Package ‘REDseq’

May 3, 2024

Type Package

Title Analysis of high-throughput sequencing data processed by restriction enzyme digestion

Version 1.50.0

Date 2021-05-02

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Depends R (>= 3.5.0), BiocGenerics, BSgenome.Celegans.UCSC.ce2, multtest, Biostrings, BSgenome, ChIPpeakAnno

Imports AnnotationDbi, graphics, IRanges (>= 1.13.5), stats, utils

biocViews Sequencing, SequenceMatching, Preprocessing

Description The package includes functions to build restriction enzyme cut site (RECS) map, distribute mapped sequences on the map with five different approaches, find enriched/depleted RECSs for a sample, and identify differentially enriched/depleted RECSs between samples.

License GPL (>=2)

git_url https://git.bioconductor.org/packages/REDseq
git_branch RELEASE_3_19
git_last_commit 22e9124
git_last_commit_date 2024-04-30

Repository Bioconductor 3.19

Date/Publication 2024-05-02

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REDSeq is a Bioconductor package for building genomic map of restriction enzyme sites REmap, assigning sequencing tags to RE sites using five different strategies, visualizing genome-wide distribution of differentially cut regions with the REmap as reference and the distance distribution of sequence tags to corresponding RE sites, generating count table for identifying statistically significant RE sites using edgeR or DEseq.

Details

Package: REDseq
Type: Package
Version: 1.0
Date: 2011-05-10
License: GPL
LazyLoad: yes

-- An overview of how to use the package, including the most important functions --

Author(s)

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References


See Also
buildREmap, assignSeq2REsite, plotCutDistribution, distanceHistSeq2RE, summarizeByRE, summarizeBySeq, compareREseq, binom.test.REDseq

Examples

if(interactive()){
  library(ChIPpeakAnno)
  REpatternFilePath = system.file("extdata", "examplePattern.fa", package="REDseq")
  library(BSgenome.Celegans.UCSC.ce2)
  buildREmap( REpatternFilePath, BSgenomeName=Celegans, outfile=tempfile())
  library(REDseq)
  data(example.REDseq)
  data(example.map)
  r.unique = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1,
    seq.length = 36, allowed.offset = 5, min.FragmentLength = 60,
    max.FragmentLength = 300, partitionMultipleRE = "unique")
  r.average = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1,
    seq.length = 36, allowed.offset = 5, min.FragmentLength = 60,
    max.FragmentLength = 300, partitionMultipleRE = "average")
  r.random = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1,
    seq.length = 36, allowed.offset = 5, min.FragmentLength = 60,
    max.FragmentLength = 300, partitionMultipleRE = "random")
  r.best = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1,
    seq.length = 36, allowed.offset = 5, min.FragmentLength = 60,
    max.FragmentLength = 300, partitionMultipleRE = "best")
  r.estimate = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1,
    seq.length = 36, allowed.offset = 5, min.FragmentLength = 60,
    max.FragmentLength = 300, partitionMultipleRE = "estimate")
  r.estimate$passed.filter
  r.estimate$notpassed.filter
  data(example.assignedREDseq)
  plotCutDistribution(example.assignedREDseq,example.map,
    chr="2", xlim =c(3012000, 3020000))
  distanceHistSeq2RE(example.assignedREDseq,ylim=c(0,20))
  summarizeByRE(example.assignedREDseq,by="Weight",sampleName="example")
  REsummary =summarizeByRE(example.assignedREDseq,by="Weight")
  binom.test.REDseq(REsummary)
}
**assignSeq2REsite**

Assign mapped sequence tags to corresponding restriction enzyme (RE) cut sites

**Description**

Given the sequence tags aligned to a genome as a GRanges, and a map built using the buildREmap function, assignSeq2REsite first identifies RE sites that have mapped sequence tags around the cut position taking consideration of user-defined offset, sequence length and strand in the aligned sequences. These RE sites are used as seeds for assigning the remaining tags depending on which of five strategies the users select for partitioning sequences associated with multiple RE sites, i.e., unique, average, estimate, best and random. Please note that the default setting is for single-end sequencing data. For paired-end sequencing data, please create inputS.RD and inputE.RD from input.RD first with start(input.RD) and end(input.RD), where inputS.RD contains the start of the input.RD and inputE.RD contains the end of the input.RD. Then call assignSeq2REsite twice with inputS.RD and inputE.RD respectively. Please set min.FragmentLength = 0, max.FragmentLength = 1, seq.length = 1 with both calls.

