Package ‘regioneR’

January 15, 2017

**Type** Package

**Title** Association analysis of genomic regions based on permutation tests

**Version** 1.6.0

**Date** 2016-04-06

**Author** Anna Diez-Villanueva <adiez@imppc.org>, Roberto Malinverni
<rmalinverni@carrerasresearch.org> and Bernat Gel <bge1@imppc.org>

**Maintainer** Bernat Gel <bge1@imppc.org>

**Description** regioneR offers a statistical framework based on customizable permutation tests to assess the association between genomic region sets and other genomic features.

**License** Artistic-2.0

**Depends** memoise, GenomicRanges, BSgenome, rtracklayer, parallel

**Imports** memoise, GenomicRanges, BSgenome, rtracklayer, parallel, graphics, stats, utils, GenomeInfoDb, IRanges

**Suggests** BiocStyle, knitr, BSgenome.Hsapiens.UCSC.hg19.masked, testthat

**VignetteBuilder** knitr

**biocViews** Genetics, ChIPSeq, DNASeq, MethylSeq, CopyNumberVariation

**NeedsCompilation** no

**RoxygenNote** 5.0.1

**R topics documented:**

- characterToBSGenome .......................................................... 2
- circularRandomizeRegions ............................................... 3
- commonRegions ............................................................... 4
- createFunctionsList ...................................................... 5
- createRandomRegions ..................................................... 6
- emptyCacheRegioneR ....................................................... 7
- extendRegions ............................................................... 8
- filterChromosomes .......................................................... 9
- getChromosomesByOrganism ............................................... 10
- getGenome ..................................................................... 10
- getGenomeAndMask .......................................................... 11
characterToBSGenome

Description

Given a character string with the "name" of a genome, it returns a BSgenome object if available.

Usage

characterToBSGenome(genome.name)

Arguments

genome.name a character string uniquely identifying a BSgenome (e.g. "hg19", "mm10" are ok, but "hg" is not)

Value

A BSgenome object

Note

This function is memoised (cached) using the memoise package. To empty the cache, use forget(characterToBSGenome)
circularRandomizeRegions

See Also

getGenomeAndMask, maskFromBSGenome

Examples

g <- characterToBSGenome("hg19")

circularRandomizeRegions

Circular Randomize Regions

Description

Given a set of regions A and a genome, this function returns a new set of regions created by applying a random spin to each chromosome.

Usage

circularRandomizeRegions(A, genome="hg19", mask=NULL, max.mask.overlap=NULL, max.retries=10, verbose=TRUE, ...)

Arguments

A
  The set of regions to randomize. A region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

 genome
  The reference genome to use. A valid genome object. Either a GenomicRanges or data.frame containing one region per whole chromosome or a character uniquely identifying a genome in BSgenome (e.g. "hg19", "mm10" but not "hg"). Internally it uses getGenomeAndMask.

 mask
  The set of regions specifying where a random region can not be (centromeres, repetitive regions, unmappable regions,...). A region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, ...). If NULL it will try to derive a mask from the genome (currently only works is the genome is a character string) and if NA it will explicitly give an empty mask.

 max.mask.overlap
  numeric value

 max.retries
  numeric value

 verbose
  a boolean.

 ... further arguments to be passed to or from methods.

Details

This randomization strategy is useful when the spatial relation between the regions in the RS is important and has to be conserved.

Value

It returns a GenomicRanges object with the regions resulting from the randomization process.
**commonRegions**

**See Also**

randomizeRegions, toDataframe, toGRanges, getGenome, getMask, getGenomeAndMask, characterToBSGenome, maskFromBSGenome, resampleRegions, createRandomRegions

**Examples**

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
mask <- data.frame("chr1", c(20000000, 100000000), c(22000000, 130000000))
genome <- data.frame(c("chr1", "chr2"), c(1, 1), c(18000000, 20000000))
circularRandomizeRegions(A)
circularRandomizeRegions(A, genome=genome, mask=mask, per.chromosome=TRUE, non.overlapping=TRUE)
```

---

**commonRegions**

**Common Regions**

**Description**

Returns the regions that are common in two region sets, its intersection.

**Usage**

```r
commonRegions(A, B)
```

**Arguments**

<table>
<thead>
<tr>
<th>A</th>
<th>a region set in any of the accepted formats by <code>toGRanges</code> (GenomicRanges, data.frame, etc...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>a region set in any of the accepted formats by <code>toGRanges</code> (GenomicRanges, data.frame, etc...)</td>
</tr>
</tbody>
</table>

**Value**

It returns a `GenomicRanges` object with the regions present in both region sets.

**Note**

All metadata (additional columns in the region set in addition to chromosome, start and end) will be ignored and not present in the returned region set.

**See Also**

plotRegions, toDataframe, toGRanges, subtractRegions, splitRegions, extendRegions, joinRegions, mergeRegions, overlapRegions
createFunctionsList

Examples

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
B <- data.frame("chr1", 25, 35)
commons <- commonRegions(A, B)
plotRegions(list(A, B, commons), chromosome="chr1", regions.labels=c("A", "B", "common"), regions.colors=3:1)
```

createFunctionsList  
*Create Functions List*

Description

Partially applies (the standard Curry function in functional programming) a list of arguments to a function and returns a list of preapplied functions. The result of this function is a list of functions suitable for the multiple evaluation functions in permTest.

Usage

```r
createFunctionsList(FUN, param.name, values, func.names)
```

Arguments

- **FUN**: Function. the function to be partially applied
- **param.name**: Character. The name of the parameter to pre-set.
- **values**: A list or vector of values to preassign. A function will be created for each of the values in values. If present, the names of the list will be the names of the functions.
- **func.names**: Character. The names of the functions created. Useful to identify the functions created. Defaults to the names of the values list or to Function1, Function2... if the values list has no names.

