Package ‘snapCGH’

November 21, 2016

Title Segmentation, normalisation and processing of aCGH data.

Version 1.44.0

Date 2009-10-08

Author Mike L. Smith, John C. Marioni, Steven McKinney, Thomas Hardcastle, Natalie P. Thorne

Description Methods for segmenting, normalising and processing aCGH data; including plotting functions for visualising raw and segmented data for individual and multiple arrays.

Maintainer John Marioni <marioni@uchicago.edu>

Depends limma, DNAcopy, methods

Imports aCGH, cluster, DNAcopy, GLAD, graphics, grDevices, limma, methods, stats, tilingArray, utils

License GPL

biocViews Microarray, CopyNumberVariation, TwoChannel, Preprocessing

NeedsCompilation yes

R topics documented:

  cbind .......................................................... 2
  chrominfo.Mb ................................................ 3
  compareSegmentations ................................... 4
  convert.output ........................................... 4
  dim .......................................................... 5
  dimnames ................................................... 6
  filterClones ............................................. 7
  find.param.five .......................................... 8
  find.param.four .......................................... 8
  find.param.one .......................................... 9
  find.param.three ........................................ 9
  find.param.two .......................................... 10
  findBreakPoints ......................................... 11
  fit.model .................................................. 11
  genomePlot ............................................... 12
  heatmapGenome .......................................... 13
  IDProbes .................................................. 15
  imputeMissingValues ................................. 16
**cbind**

Combine SegList Objects

**Description**

Combine a series of SegList objects.

**Usage**

```r
## S3 method for class 'SegList'
cbind(..., deparse.level=1)
```

**Arguments**

- `...`: SegList objects
- `deparse.level`: not currently used, see `cbind` in the base package
**Details**

cbind combines data objects assuming the same gene lists but different arrays. For cbind, the matrices of expression data from the individual objects are cbinded. The data.frames of target information, if they exist, are rbinded. The combined data object will preserve any additional components or attributes found in the first object to be combined. It is not recommended to use the is rbind function for the SegList object. This is because it would require SegLists with mutually exclusive chromosomes or would result in combining multiple different segmentations for the same chromosome, which is pointless. If rbind is required perform it on an MAList and then segment it. It is currently only included as an internal function called within other library functions.

**Value**

An SegList object holding data from all the arrays and all genes from the individual objects.

**Author(s)**

Gordon Smyth, modified by Mike Smith for SegList object

**See Also**

cbind in the base package.

---

**chrominfo.Mb**

*Basic Chromosomal Information for UCSC Human Genome Assembly July 2003 freeze*

**Description**

This dataset contains basic chromosomal information for UCSC Human Genome Assembly July 2003 freeze.

**Usage**

chrominfo.basepair

**Format**

A data frame with 24 observations on the following 3 variables.

- **chrom** Chromosomal index, X is coded as 23 and Y as 24.
- **length** Length of each chromosome in megabases.
- **centromere** Location of the centromere on the chromosome (Mb).

**Details**

This file is used for many plotting functions. The centromeric location is approximately estimated by taking mid-point between the last fish-mapped clone on the p-arm and the first fish-mapped clone on the q-arm using relevant UCSC freeze. For an alternative freeze, one needs to manually create a 3-column file of the format described above.

**Source**

http://genome.ucsc.edu/cgi-bin/hgText
### `compareSegmentations`  
**Function for comparing segmentation methods to a known truth**

**Description**

This function takes a `SegList` and compares the breakpoints indicated in other `SegLists` with this original one.

**Usage**

```r
compareSegmentations(TrueSeg, offset = 0, ...)  
```

**Arguments**

- **TrueSeg**
  - An object of class `SegList` which is scored against. Normally the output from `simulateData`.

- **offset**
  - Integer value between 0 and 2 specifying how close (in number of clones) to a true breakpoint the segmentation method must be before it is scored.

- **...**
  - One or more objects of class `SegList`. These are compared to `TrueSeg`.

**Value**

The method returns a list containing two matrices. The first of these, \$TPR, contains the true positive rate, whilst the second, \$FDR, holds the false discovery rate. Both of these matrices are arranged such that a row represents a segmentation method and each column is an array.

**Author(s)**

John Marioni and Mike Smith

---

### `convert.output`  
**Converts the output from the simulation to a format which can be used by segmentation schemes available within R**

**Description**

This function converts the output obtained by applying our simulation scheme into a format that can be used (either directly or indirectly) as the input to various segmentation schemes available within R. Additionally, we are in the process of submitting a library to CRAN which will enable the user to apply a number of the segmentation schemes available within R to datasets which have the same structure as that generated by this function.

**Usage**

```r
convert.output(input)  
```

**Arguments**

- **input**
  - The output obtained upon applying the `sim.structure` function
Details
This function outputs an object which is similar in structure/format to an RG or MA object used in Limma.

Value
This function outputs a list with entries
- \( M \) A matrix containing the \( \log_2 \) ratios
- genes A matrix containing the simulated midpoints and the chromosome which forms the template upon which the simulation is based.

Author(s)
Michael Smith, John Marioni

Examples
```r
## The function is currently defined as
function(input){
    holder <- list()
    for (i in 1:length(input)){
        holder[[i]] <- list()
        holder[[i]]$genes <- matrix(NA, nrow = length(input[[i]]$clones$mid.point),
                                 ncol = 2)
        for(i in 1:length(input)){
            holder[[i]]$genes[[i]] <- holder[[i]]$genes
        }
        for(i in 1:length(input)){
            holder[[i]]$M <- as.matrix(input[[i]]$datamatrix)
            holder[[i]]$genes[,1] <- input[[i]]$clones$mid.point
            holder[[i]]$genes[,2] <- rep(input[[i]]$chrom,length(input[[i]]$clones$mid.point))
            colnames(holder[[i]]$genes) <- c("kb", "Chrom")
            holder[[i]] <- new("aCGHList", holder[[i]])
        }
        holder
    }
}
```

---

**dim**

*Retrieve the Dimensions of an RGList, MAList or SegList Object*

Description
Retrieve the number of rows (genes) and columns (arrays) for an RGList, MAList or SegList object.

Usage
```r
## S3 method for class 'SegList'
dim(x)
## S3 method for class 'SegList'
length(x)
```

Arguments
- \( x \) an object of class RGList, MAList or SegList
Microarray data objects share many analogies with ordinary matrices in which the rows correspond to spots or genes and the columns to arrays. These methods allow one to extract the size of microarray data objects in the same way that one would do for ordinary matrices.