**Usage**

```r
assignSeq2REsite(input.RD, REmap.RD, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = c("unique", "average", "estimate", "best", "random"))
```

**Arguments**

- **input.RD**: GRanges as mapped sequences: see example below
- **REmap.RD**: GRanges as restriction enzyme (RE) cut site map: see example below
- **cut.offset**: The cut offset from the start of the RE recognition sequence: index is 0 based, i.e., 1 means the RE cuts at position 2.
- **seq.length**: Sequence length: 36 means that the sequence tags are 36-base long.
- **allowed.offset**: Offset allowed to count for imperfect sticky end repair and primer addition.
- **min.FragmentLength**: Minimum fragment length of the sequences size-selected for sequencing
- **max.FragmentLength**: Maximum fragment length of the sequences size-selected for sequencing
- **partitionMultipleRE**: The strategy for partitioning sequences associated with multiple RE sites. For strategy unique, only sequence tags that are associated with a unique RE site within the distance between min.FragmentLength and max.FragmentLength are kept for downstream analysis. For strategy average, sequence tags are partitioned equally among associated RE sites. For strategy estimate, sequence tags are partitioned among associated RE sites with a weight function, which is determined using the count distribution of the RE seed sites described in the description section above. For strategy best, sequence tags are assigned to the most
probable RE sites with the same weight function as that in strategy estimate. For strategy random, the sequence tags are randomly assigned to one of the multiple associated RE sites.

**Value**

- `passed.filter`: Sequences assigned to RE(s), see the example `r.unique$passed.filter`
- `notpassed.filter`: Sequences not assigned to any RE, see example `r.unique$notpassed.filter`
- `mREwithDetail`: Detailed assignment information for sequences associated with multiple RE sites. Only available when `partitionMultipleRE` is set to average or estimate, see `r.estimate$mREwithDetail` in the examples

**Author(s)**

Lihua Julie Zhu

**References**


**See Also**

- `buildREMap`, `example.REDseq`, `example.map`, `example.assignedREDseq`

**Examples**

```r
library(REDseq)
data(example.REDseq)
data(example.map)
r.unique = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = "unique")
r.average = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = "average")
r.random = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = "random")
r.best = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = "best")
r.estimate = assignSeq2REsite(example.REDseq, example.map, cut.offset = 1, seq.length = 36, allowed.offset = 5, min.FragmentLength = 60, max.FragmentLength = 300, partitionMultipleRE = "estimate")
```
binom.test.REDseq

Description

For any early stage experiment with one experimental condition and one biological replicate, binom.test.REDseq computes p-value for each RE site in the genome.

Usage

binom.test.REDseq(REsummary, col.count = 2, multiAdj = TRUE, multiAdjMethod = "BH", prior.p = 0.000001)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>REsummary</td>
<td>A matrix returned from summarizeByRE with a RE id column, a count/weight column. See examples</td>
</tr>
<tr>
<td>col.count</td>
<td>The column where the total count/weight is</td>
</tr>
<tr>
<td>multiAdj</td>
<td>Whether apply multiple hypothesis testing adjustment, TRUE or FALSE</td>
</tr>
<tr>
<td>multiAdjMethod</td>
<td>Multiple testing procedures, for details, see mt.rawp2adjp in multtest package</td>
</tr>
<tr>
<td>prior.p</td>
<td>It is the probability of assigning a mapped sequence tag to a given RE site. Assuming each RE site gets cut equally, then the prior.p = 1/number of total RE sites in the genome.</td>
</tr>
</tbody>
</table>

Value

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>p.value</td>
<td>p-value of the test</td>
</tr>
<tr>
<td>*.count</td>
<td>weight/count from the input REsummary</td>
</tr>
<tr>
<td>REid</td>
<td>the id of the restriction enzyme from the input REsummary</td>
</tr>
<tr>
<td>cut.frequency</td>
<td>cut frequency</td>
</tr>
<tr>
<td>*.adjusted.p.value</td>
<td>applicable if multiAdj=TRUE, adjusted p.value using * method specified in multiAdjMethod</td>
</tr>
</tbody>
</table>

