Package 'methylKit'

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Type Package

Title DNA methylation analysis from high-throughput bisulfite sequencing results

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Description methylKit is an R package for DNA methylation analysis and annotation from high-throughput bisulfite sequencing. The package is designed to deal with sequencing data from RRBS and its variants, but also target-capture methods and whole genome bisulfite sequencing. It also has functions to analyze base-pair resolution 5hmC data from experimental protocols such as oxBS-Seq and TAB-Seq. Methylation calling can be performed directly from Bismark aligned BAM files.

License Artistic-2.0

URL https://github.com/al2na/methylKit

 $\pmb{BugReports} \ \, \text{https://github.com/al2na/methylKit/issues}$

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Suggests testthat (>= 2.1.0), knitr, rmarkdown, genomation, BiocManager

2 Contents

VignetteBuilder knitr
Collate 'methylKit.R' 'backbone.R' 'diffMeth.R' 'clusterSamples.R'
'regionalize.R' 'processBismarkAln.R' 'RcppExports.R'
'document_data.R' 'bedgraph.R' 'reorganize.R'
'percMethylation.R' 'normalizeCoverage.R' 'pool.R'
'adjustMethylC.R' 'updateMethObject.R' 'batchControl.R'
'dataSim.R' 'methylDBClasses.R' 'methylDBFunctions.R'
'tabix.functions.R' 'methSeg.R' 'diffMethDSS.R'
'deprecated_defunct.R' 'onUnload.R'
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Contents

adjustMethylC	
assocComp	
bedgraph	
calculateDiffMeth	
calculateDiffMethDSS	
clusterSamples	
dataSim	
diffMethPerChr	
extract	
filterByCoverage	
getAssembly	
getContext	
getCorrelation	
getCoverageStats	
getData	
getDBPath	
getMethylationStats	
getMethylDiff	
getSampleID	
getTreatment	
joinSegmentNeighbours	
makeMethylDB	
methRead	
methSeg	
methSeg2bed	
methylBase-class	

adjustMethylC 3

	methylBase.obj	46
	methylBaseDB-class	1 7
		48
	methylDiff.obj	1 9
		1 9
		51
	methylRaw-class	51
		53
	methylRawList-class	54
		55
	· · · · · · · · · · · · · · · · · · ·	55
	normalizeCoverage	56
		58
	percMethylation	50
	pool	51
	processBismarkAln	53
	readMethylDB	55
	reconstruct	56
	regionCounts	58
	removeComp	72
	reorganize	74
	select	77
	selectByOverlap	78
	show,methylBase-method	30
	tileMethylCounts	31
		34
	updateMethObject	36
		_
Index		37

adjustMethylC

Adjust measured 5mC levels using 5hmC levels

Description

Measured 5mC levels via bisulfite sequencing might be a combination of 5hmC and 5mC levels since bisulfite sequencing can not distinguish between the two. This function can adjust 5mC levels of a bisulfite sequencing experiment if the user supplies corresponding 5hmC levels from the same sample.

```
adjustMethylC(mc,hmc,save.db,...,chunk.size)
## S4 method for signature 'methylRaw,methylRaw'
adjustMethylC(mc, hmc, save.db = FALSE, ..., chunk.size = 1e+06)
## S4 method for signature 'methylRawList,methylRawList'
```

4 adjustMethylC

```
adjustMethylC(mc, hmc, save.db = FALSE, ..., chunk.size = 1e+06)
## S4 method for signature 'methylRawDB,methylRawDB'
adjustMethylC(mc, hmc, save.db = TRUE, ..., chunk.size = 1e+06)
## S4 method for signature 'methylRawListDB,methylRawListDB'
adjustMethylC(mc, hmc, save.db = TRUE, ..., chunk.size = 1e+06)
```

Arguments

mc a methylRawList, methylRaw, methylRawDB or methylRawListDB containing

5mC levels of a sample or set of samples

hmc a methylRawList, methylRaw, methylRawDB or methylRawListDB containing

5hmC levels of a sample or set of samples. If a methylRawList or methylRawListDB given the sample order should be same as "mc" methylRawList or methylRawListDB

object.

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_filtered" to current file-name if database already exists or generate new file with filename "sampleID_filtered" dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only

used for newly stored databases)

chunk.size Number of rows to be taken as a chunk for processing the methylRawDB or

methylRawListDB objects (default: 1e6)

Value

returns adjusted 5-methyl cytosine levels in the form of methylRawList, methylRaw, methylRawDB or methylRawListDB object depending on the input object

Details

The parameter chunk.size is only used when working with methylRawDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save. db is per default TRUE for methylDB objects as methylRawDB and methylRawListDB, while being per default FALSE for methylRaw and methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might change the value of this parameter.

assocComp 5

References

1. Booth, Branco, et al. (2012). Quantitative Sequencing of 5-Methylcytosine and 5-Hydroxymethylcytosine at Single-Base Resolution. Science, 934

2. Yu, Hon, et al. (2012). Base-resolution analysis of 5-hydroxymethylcytosine in the Mammalian genome. Cell, 149(6), 1368-80.

Examples

```
# read 5hmC and 5mC files
hmc.file=system.file("extdata", "test1.myCpG.txt", package = "methylKit")
mc.file =system.file("extdata", "test2.myCpG.txt", package = "methylKit")
my5hmC=methRead( hmc.file,sample.id="hmc",assembly="hg18")
my5mC =methRead( mc.file,sample.id="mc",assembly="hg18")
# adjusting the 5mC levels using 5hmC levels
adjusted.5mC=adjustMethylC(my5mC,my5hmC)
```

assocComp

Associate principal components with sample annotations

Description

This function associates principal components with sample annotations such as age, gender, batch_id. Can be used to detect which batch effects are associated with the variation in the methylation values.

Usage

```
assocComp(mBase, sampleAnnotation)
```

Arguments

mBase methylBase or methylBaseDB object with no NA values in the data part. sampleAnnotation

a data frame where columns are different annotations and rows are the samples, in the same order as in the methylBase object.

Value

a named list of principal component matrix (named 'pcs'), by principal components (named 'vars') and a p-value matrix showing association p-values between sample annotations and principal components (named 'association').

Author(s)

Altuna Akalin

6 bedgraph

Examples

```
data(methylKit)
sampleAnnotation=data.frame(batch_id=c("a","a","b","b"),age=c(19,34,23,40))
as=assocComp(mBase=methylBase.obj,sampleAnnotation)
```

bedgraph

Get bedgraph from methylRaw, methylRawList and methylDiff objects

Description

The function converts methylRaw, methylRawDB, methylRawList, methylRawListDB, methylDiff or methylDiffDB object into a bedgraph format. It either writes as a file or returns a data.frame

```
bedgraph(
 methylObj,
  file.name = NULL,
  col.name,
  unmeth = FALSE,
  log.transform = FALSE,
  negative = FALSE,
  add.on = "",
  chunk.size = 1e+06
)
## S4 method for signature 'methylDiff'
bedgraph(
 methylObj,
  file.name,
  col.name,
  unmeth,
  log.transform,
  negative,
  add.on
)
## S4 method for signature 'methylRaw'
bedgraph(
 methylObj,
  file.name,
  col.name,
  unmeth,
  log.transform,
```

bedgraph 7

```
negative,
  add.on
)
## S4 method for signature 'methylRawList'
bedgraph(
 methylObj,
  file.name,
  col.name,
  unmeth,
  log.transform,
  negative,
  add.on
)
## S4 method for signature 'methylRawDB'
bedgraph(
 methylObj,
  file.name = NULL,
  col.name,
  unmeth = FALSE,
  log.transform = FALSE,
  negative = FALSE,
  add.on = "",
  chunk.size = 1e+06
)
## S4 method for signature 'methylRawListDB'
bedgraph(
 methylObj,
  file.name = NULL,
  col.name,
  unmeth = FALSE,
  log.transform = FALSE,
  negative = FALSE,
  add.on = "",
  chunk.size = 1e+06
)
## S4 method for signature 'methylDiffDB'
bedgraph(
 methylObj,
  file.name,
  col.name,
  log.transform,
  negative,
  add.on,
  chunk.size
```

8 bedgraph

)

Arguments

methylObj	$a \; methylRaw, \; methylRawDB, \; methylRawList, \; methylRawListDB, \; methylDiff \\ or \; methylDiffDB \; object$
file.name	Default: NULL. if a string is given a bedgraph file will be written, if NULL a data.frame or a list of data frames will be returned
col.name	name of the column in methylRaw, methylRawDB, methylRawList, methylRawListDB, methylDiff or methylDiffDB objects to be used as a score for the bedgraph. For methylDiff or methylDiffDB, col.name must be one of the following 'pvalue', 'qvalue', 'meth.diff'. For methylRaw, methylRawDB, methylRawList and methylRawListDB it must be one of the following 'coverage', 'numCs', 'numTs', 'perc.meth'
unmeth	when working with methylRaw, methylRawDB, methylRawList and methylRawListDB objects should you output unmethylated C percentage this makes it easier to see the unmethylated bases because their methylation percentage values will be zero. Only invoked when file.name is not NULL.
log.transform	Default FALSE, If TRUE the score column of the bedgraph wil be in log10 scale. Ignored when col.name='perc.meth'
negative	Default FALSE, If TRUE, the score column of the bedgraph will be multiplied by -1. Ignored when col.name='perc.meth'
add.on	additional string to be add on the track line of bedgraph. can be viewlimits,priority etc. Check bedgraph track line options at UCSC browser
chunk.size	Number of rows to be taken as a chunk for processing the methylRawDB, methylRawListDB or methylDiffDB objects, default: 1e6