A consequence is that row and column commands `nrow(x)`, `ncol(x)` and so on also work.

Numeric vector of length 2. The first element is the number of rows (genes) and the second is the number of columns (arrays).

Gordon Smyth, modified by Mike Smith for SegList object

Retrieve the dimension names of a microarray data object.

## Usage

```r
## S3 method for class 'SegList'
dimnames(x)
```

### Arguments

- `x` An object of class `SegList`

The dimension names of an microarray object are the same as those of the most important matrix component of that object.

A consequence is that `rownames` and `colnames` will work as expected.
filterClones

Value

Either NULL or a list of length 2. If a list, its components are either 'NULL' or a character vector the length of the appropriate dimension of x.

Author(s)

Gordon Smyth, edited by Mike Smith

See Also

dimnames in the base package.

Description

Function for filtering clones via a user defined function.

Usage

filterClones(MA, filterFunc, ...)

Arguments

MA	An object of class MAList
filterFunc	A user specified function that accepts an MAList and returns the indices of the clones to be removed.
...\tAdditional arguments to be passed to the filter function.

Details

Any clones identified by the filter function are turned into NA’s. These are then removed or imputed within the processCGH function.

Author(s)

Mike Smith
find.param.five

Yields the output in a model with five underlying states

Description

This function is a workhorse of the process.data function. It outputs state means/variances and transitions matrices in the model with five states.

Usage

find.param.five(output.optim, var.fixed)

Arguments

output.optim output of the optimisation with 5 underlying states
var.fixed Logical variable - TRUE if you want to fix the variance to be the same across states

Value

Outputs the mean/variance, transition matrix, maximised likelihood and convergence information

Author(s)

John Marioni

find.param.four

Yields output when there are 4 underlying states

Description

This function provides the output (means/variances, transition matrix, likelihood) when the heterogeneous HMM is fitted with four underlying states. It is a workhorse of the process.data function.

Usage

find.param.four(output.optim, var.fixed)

Arguments

output.optim The output from fitting a heterogeneous HMM when there are four underlying states
var.fixed Logical variable - TRUE if you want the variance to be tied across states. Defaults to FALSE

Value

This function outputs the state means/variances, transition matrices, rate parameters, maximised likelihood and convergence information provided by fitting a heterogeneous HMM with four underlying states.
find.param.one

Author(s)
John Marioni

Description
This function provides the output (means/variances, transition matrix, likelihood) when the heterogeneous HMM is fitted with one underlying state. It is a workhorse of the process.data function.

Usage
find.param.one(output.optim)

Arguments
output.optim The output from fitting a heterogeneous HMM when there is one underlying states

Value
This function outputs the state means/variances, transition matrices, rate parameters, maximised likelihood and convergence information provided by fitting a heterogeneous HMM with one underlying state.

Author(s)
John Marioni

find.param.three

Yields output when there are 3 underlying states

Description
This function provides the output (means/variances, transition matrix, likelihood) when the heterogeneous HMM is fitted with three underlying states. It is a workhorse of the process.data function.

Usage
find.param.three(output.optim, var.fixed)

Arguments
output.optim The output from fitting a heterogeneous HMM when there are four underlying states
var.fixed Logical variable - TRUE if you want the variances to be tied across states. Defaults to FALSE
Value

This function outputs the state means/variances, transition matrices, rate parameters, maximised likelihood and convergence information provided by fitting a heterogeneous HMM with three underlying states.

Author(s)

John Marioni

---

**find.param.two**  
*Yields output when there are 2 underlying states*

Description

This function provides the output (means/variances, transition matrix, likelihood) when the heterogeneous HMM is fitted with two underlying states. It is a workhorse of the process.data function.

Usage

```r
find.param.two(output.optim, var.fixed)
```

Arguments

- `output.optim`: The output from fitting a heterogeneous HMM when there are two underlying states
- `var.fixed`: Logical variable - TRUE if you want to tie the variance across states. Defaults to FALSE

Value

This function outputs the state means/variances, transition matrices, rate parameters, maximised likelihood and convergence information provided by fitting a heterogeneous HMM with two underlying states.

Author(s)

John Marioni
findBreakPoints

Description

Function to returns the start and end of segments when given a SegList and an array. Currently only used within the plotSegmentedGenome function.

Usage

findBreakPoints(seg, array)

Arguments

seg An object of class SegList.
array Numeric value corresponding to a column in seg.

Author(s)

Mike Smith

fit.model

Fitting a heterogeneous HMM to the log2 ratios on a particular chromosome.

Description

This function fits five homogeneous HMMs to the log2 ratios on a particular chromosome. It then uses either the AIC or BIC to determine which of the five models is optimal before using a scaled version of the Viterbi algorithm to assign clones to states with the same underlying copy number.

Usage

fit.model(sample, chrom, dat, datainfo = clones.info, useCloneDists = TRUE, covariates, aic = TRUE, bic = FALSE, delta = 1, var.fixed=FALSE, epsilon = 1e-06, numiter = 30000)

Arguments

sample If there are multiple samples, the number of the sample to be segmented
chrom The chromosome on which the segmentation is to be carried out on
dat The log2 ratios obtained from the clones located on that chromosome
datainfo A dataframe containing information about the clones on that chromosome (name, chromosome and location (in Mbs))
useCloneDists Boolean stating whether the distance between clones should be incorporated into the HMM. If false then the HMM become homogeneous.
genomePlot

Description

Basic plot of the log2 ratios for each array ordered along the genome.

Usage

genomePlot(input, array = 1, naut = 22, Y = FALSE, X = FALSE, main = NA, status, values, pch, cex, col, chrominfo = chrominfo.Mb, ylim = c(-2, 2), ylb = "Log2Ratio", chrom.to.plot = NA, xlim = c(0, NA), ...)

Arguments

input an object of class MAList or SegList
array integer of the array (sample) to be plotted.
naut number of autosomes in the organism
Y TRUE if chromosome Y is to be plotted, FALSE otherwise
X TRUE if chromosome X is to be plotted, FALSE otherwise
main provides the title of the plot
status character vector giving the control status of each spot on the array, of same length as the number of rows of log2ratios(input). If omitted, all points are plotted in the default color, symbol and size.
values character vector giving values of status to be highlighted on the plot. Defaults to unique values of status. Ignored if there is no status vector.
**heatmapGenome**

`pch` vector or list of plotting characters. Default to integer code 16. Ignored if there is no status vector.

