matrix or vector, ordered wrt. position                                                                                                                         |
| xid      | name of the sample                                                                                                                                                         |
| xRange   | a IRanges/GRanges object, same length as x rows                                                                                                                            |
| soj      | a list object containing the relevant sojourn distribution parameters                                                                                                      |
| emis     | a list object containing the relevant emission distribution parameters                                                                                                     |
| cMethod  | C algorithm used for the most likely state sequence, 'F-B' or 'Viterbi'                                                                                                    |
| maxit    | max iteration of the EM run with Forward-Backward algorithm                                                                                                                |
| maxgap   | max distance between neighbouring feature to consider a split                                                                                                              |
| tol      | tolerance level of the likelihood change to terminate the EM run                                                                                                           |
| avg.m    | method to calculate average value for each segment, 'median' or 'mean' possibly trimmed                                                                                    |
| trim     | the fraction (0 to 0.5) of observations to be trimmed from each end of x before the mean is computed. Values of trim outside that range are taken as the nearest endpoint. |
| na.rm    | TRUE if NA value should be ignored                                                                                                                                         |
| com.emis | whether to set a common emission prior across different seqnames. if TRUE, the emission will not be updated during individual runs.                                        |

## Details

The function fits a Hidden-semi Markov model for the input data matrix / vector, which should contains ordered data from a continuous region on one chromosome. The model will start with flat prior for the initial state probability and transition probability, while emission parameter for each state will be estimated using different quantiles of the input controlled by argument `q.alpha` and `r.var`. Argument for the sojourn density should be provided via the list object `soj`, which is either initialized as flat prior or estimated from other data in a previous call. The positional information in the `xRange` is used for the optional spiting of physically distant features and construction of returning `GRanges` object `res`.

**Value**

a list object,

|      |                                                                                                                                                                                                         |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| yhat | a "Rle" object, the most likely state sequence, same length as x rows number                                                                                                                            |
| yp   | "Rle", the associated state probability, same length as x rows number                                                                                                                                   |
| res  | Object of class "GRanges", each range represent one continuous segment identified, with sample name slot 'SAMPLE', estimated state slot 'STATE' and segment mean slot 'MEAN' stored in the meta columns |

**Author(s)**

Yang Du

**References**

Guedon, Y. (2003). Estimating hidden semi-Markov chains from discrete sequences. *Journal of Computational and Graphical Statistics*, 12(3), 604-639.

**See Also**

[biomvRhsmm](#)

**Examples**

```
data(coriell)
# select only chr1
x<-coriell[coriell[,2]==1,]
xgr<-GRanges(seqnames=paste('chr', x[,2], sep=''), IRanges(start=x[,3], width=1, names=x[,1]))
values(xgr)<-DataFrame(x[,4:5], row.names=NULL)
xgr<-xgr[order(xgr)]

J<-2 ; maxk<-50
# a uniform initial sojourn, not utilizing positional information, just the index
soj<-list(J=J, maxk=maxk, type='gamma', d=cbind(dunif(1:maxk, 1, maxk), dunif(1:maxk, 1, maxk)))
soj$d <- sapply(1:J, function(j) rev(cumsum(rev(soj$d[1:maxk,j]))))
# run 1 sample only, Coriell.13330
sample<-colnames(coriell)[5]
runout<-hsmmRun(matrix(values(xgr)[,sample]), sample, xgr, soj, emis=list(type='norm', mu=range(x[,4:5]), va
```

---

maxGapminRun

*Max-gap-min-run algorithm for 2 states segmentation*

---

**Description**

A custom Max-gap-min-run implementation using physical position for gap and run length calculation.