Value

It returns a list of functions with parameter param.value pre-set to values.

Note

It uses the code posted by "hadley" at http://stackoverflow.com/questions/6547219/how-to-bind-function-arguments

See Also

```r
permTest, overlapPermTest
```
createRandomRegions

Create Random Regions

Description

Creates a set of random regions with a given mean size and standard deviation.

Usage

createRandomRegions(nregions=100, length.mean=250, length.sd=20, genome="hg19", mask=NULL, non.overlapping=TRUE)

Arguments

- `nregions`  
The number of regions to be created.
- `length.mean`  
The mean size of the regions created. This is not guaranteed to be the mean of the final region set. See note.
- `length.sd`  
The standard deviation of the region size. This is not guaranteed to be the standard deviation of the final region set. See note.
- `genome`  
The reference genome to use. A valid genome object. Either a GenomicRanges or data.frame containing one region per whole chromosome or a character uniquely identifying a genome in BSgenome (e.g. "hg19", "mm10" but not "hg"). Internally it uses getGenomeAndMask.
- `mask`  
The set of regions specifying where a random region can not be (centromeres, repetitive regions, unmappable regions...). A region set in any of the accepted formats (GenomicRanges, data.frame, ...). NULL will try to derive a mask from the genome (currently only works is the genome is a character string) and NA explicitly gives an empty mask.
- `non.overlapping`  
A boolean stating whether the random regions can overlap (FALSE) or not (TRUE).
emptyCacheRegionR

Details
A set of nregions will be created and randomly placed over the genome. The lengths of the region set will follow a normal distribution with a mean size length.mean and a standard deviation length.sd. The new regions can be made explicitly non-overlapping by setting non.overlapping to TRUE. A mask can be provided so no regions fall in a forbidden part of the genome.

Value
It returns a GenomicRanges object with the regions resulting from the randomization process.

Note
If the standard deviation of the length is large with respect to the mean, negative lengths might be created. These region lengths will be transformed to into a 1 and so the, for large standard deviations the mean and sd of the lengths are not guaranteed to be the ones in the parameters.

See Also
getGenome, getMask, getGenomeAndMask, characterToBSGenome, maskFromBSGenome, randomizeRegions, resampleRegions

Examples
```
genome <- data.frame(c("chr1", "chr2"), c(1, 1), c(180000000, 20000000))
mask <- data.frame("chr1", c(20000000, 100000000), c(22000000, 130000000))
createRandomRegions(nregions=10, length.mean=1000, length.sd=500)
createRandomRegions(nregions=10, genome=genome, mask=mask, non.overlapping=TRUE)
```
extendRegions

Extend Regions

Description
Extends the regions a number of bases at each end. Negative numbers will reduce the region instead of enlarging it.

Usage
extendRegions(A, extend.start=0, extend.end=0)

Arguments
A
a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

extend.start
an integer. The number of bases to be subtracted from the start of the region.

extend.end
an integer. The number of bases to be added at the end of the region.

Value
a GenomicRanges object with the extended regions.

Note
If negative values are provided and the new extremes are "flipped", the function will fail. It does not check if the extended regions fit into the genome.

See Also
plotRegions, toDataframe, toGRanges, subtractRegions, splitRegions, overlapRegions, commonRegions, mergeRegions, joinRegions

Examples
A <- data.frame("chr1", c(10, 20, 30), c(13, 28, 40))

extend1 <- extendRegions(A, extend.start=5, extend.end=2)

extend2 <- extendRegions(A, extend.start=15)

extend3 <- extendRegions(A, extend.start=-1)

plotRegions(list(A, extend1, extend2, extend3), chromosome="chr1", regions.labels=c("A", "extend1", "extend2", "extend3"))
Description

Filters the chromosomes in a region set. It can either filter using a predefined chromosome set (e.g. "autosomal chromosomes in Homo sapiens") or using a custom chromosome set (e.g. only chromosomes "chr22" and "chrX")

Usage

filterChromosomes(A, organism="hg", chr.type="canonical", keep.chr=NULL)

Arguments

A a region set in any of the formats accepted by toGRanges (GenomicRanges, data.frame, etc...)
organism a character indicating the organism from which to get the predefined chromosome sets. It can be the organism code as used in BSgenome (e.g. hg for human, mm for mouse...) or the full genome assembly identifier, since any digit will be removed to get the organism code.
chr.type a character indicating the specific chromosome set to be used. Usually "autosomal" or "canonical", although other values could be available for certain organisms.
keep.chr is a character vector stating the names of the chromosomes to keep. Any chromosome not in the vector will be filtered out. If keep.chr is supplied, organism and chr.type are ignored.

Value

A GRanges object containing only the regions in the original region set belonging to the selected chromosomes. All regions in non selected chromosomes are removed.

See Also

getGenomeAndMask, listChrTypes getChromosomesByOrganism

Examples

g <- getGenomeAndMask("hg19")$genome
listChrTypes()
g <- filterChromosomes(g, chr.type="autosomal", organism="hg19")
g <- filterChromosomes(g, keep.chr=c("chr1", "chr2", "chr3"))
getChromosomesByOrganism

Description

Function to obtain a list of organisms with their canonical and (when applicable) the autosomal chromosome names. This function is not usually used by the end user directly but through the filterChromosomes function.