`col` numeric or character vector of colors, of the same length as `values`. Defaults to `1:length(values)`. Ignored if there is no status vector.

`cex` numeric vector of plot symbol expansions, of the same length as `values`. Defaults to 0.2 for the most common status value and 1 for the others. Ignored if there is no status vector.

`chrominfo` a chromosomal information associated with the mapping of the data.

`ylim` Minimum y-scale to use for plotting.

`chrom.to.plot` Specify which chromosome to plot

`ylb` label for the Y-axis.

`xlim` limits for the x-axis

`...` Any other parameters

**Details**

The status vector is intended to specify the control status of each spot, for example "gene", "ratio control", "house keeping gene", "buffer" and so on. The vector is usually computed using the function `controlStatus` and a spot-types file. However the function may be used to highlight any subset of spots.

**Author(s)**

John Marioni

**See Also**

`MAList` `SegList`

---

**Description**

This function clusters samples and shows their heatmap

**Usage**

```r
heatmapGenome(input, response = as.factor(rep("All", ncol(input))),
  chrominfo = chrominfo.Mb, cutoff = 1, lowCol = "blue", highCol = "yellow", midCol = "white", ncolors = 50, byclass = FALSE, showaber = FALSE, amplif = 1, homdel = -0.75, samplenames = colnames(input),
  vecchrom = 1:22, titles = "Image Plot", methodS = "ward", categoricalPheno = TRUE, CENTROMERE = FALSE)
```
Arguments

input  object of class MAList or SegList
response phenotype of interest. defaults to the same phenotype assigned to all samples
chrominfo a chromosomal information associated with the mapping of the data
cutoff maximum absolute value. all the values are floored to +/-cutoff depending on whether they are positive of negative. defaults to 1
ncolors number of colors in the grid. input to maPalette. defaults to 50
lowCol color for the low (negative) values. input to maPalette. defaults to "red"
highCol color for the high (positive) values. input to maPalette. defaults to "green"
midCol color for the values close to 0. input to maPalette. defaults to "black"
byclass logical indicating whether samples should be clustered within each level of the phenotype or overall. defaults to F
showaber logical indicating whether high level amplifications and homozygous deletions should be indicated on the plot. defaults to F
amplif positive value that all observations equal or exceeding it are marked by yellow dots indicating high-level changes. defaults to 1
homdel negative value that all observations equal or below it are marked by light blue dots indicating homozygous deletions. defaults to -0.75
samplenames sample names
vecchrom vector of chromosomal indeces to use for clustering and to display. defaults to 1:23
titles plot title. defaults to "Image Plots"
methodS clustering method to cluster samples. defaults to "ward"
categoricalPheno logical indicating whether phenotype is categorical. Continuous phenotypes are treated as "no groups" except that their values are displayed. defaults to TRUE.
CENTROMERE logical indicating whether to plot the centromere

Details

This functions is a more flexible version of the heatmap. It can cluster within levels of categorical phenotype as well as all of the samples while displaying phenotype levels in different colors. It also uses any combination of chromosomes that is requested and clusters samples based on these chromosomes only. It draws the chromosomal boundaries and displays high level changes and homozygous deletions. If phenotype if not categorical, its values may still be displayed but groups are not formed and byclass = F. Image plot has the samples reordered according to clustering order.

See Also

heatmap
IDProbes

Interactive version of genomePlot

Description

Interactive version of `genomePlot`. Allows the user to click near a probe and the name of that probe will be displayed next to it.

Usage

```
IDProbes(input, array = 1, naut = 22, Y = FALSE, X = FALSE, status, values, pch, cex, col, chrominfo = chrominfo.Mb, ylim = c(-2, 2), ylb = "Log2Ratio", chrom.to.plot = 1, xlim = c(0,NA))
```

Arguments

- `input`: an object of class `MAList` or `SegList`
- `array`: integer of the array (sample) to be plotted.
- `naut`: number of autosomes in the organism
- `Y`: TRUE if chromosome Y is to be plotted, FALSE otherwise
- `X`: TRUE if chromosome X is to be plotted, FALSE otherwise
- `status`: character vector giving the control status of each spot on the array, of same length as the number of rows of `log2ratios(input)`. If omitted, all points are plotted in the default color, symbol and size.
- `values`: character vector giving values of `status` to be highlighted on the plot. Defaults to unique values of `status`. Ignored if there is no `status` vector.
- `pch`: vector or list of plotting characters. Default to integer code 16. Ignored if there is no `status` vector.
- `col`: numeric or character vector of colors, of the same length as `values`. Defaults to `1:length(values)`. Ignored if there is no `status` vector.
- `cex`: numeric vector of plot symbol expansions, of the the same length as `values`. Defaults to 0.2 for the most common `status` value and 1 for the others. Ignored if there is no `status` vector.
- `chrominfo`: a chromosomal information associated with the mapping of the data.
- `ylim`: Minimum y-scale to use for plotting.
- `chrom.to.plot`: Specify which chromosome to plot
- `ylb`: label for the Y-axis.
- `xlim`: limits for the x-axis

Author(s)

Mike Smith

See Also

`genomePlot`
imputeMissingValues  Imputing log2 ratios

Description

Imputing log2 ratios

Usage

imputeMissingValues(seg, chrominfo = chrominfo.Mb, maxChrom = 23, smooth = 0.1)

Arguments

seg  Object of class SegList
chrominfo  a chromosomal information associated with the mapping of the data
maxChrom  Highest chromosome to impute
smooth  smoothing parameter for the lowess procedure

Details

There are two main reasons to impute data. One is that given that imputation is reasonable, one can increase the analytical power and improve results. Another, more practical, is that at the moment many widely used functions in R do not support missing values. While procedures such as kNN imputations is widely used for gene expression data, it is more powerful to take advantage of the genomic structure of the array CGH data and use a smoother. Note that we perform only one pass of smoothing. If there still remain missing values, they are imputed by the median on the chromosome or chromosomal arm where applicable.

Value

Computes and returns the imputed log2 ratio matrix of the aCGH object.

See Also

SegList

LargeDataObject-class  Large Data Object - class

Description

A virtual class including the data classes RGList, MAList and SegList, all of which typically contain large quantities of numerical data in vector, matrices and data.frames.