**Usage**

```
maxGapminRun(x, xPos = NULL, xRange = NULL, cutoff = NULL, q = 0.9, high=TRUE, minrun = 5, maxgap = 2,
```

**Arguments**

|          |                                                                                                      |
|----------|------------------------------------------------------------------------------------------------------|
| x        | a numeric vector for the input signal                                                                |
| xPos     | a numeric vector, same length as x, carrying positional information for each element of x            |
| xRange   | an IRanges object, same length as x, carrying range information for each element of x                |
| cutoff   | numeric value used as cut-off, optional if q is specified                                            |
| q        | numeric value used to derive cut-off of x, as the q quantile of x , optional if cutoff is specified  |
| high     | TRUE if the cutoff or q here is the lower bound and values greater than the threshold are considered |
| minrun   | minimum run length for the resulting segments                                                        |
| maxgap   | maximum genomic distance below which two adjacent qualified tiles can be joined                      |
| splitLen | numeric value, maximum length of segments, split if too long                                         |
| na.rm    | TRUE if NA value should be ignored                                                                   |

**Details**

A custom Max-gap-min-run implementation using physical position for gap and run length calculation.

**Value**

|                                           |                                  |
|-------------------------------------------|----------------------------------|
| a list of segment starts and ends indices |                                  |
| IS                                        | the start index for each segment |
| IE                                        | the end index for each segment   |
| CUTOFF                                    | the cutoff value used in the run |
| MG                                        | the parameter value for maxgap   |
| MR                                        | the parameter value for minrun   |
| SPL                                       | the parameter value for splitLen |

**Author(s)**

Yang Du

**See Also**

[biomvRhsmm](#) [biomvRseg](#) [biomvRmgmr](#)

**Examples**

```
x<-rpois(50, 10)
xpos<-rnorm(50, 300, 100)
xpos<-xpos[order(xpos)]
maxGapminRun(x, xpos, cutoff=9.5, maxgap=30, minrun=100)
```

---

|                  |                                                                                                                                        |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| regionSegAlphaNB | <i>Estimate matrix of dispersion parameter alpha (size) used in <a href="#">regionSegCost</a> for negative binomial distributed x.</i> |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------|

---

### Description

Estimate matrix of dispersion parameter alpha (size) used in [regionSegCost](#) for negative binomial distributed x.

### Usage

```
regionSegAlphaNB(x, maxk = NULL, segs = NULL, useMC = FALSE, tol=1e-06)
```

### Arguments

|       |                                                                                                                                           |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------|
| x     | The input data matrix or vector                                                                                                           |
| maxk  | Maximum number of index to search forward                                                                                                 |
| segs  | Starting indices (excluding 1) for the candidate segments, for the second stage model, maxk will be overridden with length(segs)+1.       |
| useMC | TRUE if <a href="#">mclapply</a> should be used to speed up the calculation                                                               |
| tol   | tolerance level for the convergence criteria in the maximum likelihood estimation of negative binomial distribution dispersion parameter. |

### Details

Estimate matrix of dispersion parameter alpha (size) used in [regionSegCost](#) for negative binomial distributed x.

### Value

Matrix with maxk rows and nrow(x) columns, or a length(segs)+1 square matrix for the second stage model.

### References

Piegorsch, W. W. (1990). Maximum likelihood estimation for the negative binomial dispersion parameter. *Biometrics*, 863-867.

Robinson MD and Smyth GK (2008). Small-sample estimation of negative binomial dispersion, with applications to SAGE data. *Biostatistics*, 9, 321-332

### See Also

[regionSegCost](#)

### Examples

```
x<-matrix(rnbinom(120, size=0.05, mu=20), ncol=3)
Aa<-regionSegAlphaNB(x, maxk=20)
dim(Aa) # [1] 20 40
Ab<-regionSegAlphaNB(x, segs=as.integer(c(3, 6, 12, 30)))
dim(Ab) # [1] 5 5
```

---

|               |                                          |
|---------------|------------------------------------------|
| regionSegCost | <i>Regional segmentation cost matrix</i> |
|---------------|------------------------------------------|

---

### Description

To calculate regional cost matrix for the initial stage and second merging stage of the segmentation model.

