Package ‘methylscaper’
March 26, 2024

Type Package
Title Visualization of Methylation Data
Description methylscaper is an R package for processing and visualizing data jointly profiling methylation and chromatin accessibility (MAPit, NOme-seq, scNMT-seq, nanoNOme, etc.). The package supports both single-cell and single-molecule data, and a common interface for jointly visualizing both data types through the generation of ordered representational methylation-state matrices. The Shiny app allows for an interactive seriation process of refinement and re-weighting that optimally orders the cells or DNA molecules to discover methylation patterns and nucleosome positioning.

Version 1.10.0
Depends R (>= 4.1.0)
License GPL-2
Encoding UTF-8
Imports shiny, shinyjs, seriation, BiocParallel, seqinr, Biostrings, Rfast, grDevices, graphics, stats, utils, tools, methods, shinyFiles, data.table, SummarizedExperiment
RoxygenNote 7.2.3
Suggests BiocStyle, knitr, rmarkdown, devtools, R.utils
VignetteBuilder knitr
biocViews DNAMethylation, Epigenetics, Sequencing, Visualization, SingleCell, NucleosomePositioning
Maintainer Rhonda Bacher <rbacher@ufl.edu>
git_url https://git.bioconductor.org/packages/methylscaper
git_branch RELEASE_3_18
git_last_commit e2d8ace
git_last_commit_date 2023-10-24
Repository Bioconductor 3.18
Date/Publication 2024-03-25
Author Bacher Rhonda [aut, cre], Parker Knight [aut]
**R topics documented:**

- check_package ............................... 2
- forceReverse ................................ 3
- human_bm .................................... 3
- initialOrder .................................. 4
- methylscaper .................................. 5
- methyl_average_status ...................... 5
- methyl_percent_sites ....................... 6
- methyl_proportion ......................... 7
- mouse_bm ..................................... 7
- plotSequence .................................. 8
- prepSC ......................................... 9
- reads_sm ..................................... 10
- refineFunction ............................... 10
- reformatSCE .................................. 11
- ref_seq ...................................... 11
- runAlign ...................................... 12
- singlecell_subset ........................... 13
- singlemolecule_example .................... 13
- subsetSC ..................................... 14

**Index**

| check_package | Check if a package is installed |

**Description**

Check if a package is installed

**Usage**

```
check_package(package)
```

**Arguments**

- **package** Name of the package.

**Value**

Message is returned if package not installed.
forceReverse

Force reversal of a subset of the ordering

Description

This reverses a subset of the ordering, as determined by the user. By default, the entire ordering is reversed.

Usage

forceReverse(
  orderObject,
  reverseStart = 1,
  reverseEnd = length(orderObject$order1)
)

Arguments

orderObject An object of class orderObject, generated with the initialOrder function.
reverseStart The first index to be included in the reversal.
reverseEnd The last index to be included in the reversal.

Value

The new complete ordering, with the reversal applied.

Examples

data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
# reorder first 50 cells/molecules (rows)
orderObj$order1 <- refineFunction(orderObj, 1, 50)
orderObj$order1 <- forceReverse(orderObj, 1, 50)

human_bm

Human gene symbols and positions

Description

library(biomaRt) #v2.44.4 ensembl <- useMart("ensembl") # GRCh38 ensembl <- useDataset("hsapiens_gene_ensembl",mart=ensembl)
my_chr <- c(1:22, 'M', 'X', 'Y') human_bm <- getBM(attributes=c('chromosome_name', 'start_position', 'end_position', 'hgnc_symbol'), filters = 'chromosome_name', values = my_chr, mart=ensembl)
initialOrder

Usage

data(human_bm)

Format

An object of class data.frame with 60580 rows and 4 columns.

initialOrder Ordering the molecules/reads

Description

This function performs the weighted seriation procedure described in the methylscaper manuscript if the method is set to "PCA". The data may also be ordered using a given seriation method from the seriation R package. The weighting is done between a designated start and end base pair chosen by the user, and the weight can be done on the endogenous methylation or the accessibility.

Usage

initialOrder(
  dataIn,
  Method = "PCA",
  weightStart = NULL,
  weightEnd = NULL,
  weightFeature = "red",
  updateProgress = NULL
)

Arguments

dataIn A list object containing two elements labelled gch and hcg (already pre-processed.)
Method Indicates the seriation method to use. The default option is "PCA", which orders the data using a weighted first principal component approach. Any seriation method provided in the seriation package is also valid input.
weightStart Index of the first column used in the weighted seriation.
weightEnd Index of the last column used in the weighted seriation.
weightFeature Indicates whether to weight the GCH or HCG data. Valid input to weight the GCH is 'gch', 'acc', or 'yellow'. To weight the HCG, valid input for this option is 'hcg', 'met', or 'red'.
updateProgress A function to handle the progress bar for the Shiny app. Should not be used when using the function independently.