Value

Returns a data.frame or list of data.frames if file.name=NULL, if a file.name given appropriate bed file will be written to that file

Details

The parameter chunk.size is only used when working with methylRawDB, methylRawListDB or methylDiffDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

calculateDiffMeth 9

calculateDiffMeth

Calculate differential methylation statistics

Description

The function calculates differential methylation statistics between two groups of samples. The function uses either logistic regression test or Fisher's Exact test to calculate differential methylation. See the rest of the help page and references for detailed explanation on statistics.

```
calculateDiffMeth(
  .Object,
  covariates = NULL,
  overdispersion = c("none", "MN", "shrinkMN"),
 adjust = c("SLIM", "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr",
    "none", "qvalue"),
  effect = c("wmean", "mean", "predicted"),
  parShrinkMN = list(),
  test = c("F", "Chisq", "fast.fisher", "midPval"),
  mc.cores = 1,
  slim = TRUE,
  weighted.mean = TRUE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylBaseDB'
calculateDiffMeth(
  .Object,
  covariates = NULL,
  overdispersion = c("none", "MN", "shrinkMN"),
 adjust = c("SLIM", "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr",
    "none", "qvalue"),
  effect = c("wmean", "mean", "predicted"),
```

10 calculateDiffMeth

```
parShrinkMN = list(),
  test = c("F", "Chisq", "fast.fisher", "midPval"),
  mc.cores = 1,
  slim = TRUE,
  weighted.mean = TRUE,
  chunk.size = 1e+06,
  save.db = TRUE,
  ...
)
```

Arguments

. Object a methylBase or methylBaseDB object to calculate differential methylation

covariates a data. frame containing covariates, which should be included in the test.

overdispersion If set to "none" (default), no overdispersion correction will be attempted. If set

to "MN", basic overdispersion correction, proposed by McCullagh and Nelder (1989) will be applied. This correction applies a scaling parameter to variance estimated by the model. EXPERIMENTAL: If set to "shrinkMN", scaling parameter will be shrunk towards a common value (not thoroughly tested as of

yet).

adjust different methods to correct the p-values for multiple testing. Default is "SLIM"

from methylKit. For "qvalue" please see qvalue and for all other methods see

p.adjust.

effect method to calculate the mean methylation different between groups using read

coverage as weights (default). When set to "mean", the generic mean is applied and when set to "predicted", predicted means from the logistic regression model

is used for calculating the effect.

parShrinkMN a list for squeezeVar(). (NOT IMPLEMENTED)

test the statistical test used to determine the methylation differences. The Chisq-test

is used by default for more than two groups, while the F-test can be chosen if overdispersion control is applied. If there is one sample per group the Fisher's exact test will be applied using "fast.fisher", while "midPval" can be chosen to

boost calculation speed. See details section for more information.

mc.cores integer denoting how many cores should be used for parallel differential methy-

lation calculations (can only be used in machines with multiple cores).

slim If set to FALSE, adjust will be set to "BH" (default behaviour of earlier ver-

sions)

weighted.mean If set to FALSE, effect will be set to "mean" (default behaviour of earlier

versions)

chunk.size Number of rows to be taken as a chunk for processing the methylBaseDB objects

(default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details section.

... optional Arguments used when save.db is TRUE

calculateDiffMeth 11

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: The default suffix is a 13-character random string appended to the fixed prefix "methylDiff", e.g. "methylDiff_16d3047c1a254.txt.bgz".

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only used for newly stored databases)

Value

a methylDiff object containing the differential methylation statistics and locations for regions or bases

Details

Covariates can be included in the analysis. The function will then try to separate the influence of the covariates from the treatment effect via a linear model.

The Chisq-test is used per default only when no overdispersion correction is applied. If overdispersion correction is applied, the function automatically switches to the F-test. The Chisq-test can be manually chosen in this case as well, but the F-test only works with overdispersion correction switched on.

If there is one sample in each group, e.g. after applying the pooling samples, the Fisher's exact test will be applied for differential methylation. methyKit offers two implementations to perform this test, which yield slightly different results but differ much in computation time. "fast.fisher" is a cut down version 'fisher.test()' that should produce the exact same results as the base implementation, while "midPval" will produce marginaly different p-values, but offers a large boost in calculation speed.

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylBaseDB, while being per default FALSE for methylBase. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

References

Altuna Akalin, Matthias Kormaksson, Sheng Li, Francine E. Garrett-Bakelman, Maria E. Figueroa, Ari Melnick, Christopher E. Mason. (2012). "methylKit: A comprehensive R package for the analysis of genome-wide DNA methylation profiles." Genome Biology.

McCullagh and Nelder. (1989). Generalized Linear Models. Chapman and Hall. London New York.

Barnard. (1989). On alleged gains in power from lower P-values. Statistics in Medicine. Armitage and Berry. (1994) Statistical Methods in Medical Research (3rd edition). Blackwell.

12 calculateDiffMethDSS

See Also

```
pool, reorganize dataSim
```

Examples

```
data(methylKit)
# The Chisq-test will be applied when no overdispersion control is chosen.
my.diffMeth=calculateDiffMeth(methylBase.obj,covariates=NULL,
                              overdispersion=c("none"),
                              adjust=c("SLIM"))
# pool samples in each group
pooled.methylBase=pool(methylBase.obj,sample.ids=c("test","control"))
# After applying the pool() function, there is one sample in each group.
# The Fisher's exact test will be applied for differential methylation.
my.diffMeth2=calculateDiffMeth(pooled.methylBase,covariates=NULL,
                               overdispersion=c("none"),
                               adjust=c("SLIM"))
# Covariates and overdispersion control:
# generate a methylBase object with age as a covariate
covariates=data.frame(age=c(30,80,30,80))
sim.methylBase<-dataSim(replicates=4,sites=1000,treatment=c(1,1,0,0),
                        covariates=covariates,
                        sample.ids=c("test1","test2","ctrl1","ctrl2"))
# Apply overdispersion correction and include covariates
# in differential methylation calculations.
my.diffMeth3<-calculateDiffMeth(sim.methylBase,</pre>
                                covariates=covariates,
                                overdispersion="MN",test="Chisq",mc.cores=1)
```

calculateDiffMethDSS calculate Differential Methylation with DSS

Description

This function provides an interface to the beta-binomial model from DSS package by Hao Wu. It calculates the differential methylation statistics using a beta-binomial model with parameter shrinkage. See the reference for details.

```
calculateDiffMethDSS(
  meth,
  adjust = c("SLIM", "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr",
```

clusterSamples 13

Arguments

meth a methylBase object

adjust different methods to correct the p-values for multiple testing. Default is "SLIM"

from methylKit. For "qvalue" please see qvalue and for all other methods see

p.adjust.

mc.cores integer denoting how many cores should be used for parallel differential methy-

lation calculations (can only be used in machines with multiple cores).

Value

a methylDiff object

References

Feng H, Conneely K and Wu H (2014). A bayesian hierarchical model to detect differentially methylated loci from single nucleotide resolution sequencing data. Nucleic acids research

Examples

```
data(methylKit)
dssDiffay <- calculateDiffMethDSS(methylBase.obj, adjust="SLIM", mc.cores=1)</pre>
```

clusterSamples

Hierarchical Clustering using methylation data The function clusters samples using hclust function and various distance metrics derived from percent methylation per base or per region for each sample.

Description

Hierarchical Clustering using methylation data

The function clusters samples using hclust function and various distance metrics derived from percent methylation per base or per region for each sample.

14 clusterSamples

Usage

```
clusterSamples(.Object, dist="correlation", method="ward",
                        sd.filter=TRUE, sd.threshold=0.5,
                        filterByQuantile=TRUE, plot=TRUE, chunk.size)
## S4 method for signature 'methylBase'
clusterSamples(
  .Object,
  dist,
 method,
  sd.filter,
  sd.threshold,
  filterByQuantile,
  plot
)
## S4 method for signature 'methylBaseDB'
clusterSamples(
  .Object,
  dist = "correlation",
  method = "ward",
  sd.filter = TRUE,
  sd.threshold = 0.5,
  filterByQuantile = TRUE,
  plot = TRUE,
  chunk.size = 1e+06
)
```

Arguments

. Object a methylBase or methylBaseDB object

dist the distance measure to be used. This must be one of "correlation", "euclidean",

"maximum", "manhattan", "canberra", "binary" or "minkowski". Any unam-

biguous abbreviation can be given. (default:"correlation")

method the agglomeration method to be used. This should be (an unambiguous ab-

breviation of) one of "ward.D", "ward.D", "single", "complete", "average",

"mcquitty", "median" or "centroid". (default:"ward")

sd. filter If TRUE, the bases/regions with low variation will be discarded prior to clustering

(default:TRUE)

sd.threshold A numeric value. If filterByQuantile is TRUE, features whose standard de-

viations is less than the quantile denoted by sd.threshold will be removed. If filterByQuantile is FALSE, then features whose standard deviations is less

than the value of sd. threshold will be removed.(default:0.5)

filterByQuantile

A logical determining if sd. threshold is to be interpreted as a quantile of all Standard Deviation values from bases/regions (the default), or as an absolute value

dataSim 15

plot a logical value indicating whether to plot hierarchical clustering. (default:TRUE) chunk.size

Number of rows to be taken as a chunk for processing the methylBaseDB objects, default: 1e6

Value

a tree object of a hierarchical cluster analysis using a set of dissimilarities for the n objects being clustered.