### Usage

```
regionSegCost(x, maxk = NULL, segs = NULL, family = NULL, alpha = NULL, useSum = TRUE, useMC = FALSE,
```

### Arguments

|        |                                                                                                                                     |
|--------|-------------------------------------------------------------------------------------------------------------------------------------|
| x      | The input data matrix or vector                                                                                                     |
| maxk   | Maximum number of index to search forward                                                                                           |
| segs   | Starting indices (excluding 1) for the candidate segments, for the second stage model, maxk will be overridden with length(segs)+1. |
| family | which exponential family the data belongs to, possible values are 'norm', 'pois' and 'nbinom'                                       |
| alpha  | alpha matrix for negative binomial cost calculation, estimated from <a href="#">regionSegAlphaNB</a>                                |
| useSum | TRUE if using grand sum across sample / x columns, like in the <code>tilingArray</code> solution                                    |
| useMC  | TRUE if <code>mclapply</code> should be used to speed up                                                                            |
| comVar | TRUE if assuming common variance across samples (x columns)                                                                         |

### Details

Preparing the cost matrix for the follow-up segmentation. Using residual sum of squares for 'norm' data, and negative log-likelihood for 'pois' and 'nbinom' data. Extension of the `costMatrix` function in `tilingArray`.

### Value

Matrix with maxk rows and nrow(x) columns, or a length(segs)+1 square matrix for the second stage model.

### References

- Piegorsch, W. W. (1990). Maximum likelihood estimation for the negative binomial dispersion parameter. *Biometrics*, 863-867.
- Picard,F. et al. (2005) A statistical approach for array CGH data analysis. *BMC Bioinformatics*, 6, 27.
- Huber,W. et al. (2006) Transcript mapping with high density oligonucleotide tiling arrays. *Bioinformatics*, 22, 1963-1970. .
- Robinson MD and Smyth GK (2008). Small-sample estimation of negative binomial dispersion, with applications to SAGE data. *Biostatistics*, 9, 321-332

**See Also**

[regionSegAlphaNB](#)

**Examples**

```
x<-matrix(rnorm(120), ncol=3)
Ca<-regionSegCost(x, maxk=20, family='norm')
dim(Ca) # [1] 20 40
Cb<-regionSegCost(x, segs=as.integer(c(3, 6, 12, 30)), family='norm')
dim(Cb) # [1] 5 5
```

---

simSegData

*Simulate exemplary segmentation data.*


---

**Description**

Simulate exemplary segmentation data.

**Usage**

```
simSegData(nseg=10, J=3, soj, emis, seed=1234, toPlot=FALSE)
```

**Arguments**

|        |                                                       |
|--------|-------------------------------------------------------|
| nseg   | size of initial segments pool                         |
| J      | states number                                         |
| soj    | a list object containing sojourn settings             |
| emis   | a list object containing emission settings            |
| seed   | seed for simulation                                   |
| toPlot | whether to output a pdf image of the simulated series |

**Value**

a list object containing the simulated data and the segment info

|     |                                                    |
|-----|----------------------------------------------------|
| E   | a numeric vector of the simulated data serie       |
| L   | a vector of the length for each continuous segment |
| S   | a vector of state assignment for each segment      |
| pdf | the name of the output pdf file if any             |

**Examples**

```
soj<-list(type='pois', lambda=c(200, 100, 10))
emis<-list(type='pois', lambda=1:3)
simSegData(soj=soj, emis=emis)
```

---

|             |                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------|
| sojournAnno | <i>Estimate sojourn distribution parameters from posterior information like annotation data</i> |
|-------------|-------------------------------------------------------------------------------------------------|

---

## Description

Using prior information from previous studies or annotation data to determine sojourn distribution parameters

## Usage

```
sojournAnno(xAnno, soj.type = "gamma", pbdist = NULL)
```

## Arguments

|          |                                                                                                                                                                                                                       |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| xAnno    | a GRanges / GRangesList / TxDb object, with its first meta column to represent the possible type of the range; Or a list object with named initial value vectors matching required parameters for a specific soj.type |
| soj.type | type of the sojourn distribution, following types are supported: 'gamma', 'pois', 'nbinom'                                                                                                                            |
| pbdist   | average distance between neighbouring features, in this case in the link{biomvRhsmm} call one should only use the rank rather than the position.                                                                      |

## Details

Be default, the hidden-semi Markov model implemented in this package uses a uniform prior for the initial sojourn distribution. However user can provide custom data from related studies to learn the prior of the sojourn distribution. The number of possible state will also be estimated from the unique level of feature type in the first meta column of xAnno if it is not a TxDb object.