Methods

A show method is defined for objects of class LargeDataObject which uses printHead to print only the leading elements or rows of components or slots which contain large quantities of data.


**Extracting log2 ratios**

This function extracts the log2 ratios from either an `MAList` object or a `SegList` object.

**Usage**

```r
log2ratios(x)
```

**Arguments**

- **x**
  
  An object of class `MAList` or `SegList`.

**Description**

`mergeStates` takes the output of a segmentation algorithm in the form of a `SegList` and iteratively merges the states with means closer than a supplied threshold.

**Usage**

```r
mergeStates(segList, MergeType = 1, pv.thres=0.0001, ansari.sign=0.01, minDiff = 0.25)
```

**Arguments**

- **segList**
  
  Object of class `SegList`.

- **MergeType**
  
  Select either 1 or 2. 1 uses a new merging algorithm developed by Hanni Willingenbrock and Jane Fridlyand.

- **pv.thres**
  
  Significance threshold for Wilcoxon test for level merging. Used when `MergeType = 1`.

- **ansari.sign**
  
  Significance threshold for Ansari-Bradley test. Used when `MergeType = 1`.

- **minDiff**
  
  The states whose predicted values are less than `minDiff` apart are merged into one state and all the predicted values are recomputed. Used when `MergeType = 2`. 
Details

This function is intended to reduce effect of the possible small magnitude technological artifacts on the structure determination.

Value

A SegList object is returned with the merged states stored in the pred list.

Author(s)

Jane Fridlyand

References

Application of Hidden Markov Models to the analysis of the array CGH data, Fridlyand et.al., *JMVA*, 2004

See Also

SegList, runHomHMM, runGLAD, runDNAcopy

non.zero.length.distr.non.tiled

*Empirical distribution of segment lengths in non-tiled regions with copy number gains or losses*

Description

This file contains the empirical distribution of segment lengths (of untiled regions and whose state mean indicates that they correspond to regions of copy number gain or loss) derived by applying the DNAcopy segmentation scheme (Olshen et al., 2004) to an unpublished breast cancer dataset. Instead of using the physical length of the segments we calculate the lengths as a proportion of the length of the untiled region.

Usage

data(non.zero.length.distr.non.tiled)

Source

The empirical distribution was derived using an unpublished breast cancer dataset.
**non.zero.length.distr.tiled**

*Empirical distribution of segment lengths in tiled regions with copy number gains or losses*

**Description**

This file contains the empirical distribution of segment lengths (of tiled regions and whose state mean indicates that they correspond to regions of copy number gain or loss) derived by applying the DNAcopy segmentation scheme (Olshen et al., 2004) to an unpublished breast cancer dataset. Instead of using the physical length of the segments we calculate the lengths as a proportion of the length of the tiled region.

**Usage**

```r
data(non.zero.length.distr.tiled)
```

**Source**

The empirical distribution was derived using an unpublished breast cancer dataset.

**plotSegmentedGenome**  *Plots the genome*

**Description**

Basic plot of the log2 ratios for each array ordered along the genome.

**Usage**

```r
plotSegmentedGenome(..., array = 1, naut = 22, Y = FALSE, X = FALSE, status, values, pch, cex, col, chrominfo = chrominfo.Mb, ylim = c(-2, 2), ylb = "Log2Ratio", chrom.to.plot = NA, xlim = c(0,NA), colors = NULL, mark.regions = FALSE, main = NA)
```

**Arguments**

- `...` Objects of class `SegList`
- `array` integer of the array (sample) to be plotted.
- `naut` number of autosomes in the organism
- `Y` TRUE if chromosome Y is to be plotted, FALSE otherwise
- `X` TRUE if chromosome X is to be plotted, FALSE otherwise
- `status` character vector giving the control status of each spot on the array, of same length as the number of rows of `log2ratios(input)`. If omitted, all points are plotted in the default color, symbol and size.
- `values` character vector giving values of `status` to be highlighted on the plot. Defaults to unique values of `status`. Ignored if there is no `status` vector.
processCGH

pch vector or list of plotting characters. Default to integer code 16. Ignored if there is no status vector.
col numeric or character vector of colors, of the same length as values. Defaults to 1:length(values). Ignored if there is no status vector.
cex numeric vector of plot symbol expansions, of the same length as values. Defaults to 0.2 for the most common status value and 1 for the others. Ignored if there is no status vector.
chrominfo a chromosomal information associated with the mapping of the data.
ylim Minimum y-scale to use for plotting.
chrom.to.plot Specify which chromosome to plot
ylb label for the Y-axis.
xlim limits for the x-axis
colors vector of colors to plot segmented states of each SegList passed to the function.
mark.regions Boolean. If true will colour code the segmentation plot using the information stored in $regions and generated by bayesCGH::nudSegmentation, or an equivalent method.
main Specify the title of the plot

Details

The status vector is intended to specify the control status of each spot, for example "gene", "ratio control", "house keeping gene", "buffer" and so on. The vector is usually computed using the function controlStatus and a spot-types file. However the function may be used to highlight any subset of spots.

Author(s)

Mike Smith

See Also

genomePlot SegList

processCGH

Process data in an MAList

Description

This function takes object of class MAList and it re-orders and filters clones based on their mapping information and proportion missing. It also average duplicated clones and imputes missing values for clones that are still NA after the filtering step. Note that imputation will only take place if duplicated clones are removed.

Usage

processCGH(input, maxChromThreshold = 22, minChromThreshold = 1, method.of.averaging = NULL, ID = "ID", prop.missing = 0.1)
Arguments

input  
Object of class MAList or RGList

maxChromThreshold
Chromosomes are ordered and numbered as usual, except for X and Y chromosome, which in for Homo sapiens genome have numbers 23 and 24 respectively, in for Mus musculus 20 and 21, etc. Remove chromosomes from segmentation analysis which are greater than this value.

minChromThreshold
Chromosomes are ordered and numbered as usual, except for X and Y chromosome, which in for Homo sapiens genome have numbers 23 and 24 respectively, in for Mus musculus 20 and 21, etc. Remove chromosomes from segmentation analysis which are lower than this value.

method.of.averaging
If left as the default no combining of replicate spots takes place. Otherwise this should specify a function which takes a vector of duplicates and combines them into a single value.