Value

An object of class orderObject, which contains the generated ordering ($order1) and a clean data matrix ($toClust) to be passed into the plotting function plotSequence().
methylscaper

**Examples**

```r
data(singlemolecule_example)
orderObj <- initialOrder(singlemolecule_example)
```

**Description**

Runs the methylscaper Shiny app.

**Usage**

`methylscaper()`

**Value**

This starts up the shiny app interface for methylscaper.

**Examples**

```r
# methylscaper()
```

---

**methyl_average_status** *Calculate the average methylation/accessibility status across all cells/molecules.*

**Description**

Calculate the average methylation/accessibility status across all cells/molecules.

**Usage**

`methyl_average_status(orderObject, window_length = 20, makePlot = TRUE, ...)`

**Arguments**

- `orderObject` An object of class `orderObject`
- `window_length` Length of the window to be used to compute a moving average. Default is 20.
- `makePlot` Logical, indicates whether to generate a line plot of average status.
- `...` Addition parameters used by the `plot` function.
methyl_percent_sites

Value
The proportion of methylated bases for each cell/molecule within a defined moving window. Output is a list with elements "meth_avg" and "acc_avg", indicating endogenous or accessible methylation respectively.

Examples
data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
methyl_average_status(orderObj, makePlot = TRUE)

methyl_percent_sites
Calculates the percentage of methylated cells/molecules per site

Description
Calculates the percentage of methylated cells/molecules per site

Usage
methyl_percent_sites(orderObject, makePlot = TRUE, ...)

Arguments
orderObject An object of class orderObject
makePlot Logical, indicates whether to generate the percentage plot
... Additional parameters used by the plot function.

Value
The percent of molecules or cells methylated (endogenous (yellow) or accessible) at each site. Output is a list with names "red" and "yellow". Red represents the endogenous methylation and yellow represents the accessibility. Within each list object is a vector of the percent of cells/molecules methylated. The location of the site is also represent in the form CXX, where XX is the position of the site within the defined region.

Examples
data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
methyl_percent_sites(orderObj, makePlot = TRUE)
methyl_proportion

Description

Calculate the proportion of methylated bases for each cell/molecule

Usage

methyl_proportion(orderObject, type = "yellow", makePlot = TRUE, ...)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>orderObject</td>
<td>An object of class orderObject</td>
</tr>
<tr>
<td>type</td>
<td>Indicates which data set to compute proportions for. This should be 'met' or 'hcg' or 'red' for endogenous methylation; 'acc' or 'gch' or 'yellow' for accessibility.</td>
</tr>
<tr>
<td>makePlot</td>
<td>Indicates whether to plot a histogram of the proportions across all cells/molecules.</td>
</tr>
<tr>
<td>...</td>
<td>Additional parameters used by the hist function.</td>
</tr>
</tbody>
</table>

Value

The proportion of methylated (endogenous (yellow) or accessible) bases for each cell/molecule. Output is vector with length the number of cells/molecules and contains a proportion.

Examples

data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
methyl_proportion(orderObj, makePlot = TRUE)

mouse_bm

Mouse gene symbols and positions

Description

library(biomaRt) v2.44.4 ensembl <- useMart("ensembl") GRCm39 ensembl <- useDataset("mmusculus_gene_ensembl", mart=ensembl)

my_chr <- c(1:19, 'M', 'X', 'Y') mouse_bm <- getBM(attributes=c('chromosome_name', 'start_position', 'end_position', 'mgi_symbol'), filters = 'chromosome_name', values = my_chr, mart=ensembl)

Usage

data(mouse_bm)
plotSequence

Format

An object of class `data.frame` with 55365 rows and 4 columns.

plotSequence Generate Sequence Plot

Description

Generates an ordered sequence plot of methylation data.

Usage

```r
plotSequence(
  orderObject,
  plotFast = TRUE,
  blankWidth = NULL,
  Title = "",
  drawLine = TRUE,
  drawKey = TRUE
)
```

Arguments

- `orderObject`: An object of class `orderObject` that contains the processed data and the ordering.
- `plotFast`: Logical, setting to FALSE will generate a higher quality plot. TRUE generates a lower resolution file, useful to improve speed while testing. For publication quality use `plotFast=TRUE`.
- `blankWidth`: Indicates the amount of space to leave between the two plots.
- `Title`: The title of the plot.
- `drawLine`: Logical, indicates whether to draw a line above the CG/GC sites.
- `drawKey`: Logical, indicates whether to draw a key representing a 147bp nucleosome at the bottom of the plot.