## Value

a list object containing the sojourn distribution parameter

|                    |                                                                                                                                  |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------|
| type               | type of the sojourn distribution                                                                                                 |
| fttypes            | unique levels of the types stored in the first meta column of xAnno, alphabetically sorted                                       |
| J                  | number of possible states                                                                                                        |
| <code>{...}</code> | distribution parameters, 'lambda' and 'shift' for 'pois'; 'size', 'mu' and 'shift' for 'nbinom'; 'scale' and 'shape' for 'gamma' |

## Author(s)

Yang Du

## Examples

```
data(encodeTP53)
encodeTP53$gmgr # a GRanges object
soj<-sojournAnno(encodeTP53$gmgr, soj.type='gamma')
```

---

|                   |                                                                    |
|-------------------|--------------------------------------------------------------------|
| splitFarNeighbour | <i>Split segments if long gaps exist between feature positions</i> |
|-------------------|--------------------------------------------------------------------|

---

### Description

Split segments if long gaps exist between feature positions, due to low coverage or resolution.

### Usage

```
splitFarNeighbour(intStart = NULL, intEnd = NULL, xPos = NULL, xRange = NULL, maxgap = Inf, minrun = 1)
```

### Arguments

|          |                                                                                                                        |
|----------|------------------------------------------------------------------------------------------------------------------------|
| intStart | indices of start for each segment                                                                                      |
| intEnd   | indices of end for each segment                                                                                        |
| xPos     | position vector, the distance of neighbouring features will be counted as point to point                               |
| xRange   | IRanges / GRanges object for the positions, the the distance of neighbouring features will be counted as end to start. |
| maxgap   | maximum distance between neighbouring features                                                                         |
| minrun   | when splitting, the minimum length of the features spanning, which half will be ignored if shorter.                    |

### Value

a list object containing the start and end indices for new segments

|    |                                    |
|----|------------------------------------|
| IS | the start indices for new segments |
| IE | the end indices for new segments   |

### Author(s)

Yang Du

### Examples

```
set.seed(123)
pos<-cumsum(rnbinom(20, size=10, prob=0.01))
splitFarNeighbour(intStart=c(1, 10), intEnd=c(6, 18), xPos=pos, maxgap=1000)
```

---

variosm*Differential methylation data from sequencing*

---

**Description**

Extracted from package BiSeq, which is a small subset of a published study using targeted bisulfite sequencing data to detect differentially methylated regions (DMRs).

**Format**

Containing one GRanges object

**References**

<http://dx.doi.org/10.1182> Schoofs et al. DNA methylation changes are a late event in acute promyelocytic leukemia and coincide with loss of transcription factor binding. Blood, Nov 2012.

# Index

- \* **classes**
  - biomvRCNS-class, [2](#)
- \* **datasets**
  - coriell, [10](#)
  - encodeTP53, [10](#)
  - variosm, [19](#)
- \* **data**
  - coriell, [10](#)
  - encodeTP53, [10](#)
  - variosm, [19](#)
- \* **hsmm**
  - biomvRhsmm, [4](#)
  - hsmmRun, [11](#)
- biomvRCNS-class, [2](#)
- biomvRGviz, [3](#)
- biomvRhsmm, [2](#), [4](#), [7](#), [9](#), [12](#), [13](#)
- biomvRmgmr, [2](#), [6](#), [13](#)
- biomvRseg, [2](#), [6](#), [8](#), [13](#)
- coriell, [10](#)
- encodeTP53, [10](#)
- hsmmRun, [11](#)
- maxGapminRun, [7](#), [12](#)
- mclapply, [5](#), [8](#), [14](#), [15](#)
- plot,biomvRCNS,ANY-method  
(biomvRCNS-class), [2](#)
- regionSegAlphaNB, [14](#), [15](#), [16](#)
- regionSegCost, [14](#), [15](#)
- show,biomvRCNS-method  
(biomvRCNS-class), [2](#)
- simSegData, [16](#)
- sojournAnno, [4](#), [17](#)
- splitFarNeighbour, [18](#)
- variosm, [19](#)