Usage

getChromosomesByOrganism()

Value

a list with the organism as keys and the list of available chromosome sets as values

See Also

getGenome, filterChromosomes

Examples

chrsByOrg <- getChromosomesByOrganism()
chrsByOrg[["hg"]]
chrsByOrg[["hg"]][["autosomal"]]

getGenome

Description

Function to obtain a genome

Usage

getGenome(genome)

Arguments

genome The genome object or genome identifier.
getGenomeAndMask

Details
If genome is a BSgenome (from the package BioStrings), it will transform it into a GRanges with chromosomes and chromosome lengths.
If genome is a data.frame with 3 columns, it will transform it into a GRanges.
If genome is a data.frame with 2 columns, it will assume the first is the chromosome, the second is the length of the chromosomes and will add 1 as start.
If genome is a character string uniquely identifying a BSgenome installed in the system (e.g. "hg19", "mm10"... but not "hg"), it will create a genome based on the BSgenome object identified by the character string.
If genome is a GRanges object, it will return it as is.
If genome is non of the above, it will give a warning and try to transform it into a GRanges using toGRanges. This can be helpful if genome is a connection to a file.

Value
A GRanges object with the "genome" data c(Chromosome, Start (by default, 1), Chromosome Length) given a BSgenome, a genome name, a data.frame or a GRanges.
A GRanges representing the genome with one region per chromosome.

Note
This function is memoised (cached) using the memoise package. To empty the cache, use forget(getGenome)
Please note that passing this function the path to a file will not work, since it will assume the character is the identifier of a genome. To read the genome from a file, please use getGenome(toGRanges("path/to/file"))

See Also
getMask, getGenomeAndMask, characterToBSGenome, maskFromBSGenome, emptyCacheRegioneR

Examples
getGenome("hg19")
getGenome(data.frame(c("chrA", "chrB"), c(15000000, 10000000)))

Description
Function to obtain a valid genome and mask pair given a valid genome identifier and optionally a mask.
If the genome is not a BSgenome object or a character string uniquely identifying a BSgenome package installed, it will return the genome "as is". If a mask is provided, it will simply return it. Otherwise it will return the mask returned by getMask(genome) or an empty mask if genome is not a valid BSgenome or BSgenome identifier.
**Usage**

`getGenomeAndMask(genome, mask=NULL)`

**Arguments**

- `genome` the genome object or genome identifier.
- `mask` the mask of the genome in a valid RS format (data.frame, GRanges, BED-like file...). If mask is `NULL`, it will try to get a mask from the genome. If mask is `NA` it will return an empty mask. (Default=NULL)

**Value**

A list with two elements: genome and mask. Genome and mask are GRanges objects.

**Note**

This function is memoised (cached) using the `memoise` package. To empty the cache, use `forget(getGenomeAndMask)`

**See Also**

`getMask`, `getGenome`, `characterToBSGenome`, `maskFromBSGenome`, `emptyCacheRegioneR`

**Examples**

```r
getGenomeAndMask("hg19", mask=NA)
getGenomeAndMask(genome=data.frame(c("chrA", "chrB"), c(15000000, 10000000)), mask=NA)
```

---

**Description**

Function to obtain a mask given a genome available as a BSgenome. The mask returned is the merge of all the active masks in the BSgenome.

Since it uses `characterToBSGenome`, the genome can be either a BSgenome object or a character string uniquely identifying the a BSgenome object installed.

**Usage**

`getMask(genome)`

**Arguments**

- `genome` the genome from where the mask will be extracted. It can be either a BSgenome object or a character string uniquely identifying a BSgenome object installed (e.g. "hg19", "mm10", ...)

**Value**

A GRanges object with the genomic regions to be masked out
joinRegions

Note

This function is memoised (cached) using the memoise package. To empty the cache, use forget(getMask)

See Also

getGenome, getGenomeAndMask, characterToBSGenome, maskFromBSGenome, emptyCacheRegioneR

Examples

hg19.mask <- getMask("hg19")

hg19.mask

joinRegions  Join Regions

Description

Joins the regions from a region set A that are less than min.dist bases apart.

Usage

joinRegions(A, min.dist=1)

Arguments

A  a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

min.dist  an integer indicating the minimum distance required between two regions in order to not fuse them. Any pair of regions closer than min.dist bases will be fused in a larger region. Defaults to 1, so it will only join overlapping regions.

Value

It returns a GenomicRanges object with the regions resulting from the joining process.

Note

All metadata (additional columns in the region set in addition to chromosome, start and end) will be ignored and not present in the returned region set.

The implementation relies completely in the reduce function from IRanges package.

See Also

plotRegions, toDataframe, toGRanges, subtractRegions, splitRegions, extendRegions, commonRegions, mergeRegions, overlapRegions
Examples

A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
join1 <- joinRegions(A)
join2 <- joinRegions(A, min.dist=3)
join3 <- joinRegions(A, min.dist=10)
plotRegions(list(A, join1, join2, join3), chromosome="chr1", regions.labels=c("A", "join1", "join2", "join3")

Description

Prints a list of the available organisms and chromosomes sets in the predefined chromosomes sets information.

Usage

listChrTypes()

Value

the list of available chrs and organisms is printed

See Also

filterChromosomes, getChromosomesByOrganism

Examples

g <- getGenomeAndMask("hg19")$genome
listChrTypes()
g <- filterChromosomes(g, chr.type="autosomal", organism="hg19")
localZScore

Local z-score

Description

Evaluates the variation of the z-score in the vicinity of the original region set

Usage

localZScore(A, pt, window, step, ...)

Arguments

- `A`: a region set in any of the formats accepted by `toGRanges` (GenomicRanges, data.frame, etc...)
- `pt`: a permTestResult object
- `window`: a window in which the local Z-score will be calculated (bp)
- `step`: the number of bp that divide each Z-score evaluation
- `...`: further arguments to be passed to other methods.