Author(s)

Lihua Julie Zhu

See Also

compareREDseq
buildREmap

Examples

```r
library(REDseq)
REsummary = cbind(c("RE1", "RE2", "RE3"), c(10, 1, 100))
colnames(REsummary) = c("REid", "control")
binom.test.REDseq(REsummary)
```

---

**buildREmap**  
*Build a genome wide cut site map for a Restriction Enzyme (RE)*

**Description**

Build a genome-wide cut map for a Restriction Enzyme (RE)

**Usage**

```r
buildREmap(REpatternFilePath, format = "fasta", BSgenomeName, outfile)
```

**Arguments**

- `REpatternFilePath`  
  File path storing the recognition pattern of a RE

- `format`  
  format of the pattern file, either "fasta" (the default) or "fastq"

- `BSgenomeName`  
  BSgenome object, please refer to available.genomes in BSgenome package for details

- `outfile`  
  temporary output file for writing the matched chromosome location to

**Value**

Output REmap as a GRanges

**Author(s)**

Lihua Julie Zhu

**Examples**

```r
library(REDseq)
REpatternFilePath = system.file("extdata", "examplePattern.fa", package="REDseq")
library(BSgenome.Celegans.UCSC.ce2)
buildREmap(REpatternFilePath, BSgenomeName=celegans, outfile=tempfile())
```
compareREDseq  

**Compare two RED Sequencing Dataset**

**Description**

For early stage experiment without replicates, compareREDseq outputs differentially cut RE sites between two experimental conditions using Fisher’s Exact Test.

**Usage**

```r
compareREDseq(REsummary, col.count1 = 2, col.count2 = 3, multiAdj = TRUE, multiAdjMethod = "BH", maxP = 1, minCount = 1)
```

**Arguments**

- `REsummary`: A matrix with a RE id column, 2 count/weight column, see examples
- `col.count1`: The column where the total count/weight for the 1st experimental condition is
- `col.count2`: The column where the total count/weight for the 2nd experimental condition is
- `multiAdj`: Whether apply multiple hypothesis testing adjustment, TRUE or FALSE
- `multiAdjMethod`: Multiple testing procedures, for details, see `mt.rawp2adjp` in `multtest` package
- `maxP`: The maximum p-value to be considered to be significant
- `minCount`: For a RE site to be included, the tag count from at least one of the experimental conditions >= minimumCount

**Value**

- `p.value`: the p-value of the test
- `*.count`: weight/ count from the input column `col.count1` and `col.count2`
- `*.total`: total weight/ count from input column `col.count1` and `col.count2`
- `REid`: the id of the restriction enzyme from the input
- `odds.ratio`: an estimate of the odds ratio for 2nd experimental condition vs. 1st experimental condition
- `*.adjusted.p.value`: applicable if `multiAdj=TRUE`, adjusted p.value using the method * specified in `multiAdjMethod`

**Author(s)**

Lihua Julie Zhu

**See Also**

`binom.test.REDseq`
Examples

```r
library(REDseq)
x = cbind(c("RE1", "RE2", "RE3", "RE4"), c(10, 1, 100, 0), c(5, 5, 50, 40))
colnames(x) = c("REid", "control", "treated")
compareREDseq(x)
```

distanceHistSeq2RE  Plot the distance distribution from sequence to the associated RE sites

Description

Give an overview of the distance distribution from all assigned sequences to the associated RE sites. If average or estimate is used for assigning sequences to RE sites, the count for histogram drawing will be adjusted with the weight assigned.