ID
Name of column in RG$genes corresponding to the clone names. For most data the default will work, however for affy data the value for ID should be "CloneName"

prop.missing
For each probe the proportion of NA’s is calculated, and the probe is kept for further analysis if the proportion of NA’s is less than missing.prop

Value

Object of class SegList

Author(s)

Jane Fridlyand, Peter Dimitrov, John Marioni and Mike Smith

See Also

MAList

Description

Function to read the chromosomal position information of each clone and incorporate it into the genes data.frame of the relevant object.

Usage

read.clonesinfo(file, RG, path = NULL, sep = "\t", quote = "\"")
**removeByWeights**

**Arguments**

- `file` Name of the file containing the chromosomal information.
- `RG` Object containing a \$genes data.frame that the information should be incorporated into.
- `path` Path to the chromosomal information file.
- `sep` Identifying the column separator in the designated file.
- `quote` Identifying the quotation character used in the designated file.

**Author(s)**

Mike Smith

---

**readPositionalInfo**  
**readPositionalInfo**

**Description**

This function automatically inserts information about the chromosomal positional of a clone into the \$genes matrix of an RGList or MAList. This information is used in all the available segmentation methods as well as many of the plotting functions available in snapCGH.

**Usage**

`readPositionalInfo(input, source, path = NULL)`

**Arguments**

- `input` An object of class `RGList` or `MAList`
- `source` Defines which platform or technology this data was produced on. Currently supported options are: "aglient", "bluefuse", "nimblegen". This list will be expanded in time.
- `path` Optional parameter to specify where the original data is stored. Defaults to the current working directory. This option is only required for reading "bluefuse" data at the moment, as chromosome information isn’t read by limma as default.

---

**removeByWeights**  
*Remove clones based on a weights matrix*

**Description**

An example function to be used by the filterClones method. This function takes an MA list, a weights matrix and a threshold and returns the indices of any clones with weight below the threshold.

**Usage**

`removeByWeights(MA, weights=MA$weights, threshold = 0.2)`
runBioHMM

Arguments

MA       An object of class `MAList`
weights  A matrix with the same dimensions as MA containing weight information.
threshold Threshold value. Any clones with weight below this are removed.

Author(s)

Mike Smith

See Also

`filterClones`

---

runBioHMM

This function implements the BioHMM

Description

This function reads in a dataset of log2 ratios and the corresponding clone and covariate information. It calculates a heterogeneous HMM when there are 1, 2, 3, 4 or 5 underlying states and chooses between them using either the AIC or BIC. It then assigns clones using a modified version of the Viterbi algorithm.

Usage

```r
runeBioHMM(input, useCloneDists = TRUE, covariates, criteria = "AIC", delta = NA,
            var.fixed = FALSE, epsilon = 1e-06, numiter = 30000)
```

Arguments

input An object of class `MAList` or `SegList`
useCloneDists Boolean stating whether the distance between clones should be incorporated into the HMM. If false then the HMM becomes homogeneous.
covariates This is a dataframe containing information about covariate factors. The first two columns should be Chrom (giving the chromosome on which a clone is located) and Mb (giving the position of the chromosome along a particular chromosome in Megabases). The order should be the same as that described above with the following crucial difference. No covariate information about the first clone is used in the segmentation. Hence, for each chromosome, there should be one less row in the covariate dataframe than in the datainfo dataframe corresponding to this missing chromosome. This is important if the transition matrix is to be calculated correctly.
criteria Options are AIC or BIC depending upon which we want to use to distinguish between the number of states
delta A variable to be assigned if the BIC is used.
var.fixed Logical variable - TRUE if you want to tie the variance to be the same across all states. Defaults to FALSE
epsilon Stopping criterion for the optimization algorithm.
umiter Number of iterations to be used in the optimization algorithm.
The model returns an object of class `SegList`.

**Author(s)**

John Marioni and Mike Smith

**References**


---

**runDNAcopy**

*Results of segmenting an MAList data object using the DNAcopy library*

**Description**

The results of segmenting data from copy number array experiments from programs such as circular binary segmentation (CBS). This function requires the library DNAcopy to be loaded.

**Usage**

```r
runDNAcopy(input, smooth.region=2, outlier.SD.scale = 4, smooth.SD.scale = 2, trim=0.025, alpha = "perm", kmax = 25, nmin = 200, undo.splits = c("none", "prune", "sdundo"), undo.prune = 0.05, undo.SD = 3, nperm = 10000, eta = 0.05)
```

**Arguments**

- **input**: An object of class `MAList` or `SegList`
- **smooth.region**: number of points to consider on the left and the right of a point to detect it as an outlier.
- **outlier.SD.scale**: the number of SDs away from the nearest point in the smoothing region to call a point an outlier.
- **smooth.SD.scale**: the number of SDs from the median in the smoothing region where a smoothed point is positioned.
- **trim**: proportion of data to be trimmed for variance calculation for smoothing outliers and undoing splits based on SD.
- **alpha**: significance levels for the test to accept change-points.
- **p.method**: method used for p-value computation. For the "perm" method the p-value is based on full permutation. For the "hybrid" method the maximum over the entire region is split into maximum of max over small segments and max over the rest. Approximation is used for the larger segment max. Default is hybrid.
- **kmax**: the maximum width of smaller segment for permutation in the hybrid method.
- **nmin**: the minimum length of data for which the approximation of maximum statistic is used under the hybrid method.
undo.splits A character string specifying how change-points are to be undone, if at all. Default is "none". Other choices are "prune", which uses a sum of squares criterion, and "sundo", which undoes splits that are not at least this many SDs apart.
undo.prune the proportional increase in sum of squares allowed when eliminating splits if undo.splits="prune".
undo.SD the number of SDs between means to keep a split if undo.splits="sundo".
nperm number of permutations used for p-value computation.
eta the probability to declare a change conditioned on the permuted statistic exceeding the observed statistic exactly j (= 1,...,nperm*alpha) times.

Value
The function returns an object of class *SegList*

Author(s)
Mike Smith, based upon DNAcopy help files written by E. S. Venkatraman and Adam Olshen

See Also
*segment MAList runHomHMM runGLAD SegList*

---

runGLAD  
*Results of segmenting an aCGHList data object using the GLAD library*

Description
This function allows the detection of breakpoints in genomic profiles obtained by array CGH technology and affects a status (gain, normal or lost) to each clone. It requires that the library GLAD is loaded.