Value

It returns a local z-score object

See Also

`overlapPermTest`, `permTest`

Examples

```r
genome <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=10000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=10000, length.sd=20000, genome=genome, non.overlapping=FALSE))
pt <- overlapPermTest(A=A, B=B, ntimes=10, genome=genome, non.overlapping=FALSE)
plot(pt)
lz <- localZScore(A=A, B=B, pt=pt)
plot(lz)

pt2 <- permTest(A=A, B=B, ntimes=10, randomize.function=randomizeRegions, evaluate.function=list(overlap=numOverlaps, distance=meanDistance), genome=genome, non.overlapping=FALSE)
plot(pt2)
lz2 <- localZScore(A=A, B=B, pt2)
plot(lz2)
```
**maskFromBSGenome**

**Description**

Extracts the merge of all the active masks from a BSgenome

**Usage**

```r
maskFromBSGenome(bsgenome)
```

**Arguments**

- `bsgenome` a BSgenome object

**Value**

A GRanges object with the active mask in the BSgenome

**Note**

This function is memoised (cached) using the memoise package. To empty the cache, use `forget(maskFromBSGenome)`

**See Also**

`getGenomeAndMask`, `characterToBSGenome`, `emptyCacheRegionR`

**Examples**

```r
g <- characterToBSGenome("hg19")
maskFromBSGenome(g)
```

---

**meanDistance**

**Mean Distance**

**Description**

Computes the mean distance of regions in A to the nearest element in B

**Usage**

```r
meanDistance(A, B, ...)
```

**Arguments**

- `A` a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- `B` a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- `...` any additional parameter needed
Value

The mean of the distances of each region in A to the nearest region in B.

Note

If a region in A is in a chromosome where no B region is, it will be ignored and removed from the mean computation.

Examples

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
B <- data.frame("chr1", 25, 35)
meanDistance(A, B)
```

### meanInRegions

**Mean In Regions**

**Description**

Returns the mean of a value defined by a region set over another set of regions.

**Usage**

```r
meanInRegions(A, x, col.name=NULL, ...)
```

**Arguments**

- **A**
  a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- **x**
  a region set in any of the accepted formats with an additional column with a value associated to every region. Regions in x can be points (single base regions).
- **col.name**
  character indicating the name of the column. If NULL and if a column with the name "value" exist, it will be used. The 4th column will be used otherwise (or the 5th if 4th is the strand).
- **...**
  any additional parameter needed

**Value**

It returns a numeric value that is the weighted mean of "value" defined in x over the regions in A. That is, the mean of the value of all regions in x overlapping each region in A weighted according to the number of bases overlapping.

**See Also**

- `permTest`
Examples

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
positions <- sample(1:40, 30)
x <- data.frame("chr1", positions, positions, rnorm(30, 4, 1))
meanInRegions(A, x)
x <- GRanges(seqnames=x[,1], ranges=IRanges(x[,2], end=x[,2]), mcols=x[,3])
meanInRegions(A, x)
```

---

mergeRegions Merge Regions

Description

Merges the overlapping regions from two region sets. The two region sets are first merged into one and then overlapping regions are fused.

Usage

```r
mergeRegions(A, B)
```

Arguments

- **A** a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- **B** a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)

Value

It returns a GenomicRanges object with the regions resulting from the merging process. Any two overlapping regions from any of the two sets will be fused into one.

Note

All metadata (additional columns in the region set in addition to chromosome, start and end) will be ignored and not present in the returned region set.

The implementation relies completely in the `reduce` function from IRanges package.

See Also

`plotRegions`, `toDataframe`, `toGRanges`, `subtractRegions`, `splitRegions`, `extendRegions`, `joinRegions`, `commonRegions`, `overlapRegions`
Examples

```r
A <- data.frame("chr1", c(1, 5, 20, 30), c(8, 13, 28, 40), x=c(1,2,3,4), y=c("a", "b", "c", "d"))
B <- data.frame("chr1", 25, 35)
merges <- mergeRegions(A, B)
plotRegions(list(A, B, merges), chromosome="chr1", regions.labels=c("A", "B", "merges"), regions.colors=3:1)
```

---

### numOverlaps

**Number Of Overlaps**

<table>
<thead>
<tr>
<th>numOverlaps</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returns the number of regions in A overlapping any region in B</td>
<td></td>
</tr>
</tbody>
</table>

#### Usage

```r
numOverlaps(A, B, count.once=FALSE, ...)
```

#### Arguments

- **A**
  - a region set in any of the formats accepted by `toGRanges` *(GenomicRanges, data.frame, etc...)*
- **B**
  - a region set in any of the formats accepted by `toGRanges` *(GenomicRanges, data.frame, etc...)*
- **count.once**
  - boolean indicating whether the overlap of multiple B regions with a single A region should be counted once or multiple times
- **...**
  - any additional parameters needed

#### Value

It returns a numeric value that is the number of regions in A overlapping at least one region in B.

#### See Also

- `overlapPermTest`, `permTest`

#### Examples

```r
genoem <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=1000000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=10000, length.sd=20000, genome=genome, non.overlapping=FALSE))
numOverlaps(A, B)
numOverlaps(A, B, count.once=TRUE)
```
overlapGraphicalSummary

**Overlap Graphical Summary**

Description

Graphical summary of the overlap between two set of regions.

Usage

```r
overlapGraphicalSummary(A, B, regions.labels=c("A","B"), regions.colors=c("black","forestgreen"), ...)
```

Arguments

- **A**
  - A region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- **B**
  - A region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- **regions.labels**
  - vector indicating the labels for the y axes.
- **regions.colors**
  - character vector indicating the colors for the regions.
- **...**
  - Arguments to be passed to methods, such as graphical parameters (see `par`).