Usage

```r
distanceHistSeq2RE(assignedSeqs, longestDist = 1000,
title = "histogram of distance to assigned RE site",
xlab = "Distance to assigned RE site", ylab = "Frequency", ylim="")
```

Arguments

- `assignedSeqs`: result returned from `assignSeq2REsite`
- `longestDist`: longest distance to keep in the plot
- `title`: an overall title for the plot
- `xlab`: a title for the x axis
- `ylab`: a title for the y axis
- `ylim`: range of y to be plotted

Author(s)

Lihua Julie Zhu

See Also

`assignSeq2REsite, distanceHistSeq2RE`

Examples

```r
library(REDseq)
data(example.assignedREDseq)
distanceHistSeq2RE(example.assignedREDseq, ylim=c(0,20))
```
example.assignedREDseq

an example assigned REDseq dataset

Description

an example assigned REDseq dataset generated from assignSeq2REsite

Usage

data(example.assignedREDseq)

Format

The format is: List of 3
$ passed.filter :'data.frame': Sequences that passed the filters:
  ..$ SEQid :Sequence ID
  ..$ REid : Restriction Enzyme Site ID
  ..$ Chr : Chromosome
  ..$ strand : Strand
  ..$ SEQstart: Sequence Start
  ..$ SEQend : Sequence End
  ..$ REstart : Restriction Enzyme Site Start
  ..$ REend : Restriction Enzyme Site End
  ..$ Distance: Distance from SEQstart to REstart
  ..$ Weight : Weighted count for this REid and this SEQid
$ notpassed.filter:'data.frame' : Sequences that did not pass the filters
  ..$ SEQid :Sequence ID
  ..$ REid : Restriction Enzyme Site ID
  ..$ Chr : Chromosome
  ..$ strand : Strand
  ..$ SEQstart: Sequence Start
  ..$ SEQend : Sequence End
  ..$ REstart : Restriction Enzyme Site Start
  ..$ REend : Restriction Enzyme Site End
  ..$ Distance: Distance from SEQstart to REstart
  ..$ Weight : Weighted count for this REid and this SEQid
$ mREwithDetail :'data.frame': Detailed information about the sequences that are associated with multiple REid - for debugging:
  ..$ SEQid :Sequence ID
  ..$ REid : Restriction Enzyme Site ID
  ..$ Chr : Chromosome
  ..$ strand : Strand
  ..$ SEQstart: Sequence Start
  ..$ SEQend : Sequence End
  ..$ REstart : Restriction Enzyme Site Start
  ..$ REend : Restriction Enzyme Site End
example.map

..$ Distance: Distance from SEQstart to REstart
..$ Weight: Weighted count for this REid and this SEQid
..$ count: count of seed for this REid and SEQid
..$ total.count: total number of seeds that are associated with this SEQid

Examples

library(REDseq)
data(example.assignedREDseq)
## maybe str(example.assignedREDseq) ; plot(example.assignedREDseq) ...

---

example.map  an example REmap dataset

Description

an example REmap dataset as GRanges generated from buildREmap

Usage

data(example.map)

Format

The format is: Formal class 'GRanges' [package "GenomicRanges"]

Examples

library(REDseq)
data(example.map)
## maybe str(example.map) ; plot(example.map) ...

---

data example.REDseq   an example sequencing dataset from a restoration enzyme digestion (RED) experiment

Description

an example RED sequencing dataset as a GRanges

Usage

data(example.REDseq)
Format

The format is: Formal class 'GRanges' [package "GenomicRanges"]

Examples

library(REDseq)
data(example.REDseq)
## maybe str(example.REDseq) ; plot(example.REDseq) ...

plotCutDistribution plot cut frequencies of RE sites along a given chromosome

Description

plot cut frequencies of RE sites along a chromosome, which gives a bird-eye view of genome-wide frequent-cut regions and RE inaccessible regions.

Usage

plotCutDistribution(assignedSeqs,REmap, chr="chr1",xlim,
title="RE cut frequency distribution",
xlab="Chromosome Location (bp)",ylab="Frequency",
round=TRUE, n.sequence)

Arguments

assignedSeqs result returned from assignSeq2REsite
REmap REmap used in assignSeq2REsite and generated from buildREmap
chr chromosome to be plotted
xlim range of x to be plotted
title an overall title for the plot
xlab a title for the x axis
ylab a title for the y axis
round TRUE: the sum of the weight is rounded up if the fraction part is greater than 0.5. FALSE: as it is.
n.sequence total uniquely mapped sequences in the dataset for estimating the expected count for each RE site. If omitted, the expected count for each RE site will be set as 1 as default.