Usage
```
runGLAD(input, smoothfunc="lawsglad", base=FALSE, sigma = NULL, bandwidth=10, round=2, lambdabreak=8, lambdacluster=8, lambdaclusterGen=40, type="tricubic", param=c(d=6), alpha=0.001, method="centroid", nmax=8, verbose=FALSE, ...)
```

Arguments
- **input** An object of class *MAList* or *SegList*
- **smoothfunc** Type of algorithm used to smooth LogRatio by a piecewise constant function. Choose either lawsglad, aws::aws or aws::laws.
- **base** If TRUE, the position of clone is the physical position onto the chromosome, otherwise the rank position is used.
- **sigma** Value to be passed to either argument sigma2 of aws::aws function or shape of aws::laws. If NULL, sigma is calculated from the data.
### runHomHMM

Set the maximal bandwidth \( h_{\text{max}} \) in the `aws::aws` or `aws::laws` function. For example, if \( \text{bandwidth}=10 \) then the \( h_{\text{max}} \) value is set to \( 10 \times X_N \) where \( X_N \) is the position of the last clone.

### round

The smoothing results are rounded or not depending on the `round` argument. The `round` value is passed to the argument digits of the `round` function.

### lambdabreak

Penalty term \( (\lambda') \) used during the **Optimization of the number of breakpoints** step.

### lambdacluster

Penalty term \( (\lambda^*) \) used during the **MSHR clustering by chromosome** step.

### lambdaclusterGen

Penalty term \( (\lambda^*) \) used during the **HCSR clustering throughout the genome** step.

### type

Type of kernel function used in the penalty term during the **Optimization of the number of breakpoints** step, the **MSHR clustering by chromosome** step and the **HCSR clustering throughout the genome** step.

### param

Parameter of kernel used in the penalty term.

### alpha

Risk alpha used for the **Outlier detection** step.

### method

The agglomeration method to be used during the **MSHR clustering by chromosome** and the **HCSR clustering throughout the genome** clustering steps.

### nmax

Maximum number of clusters \( (N_{\text{max}}) \) allowed during the the **MSHR clustering by chromosome** and the **HCSR clustering throughout the genome** clustering steps.

### verbose

If `TRUE` some information are printed

---

#### Details

For a detailed explanation of the GLAD algorithm please see the relevant section of the GLAD manual: `glad`

#### Value

The function returns an object of class `SegList`

#### See Also

`glad` `MAList` `runHomHMM` `runDNAcopy` `SegList`

---

### runHomHMM

**A function to fit unsupervised Hidden Markov model**

#### Description

This function fits an unsupervised Hidden Markov model to a given `MAList` or `SegList`

#### Usage

```r
runHomHMM(input, vr = 0.01,
          maxiter = 100, criteria = "AIC", delta = NA,
          full.output = FALSE, eps = 0.01)
```
runTilingArray

Arguments

- **input**: an object of class `MAList` or `SegList`
- **vr**: Gets passed to the function `repeated::hidden` as the `pshape` argument.
- **maxiter**: Gets passed to the function `repeated::hidden` as the `iterlim` argument.
- **criteria**: Choice of which selection criteria should be used in the algorithm. The choices are either AIC or BIC.
- **delta**: Delta value used of the BIC is selected. If no value is entered it defaults to 1.
- **full.output**: if true the `SegList` output includes a probability that a clone is in its assigned state and a smoothed value for the clone.
- **eps**: parameter controlling the convergence of the EM algorithm.

See Also

- `runDNAcopy`
- `runGLAD`
- `SegList`

Description

Wrapper calling the Tiling Array segmentation algorithm on an `MAList` object. This function requires the library `DNAcopy` to be loaded.

Usage

```r
runTilingArray(input, maxSeg = 5, maxk = 200, criteria = "BIC")
```

Arguments

- **input**: An object of class `MAList` or `SegList`
- **maxSeg**: integer of length 1, maximum number of segments (= 1 + maximum number of change points)
- **maxk**: integer of length 1, maximum length of a single segment
- **criteria**: Criteria for model selection. Options are "none", "AIC" and "BIC" (default)

Value

The function returns an object of class `SegList`

Author(s)

Mike Smith

See Also

- `segment MAList runHomHMM runGLAD SegList`
SegList-class  Segmentation States - class

Description

A list based class for storing the results of a segmentation algorithm. They are generally created by running one of the following functions `runHomHMM`, `runGLAD` or `runDNAcopy` on an `MAList` object.

Slots/List Components

Objects should contain the following list components:

- **pred**: Predicted value of the state.
- **disp**: Dispersion.
- **obs**: Observed value.
- **state**: Numeric value.
- **nstates.hmm**: The number of states per chromosome. Each row represents a chromosome and each column is an array.
- **genes**: data.frame that contains the chromosome and position on the chromosome for each clone. Used for plotting functions.

Optional:

- **rpred**: Smoothed value for the clone.
- **prob**: Probability of the clone being in the assigned state.

Methods

SegLists can be subsetted and combined. They also return dimensions so functions such as `dim`, `nrow` and `ncol` are also defined. SegList inherits the `show` method from the Limma class `LargeDataObject`. This means that the SegList will print in a relatively compact way.

Author(s)

Mike Smith

simulateData

A function for simulating aCGH data and the corresponding clone layout

Description

This simulation scheme operates in two stages. Initially, we simulate the layout of clones before using a modified version of the scheme developed by Willenbrock et al., 2005 to generate the log\(_2\) ratios. For each simulated clone layout we generate 20 sets of simulated log\(_2\) ratios from one of five templates. Additionally, we also take account of the cellularity of the test sample in our simulation.
simulateData(nArrays = 20, chrominfo = NULL, prb.short.tiled = 0.5,
prb.long.tiled = 0.5, non.tiled.lower.res = 0.9,
non.tiled.upper.res = 1.1, length.clone.lower = 0.05,
length.clone.upper = 0.2, tiled.lower.res = -0.05,
tiled.upper.res = 0, sd = NULL, output = FALSE,
prb.proportion.tiled = c(0.2, 0.2, 0.2, 0.2, 0.2),
cezolengthnontiled = NULL, zerolengthtiled = NULL,
nonzerolengthnontiled = NULL, nonzerolengthtiled =
NULL, seed = 1)

Arguments

nArrays The number of arrays we want to simulate

chrominfo The information about chromosome length/centromere location to be used. De-
defaults to the information provided in aCGH package of Jane Fridlyand and Peter
Dimitrov.

prb.short.tiled The probability of a tiled region on the short arm of the simulated chromosome
(defaults to 0.5).