@return A plot is created on the current graphics device.

See Also

- `overlapPermTest`, `overlapRegions`

Examples

```r
A <- data.frame(chr=1, start=c(1,15,24,40,50), end=c(10,20,30,45,55))
B <- data.frame(chr=1, start=c(2,12,28,35), end=c(5,25,33,43))
overlapGraphicalSummary(A, B, regions.labels=c("A","B"), regions.colors=c(4,5,6))
```

overlapPermTest

**Permutation Test for Overlap**

Description

Performs a permutation test to see if there is an association in overlap between a region set A and a region set B creating random regions through the genome.

Usage

```r
overlapPermTest (A, B, alternative="auto", ...)
```
Arguments

A  a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

B  a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

alternative  the alternative hypothesis must be one of "greater", "less" or "auto". If "auto", the alternative will be decided depending on the data.

...  further arguments to be passed to or from methods.

Value

A list of class permTestResults containing the following components:

• pval the p-value of the test.
• ntimes the number of permutations.
• alternative a character string describing the alternative hypothesis.
• observed the value of the statistic for the original data set.
• permuted the values of the statistic for each permuted data set.
• zscore the value of the standard score. (observed-mean(permuted))/sd(permuted)

See Also

overlapGraphicalSummary, overlapRegions, toDataframe, toGRanges, permTest

Examples

genome <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=10000000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=10000, length.sd=20000, genome=genome, non.overlapping=FALSE))
pt <- overlapPermTest(A=A, B=B, ntimes=10, genome=genome, non.overlapping=FALSE, verbose=TRUE)
summary(pt)
plot(pt)
plot(pt, plotType="Tailed")
Arguments

A
a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

B
a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

colA
numeric vector indicating which columns of A the results will contain (default NULL)

colB
numeric vector indicating which columns of B the results will contain (default NULL)

type
• A in B: the region in A is contained in a region in B
• B in A: the region in B is contained in A
• within: the region in A or B is contained in a region in the other region set
• equal: the region in A has the same chromosome, start and end as a region in B
• A left B: the end of the region from A overlaps the beginning of a region in B
• A right B: the start of a region from A overlaps the end of a region in B
• any: any kind of overlap is returned

min.bases
numeric minimum number of bp accepted to define a overlap (default 1)

min.pctA
numeric minimum percentage of bases of A accepted to define a overlap (default NULL)

min.pctB
numeric minimum percentage of bases of B accepted to define a overlap (default NULL)

get.pctA
boolean if TRUE add a column in the results indicating the number percentage of A are involved in the overlap (default FALSE)

get.pctB
boolean if TRUE add a column in the results indicating the number percentage of B are involved in the overlap (default FALSE)

get.bases
boolean if TRUE add in the results the number of overlapped bases (default FALSE)

only.boolean
boolean if TRUE devolve as result a boolean vector containing the overlap state of each regions of A (default FALSE)

only.count
boolean if TRUE devolve as result the number of regions of A overlapping with B

... any additional parameter (are there any left?)

Value

the default results is a data.frame with at least 5 columns "chr" indicating the chromosome of the appartenence of each overlap, "startA", "endA", "startB", "endB", indicating the coordinates of the region A and B for each overlap "type" that describe the nature of the overlap (see arguments "type") eventually other columns can be added (see see arguments "colA", "colB", "get.pctA", "get.pctB", "get.bases")

Note

The implementation uses when possible the countOverlaps function from IRanges package.
permTest

See Also
plotRegions, toDataframe, toGRanges, subtractRegions, splitRegions, extendRegions, commonRegions, mergeRegions, joinRegions

Examples
A <- data.frame("chr1", c(1, 5, 20, 30), c(8, 13, 28, 40), x=c(1,2,3,4), y=c("a", "b", "c", "d"))
B <- data.frame("chr1", 25, 35)
overlapRegions(A, B)

Description
Performs a permutation test to see if there is an association between a region set and some other feature using an evaluation function.

Usage
permTest(A, ntimes=100, randomize.function, evaluate.function, alternative="auto", min.parallel=1000, force.parallel=NULL, randomize.function.name=NULL, evaluate.function.name=NULL, verbose=FALSE, ...)

Arguments
A a region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)
ntimes number of permutations
randomize.function function to create random regions. It must return a set of regions.
evaluate.function function to search for association. It must return a numeric value.
alternative the alternative hypothesis must be one of "greater", "less" or "auto". If "auto", the alternative will be decided depending on the data.
min.parallel if force.parallel is not specified, this will be used to determine the threshold for parallel computation. If length(A) * ntimes > min.parallel, it will activate the parallel computation. Single threaded otherwise.
force.parallel logical indicating if the computation must be parallelized.
randomize.function.name character. If specified, the permTestResults object will have this name instead of the name of the randomization function used. Useful specially when using unnamed anonymous functions.
evaluate.function.name character. If specified, the permTestResults object will have this name instead of the name of the evaluation function used. Useful specially when using unnamed anonymous functions.
verbose

void Test

... a boolean. If verbose=TRUE it creates a progress bar to show the computation progress. When combined with parallel computation, it might have an impact in the total computation time.

further arguments to be passed to other methods.

Details

permTest performs a permutation test of the regions in RS to test the association with the feature evaluated with the evaluation function. The regions are randomized using the randomization function and the evaluation function is used to evaluate them. More information can be found in the vignette.