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

Examples

```
data(methylKit)
clusterSamples(methylBase.obj, dist="correlation", method="ward", plot=TRUE)
```

dataSim

Simulate DNA methylation data

Description

The function simulates DNA methylation data from multiple samples. See references for detailed explanation on statistics.

```
dataSim(
  replicates,
  sites,
  treatment,
  percentage = 10,
  effect = 25,
  alpha = 0.4,
  beta = 0.5,
  theta = 10,
  covariates = NULL,
  sample.ids = NULL,
  assembly = "hg18",
  context = "CpG",
```

16 dataSim

```
add.info = FALSE
)
```

Arguments

replicates the number of samples that should be simulated.

sites the number of CpG sites per sample.

treatment a vector containing treatment information.

percentage the proportion of sites which should be affected by the treatment.

effect a number between 0 and 100 specifying the effect size of the treatment. This is

essentially describing the average percent methylation difference between dif-

ferentially methylated bases. See 'Examples' and 'Details'.

alpha shape1 parameter for beta distribution (used for initial sampling of methylation

proportions)

beta shape2 parameter for beta distribution (used for initial sampling of methylation

proportions)

theta dispersion parameter for beta distribution (initial sampling of methylation pro-

portions)

covariates a data.frame containing covariates (optional)

sample.ids will be generated automatically from treatment, but can be overwritten by a

character vector containing sample names.

assembly the assembly description (e.g. "hg18"). Only needed for book keeping.

context the experimanteal context of the data (e.g. "CpG"). Only needed for book keep-

ing.

add. info if set to TRUE, the output will be a list with the first element being the methyl-

base object and a vector of indices that indicate which CpGs should be differentially methylated. This vector can be used to subset simulated methylBase or

methylDiff object with differentially methylated bases.

Value

a methylBase object containing simulated methylation data, or if add.info=TRUE a list containing the methylbase object and the indices of all treated sites (differentially methylated bases or regions) as the second element.

Details

The function uses a Beta distribution to simulate the methylation proportion background across all samples. The parameters alpha, beta used in a beta distribution to draw methylation proportions, μ , from a typical bimodal distribution. For each initial methylation proportion drawn using the parameters above, a range of methylation proportions is distributed around the original μ with overdispersion parameter θ , this is using an alternative parameterization of Beta distribution: $Beta(\mu,\theta)$. The parameters percentage and effect determine the proportion of sites that are affected by the treatment (meaning differential sites) and the strength of this influence, respectively. effect is added on top of μ for the CpGs that are affected by the treatment. The affected group of samples

diffMethPerChr 17

for that particular CpG will now be distributed by $Beta(\mu + effect, \theta)$. The coverage is modeled with a negative binomial distribution, using rnbinom function with size=1 and prob=0.01. The additional information needed for a valid methylBase object, such as CpG start, end and strand, is generated as "dummy values", but can be overwritten as needed.

Examples

```
data(methylKit)
# Simulate data for 4 samples with 20000 sites each.
# The methylation in 10% of the sites are elevated by 25%.
my.methylBase=dataSim(replicates=4,sites=2000,treatment=c(1,1,0,0),
percentage=10,effect=25)
```

diffMethPerChr

Get and plot the number of hyper/hypo methylated regions/bases per chromosome

Description

This function gets number of hyper/hypo methylated regions/bases from methylDiff object. It can also plot percentages of differentially methylated bases per chromosome.

```
diffMethPerChr(
    x,
    plot = TRUE,
    qvalue.cutoff = 0.01,
    meth.cutoff = 25,
    exclude = NULL,
    keep.empty.chrom = FALSE,
    ...
)

## S4 method for signature 'methylDiff'
diffMethPerChr(
    x,
    plot = TRUE,
    qvalue.cutoff = 0.01,
    meth.cutoff = 25,
    exclude = NULL,
    keep.empty.chrom = FALSE,
    ...
)
```

18 extract

```
## S4 method for signature 'methylDiffDB'
diffMethPerChr(
    x,
    plot = TRUE,
    qvalue.cutoff = 0.01,
    meth.cutoff = 25,
    exclude = NULL,
    keep.empty.chrom = FALSE,
    ...
)
```

Arguments

x a methylDiff object

plot TRUEIFALSE. If TRUE horizontal barplots for proportion of hypo/hyper methylated bases/regions

qvalue.cutoff cutoff for q-value

meth.cutoff cutoff for percent methylation difference

exclude names of chromosomes to be excluded from plot

keep.empty.chrom

keep chromosome in list / plot, even if it contains no hyper/hypo sites

... extra graphical parameters to be passed to barplot function

Value

plots a piechart or a barplot for percentage of the target features overlapping with annotation

Examples

extract

extract parts of methylRaw,methylRawDB,methylBase,methylBaseDB and methylDiff data

Description

The function extracts part of the data and returns a new object.

extract 19

Usage

```
## S4 method for signature 'methylRaw,ANY,ANY',ANY'
x[i, j]

## S4 method for signature 'methylBase,ANY,ANY,ANY'
x[i, j]

## S4 method for signature 'methylDiff,ANY,ANY,ANY'
x[i, j]

## S4 method for signature 'methylRawDB,ANY,ANY,ANY'
x[i, j]

## S4 method for signature 'methylBaseDB,ANY,ANY,ANY'
x[i, j]

## S4 method for signature 'methylDiffDB,ANY,ANY,ANY'
x[i, j]
```

Arguments

- x an methylBase,methylBaseDB, methylRaw,methylRawDB or methylDiff object
- i a numeric or logical vector. This vector corresponds to bases or regions contained in methylKit objects. The vector is used to subset the data.
- j This argument can not be used for the extraction of columns. As unintentional extraction of the columns will cause an error in the downstream analysis. Using this argument will cause an error. Use getData to access the data part of the objects.

```
data(methylKit)
# selects first hundred rows, returns a methylRaw object
subset1=methylRawList.obj[[1]][1:100]
# selects first hundred rows, returns a methylBase object
subset2=methylBase.obj[1:100,]
# selects first hundred rows, returns a methylDiff object
subset3=methylDiff.obj[1:100,]
# This will get chromomsomes, will return a factor
# That means the resulting object will ceases to be a methylKit object
chrs=methylDiff.obj[[2]]
```

20 filterByCoverage

filterByCoverage

Filter methylRaw, methylRawDB, methylRawList and methyl-RawListDB object based on read coverage

Description

This function filters methylRaw, methylRawDB, methylRawList and methylRawListDB objects. You can filter based on lower read cutoff or high read cutoff. Higher read cutoff is usefull to eliminate PCR effects Lower read cutoff is usefull for doing better statistical tests.

```
filterByCoverage(
  methylObj,
  lo.count = NULL,
  lo.perc = NULL,
  hi.count = NULL,
  hi.perc = NULL,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylRaw'
filterByCoverage(
  methylObj,
  lo.count = NULL,
  lo.perc = NULL,
  hi.count = NULL,
  hi.perc = NULL,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylRawList'
filterByCoverage(
  methylObj,
  lo.count = NULL,
  lo.perc = NULL,
  hi.count = NULL,
  hi.perc = NULL,
  chunk.size = 1e+06,
  save.db = FALSE,
)
```

filterByCoverage 21

```
## S4 method for signature 'methylRawDB'
filterByCoverage(
 methylObj,
 lo.count = NULL,
 lo.perc = NULL,
 hi.count = NULL,
 hi.perc = NULL,
 chunk.size = 1e+06,
 save.db = TRUE,
)
## S4 method for signature 'methylRawListDB'
filterByCoverage(
 methylObj,
 lo.count = NULL,
 lo.perc = NULL,
 hi.count = NULL,
 hi.perc = NULL,
 chunk.size = 1e+06,
 save.db = TRUE,
)
```

Arguments

methylObj	$a \ methylRawList \ or \ methylRawListDB \ object$
lo.count	An integer for read counts.Bases/regions having lower coverage than this count is discarded
lo.perc	A double [0-100] for percentile of read counts. Bases/regions having lower coverage than this percentile is discarded
hi.count	An integer for read counts. Bases/regions having higher coverage than this is count discarded
hi.perc	A double [0-100] for percentile of read counts. Bases/regions having higher coverage than this percentile is discarded
chunk.size	Number of rows to be taken as a chunk for processing the methylRawDB or methylRawListDB objects, default: 1e6
save.db	A Logical to decide whether the resulting object should be saved as flat file database or not, default: explained in Details sections
	optional Arguments used when save.db is TRUE
	suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_filtered" to current filename if database already exists or generate new file with filename "sampleID_filtered"
	dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to original directory for already existing database

22 getAssembly

dbtype The type of the flat file database, currently only option is "tabix" (only used for newly stored databases)

Value

methylRaw, methylRawDB, methylRawList or methylRawListDB object depending on input object

Details

The parameter chunk.size is only used when working with methylRawDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save. db is per default TRUE for methylDB objects as methylRawDB and methylRawListDB, while being per default FALSE for methylRaw and methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might change the value of this parameter.

```
data(methylKit)
# filter out bases with covereage above 500 reads
filtered1=filterByCoverage(methylRawList.obj,lo.count=NULL,lo.perc=NULL,
hi.count=500, hi.perc=NULL)
# filter out bases with cread coverage above 99.9th percentile of coverage
# distribution
filtered2=filterByCoverage(methylRawList.obj,lo.count=NULL,lo.perc=NULL,
hi.count=NULL,hi.perc=99.9)
# filter out bases with covereage above 500 reads and save to database
# "test1_max500.txt.bgz"
# in directory "methylDB", filtered3 now becomes a \code{methylRawDB} object
filtered3=filterByCoverage(methylRawList.obj[[1]], lo.count=NULL,lo.perc=NULL,
                           hi.count=500, hi.perc=NULL, save.db=TRUE,
                           suffix="max500", dbdir="methylDB")
# tidy up
rm(filtered3)
unlink("methylDB", recursive=TRUE)
```

getAssembly 23

Description

The function returns the genome assembly stored in any of the methylBase,methylBaseDB,methylRaw, methylRawDB,methylDiff objects