prb.long.tiled The probability of a tiled region on the long arm of the simulated chromosome
(defaults to 0.5).

non.tiled.lower.res The lower limit for the distance (in Mbs) between adjacent clones in non-tiled
regions of the genome (defaults to 0.9Mb).

non.tiled.upper.res The upper limit for the distance (in Mbs) between adjacent clones in non-tiled
regions of the genome (defaults to 1.1Mb).

length.clone.lower The lower limit for the length (in Mbs) of a clone (this defaults to 0.05Mb).

length.clone.upper The upper limit for the length (in Mbs) of a clone (this defaults to 0.2Mb).

tiled.lower.res The lower limit for the distance (in Mbs) between adjacent clones in tiled regions
of the genome (defaults to -0.05Mb).

tiled.upper.res The upper limit for the distance (in Mbs) between adjacent clones in tiled regions
of the genome (defaults to 0Mb).

sd The standard deviation of the simulated data in each of the states. Defaults to
being randomly sampled between 0.1 and 0.2.

output A logical variable which is TRUE if you want the output to be written to txt files
in the present working directory. Defaults to FALSE.

prb.proportion.tiled Given that an arm of a chromosome contains a tiled region this variable (which
is a vector of length 5) gives the probability that 20,30,40,50 or 100% of
the chromosome is tiled. It defaults to (0.2,0.2,0.2,0.2,0.2)

zerolengthnontiled The empirical distribution for regions of the genome which are non-tiled and
contain no copy number gains or losses. Defaults to zero.length.distr.non.tiled
zerolengthtiled
The empirical distribution for regions of the genome which are tiled and contain
no copy number gains or losses. Defaults to zero.length.distr.tiled

nonzerolengthnontiled
The empirical distribution for regions of the genome which are non-tiled and
contain no copy number gains or losses. Defaults to non.zero.length.distr.non.tiled

nonzerolengthtiled
The empirical distribution for regions of the genome which are tiled and contain
copy number gains or losses. Defaults to non.zero.length.distr.tiled

seed
Seed value allowing simulation to be reproduced if the same seed value is set.

Details
For more details see the article by Marioni and Thorne published in Bioinformatics.

Value
The function returns a list containing the following elements.

clones
Gives the start, end and midpoint of the simulated clones.

class.output
A list of the true underlying state clones are assigned to for each of the twenty
simulations associated with each clone layout.

class.matrix
Defines the true underlying state clones are assigned to in each of the five classes

classes
Which of the five class outputs has been used to simulate the \( \log_2 \) ratios

datamatrix
A matrix containing twenty columns each of which contains the simulated \( \log_2 \)
ratios associated with each of the simulations for a particular clone layout.

samples
Gives information about the cellularity associated with each of the samples.

Author(s)
John Marioni and Natalie Thorne

References
See the relevant article in Bioinformatics or the following website: www.damtp.cam.ac.uk/user/jcm68

Viterbi.five
A scaled Viterbi algorithm for allocating clones to one of five underlying states.

Description
A work horse of the fit.model function. It uses a scaled version of the Viterbi algorithm to allocate
clones to one of five underlying states as fitted using a heterogeneous HMM.

Usage
Viterbi.five(y, BFGS.output, BFGS.trans.mat)
**Viterbi.four**

**Arguments**

- `y` the data to be allocated to states
- `BFGS.output` The output obtained from the `find.param.five` function
- `BFGS.trans.mat` A list of the heterogeneous transition matrices

**Value**

A vector of numbers indicating to which state clones are allocated to.

**Author(s)**

John Marioni

---

**Description**

A work horse of the `fit.model` function. It uses a scaled version of the Viterbi algorithm to allocate clones to one of four underlying states as fitted using a heterogeneous HMM.

**Usage**

```r
Viterbi.four(y, BFGS.output, BFGS.trans.mat)
```

**Arguments**

- `y` the data to be allocated to states
- `BFGS.output` The output obtained from the `find.param.four` function
- `BFGS.trans.mat` A list of the heterogeneous transition matrices

**Value**

A vector of numbers indicating to which state clones are allocated to.

**Author(s)**

John Marioni
Viterbi.three  

A scaled Viterbi algorithm for allocating clones to one of two underlying states.

Description

A work horse of the fit.model function. It uses a scaled version of the Viterbi algorithm to allocate clones to one of three underlying states as fitted using a heterogeneous HMM.

Usage

Viterbi.three(y, BFGS.output, BFGS.trans)

Arguments

- **y**: the data to be allocated to states
- **BFGS.output**: The output obtained from the find.param.three function
- **BFGS.trans**: A list of the heterogeneous transition matrices

Value

A vector of numbers indicating to which state clones are allocated to.

Author(s)

John Marioni

Viterbi.two  

A scaled Viterbi algorithm for allocating clones to one of two underlying states.

Description

A work horse of the fit.model function. It uses a scaled version of the Viterbi algorithm to allocate clones to one of two underlying states as fitted using a heterogeneous HMM.

Usage

Viterbi.two(y, BFGS.output, BFGS.trans.mat)

Arguments

- **y**: the data to be allocated to states
- **BFGS.output**: The output obtained from the find.param.two function
- **BFGS.trans.mat**: A list of the heterogeneous transition matrices

Value

A vector of numbers indicating to which state clones are allocated to.
zero.length.distr.non.tiled

Empirical distribution of segment lengths in non-tiled regions with no copy number gains or losses

Description
This file contains the empirical distribution of segment lengths (of untiled regions and whose state mean indicates that they correspond to regions of no copy number gain or loss) derived by applying the DNAcopy segmentation scheme (Olshen et al., 2004) to an unpublished breast cancer dataset. Instead of using the physical length of the segments we calculate the lengths as a proportion of the length of the untiled region.

Usage
data(zero.length.distr.non.tiled)

Source
The empirical distribution was derived using an unpublished breast cancer dataset.

zero.length.distr.tiled

Empirical distribution of segment lengths in tiled regions with no copy number gains or losses

Description
This file contains the empirical distribution of segment lengths (of tiled regions and whose state mean indicates that they correspond to regions of no copy number gain or loss) derived by applying the DNAcopy segmentation scheme (Olshen et al., 2004) to an unpublished breast cancer dataset. Instead of using the physical length of the segments we calculate the lengths as a proportion of the length of the tiled region.