Value

A list of class permTestResults containing the following components:

• pval the p-value of the test.
• ntimes the number of permutations.
• alternative a character string describing the alternative hypothesis.
• observed the value of the statistic for the original data set.
• permuted the values of the statistic for each permuted data set.
• zscore the value of the standard score. (observed-mean(permuted))/sd(permuted)
• randomize.function the randomization function used.
• randomize.function.name the name of the randomization used.
• evaluate.function the evaluation function used.
• evaluate.function.name the name of the evaluation function used.

References


See Also

genome <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=1000000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=100000, length.sd=20000, genome=genome, non.overlapping=FALSE))
pt2 <- permTest(A=A, B=B, ntimes=10, alternative="auto", verbose=TRUE, genome=genome, evaluate.function=meanDistance, randomize.function=randomizeRegions, non.overlapping=FALSE)
summary(pt2)
plot(pt2)
plot(pt2, plotType="Tailed")
plot.localZScoreResults

Plot localZscore results

Description

Function for plotting the a localZScoreResults object.

Usage

## S3 method for class 'localZScoreResults'
plot(x, main = "", num.x.labels = 5, ...)

Arguments

x
an object of class localZScoreResults.

main
a character specifying the main title of the plot. Defaults to no title.

num.x.labels
a numeric specifying the number of ticks to label the x axis. The total number
will be 2*num.x.labels + 1. Defaults to 5.

... further arguments to be passed to or from methods.

Value

A plot is created on the current graphics device.

See Also

localZScore

Examples

genome <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=10000000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=100000, length.sd=20000, genome=genome, non.overlapping=FALSE))
pt <- overlapPermTest(A=A, B=B, ntimes=10, genome=genome, non.overlapping=FALSE)
lz <- localZScore(A=A, B=B, pt=pt)
plot(lz)
Function for plotting the results from a `permTestResults` object.

## Description
Function for plotting the results from a `permTestResults` object.

## Usage
```r
## S3 method for class 'permTestResults'
plot(x, pvalthres = 0.05, plotType = "Tailed",
     main = "", xlab = NULL, ylab = "", ...)
```

## Arguments
- `x`: an object of class `permTestResults`.
- `pvalthres`: p-value threshold for significance. Default is 0.05.
- `plotType`: the type of plot to display. This must be one of "Area" or "Tailed". Default is "Area".
- `main`: a character specifying the title of the plot. Defaults to "".
- `xlab`: a character specifying the label of the x axis. Defaults to NULL, which produces a plot with the evaluation function name as the x axis label.
- `ylab`: a character specifying the label of the y axis. Defaults to "".
- `...`: further arguments to be passed to or from methods.

## Value
A plot is created on the current graphics device.

## See Also
- `permTest`

## Examples
```r
geno <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=1000000, length.sd=20000, genome=geno, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=10000, length.sd=20000, genome=geno, non.overlapping=FALSE))
pt <- overlapPermTest(A=A, B=B, ntimes=10, genome=geno, non.overlapping=FALSE)
summary(pt)
plot(pt)
plot(pt, plotType="Tailed")

pt2 <- permTest(A=A, B=B, ntimes=10, alternative="auto", genome=geno, evaluate.function=meanDistance, randomize.function=randomizeRegions, non.overlapping=FALSE)
summary(pt2)
plot(pt2)
plot(pt2, plotType="Tailed")
```
Function for plotting the results from a `permTestResultsList` object when more than one evaluation function was used.

#### Description

Function for plotting the results from a `permTestResultsList` object when more than one evaluation function was used.

#### Usage

```r
## S3 method for class 'permTestResultsList'
plot(x, ncol = NA, pvalthres = 0.05,
    plotType = "Tailed", main = "", xlab = NULL, ylab = "", ...)
```

#### Arguments

- `x`: an object of class `permTestResultsList`.
- `ncol`: number of plots per row. `ncol=NA` means `ncol=floor(sqrt(length(x)))` so the plot is more or less square (default=NA).
- `pvalthres`: p-value threshold for significance. Default is 0.05.
- `plotType`: the type of plot to display. This must be one of "Area" or "Tailed". Default is "Area".
- `main`: a character specifying the title of the plot. Defaults to "".
- `xlab`: a character specifying the label of the x axis. Defaults to NULL, which produces a plot with the evaluation function name as the x axis label.
- `ylab`: a character specifying the label of the y axis. Defaults to "".
- `...`: further arguments to be passed to or from methods.

#### Value

A plot is created on the current graphics device.

#### See Also

- `permTest`

#### Examples

```r
gene <- filterChromosomes(getGenome("hg19"), keep.chr="chr1")
A <- createRandomRegions(nregions=20, length.mean=10000000, length.sd=20000, genome=genome, non.overlapping=FALSE)
B <- c(A, createRandomRegions(nregions=10, length.mean=10000, length.sd=20000, genome=genome, non.overlapping=FALSE))
pt <- overlapPermTest(A=A, B=B, ntimes=10, genome=genome, non.overlapping=FALSE)
summary(pt)
plot(pt)
plot(pt, plotType="Tailed")
```
plotRegions

```
pt2 <- permTest(A=A, B=B, ntimes=10, alternative="auto", genome=genome, evaluate.function=list(distance=meanDistance, numberOfOverlaps=numOverlaps), randomize.function=randomizeRegions, non.overlapping=FALSE)
summary(pt2)
plot(pt2)
plot(pt2, plotType="Tailed")
```

### Description

Plots sets of regions

### Usage

```
plotRegions(x, chromosome, start=NULL, end=NULL, regions.labels=NULL, regions.colors=NULL, ...)
```

### Arguments

- `x`: list of objects to be plotted.
- `chromosome`: character or numeric value indicating which chromosome you want to plot.
- `start`: numeric value indicating from which position you want to plot.
- `end`: numeric value indicating to which position you want to plot.
- `regions.labels`: vector indicating the labels for the y axes. It must have the same length as `x`.
- `regions.colors`: character vector indicating the colors for the plotted regions. It must have the same length as `x`.
- `...`: Arguments to be passed to methods, such as graphical parameters (see `par`).