Usage

```
getAssembly(x)
## S4 method for signature 'methylBase'
getAssembly(x)
## S4 method for signature 'methylRaw'
getAssembly(x)
## S4 method for signature 'methylDiff'
getAssembly(x)
## S4 method for signature 'methylRawDB'
getAssembly(x)
## S4 method for signature 'methylBaseDB'
getAssembly(x)
## S4 method for signature 'methylBaseDB'
getAssembly(x)
```

Arguments

 $x \qquad \qquad \text{an methylBase,methylBaseDB, methylRaw,methylRawDB or methylDiff object} \\$

Value

the assembly string for the object

```
data(methylKit)
getAssembly(methylBase.obj)
getAssembly(methylDiff.obj)
getAssembly(methylRawList.obj[[1]])
```

24 getContext

getContext

get the context of methylation

Description

The function returns the context of methylation. For example: "CpG", "CHH" or "CHG"

Usage

```
getContext(x)
## S4 method for signature 'methylBase'
getContext(x)
## S4 method for signature 'methylRaw'
getContext(x)
## S4 method for signature 'methylDiff'
getContext(x)
## S4 method for signature 'methylRawDB'
getContext(x)
## S4 method for signature 'methylBaseDB'
getContext(x)
## S4 method for signature 'methylBaseDB'
getContext(x)
```

Arguments

 $x \qquad \qquad an \, \mathsf{methylBase,methylBaseDB}, \, \mathsf{methylRaw,methylRawDB} \, \, \mathsf{or} \, \, \mathsf{an} \, \, \mathsf{methylDiff} \, \, \mathsf{object} \\$

Value

a string for the context methylation

```
data(methylKit)
getContext(methylBase.obj)
getContext(methylDiff.obj)
getContext(methylRawList.obj[[1]])
```

getCorrelation 25

${\it get Correlation} \qquad {\it get correlation between samples in methylBase or methylBaseDB object}$

Description

The functions returns a matrix of correlation coefficients and/or a set of scatterplots showing the relationship between samples. The scatterplots will contain also fitted lines using lm() for linear regression and lowess for polynomial regression.

Usage

```
getCorrelation(object,method="pearson",plot=FALSE,nrow)
## S4 method for signature 'methylBase'
getCorrelation(object, method = c("pearson", "kendall", "spearman"), plot)
## S4 method for signature 'methylBaseDB'
getCorrelation(object, method = "pearson", plot = FALSE, nrow = 2e+06)
```

Arguments

object	a methylBase or methylBaseDB object
method	a character string indicating which correlation coefficient (or covariance) is to be computed (default:"pearson", other options are "kendall" and "spearman")
plot	scatterPlot if TRUE (default:FALSE)
nrow	a numeric giving the number of lines to read in of methylBaseDB object, defaults to 2e6

Value

a correlation matrix object and plot scatterPlot

Details

The argument 'nrow' is only evaluated if the input is a methylBaseDB object. If 'nrow' is not specified getCorrelation will read the first 2M records of the given object, but if you want to read all records 'nrow' has to be NULL. You should change 'nrow' if using getCorrelation with all records of the methylBaseDB object would take too long.

If the scatter plot is plotted, the red line in the plot is from linear regression fit and the green line is from polynomial regression fit with stats::lowess.

26 getCoverageStats

Examples

```
data(methylKit)
getCorrelation(methylBase.obj,method="pearson",plot=FALSE)

# create methylBaseDB
methylBaseDB.obj <- unite(methylRawList.obj,save.db=TRUE,dbdir="methylDB")
getCorrelation(methylBaseDB.obj,method="pearson",plot=FALSE,nrow=10000)

# remove Database again
rm(methylBaseDB.obj)
unlink("methylDB",recursive=TRUE)</pre>
```

getCoverageStats

get coverage stats from methylRaw object

Description

The function returns basic statistics about read coverage per base. It can also plot a histogram of read coverage values.

```
getCoverageStats(
  object,
  plot = FALSE,
  both.strands = FALSE,
  labels = TRUE,
  . . . ,
  chunk.size = 1e+06
)
## S4 method for signature 'methylRaw'
getCoverageStats(
  object,
  plot = FALSE,
  both.strands = FALSE,
  labels = TRUE,
  chunk.size = 1e+06
)
## S4 method for signature 'methylRawDB'
```

getCoverageStats 27

```
getCoverageStats(
  object,
  plot = FALSE,
  both.strands = FALSE,
  labels = TRUE,
   ...,
  chunk.size = 1e+06
)
```

Arguments

object a methylRaw or methylRawDB object

plot plot a histogram of coverage if TRUE (default:FALSE)

both.strands do stats and plot for both strands if TRUE (default:FALSE)

labels should the bars of the histrogram have labels showing the percentage of values

in each bin (default:TRUE)

... options to be passed to hist function

chunk.size Number of rows to be taken as a chunk for processing the methylRawDB objects

(default: 1e6)

Value

a summary of coverage statistics or plot a histogram of coverage

Details

The parameter chunk.size is only used when working with methylRawDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

```
data(methylKit)
# gets coverage stats for the first sample in methylRawList.obj object
getCoverageStats(methylRawList.obj[[1]],plot=TRUE,
both.strands=FALSE,labels=TRUE)
```

28 getData

getData

get the data slot from the methylKit objects

Description

The functions retrieves the table containing methylation information from methylKit Objects. The data retrived from this function is of a data. frame. This is basically containing all relevant methylation information per genomic region or base.

Usage

```
getData(x)
## S4 method for signature 'methylBase'
getData(x)
## S4 method for signature 'methylRaw'
getData(x)
## S4 method for signature 'methylDiff'
getData(x)
## S4 method for signature 'methylRawDB'
getData(x)
## S4 method for signature 'methylBaseDB'
getData(x)
## S4 method for signature 'methylBaseDB'
getData(x)
```

Arguments

x an methylBase,methylBaseDB, methylRaw,methylRawDB or methylDiff object

Value

data frame for methylation events

```
data(methylKit)
# following commands show first lines of returned
# data.frames from getData() function
head(
getData(methylBase.obj)
```

getDBPath 29

```
head( getData(methylDiff.obj))
head(getData(methylRawList.obj[[1]]))
```

getDBPath

Get path to database of the methylDB objects

Description

The function returns the path to the flat file database that stores the data of the methylRawDB, methylRawListDB, methylBaseDB or methylDiffDB objects.

Usage

```
getDBPath(x)
## S4 method for signature 'methylRawListDB'
getDBPath(x)
## S4 method for signature 'methylBaseDB'
getDBPath(x)
## S4 method for signature 'methylRawDB'
getDBPath(x)
## S4 method for signature 'methylDiffDB'
getDBPath(x)
```

Arguments

 $x \hspace{1cm} an \hspace{0.1cm} methyl Base DB, methyl Raw DB, \hspace{0.1cm} methyl Raw List DB \hspace{0.1cm} or \hspace{0.1cm} methyl Diff DB \hspace{0.1cm} object$

```
data(methylKit)
methylBaseDB.obj <- unite(methylRawList.obj,save.db=TRUE,dbdir="methylDB")
#The path to the database is returned
getDBPath(methylBaseDB.obj)
# remove Database again
rm(methylBaseDB.obj)</pre>
```

30 getMethylationStats

```
unlink("methylDB",recursive=TRUE)
```

getMethylationStats

get Methylation stats from methylRaw or methylRawDB object

Description

The function returns basic statistics about It can also plot a histogram of

Usage

```
getMethylationStats(
  object,
  plot = FALSE,
  both.strands = FALSE,
 labels = TRUE,
  chunk.size = 1e+06
## S4 method for signature 'methylRaw'
getMethylationStats(
 object,
  plot = FALSE,
  both.strands = FALSE,
  labels = TRUE,
  chunk.size = 1e+06
)
## S4 method for signature 'methylRawDB'
getMethylationStats(
 object,
  plot = FALSE,
  both.strands = FALSE,
  labels = TRUE,
  chunk.size = 1e+06
)
```

Arguments

object a methylRaw or methylRawDB object

plot plot a histogram of Methylation if TRUE (deafult:FALSE)

both.strands do plots and stats for both strands seperately if TRUE (deafult:FALSE)

getMethylDiff 31

labels	should the bars of the histrogram have labels showing the percentage of values in each bin (default:TRUE)
• • •	options to be passed to hist function.
chunk.size	Number of rows to be taken as a chunk for processing the methylRawDB objects (default: 1e6)

Value

a summary of Methylation statistics or plot a histogram of coverage

Details

The parameter chunk.size is only used when working with methylRawDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

Examples

```
data(methylKit)
# gets Methylation stats for the first sample in methylRawList.obj object
getMethylationStats(methylRawList.obj[[1]],plot=TRUE,
both.strands=FALSE,labels=TRUE)
```

getMethylDiff

get differentially methylated regions/bases based on cutoffs

Description

The function subsets a methylDiff or methylDiffDB object in order to get differentially methylated bases/regions satisfying thresholds.

```
getMethylDiff(
   .Object,
   difference = 25,
   qvalue = 0.01,
   type = "all",
   chunk.size = 1e+06,
   save.db = FALSE,
   ...
)
```