Author(s)

Lihua Julie Zhu

See Also

assignSeq2REsite, distanceHistSeq2RE
searchPattern

Examples

```r
library(REDseq)
data(example.assignedREDseq)
data(example.map)
plotCutDistribution(example.assignedREDseq, example.map,
chr="2", xlim =c(3012000, 3020000))
```

searchPattern  

search pattern(s) in a genome

Description

internal function for searching pattern(s) in a genome used by buildREmap leveraging BSgenome package

Usage

```r
searchPattern(dict0, BSgenomeName, outfile = "")
```

Arguments

- `dict0`: DNAStringSet object, see examples
- `BSgenomeName`: BSgenome object, please refer to available.genomes in BSgenome package for details
- `outfile`: The file path to write the search results as a bed file

Value

results are saved in the file specified by outfile

Author(s)

Lihua Julie Zhu

References

http://bioconductor.org/packages/2.8/bioc/vignettes/BSgenome/inst/doc/GenomeSearching.pdf

See Also

buildREmap

Examples

```r
library(REDseq)
patternFile = system.file("extdata", "examplePattern.fa", package="REDseq")
example.dict0 <- readDNAStringSet(patternFile, "fasta")
library(BSgenome.Celegans.UCSC.ce2)
REDseq:::searchPattern(dict0 = example.dict0, BSgenomeName=Celegans, outfile=tempfile())
```
summarizeByRE  

**Output count/weight summary by restriction enzyme cut site ID (REid)**

**Description**

Output count/weight summary by REid with each row representing each REid

**Usage**

```r
summarizeByRE(assignedSeqs, by=c("Weight", "REid"),sampleName="",round=TRUE)
```

**Arguments**

- **assignedSeqs**: output from assignSeq2REsite
- **by**: Weight if sum up the weight for each REid, REid if sum the occurrence of each REid.
- **sampleName**: The name of the sample used as the count column name.
- **round**: TRUE: the sum of the weight is rounded up if the fraction part is greater than 0.5. FALSE: as it is.

**Value**

a matrix with REid as the first column and total count/weight as the second column, that can be used for the downstream analysis with DEseq or edgeR.

**Author(s)**

Lihua Julie Zhu

**See Also**

summarizeBySeq, assignSeq2REsite

**Examples**

```r
library(REDseq)
data(example.assignedREDseq)
summarizeByRE(example.assignedREDseq,by="REid",sampleName="example")
summarizeByRE(example.assignedREDseq,by="Weight",sampleName="example")
```
summarizeBySeq  

**Output count/weight summary by sequences**

**Description**

Output count/weight summary by sequences with each row representing each sequences

**Usage**

```r
summarizeBySeq(assignedSeqs, by=c("Weight", "SEQid"))
```

**Arguments**

- `assignedSeqs`  
  output from assignSeq2REsite
- `by`  
  Weight if sum up the weight for each sequence, SEQid if sum the occurrence of each sequence

**Value**

a matrix with SEQid as the first column and total count/weight as the second column

**Author(s)**

Lihua Julie Zhu

**See Also**

summarizeByRE, assignSeq2REsite

**Examples**

```r
library(REDseq)
data(example.assignedREDseq)
summarizeBySeq(example.assignedREDseq, by="Weight")
summarizeBySeq(example.assignedREDseq, by="SEQid")
```

---

writeHits  

**write the hits of pattern search to a bed file**

**Description**

write the hits of pattern search to a bed file, internal function used by searchPattern

**Usage**

```r
writeHits(seqname, matches, strand, file = "", append = FALSE)
```
writeHits

Arguments

- seqname: Chromosome name
- matches: XStringViews object storing matched chromosome locations
- strand: strand of the match
- file: file path where the hits is written to
- append: TRUE if append to existing file, false if start a new file

Value

results are saved in the file specified by outfile

Author(s)

Lihua Julie Zhu

References

http://bioconductor.org/packages/2.8/bioc/vignettes/BSgenome/inst/doc/GenomeSearching.pdf

See Also

searchPattern, buildREmap

Examples

library(REDseq)
x <- DNAString("AAGCGCGATATG")
m <- matchPattern("GCGC", x)
REDseq::writeHits(seqname="chr1", m, strand="+", file="exampleWriteHits.bed", append=FALSE)
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