Value

Output is two side-by-side heatmaps with the endogenous methylation (HCG) on the left and the accessibility methylation (GCH) on the right. The tick marks at the top indicate either HCG or GCH sites when `drawLine=TRUE`. If `drawKey=TRUE` then a black rectangle key is plot at the bottom of the heatmap that is 147 basepairs long. In the HCG plot, red patches represent methylation between two sites; black patches represent unmethylated bases between two unmethylated sites; and gray patches are base pairs which have one methylated site and one unmethylated site flanking. In the HCG plot, yellow patches represent accessibility between two sites; black patches represent occupied bases between two occupied sites; and gray patches are base pairs which have one methylated site and one unmethylated site flanking.
Examples

```r
data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
plotSequence(orderObj)
```

Description

This function subsets the data and prepares it for visualizing by generating representation methylation-state matrices from single-cell methylation data (for example, sc-MNT data). We assume the data has already been preprocess using the subsetSC function in methylscaper. See the vignette for a more thorough explanation of each parameter. The output should be passed directly to the plotting function.

Usage

```r
prepSC(dataIn, startPos = NULL, endPos = NULL, updateProgress = NULL)
```

Arguments

- **dataIn**: A list object containing two elements labelled gch and hcg (already pre-processed.)
- **startPos**: The index of the first position to include in the visualization. If using this within the R console it is recomendated to specify the start and end directly. In the Shiny app, a slider will let the user refine these positions.
- **endPos**: The index of the final position to include in the visualization.
- **updateProgress**: A function for generating progress bars in the Shiny app. Should be left NULL otherwise.

Value

The output is a list containing the elements 'gch' and 'hcg. Each is a dataframe with reads/cells on the rows and each column is a base-pair. The matrix is coded as follows: -2: unmethylated GCH or HCG site -1: base pairs between two unmethylated GCH or HCG sites 0: base pairs between mismatching methylation states of two GCH or HCG sites 1: base pairs between two methylated GCH or HCG sites 2: methylated GCH or HCG site

Examples

```r
data(singlecell_subset)
prepsc.out <- prepSC(singlecell_subset,
                      startPos = 105636488, endPos = 105636993)
```
refineFunction

reads_sm  
Example reads from single-molecule experiment

Description
This dataset was loaded into R using seqinr::read.fasta

Usage
data(reads_sm)

Format
An object of class list of length 293.

refineFunction  
Refinement

Description
Reorders a subset of the methylation data.

Usage
refineFunction(orderObject, refineStart, refineEnd, Method = "PCA")

Arguments
orderObject  An object of class orderObject, generated with the initialOrder function.
refineStart  The index of the first sample (row) used in the refinement.
refineEnd    The index of the last sample (row) used in the refinement.
Method       The seriation method used to perform the refinement.

Value
The refinement reorders the cells/molecules (rows) between the indicated start and end positions. The function returns the new complete ordering with the refinement applied.

Examples
data(singlemolecule_example)

orderObj <- initialOrder(singlemolecule_example, Method = "PCA")
# reordering the first 50 cells/molecules (rows)
orderObj$order1 <- refineFunction(orderObj, 1, 50)
reformatSCE

This is an internal function for now and a place-holder in case SingleCellExperiment may be used in the future. We may need to update this later. Assumes rownames are formatted like chr_pos and there are two assays. The assay names are 'methylation_met' for endogenous methylation and 'methylation_acc' for accessibility.

Usage

reformatSCE(dataIn)

Arguments

dataIn Input SCE object passed to the prepSC() function.

Value

List object containing the met and acc tables.

---

ref_seq Example reference sequence to align reads to from a single-molecule experiment

Description

This dataset was loaded into R using seqinr::read.fasta

Usage

data(ref_seq)

Format

An object of class list of length 1.
runAlign  

Align the single-molecule data

Description

Runs the preprocessing methods for single-molecule data.

Usage

runAlign(
  ref,
  fasta,
  fasta_subset = seq(1, length(fasta)),
  multicoreParam = NULL,
  updateProgress = NULL,
  log_file = NULL
)

Arguments

ref  
A reference sequence to align the reads to.

fasta  
A list of reads/sequences from a single-molecule experiment (e.g. MAPit)

fasta_subset  
(optional) A vector of indices indicating which sequences to process if a subset should be used. Leave this blank if all sequences should be processed.

multicoreParam  
(optional) A MulticoreParam object, used to align sequences in parallel.

updateProgress  
(optional) Used to add a progress bar to the Shiny app. Should not be used otherwise.

log_file  
(optional) String indicating where to save a log of the alignment process. If left NULL, no log is saved. We highly recommend saving a log file.