32 getMethylDiff

```
## S4 method for signature 'methylDiff'
getMethylDiff(
  .Object,
  difference = 25,
  qvalue = 0.01,
  type = "all",
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylDiffDB'
getMethylDiff(
  .Object,
  difference = 25,
  qvalue = 0.01,
  type = "all",
  chunk.size = 1e+06,
  save.db = TRUE,
)
```

Arguments

.Object a methylDiff or methylDiffDB object

cutoff for absolute value of methylation percentage change between test and difference

control (default:25)

cutoff for qvalue of differential methylation statistic (default:0.01) qvalue

one of the "hyper", "hypo" or "all" strings. Specifies what type of differentially type

> menthylated bases/regions should be returned. For retrieving Hyper-methylated regions/bases type="hyper", for hypo-methylated type="hypo" (default:"all")

chunk.size Number of rows to be taken as a chunk for processing the methylDiffDB objects

(default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: see Details

optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_type" to current filename if database already exists or generate new file with filename "methylDiff_type"

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only

used for newly stored databases)

getSampleID 33

Value

a methylDiff or methylDiffDB object containing the differential methylated locations satisfying the criteria

Details

The parameter chunk.size is only used when working with methylDiffDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylDiffDB, while being per default FALSE for methylDiff. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Examples

```
data(methylKit)
# get differentially methylated bases/regions with specific cutoffs
all.diff=getMethylDiff(methylDiff.obj,difference=25,qvalue=0.01,type="all")
# get hyper-methylated
hyper=getMethylDiff(methylDiff.obj,difference=25,qvalue=0.01,type="hyper")
# get hypo-methylated
hypo=getMethylDiff(methylDiff.obj,difference=25,qvalue=0.01,type="hypo")
```

getSampleID

Get or Set Sample-IDs of the methylKit objects

Description

The function returns or replaces the sample-ids stored in any of the following methylKit objects: methylRaw, methylRawDB, methylBase, methylBaseDB, methylRawList, methylRawListDB, methylDiff, methylDiffDB.

```
getSampleID(x)
getSampleID(x) <- value

getSampleID(x) <- value

## S4 method for signature 'methylRawList'
getSampleID(x)</pre>
```

34 getSampleID

```
## S4 replacement method for signature 'methylRawList'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylBase'
getSampleID(x)
## S4 replacement method for signature 'methylBase'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylRaw'
getSampleID(x)
## S4 replacement method for signature 'methylRaw'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylDiff'
getSampleID(x)
## S4 replacement method for signature 'methylDiff'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylRawListDB'
getSampleID(x)
## S4 replacement method for signature 'methylRawListDB'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylBaseDB'
getSampleID(x)
## S4 replacement method for signature 'methylBaseDB'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylRawDB'
getSampleID(x)
## S4 replacement method for signature 'methylRawDB'
getSampleID(x) \leftarrow value
## S4 method for signature 'methylDiffDB'
getSampleID(x)
## S4 replacement method for signature 'methylDiffDB'
getSampleID(x) \leftarrow value
```

Arguments

getTreatment 35

value

a valid replacement vector for the sample-ids of the object

Examples

```
data(methylKit)
#The Sample-Ids can be printed ..
getSampleID(methylBase.obj)

# .. or replaced.
newObj <- methylBase.obj
getSampleID(newObj) <- c("sample1","sample2","sample3","sample4")
getSampleID(newObj)</pre>
```

getTreatment

Get or Set treatment vector of methylKit object

Description

The function returns or replaces the treatment vector stored in any of the following methylKit objects: methylBase,methylRawList,methylBaseDB, methylRawListDB,methylDiffDB.

```
getTreatment(x)
getTreatment(x) <- value

getTreatment(x) <- value

## S4 method for signature 'methylRawList'
getTreatment(x)

## S4 replacement method for signature 'methylRawList'
getTreatment(x) <- value

## S4 method for signature 'methylBase'
getTreatment(x)

## S4 replacement method for signature 'methylBase'
getTreatment(x) <- value

## S4 method for signature 'methylDiff'
getTreatment(x)

## S4 replacement method for signature 'methylDiff'
getTreatment(x) <- value</pre>
```

```
## S4 method for signature 'methylRawListDB'
getTreatment(x)

## S4 replacement method for signature 'methylRawListDB'
getTreatment(x) <- value

## S4 method for signature 'methylBaseDB'
getTreatment(x)

## S4 replacement method for signature 'methylBaseDB'
getTreatment(x) <- value

## S4 method for signature 'methylDiffDB'
getTreatment(x)

## S4 replacement method for signature 'methylDiffDB'
getTreatment(x) <- value</pre>
```

Arguments

```
x a methylKit objectvalue a valid replacement for the treatment vector of the object
```

Examples

```
data(methylKit)
# The treatment vector can be printed ..
getTreatment(methylBase.obj)
# .. or replaced with a new one
newObj <- methylBase.obj
getTreatment(newObj) <- c(1,2,3,4)
getTreatment(newObj)</pre>
```

joinSegmentNeighbours Join directly neighbouring segments produced by methSeg

Description

Segmentation and clustering are two distinct steps in methSeg(), leading to adjacent segments of the same class. This leads to a bias segment length distributions, which is removed by joining those neighbours.

makeMethylDB 37

Usage

```
joinSegmentNeighbours(res)
```

Arguments

res

A GRanges object with segment classification and information prudoced by methSeg

Value

A GRanges object with segment classification and information.

See Also

methSeg

makeMethylDB

coerce methylKit objects from memory to flat file database objects

Description

The function converts in-memory methylKit objects to methylDB objects

Usage

```
makeMethylDB(obj, dbdir = getwd())
## S4 method for signature 'methylBase'
makeMethylDB(obj, dbdir = getwd())
## S4 method for signature 'methylRaw'
makeMethylDB(obj, dbdir = getwd())
## S4 method for signature 'methylDiff'
makeMethylDB(obj, dbdir = getwd())
## S4 method for signature 'methylRawList'
makeMethylDB(obj, dbdir = getwd())
```

Arguments

obj an methylBase, methylRaw, methylRawList or an methylDiff object

dbdir directory where flat file database(s) should be stored, defaults to getwd(), work-

ing directory.

Value

an methylBaseDB,methylRawDB, methylRawListDB or an methylDiffDB object

Examples

```
## Not run:
data(methylKit)

makeMethylDB(methylBase.obj,"my/path")
## End(Not run)
```

methRead

read file(s) to methylRaw or methylRawList objects

Description

The function reads a list of files or single files with methylation information for bases/region in the genome and creates a methylrawList or methylraw object. The information can be stored as flat file database by creating a methylrawlistDB or methylrawDB object.

```
methRead(
  location,
  sample.id,
  assembly,
  dbtype = NA,
  pipeline = "amp",
  header = TRUE,
  skip = 0,
  sep = "\t",
  context = "CpG",
  resolution = "base",
  treatment = NA,
  dbdir = getwd(),
 mincov = 10
)
## S4 method for signature 'character, character'
methRead(
  location,
  sample.id,
  assembly,
  dbtype,
  pipeline,
  header,
  skip,
  sep,
```

```
context,
  resolution,
  dbdir,
 mincov
)
## S4 method for signature 'character, ANY, ANY'
methRead(
  location,
  sample.id,
  assembly,
  dbtype,
  pipeline,
  header,
  skip,
  sep,
  context,
  resolution,
  dbdir,
 mincov
)
## S4 method for signature 'list,list,character'
methRead(
  location,
  sample.id,
  assembly,
  dbtype = NA,
  pipeline = "amp",
  header = TRUE,
  skip = 0,
  sep = " \t",
  context = "CpG",
  resolution = "base",
  treatment = NA,
  dbdir = getwd(),
 mincov = 10
)
## S4 method for signature 'list,ANY,ANY'
methRead(
  location,
  sample.id,
  assembly,
  dbtype = NA,
  pipeline = "amp",
  header = TRUE,
  skip = 0,
```

```
sep = "\t",
context = "CpG",
resolution = "base",
treatment = NA,
dbdir = getwd(),
mincov = 10
)
```

Arguments

location file location(s), either a list of locations (each a character string) or one location

string

sample.id sample.id(s)

assembly a string that defines the genome assembly such as hg18, mm9. this is just a

string for book keeping. It can be any string. Although, when using multiple files from the same assembly, this string should be consistent in each object.

dbtype type of the flat file database, currently only option other than NA is "tabix".

When "tabix" is given the objects are stored in tabix files, which are compressed and indexed. The default value is NA, in which case the objects are stored in

memory.

pipeline name of the alignment pipeline, it can be either "amp", "bismark", "bismarkCoverage",

"bismarkCytosineReport" or a list (default:'amp'). The methylation text files generated from other pipelines can be read as generic methylation text files by supplying a named list argument as "pipeline" argument. The named list should containt column numbers which denotes which column of the text file corresponds to values and genomic location of the methylation events. See De-

tails for more on possible values for this argument.

header if the input file has a header or not (default: TRUE)

skip number of lines to skip when reading. Can be set to 1 for bed files with track

line (default: 0)

sep seperator between fields, same as read.table argument (default: "\t")

context methylation context string, ex: CpG,CHG,CHH, etc. (default:CpG)

resolution designates whether methylation information is base-pair resolution or regional

resolution. allowed values 'base' or 'region'. Default 'base'

treatment a vector containing 0 and 1 denoting which samples are control which samples

are test

dbdir directory where flat file database(s) should be stored, defaults to getwd(), work-

ing directory.

mincov minimum read coverage to be included in the methylKit objects. defaults to

10. Any methylated base/region in the text files below the mincov value will be

ignored.