Usage
data(zero.length.distr.tiled)

Source
The empirical distribution was derived using an unpublished breast cancer dataset.
**zoomChromosome**

*Interactive plot of a single chromosome*

**Description**

Plot splitting the screen into two. The top windows displays the entire chromosome, whilst the bottom plots a selected region. The plot is interactive allowing the user to click twice on a chromosome in the upper plot and have it the region between the two clicks displayed below.

**Usage**

```r
zoomChromosome(..., array = 1, chrom.to.plot, colors = NULL, chrominfo = chrominfo.Mb, ylim = c(-2, 2))
```

**Arguments**

- `...`: Objects of type `MAList` or `SegList`
- `array`: Specify which array should be plotted.
- `chrom.to.plot`: Which chromosome should be plotted.
- `colors`: Vector specify the colors for each of the SegLists.
- `chrominfo`: Chromosomal information associated with the mapping of the data.
- `ylim`: Specify the limits of the y-axis.

**Details**

If `colors` is unspecified then all SegLists passed to this function will be plotted in blue. Since this makes it quite hard to tell which is which it is highly recommended to specify the colors vector if more than one object is being passe to this function.

**Author(s)**

Mike Smith

---

**zoomGenome**

*Interactive plot of the whole genome*

**Description**

Plot splitting the screen into two. The top windows displays the entire genome, whilst the bottom plots a single chromosome. The plot is interactive allowing the user to click on a chromosome in the upper plot and have it displayed below. Clicking to either side of the plot borders ends the interactivity.

**Usage**

```r
zoomGenome(..., array = 1, colors = NULL, chrominfo = chrominfo.Mb)
```
Arguments

... Objects of type SegList
array Specify which array should be plotted.
colors Vector specify the colors for each of the SegLists
chrominfo chromosomal information associated with the mapping of the data.

Details

If colors is unspecified then all objects passed to this function will be plotted in blue. Since this makes it quite hard to tell which is which it is highly recommended to specify the colors vector if more than one object is being passed to this function.

Author(s)

Mike Smith
Index

*Topic array
  dim, 5
  dimnames, 6
*Topic classes
  LargeDataObject-class, 16
  SegList-class, 28
*Topic cluster
  heatmapGenome, 13
*Topic datasets
  chrominfo.Mb, 3
  convert.output, 4
  log2ratios, 17
  non.zero.length.distr.non.tiled, 18
  non.zero.length.distr.tiled, 19
  simulateData, 28
  zero.length.distr.non.tiled, 33
  zero.length.distr.tiled, 33
*Topic data
  LargeDataObject-class, 16
  SegList-class, 28
*Topic file
  processCGH, 20
*Topic hplot
  genomePlot, 12
  heatmapGenome, 13
  IDProbes, 15
  plotSegmentedGenome, 19
  zoomChromosome, 34
  zoomGenome, 34
*Topic manip
  cbind, 2
  compareSegmentations, 4
  readPositionalInfo, 22
*Topic methods
  filterClones, 7
  findBreakPoints, 11
  read.clonesinfo, 21
  removeByWeights, 22
  runDNAcopy, 24
  runGLAD, 25
  runTilingArray, 27
*Topic misc
  find.param.five, 8
  find.param.four, 8
  find.param.one, 9
  find.param.three, 9
  find.param.two, 10
  Viterbi.five, 30
  Viterbi.four, 31
  Viterbi.three, 32
  Viterbi.two, 32
*Topic models
  fit.model, 11
  imputeMissingValues, 16
  mergeStates, 17
  runBioHMM, 23
  runHomHMM, 26
  [.SegList (SegList-class), 28
  cbind, 2, 2, 3
  chrominfo.Mb, 3
  combine.func (mergeStates), 17
  compareBreakPoints
    (compareSegmentations), 4
  compareSegmentations, 4
  convert.output, 4
  dim, 5, 6, 28
  dim,SegList-method (dim), 5
  dim.MAList (dim), 5
  dim.RGList (dim), 5
  dim.SegList (dim), 5
  dimnames, 6, 7
  dimnames,SegList-method (dimnames), 6
  dimnames.SegList (dimnames), 6
  filterClones, 7, 23
  find.param.five, 8
  find.param.four, 8
  find.param.one, 9
  find.param.three, 9
  find.param.two, 10
  findBreakPoints, 11
  fit.model, 11
  floor.func (heatmapGenome), 13
  generate.data (simulateData), 28

36
INDEX

genomePlot, 12, 15, 20

heatmap, 14
 heatmapGenome, 13

IDProbes, 15
 imputeMissingValues, 16

LargeDataObject, 28
 LargeDataObject-class, 16
 length(dim), 5
 length.SegList-method (dim), 5
 length.MAList (dim), 5
 length.RGList (dim), 5
 length.SegList (dim), 5
 log2ratios, 17

MAList, 3, 7, 12–15, 17, 21–28, 34
 maPalette, 14
 maPalette (heatmapGenome), 13
 MergeLevels.new (mergeStates), 17
 MergeLevels.old (mergeStates), 17
 mergeStates, 17

ncol, 28
 non.zero.length.distr.non.tiled, 18
 non.zero.length.distr.tiled, 19
 nrow, 28

plotChrom (heatmapGenome), 13
 plotSegmentedGenome, 11, 19
 plotValChrom (heatmapGenome), 13
 plotValChrom.func (heatmapGenome), 13
 plotValGenome (heatmapGenome), 13
 print.SegList (SegList-class), 28
 processCGH, 7, 20
 prop.na (processCGH), 20

rbind.SegList (cbind), 2
 read.clonesinfo, 21
 readPositionalInfo, 22
 removeByWeights, 22
 RGList, 21, 22
 round, 26
 run.nelder (fit.model), 11
 runBioHMM, 23
 runDNAcopy, 18, 24, 26–28
 runGLAD, 18, 25, 26, 27, 28
 runHomHMM, 18, 25, 26, 27, 28
 runTilingArray, 27

sample.names (genomePlot), 12
 SegList, 3, 4, 11–21, 23–27, 34, 35
 SegList-class, 28
 segment, 25, 27
 show, 28
 show.LargeDataObject-method
 (LargeDataObject-class), 16
 show.SegList-method (SegList-class), 28
 simulateData, 4, 28
 states.hmm.func (runHomHMM), 26
 Viterbi.five, 30
 Viterbi.four, 31
 Viterbi.three, 32
 Viterbi.two, 32

zero.length.distr.non.tiled, 33
 zero.length.distr.tiled, 33
 zoomChromosome, 34
 zoomGenome, 34