### Value

A plot is created on the current graphics device.

### Examples

```r
A <- data.frame(chr=1, start=c(1,15,24,40,50), end=c(10,20,30,45,55))
B <- data.frame(chr=1, start=c(2,12,28,35), end=c(5,25,33,43))
plotRegions(list(A,B), chromosome=1, regions.labels=c("A","B"), regions.colors=c(3:2))
```
randomizeRegions

Description

Given a set of regions A and a genome, this function returns a new set of regions randomly distributed in the genome.

Usage

randomizeRegions(A, genome="hg19", mask=NULL, allow.overlaps=TRUE, per.chromosome=FALSE, ...)

Arguments

A The set of regions to randomize. A region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, etc...)

genome The reference genome to use. A valid genome object. Either a GenomicRanges or data.frame containing one region per whole chromosome or a character uniquely identifying a genome in BSgenome (e.g. "hg19", "mm10",... but not "hg"). Internally it uses getGenomeAndMask.

mask The set of regions specifying where a random region can not be (centromeres, repetitive regions, unmappable regions...). A region set in any of the accepted formats by toGRanges (GenomicRanges, data.frame, ...). If NULL it will try to derive a mask from the genome (currently only works if the genome is a character string). If NA it gives, explicitly, an empty mask.

allow.overlaps A boolean stating whether the random regions can overlap (FALSE) or not (TRUE).

per.chromosome Boolean. If TRUE, the regions will be created in a per chromosome manner - every region in A will be moved into a random position at the same chromosome where it was originally.

... further arguments to be passed to or from methods.

Details

The new set of regions will be created with the same sizes of the original ones, and optionally placed in the same chromosomes.

In addition, they can be made explicitly non overlapping and a mask can be provided so no regions fall in an undesirable part of the genome.

Value

It returns a GenomicRanges object with the regions resulting from the randomization process.

See Also
toDataframe, toGRanges, getGenome, getMask, getGenomeAndMask, characterToBSGenome, maskFromBSGenome, resampleRegions, createRandomRegions, circularRandomizeRegions
Examples

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
mask <- data.frame("chr1", c(20000000, 100000000), c(22000000, 130000000))
geno <- data.frame("chr1", c(1, 10), c(18000000, 20000000))
randomizeRegions(A)
randomizeRegions(A, genome=geno, mask=mask, per.chromosome=TRUE, allow.overlaps=FALSE)
```

---

**recomputePermTest**  
**Recompute Permutation Test**

Description

Recomputes the permutation test changing the alternative hypothesis

Usage

```r
recomputePermTest(ptr)
```

Arguments

- **ptr**: an object of class permTestResults

Value

A list of class permTestResults containing the same components as permTest results.

See Also

- permTest

Examples

```r
A <- createRandomRegions(nregions=10, length.mean=1000000)
B <- createRandomRegions(nregions=10, length.mean=1000000)
resPerm <- permTest(A=A, B=B, ntimes=5, alternative="less", genome="hg19", evaluate.function=meanDistance, randomize.function=randomizeRegions)
plot(resPerm)
```
resampleRegions  

Resample Regions

Description
Function for sampling a region set from a universe of region sets.

Usage
resampleRegions(A, universe, per.chromosome=FALSE, ...)

Arguments
- **A**: a region set in any of the formats accepted by `toGRanges` (GenomicRanges, data.frame, etc...)
- **universe**: a region set in any of the formats accepted by `toGRanges` (GenomicRanges, data.frame, etc...)
- **per.chromosome**: boolean indicating if sample must be by chromosome.
- **...**: further arguments to be passed to or from methods.

Value
a GenomicRanges object. A sample from the universe with the same length as A.

See Also
toDataframe, toGRanges, randomizeRegions, createRandomRegions

Examples
universe <- data.frame(chr=1, start=c(1,15,24,40,50), end=c(10,20,30,45,55))
A <- data.frame(chr=1, start=c(2,12,28,35), end=c(5,25,33,43))
resampleRegions(A, universe, per.chromosome=TRUE)

splitRegions  

Split Regions

Description
Splits a region set A by both ends of the regions in a second region set B.

Usage
splitRegions(A, B, min.size=1, track.original=TRUE)
Arguments

A  a region set in any of the formats accepted by `toGRanges` (GenomicRanges, data.frame, etc...)
B  a region set in any of the formats accepted by `toGRanges` (GenomicRanges, data.frame, etc...)

min.size numeric value, minimal size of the new regions
track.original logical indicating if you want to keep the original regions and additional information in the output

Value

A GRanges with the splitted regions.

See Also

`toDataframe`, `toGRanges`, `subtractRegions`, `commonRegions`, `extendRegions`, `joinRegions`, `mergeRegions`, `overlapRegions`

Examples