Value

returns methylRaw, methylRawList, methylRawDB, methylRawListDB object

Details

The output of methRead is determined by specific input arguments, as there are location, sample.id, assembly and dbtype. The first three are obligatory, while if the last argument is given database features are enabled. If then location refers to an uncompressed file the function will create a flat file database and the associated methylRawDB object will link to this database. If then location refers to an earlier created database file then the object will directly link to this database, skipping the preprocessing steps.

When pipeline argument is a list, it is exptected to provide a named list with following names. 'fraction' is a logical value, denoting if the column frequency of Cs has a range from [0-1] or [0-100]. If true it assumes range is [0-1]. 'chr.col" is the number of the column that has chrosome string. 'start.col' is the number of the column that has start coordinate of the base/region of the methylation event. 'end.col' is the number of the column that has end coordinate of the base/region of the methylation event. 'coverage.col' is the number of the column that has read coverage values. 'strand.col' is the number of the column that has strand information in the file has to be in the form of '+' or '-', 'freqC.col' is the number of the column that has the frequency of Cs. See examples to see how to read a generic methylation text file.

Other possible values for pipeline argument are 'amp', 'bismark', 'bismarkCoverage' and 'bismarkCytosineReport'. For 'amp' and 'bismark' the function expects a tabular format shown in the webpage (http://github.com/al2na/methylKit). "amp" and "bismark" expect identical input and are kept for historical reasons. 'amp' was a pipeline used in Akalin et al. 2012 Plos Genetics paper, publicly available in googlecode.

Bismark aligner can output methylation information per base in multiple formats. With pipeline='bismarkCoverage', the function reads bismark coverage files, which have chr,start,end, number of cytosines (methylated bases) and number of thymines (unmethylated bases) format. If bismark coverage files are used the function will not have the strand information,so beware of that fact. With pipeline='bismarkCytosineReport', the function expects cytosine report files from Bismark, which have chr,start, strand, number of cytosines (methylated bases), number of thymines (unmethylated bases),context and trinucletide context format.

The function can also read gzipped files. On unix systems, this is achieved by using zcat filename and feeding that into data.table::fread. On Windows, the file is first uncompressed then read into R using data.table::fread.

Examples

42 methSeg

```
# read one file as methylRaw object
myobj=methRead( file.list[[1]],
            sample.id="test1",assembly="hg18")
# read a generic text file containing CpG methylation values
# let's first look at the content of the file
generic.file=system.file("extdata", "generic1.CpG.txt",package = "methylKit")
read.table(generic.file,header=TRUE)
# And this is how you can read that generic file as a methylKit object
myobj=methRead( generic.file,
             pipeline=list(fraction=FALSE, chr.col=1, start.col=2, end.col=2,
                           coverage.col=4,strand.col=3,freqC.col=5),
             sample.id="test1",assembly="hg18")
# This creates tabix files that save methylation data
# Without specified dbdir first creates a folder named the following
# in working directory:
# paste("methylDB",Sys.Date(),paste(sample(c(0:9, letters, LETTERS),3,
# replace=TRUE),collapse=""))
# Then, saves tabix files from methylKit objects there
myobj=methRead( file.list,
               sample.id=list("test1","test2","ctrl1","ctrl2"),
               assembly="hg18", treatment=c(1,1,0,0),
               dbtype="tabix")
# This creates a single tabix files that saves methylation data
# first creates a "methylDB_objects" directory
# Then, saves tabix file from methylKit objects there
myobj=methRead(file.list[[1]],
               sample.id="test1",
               assembly="hg18",
               dbtype="tabix",dbdir="methylDB_objects")
 # tidy up
 rm(myobj)
 unlink(list.files(pattern = "methylDB",full.names = TRUE),recursive = TRUE)
```

methSeg

Segment methylation or differential methylation profile

Description

The function uses a segmentation algorithm (fastseg) to segment the methylation profiles. Following that, it uses gaussian mixture modelling to cluster the segments into k components. This

methSeg 43

process uses mean methylation value of each segment in the modeling phase. Each component ideally indicates quantitative classification of segments, such as high or low methylated regions.

Usage

```
methSeg(
  obj,
  diagnostic.plot = TRUE,
  join.neighbours = FALSE,
  initialize.on.subset = 1,
  ...
)
```

Arguments

obj

GRanges, methylDiff, methylDiffDB, methylRaw or methylRawDB . If the object is a GRanges it should have one meta column with methylation scores and has to be sorted by position, i.e. ignoring the strand information.

diagnostic.plot

if TRUE a diagnostic plot is plotted. The plot shows methylation and length statistics per segment group. In addition, it shows diagnostics from mixture modeling: the density function estimated and BIC criterion used to decide the optimum number of components in mixture modeling.

join.neighbours

if TRUE neighbouring segments that cluster to the same seg.group are joined by extending the ranges, summing up num.marks and averaging over seg.means.

initialize.on.subset

a numeric value indicating either percentage or absolute value of regions to subsample from segments before performing the mixture modeling. The value can be either between 0 and 1, e.g. 0.1 means that 10 integer higher than 1 to define the number of regions to sample. By default uses the whole dataset, which can be time consuming on large datasets. (Default: 1)

. . .

arguments to fastseg function in fastseg package, or to densityMclust in Mclust package, could be used to fine tune the segmentation algorithm. E.g. Increasing "alpha" will give more segments. Increasing "cyberWeight" will give also more segments. "maxInt" controls the segment extension around a breakpoint. "minSeg" controls the minimum segment length. "G" argument denotes number of components used in BIC selection in mixture modeling. For more details see fastseg and Mclust documentation.

Details

To be sure that the algorithm will work on your data, the object should have at least 5000 records

After initial segmentation with fastseg(), segments are clustered into self-similar groups based on their mean methylation profile using mixture modeling. Mixture modeling estimates the initial parameters of the distributions by using the whole dataset. If "initialize.on.subset" argument set as described, the function will use a subset of the data to initialize the parameters of the mixture modeling prior to the Expectation-maximization (EM) algorithm used by Mclust package.

44 methSeg2bed

Value

A GRanges object with segment classification and information. 'seg.mean' column shows the mean methylation per segment. 'seg.group' column shows the segment groups obtained by mixture modeling

Author(s)

Altuna Akalin, contributions by Arsene Wabo and Katarzyna Wreczycka

See Also

methSeg2bed, joinSegmentNeighbours

Examples

```
download.file(
"https://raw.githubusercontent.com/BIMSBbioinfo/compgen2018/master/day3_diffMeth/data/H1.chr21.chr22.rds",
    destfile="H1.chr21.chr22.rds",method="curl")

mbw=readRDS("H1.chr21.chr22.rds")

# it finds the optimal number of componets as 6
    res=methSeg(mbw,diagnostic.plot=TRUE,maxInt=100,minSeg=10)

# however the BIC stabilizes after 4, we can also try 4 componets
    res=methSeg(mbw,diagnostic.plot=TRUE,maxInt=100,minSeg=10,G=1:4)

# get segments to BED file
    methSeg2bed(res,filename="H1.chr21.chr22.trial.seg.bed")

unlink(list.files(pattern="H1.chr21.chr22",full.names=TRUE))
```

methSeg2bed

Export segments to BED files

Description

The segments are color coded based on their score (methylation or differential methylation value). They are named by segment group (components in mixture modeling) and the score in the BED file is obtained from 'seg.mean' column of segments object.

methylBase-class 45

Usage

```
methSeg2bed(
  segments,
  filename,
  trackLine = "track name='meth segments' description='meth segments' itemRgb=On",
  colramp = colorRamp(c("gray", "green", "darkgreen"))
)
```

Arguments

segments GRanges object with segment classification and information. This should be the

result of methSeg function

filename name of the output data trackLine UCSC browser trackline

color scale to be used in the BED display defaults to gray, green, darkgreen scale.

Value

A BED files with the segmented data which can be visualized in the UCSC browser

See Also

methSeg

methylBase-class

An S4 class for methylation events sampled in multiple experiments

Description

This class is designed to contain methylation information such as coverage, number of methylated bases, etc.. The methylation events contained in the class must be sampled in multiple experiments (ex: only CpG bases covered in multiple experiments are stored in the object of this class). The class extends data.frame and creates an object that holds methylation information and genomic location. The object belonging to this class is produced by unite function.

Slots

```
sample.ids: character vector for ids of samples in the object
assembly: name of the genome assembly
context: context of methylation. Ex: CpG,CpH,CHH, etc
treatment: treatment vector denoting which samples are test and control
coverage.index: vector denoting which columns in the data correspons to coverage values
numCs.index: vector denoting which columns in the data correspons to number of methylatedCs
values
```

46 methylBase.obj

numTs.index: vector denoting which columns in the data correspons to number of unmethylated Cs values

destranded: logical value. If TRUE object is destranded, if FALSE it is not.

resolution: resolution of methylation information, allowed values: 'base' or 'region'

Details

methylBase class extends data.frame class therefore providing novice and experienced R users with a data structure that is well known and ubiquitous in many R packages.

Subsetting

In the following code snippets, x is a methylBase. Subsetting by x[i,] will produce a new object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[.

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

Coercion

methylBase object can be coerced to GRanges object via as function.

Examples

```
data(methylKit)
library(GenomicRanges)
my.gr=as(methylBase.obj,"GRanges")
```

methylBase.obj

Example methylBase object.

Description

methylBase, methylDiff and methylRawList. You can load the data using data(methylKit)

Format

methylBase.obj object stores the location and methylation information for bases that are covered in all samples. methylBase partially extends data. frame S3 class.

methylBaseDB-class 47

methylBaseDB-class	An S4 class for storing methylation events sampled in multiple experi-
	ments as flat file database

Description

This class is designed to contain methylation information such as coverage, number of methylated bases, etc... The class creates an object that holds methylation information and genomic location as flat file database. The object belonging to this class is produced by unite function.