Value

The output is a list containing the matrices 'gch' and 'hcg. Each is a dataframe with reads/cells on the rows and each column is a base-pair. The matrix represents the methylation state for cell across all base pairs. The coding is as follows: -2: unmethylated GCH or HCG site -1: base pairs between two unmethylated GCH or HCG sites 0: base pairs between mismatching methylation states of two GCH or HCG sites 1: base pairs between two methylated GCH or HCG sites 2: methylated GCH or HCG site

Examples

data(reads_sm)
data(ref_seq)
example_alignedseq <- runAlign(fasta=reads_sm, ref = ref_seq[[1]], fasta_subset = 1:150)
singlecell_subset

Example preprocessed single-cell experiment subset

Description
This data is from GSE109262, and has been pre-processed by methylscaper. It contains a small subset of chromosome 19 region from 8947041bp - 8987041bp. The RDS in ext data was made specifically with the two commands:

```r
singlecell_subset <- subsetSC("~/Downloads/GSE109262_RAW/", chromosome="19", startPos = 8967041-20000, endPos = 8967041+20000, updateProgress = NULL)
saveRDS(singlecell_subset, file="methylscaper/inst/ext/singlecell_subset.rds", compress = 'xz')
```
A version is also saved as RData used running examples in the man pages. `save(singlecell_subset, file="methylscaper/data/singlecell_subset.RData", compress = 'xz')`

Usage

```r
data(singlecell_subset)
```

Format

An object of class `list` of length 2.

---

dataframe_subset

Example preprocessed single-molecule experiment

Description
The RDS in ext data was made specifically with the command:

```r
singlemolecule_example <- methylscaper::runAlign(fasta=reads_sm, ref=ref_seq)
saveRDS(singlemolecule_example, file="methylscaper/inst/ext/singlemolecule_example.rds", compress = 'xz')
```
A version is also saved as RData used running examples in the man pages. `save(singlemolecule_example, file="methylscaper/data/singlemolecule_example.RData", compress = 'xz')`

Usage

```r
data(singlemolecule_example)
```

Format

An object of class `list` of length 2.
subsetSC  

Load in methylation data

Description

This function loads the single-cell files. It takes a path to the data files and a chromosome number as arguments and returns the desired subset of the data. Processing by chromosome is important for speed and memory efficiency. The input files should be tab separated with three columns. The first column is the chromosome, the second is the position (basepair), and the third is the methylation indicator/rate. The folder should contain two subfolders titled met and acc, with the endogenous methylation and accessibility methylation files, respectively.

Usage

subsetSC(
  path,
  chromosome,
  startPos = NULL,
  endPos = NULL,
  updateProgress = NULL
)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>path</td>
<td>Path to the folder containing the single-cell files.</td>
</tr>
<tr>
<td>chromosome</td>
<td>The chromosome to subset the files to.</td>
</tr>
<tr>
<td>startPos</td>
<td>The index of the first position to include in the subsetting. This is optional as further narrowing of the position can be done in the visualization step/tab. In the Shiny app, a slider will let the user refine the positions.</td>
</tr>
<tr>
<td>endPos</td>
<td>The index of the final position to include in subset.</td>
</tr>
<tr>
<td>updateProgress</td>
<td>A function for generating progress bars in the Shiny app. Should be left NULL otherwise.</td>
</tr>
</tbody>
</table>

Value

The output is RDS files that can be loaded into the visualization tab on the Shiny app.

Examples

# example not run since needs directory input from user
#subsc.out <- subsetSC("filepath", chromosome=19)
Index

* datasets
  human_bm, 3
  mouse_bm, 7
  reads_sm, 10
  ref_seq, 11
  singlecell_subset, 13
  singlemolecule_example, 13

  check_package, 2
  forceReverse, 3

  human_bm, 3
  initialOrder, 4

  methyl_average_status, 5
  methyl_percent_sites, 6
  methyl_proportion, 7
  methylscaper, 5
  mouse_bm, 7

  plotSequence, 8
  prepSC, 9

  reads_sm, 10
  ref_seq, 11
  refineFunction, 10
  reformatSCE, 11
  runAlign, 12

  singlecell_subset, 13
  singlemolecule_example, 13
  subsetSC, 14