```r
A <- data.frame(chr=1, start=c(1, 15, 24, 40, 50), end=c(10, 20, 30, 45, 55))
B <- data.frame(chr=1, start=c(2, 12, 28, 35), end=c(5, 25, 33, 43))
splits <- splitRegions(A, B)
pplotRegions(list(A, B, splits), chromosome=1, regions.labels=c("A", "B", "splits"), regions.colors=3:1)
```

---

**Description**

Function for subtracting a region set from another region set.

**Usage**

`subtractRegions(A, B)`

**Arguments**

A  a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
B  a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)

**Details**

This function returns the regions in A minus the parts of them overlapping the regions in B. Overlapping regions in the result will be fused.

The implementation relies completely in the `setdiff` function from IRanges package.
toDataframe

Value

A GenomicRanges object

Examples

A <- data.frame(chr=1, start=c(1, 15, 24, 31), end=c(10, 20, 30, 35))
B <- data.frame(chr=1, start=c(2, 12, 24, 35), end=c(5, 25, 29, 40))
subtract <- subtractRegions(A, B)
plotRegions(list(A, B, subtract), chromosome=1, regions.labels=c("A", "B", "subtract"), regions.colors=3:1)

Description

Transforms a GRanges object or a data.frame containing a region set into a data.frame.

Usage

toDataframe(A, stranded=FALSE)

Arguments

A a GRanges object.
stranded (only used when A is a GRanges object) a logical indicating whether a column with the strand information have to be added to the result (Defaults to FALSE)

Details

If the object is of class data.frame, it will be returned untouched.

Value

A data.frame with the regions in A. If A was a GRanges object, the output will include any metadata present in A.

See Also
toGRanges

Examples

A <- data.frame(chr=1, start=c(1, 15, 24), end=c(10, 20, 30), x=c(1, 2, 3), y=c("a", "b", "c"))
A2 <- toGRanges(A)
toDataframe(A2)
Description

Transforms a file or an object containing a region set into a GRanges object.

Usage

toGRanges(A, ...)

Arguments

A a data.frame containing a region set, a GRanges object, a BED file or any type of file supported by rtracklayer

... further arguments to be passed to other methods.

Details

If A is already a GRanges object, it will be returned untouched.

If A is a file name or connection to a file in any of the formats supported by rtracklayer’s import function (BED, GFF...) it will be imported using rtracklayer.

If A is a data frame, the function will assume the first three columns are chromosome, start and end and create a GRanges object. Any additional column will be considered metadata and stored as such in the GRanges object.

Value

A GRanges object with the regions in A

See Also

toDataframe

Examples

A <- data.frame(chr=1, start=c(1, 15, 24), end=c(10, 20, 30), x=c(1,2,3), y=c("a", "b", "c"))

toGRanges(A)
### uniqueRegions

<table>
<thead>
<tr>
<th>uniqueRegions</th>
<th>Unique Regions</th>
</tr>
</thead>
</table>

**Description**

Returns the regions unique to only one of the two region sets, that is, all parts of the genome covered by only one of the two region sets.

**Usage**

`uniqueRegions(A, B)`

**Arguments**

- **A**: a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)
- **B**: a region set in any of the accepted formats by `toGRanges` (GenomicRanges, data.frame, etc...)

**Value**

It returns a GenomicRanges object with the regions unique to one of the region sets.

**Note**

All metadata (additional columns in the region set in addition to chromosome, start and end) will be ignored and not present in the returned region set.

**See Also**

`toGRanges`, `subtractRegions`, `commonRegions`, `mergeRegions`

**Examples**

```r
A <- data.frame("chr1", c(1, 10, 20, 30), c(12, 13, 28, 40))
B <- data.frame("chr1", 25, 35)
uniques <- uniqueRegions(A, B)
plotRegions(list(A, B, uniques), chromosome="chr1", regions.labels=c("A", "B", "uniques"), regions.colors=3:1)
```
## Index

BSgenome, 2, 3, 6, 9, 11, 12, 16, 29  
countOverlaps, 22  
circularRandomizeRegions, 3, 29  
commonRegions, 4, 8, 13, 18, 23, 32, 35  
createFunctionsList, 5  
createRandomRegions, 4, 6, 29, 31  
data.frame, 3, 4, 6, 8, 9, 11, 13, 15–23, 29, 31–35  
emptyCacheRegioneR, 7, 11–13, 16  
extendRegions, 4, 8, 13, 18, 23, 32  
filterChromosomes, 9, 10, 14  
forget, 11–13, 16  
GenomicRanges, 3, 4, 6–9, 13, 15–23, 29, 31, 32, 35  
getChromosomesByOrganism, 9, 10, 14  
getGenome, 4, 7, 10, 12, 13, 29  
getGenomeAndMask, 3, 4, 6, 7, 9, 11, 13, 16, 29  
getMask, 4, 7, 11, 12, 12, 29  
GRanges, 9, 11, 12, 16, 33, 34  
joinRegions, 4, 8, 13, 18, 23, 32  
listChrTypes, 9, 14  
localZScore, 15, 25  
maskFromBSGenome, 3, 4, 7, 11–13, 16, 29  
mean, 21, 24  
meanDistance, 16  
memoise, 11–13, 16  
mergeRegions, 4, 8, 13, 18, 23, 32, 35  
NA, 3, 6, 12, 29  
NULL, 3, 6, 12, 29  
numOverlaps, 19  
overlapGraphicalSummary, 20, 21  
overlapRegions, 4, 8, 13, 18, 20, 21, 21, 32  
par, 20, 28  
permTest, 5, 15, 17, 19, 21, 23, 26, 27, 30  
plot.localZScoreResults, 25  
plot.permTestResults, 26  
plot.permTestResultsList, 27  
plotRegions, 4, 8, 13, 18, 23, 28  
randomizeRegions, 4, 7, 29, 31  
recomputePermTest, 30  
reduce, 13, 18  
resampleRegions, 4, 7, 29, 31  
sd, 21, 24  
splitRegions, 4, 8, 13, 18, 23, 31  
subtractRegions, 4, 8, 13, 18, 23, 32, 32, 35  
toDataframe, 4, 8, 13, 18, 21, 23, 29, 31, 32, 33, 34  
toGRanges, 3, 4, 8, 9, 11, 13, 15–23, 29, 31–33, 34, 35  
uniqueRegions, 35