Slots

```
dbpath: path to flat file database(s)

num.records: number of records (lines) in the object

sample.ids: character vector for ids of samples in the object

assembly: name of the genome assembly

context: context of methylation. Ex: CpG,CpH,CHH, etc

treatment: treatment vector denoting which samples are test and control

coverage.index: vector denoting which columns in the data correspond to coverage values

numCs.index: vector denoting which columns in the data correspond to number of methylatedCs

values

numTs.index: vector denoting which columns in the data correspond to number of unmethylated

Cs values

destranded: logical value. If TRUE object is destranded, if FALSE it is not.

resolution: resolution of methylation information, allowed values: 'base' or 'region'

dbtype: string for type of the flat file database, ex: tabix
```

Details

methylBaseDB class has the same functionality as methylBase class, but the data is saved in a flat database file and therefore allocates less space in memory.

Subsetting

In the following code snippets, x is a methylBaseDB. Subsetting by x[i,] will produce a new methylBase object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[.

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

48 methylDiff-class

Coercion

methylBaseDB object can be coerced to: GRanges object via as function. methylBase object via as function.

Examples

```
data(methylKit)
methylBaseDB.obj <- unite(methylRawList.obj,save.db=TRUE,dbdir="methylDB")
library(GenomicRanges)
my.gr=as(methylBaseDB.obj,"GRanges")

# remove Database again
rm(methylBaseDB.obj)
unlink("methylDB",recursive=TRUE)</pre>
```

methylDiff-class

An S4 class that holds differential methylation information

Description

This class is designed to hold statistics and locations for differentially methylated regions/bases. It extends data.frame class. calculateDiffMeth function returns an object with methylDiff class.

Slots

```
sample.ids ids/names of samples in a vector
assembly a name of genome assembly, such as :hg18,mm9, etc
context numeric vector identifying which samples are which group
treatment numeric vector identifying which samples are which group
destranded logical denoting if methylation inormation is destranded or not
resolution string either 'base' or 'region' defining the resolution of methylation information
.Data data.frame holding the locations and statistics
```

Details

methylDiff class extends data.frame class therefore providing novice and experienced R users with a data structure that is well known and ubiquitous in many R packages.

Subsetting

In the following code snippets, x is a methylDiff object. Subsetting by x[i,] will produce a new object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[.

methylDiff.obj 49

Coercion

methylDiff object can be coerced to GRanges object via as function.

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

Examples

```
data(methylKit)
library(GenomicRanges)
my.gr=as(methylDiff.obj,"GRanges")
```

methylDiff.obj

Example methylKit objects.

Description

methylBase, methylDiff and methylRawList. You can load the data using data(methylKit)

Format

The Differential methylation information is stored in methylDiff.obj object. methylBase partially extends data, frame S3 class.

methylDiffDB-class

An S4 class that holds differential methylation information as flat file database

Description

This class is designed to hold statistics and locations for differentially methylated regions/bases as flat file database. calculateDiffMeth function returns an object with methylDiffDB class.

Slots

```
dbpath: path to flat file database(s)
num.records: number of records (lines) in the object
sample.ids ids/names of samples in a vector
assembly a name of genome assembly, such as :hg18,mm9, etc
context numeric vector identifying which samples are which group
```

50 methylDiffDB-class

treatment numeric vector identifying which samples are which group
destranded logical denoting if methylation inormation is destranded or not
resolution string either 'base' or 'region' defining the resolution of methylation information
dbtype: string for type of the flat file database, ex: tabix

Details

methylDiffDB class has the same functionality as methylDiff class, but the data is saved in a flat database file and therefore allocates less space in memory.

Subsetting

In the following code snippets, x is a methylDiffDB. Subsetting by x[i,] will produce a new object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[.

Coercion

methylDiffDB object can be coerced to: GRanges object via as function. methylDiff object via as function.

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

Examples

```
data(methylKit)
methylDiffDB.obj <- calculateDiffMeth(methylBase.obj,save.db=TRUE,dbdir="methylDB")
library(GenomicRanges)
my.gr=as(methylDiffDB.obj,"GRanges")
# remove Database again
rm(methylDiffDB.obj)
unlink("methylDB",recursive=TRUE)</pre>
```

methylKit-defunct 51

methylKit-defunct

Deprecated/Defunct functions

Description

These are deprecated or defunct functions. Most of them are replaced by genomation functions. See the vignette for examples on how to use genomation functions for annotation purposes.

Usage

```
annotate.WithFeature()
annotate.WithFeature.Flank()
annotate.WithGenicParts()
read.bed()
read.feature.flank()
read.transcript.features()
getFeatsWithTargetsStats()
getFlanks()
getMembers()
getTargetAnnotationStats()
plotTargetAnnotation()
read()
read.bismark()
adjust.methylC()
get.methylDiff()
```

methylRaw-class

An S4 class for holding raw methylation data from an alignment pipeline.

52 methylRaw-class

Description

This object stores the raw mehylation data that is read in through read function and extends data. frame. The raw methylation data is basically percent methylation values and read coverage values per genomic base/region.

Slots

```
sample.id: string for an identifier of the sample assembly: string for genome assembly, ex: hg18,hg19,mm9 context: methylation context string, ex: CpG,CpH,CHH, etc. resolution: resolution of methylation information, 'base' or 'region'
```

Details

methylRaw class extends data.frame class therefore providing novice and experienced R users with a data structure that is well known and ubiquitous in many R packages.

Subsetting

In the following code snippets, x is a methylRaw. Subsetting by x[i,] will produce a new object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[.

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

Coercion

methylRaw object can be coerced to GRanges object via as function.

Examples

methylRawDB-class 53

methylRawDB-class

An S4 class for storing raw methylation data as flat file database.

Description

This object stores the raw mehylation data that is read in through read function as flat file database. The raw methylation data is basically percent methylation values and read coverage values per genomic base/region.

Slots

```
dbpath: path to flat file database
num.records: number of records (lines) in the object
sample.id: string for an identifier of the sample
assembly: string for genome assembly, ex: hg18,hg19,mm9
context: methylation context string, ex: CpG,CpH,CHH, etc.
resolution: resolution of methylation information, 'base' or 'region'
dbtype: string for type of the flat file database, ex: tabix
```

Details

methylRawDB is created via read function and has the same functionality as methylRaw class, but the data is saved in a flat database file and therefore allocates less space in memory.

Subsetting

In the following code snippets, x is a methylRawDB. Subsetting by x[i,] will produce a new methylRaw object if subsetting is done on rows. Column subsetting is not directly allowed to prevent errors in the downstream analysis. see ?methylKit[. x[] will return the methylRawDB object as new methylRaw object

Accessors

The following functions provides access to data slots of methylDiffDB: - getData: get the data slot from the methylKit objects, - getAssembly: get assembly of the genome, - getContext: get the context of methylation

Coercion

methylRawDB object can be coerced to: GRanges object via as function. methylRaw object via as function.

54 methylRawList-class

Examples

```
# example of a raw methylation data contained as a text file
read.table(system.file("extdata", "control1.myCpG.txt", package = "methylKit"),
header=TRUE, nrows=5)
methylRawDB.obj <- methRead(</pre>
system.file("extdata", "control1.myCpG.txt", package = "methylKit"),
                        sample.id = "ctrl1", assembly = "hg18",
                        dbtype = "tabix", dbdir = "methylDB")
# example of a methylRawDB object
methylRawDB.obj
str(methylRawDB.obj)
library(GenomicRanges)
#coercing methylRawDB object to GRanges object
my.gr=as(methylRawDB.obj,"GRanges")
#coercing methylRawDB object to methylRaw object
myRaw=as(methylRawDB.obj,"methylRaw")
# remove Database again
rm(methylRawDB.obj)
unlink("methylDB",recursive=TRUE)
```

methylRawList-class

An S4 class for holding a list of methylRaw objects.

Description

This class stores the list of methylRaw objects. Functions such as lapply can be used on this list. It extends list class. This object is primarily produced by methRead function.

Usage

```
methylRawList(..., treatment)
```

Arguments

```
... vector of methylRaw objects treatment vector of treatment values
```

Slots

```
treatment numeric vector denoting control and test samples .Data a list of methylRaw objects
```

methylRawList.obj 55

Constructor

methylRawList(...) combine multiple methylRaw objects supplied in ... into a methylRawList object.

Examples

```
data(methylKit)

#applying functions designed for methylRaw on methylRawList object
lapply(methylRawList.obj,"getAssembly")
```

methylRawList.obj

Example methylRawList object.

Description

methylBase, methylDiff and methylRawList. You can load the data using data(methylKit)

Format

Methylation data from multiple the samples regardless of common coverage are stored in methyl-RawList.obj object. methylRawList extends list S3 class

methylRawListDB-class An S4 class for holding a list of methylRawDB objects.

Description

This class stores the list of methylRawDB objects. Functions such as lapply can be used on this list. It extends list class. This object is primarily produced by methRead function.

Usage

```
methylRawListDB(..., treatment)
```

Arguments

```
... vector of methylRawDB files treatment vector of treatment values
```

Slots

```
treatment numeric vector denoting control and test samples
.Data a list of methylRawDB objects
```

56 normalizeCoverage

Constructor

methylRawListDB(...) combine multiple methylRawDB objects supplied in ... into a methyl-RawListDB object.

Examples

```
file.list=list( system.file("extdata", "test1.myCpG.txt",
package = "methylKit"),
                system.file("extdata", "test2.myCpG.txt",
                package = "methylKit"),
                system.file("extdata", "control1.myCpG.txt",
                package = "methylKit"),
                system.file("extdata", "control2.myCpG.txt",
                package = "methylKit") )
methylRawListDB.obj <- methRead(file.list,</pre>
sample.id = list("test1","test2","ctrl1","ctrl2"),
                            assembly = "hg18", treatment = c(1,1,0,0),
                            dbtype = "tabix",dbdir = "methylDB")
#applying functions designed for methylRawDB on methylRawListDB object
lapply(methylRawListDB.obj,"getAssembly")
# remove Database again
rm(methylRawListDB.obj)
unlink("methylDB",recursive=TRUE)
```

normalizeCoverage

normalize read coverage between samples

Description

The function normalizes coverage values between samples using a scaling factor derived from differences between mean or median of coverage distributions

```
normalizeCoverage(obj,method="median",chunk.size,save.db,...)
## S4 method for signature 'methylRawList'
normalizeCoverage(
  obj,
  method = "median",
  chunk.size = 1e+06,
  save.db = FALSE,
  ...
```

normalizeCoverage 57

```
## S4 method for signature 'methylRawListDB'
normalizeCoverage(
  obj,
  method = "median",
  chunk.size = 1e+06,
  save.db = TRUE,
  ...
)
```

Arguments

obj methylRawList or methylRawListDB object

method a string "mean" or "median" which denotes median or mean should be used to

calculate scaling factor. (Default:median)

chunk.size Number of rows to be taken as a chunk for processing the methylRawListDB

objects. (Default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_filtered" to current file-name if database already exists or generate new file with filename "sampleID_filtered" dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

Value

a methylRawList or methylRawList object depending on class of input object

Details

The parameter chunk.size is only used when working with methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylRawListDB, while being per default FALSE for methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Author(s)

Altuna Akalin

58 PCASamples

Examples

```
data(methylKit)
# normalize by the median coverage
newObj = normalizeCoverage(methylRawList.obj,method="median")
# normalize by mean coverage and save to database in folder methylDB
newDBObj = normalizeCoverage(methylRawList.obj,method="mean",
save.db=TRUE,dbdir="methylDB")
```

PCASamples

Principal Components Analysis of Methylation data

Description

The function does a PCA analysis using prcomp function using percent methylation matrix as an input.

```
PCASamples(.Object, screeplot=FALSE, adj.lim=c(0.0004,0.1), scale=TRUE,
center=TRUE,comp=c(1,2),transpose=TRUE,sd.filter=TRUE,
           sd.threshold=0.5,filterByQuantile=TRUE,obj.return=FALSE,chunk.size)
## S4 method for signature 'methylBase'
PCASamples(
  .Object,
  screeplot,
  adj.lim,
  scale,
  center,
  comp,
  transpose,
  sd.filter,
  sd.threshold,
  filterByQuantile,
  obj.return
)
## S4 method for signature 'methylBaseDB'
PCASamples(
  .Object,
  screeplot = FALSE,
  adj.lim = c(4e-04, 0.1),
  scale = TRUE,
  center = TRUE,
  comp = c(1, 2),
```

59 **PCASamples**

```
transpose = TRUE,
  sd.filter = TRUE,
  sd.threshold = 0.5,
  filterByQuantile = TRUE,
  obj.return = FALSE,
 chunk.size = 1e+06
)
```

Arguments

.Object

screeplot a logical value indicating whether to plot the variances against the number of the principal component. (default: FALSE) a vector indicating the propotional adjustment of xlim (adj.lim[1]) and ylim adj.lim (adj.lim[2]). This is primarily used for adjusting the visibility of sample labels on the on the PCA plot. (default: c(0.0004,0.1)) scale logical indicating if prcomp should scale the data to have unit variance or not

a methylBase or methylBaseDB object

(default: TRUE)

logical indicating if prcomp should center the data or not (default: TRUE) center

vector of integers with 2 elements specifying which components to be plotted. comp

transpose if TRUE (default) percent methylation matrix will be transposed, this is equivalent to doing PCA on variables that are regions/bases. The resulting plot will location of samples in the new coordinate system if FALSE the variables for the matrix will be samples and the resulting plot whill show how each sample (variable) contributes to the principle component.the samples that are highly

correlated should have similar contributions to the principal components.

sd.filter If TRUE, the bases/regions with low variation will be discarded prior to PCA (default:TRUE)

sd.threshold A numeric value. If filterByQuantile is TRUE, the value should be between

> 0 and 1 and the features whose standard deviations is less than the quantile denoted by sd. threshold will be removed. If filterByQuantile is FALSE, then features whose standard deviations is less than the value of sd. threshold

will be removed.(default:0.5)

filterByQuantile

A logical determining if sd. threshold is to be interpreted as a quantile of all standard deviation values from bases/regions (the default), or as an absolute

value

if the result of prcomp function should be returned or not. (Default:FALSE) obj.return

chunk.size Number of rows to be taken as a chunk for processing the methylRawListDB

objects, default: 1e6

Value

The form of the value returned by PCASamples is the summary of principal component analysis by prcomp.

60 percMethylation

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

Note

cor option is not in use anymore, since prcomp is used for PCA analysis instead of princomp

Examples

percMethylation

get percent methylation scores from methylBase or methylBaseDB object

Description

get percent methylation scores from methylBase or methylBaseDB object

```
percMethylation(
   methylBase.obj,
   rowids = FALSE,
   save.txt = FALSE,
   chunk.size = 1e+06
)

## S4 method for signature 'methylBase'
percMethylation(methylBase.obj, rowids = FALSE)

## S4 method for signature 'methylBaseDB'
percMethylation(
   methylBase.obj,
   rowids = FALSE,
   save.txt = FALSE,
   chunk.size = 1e+06
)
```

pool 61

Arguments

methylBase.obj	a methylBase or methylBaseDB object
rowids	$if\ TRUE, matrix\ rownames\ have\ identifiers\ as\ base/region\ location\ (default:FALSE)$
save.txt	if TRUE, the matrix will be written to a text file, but only for methylBaseDB objects (default: FALSE)
chunk.size	Number of rows to be taken as a chunk for processing the methylBaseDB objects (default: 1e6)

Value

matrix with percent methylation values per base/region across all samples, row names would be base/region identifiers

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

Examples

```
data(methylKit)
mat=percMethylation(methylBase.obj)
head(mat)
```

pool

Pool replicates within groups to a single sample per group

Description

The function sums up coverage, numCs and numTs values within each group so one representative sample for each group will be created in a new methylBase object

```
pool(obj, sample.ids, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'methylBase'
pool(obj, sample.ids, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'methylBaseDB'
pool(obj, sample.ids, chunk.size = 1e+06, save.db = TRUE, ...)
```

62 pool

Arguments

obj	methylBase or methylBaseDB object with two groups or more and each group should have multiple samples
sample.ids	a character vector of new sample.ids ex:c("test","control"), should follow the same order as unique treatment vector, and should be equal to the length of the unique treatment vector
chunk.size	Number of rows to be taken as a chunk for processing the methylRawListDB objects, default: 1e6
save.db	A Logical to decide whether the resulting object should be saved as flat file database or not, default: explained in Details sections
	optional Arguments used when save.db is TRUE suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: The default suffix is a 13-character random string appended to the fixed prefix "methylBase", e.g. "methylBase_16d3047c1a254.txt.bgz". dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for already existing database dbtype The type of the flat file database, currently only option is "tabix" (only used for newly stored databases)

Value

a methylBase or methylBaseDB object depending on class of input object

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save db is per default TRUE for methylDB objects as methylBaseDB, while being per default FALSE for methylBase. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Author(s)

Altuna Akalin

Examples

```
data(methylKit)

# methylBase.obj has two groups, each group has two samples,
# the following function will pool the samples in each group
# so that each group will be represented by one pooled sample
pooled.methylBase=pool(methylBase.obj,sample.ids=c("test","control"))
```

processBismarkAln 63

processBismarkAln

Get methylation percentage from sorted Bismark alignments

Description

The function calls methylation percentage per base from sorted Bismark SAM or BAM files and reads methylation information as methylKit objects. Bismark is a popular aligner for high-throughput bisulfite sequencing experiments and it outputs its results in SAM format by default, and can be converted to BAM. Bismark SAM/BAM format contains aligner specific tags which are absolutely necessary for methylation percentage calling using processBismarkAln. SAM/BAM files from other aligners will not work with this function.

```
processBismarkAln(
  location,
  sample.id,
  assembly,
  save.folder = NULL,
  save.context = c("CpG"),
  read.context = "CpG",
  nolap = FALSE,
 mincov = 10,
 minqual = 20,
  phred64 = FALSE,
  treatment = NULL,
  save.db = FALSE,
  verbose = 1
)
## S4 method for signature 'character, character, character'
processBismarkAln(
  location,
  sample.id,
  assembly,
  save.folder = NULL,
  save.context = c("CpG"),
  read.context = "CpG",
  nolap = FALSE,
 mincov = 10,
 minqual = 20,
  phred64 = FALSE,
  treatment = NULL,
  save.db = FALSE,
  verbose = 1
)
```

64 processBismarkAln

```
## S4 method for signature 'list,list,character'
processBismarkAln(
  location,
  sample.id,
  assembly,
  save.folder = NULL,
  save.context = c("CpG"),
 read.context = "CpG",
 nolap = FALSE,
 mincov = 10,
 minqual = 20,
 phred64 = FALSE,
  treatment = NULL,
  save.db = FALSE,
  verbose = 1
)
```

Arguments

location	location of sam or bam file(s). If multiple files are given this argument must be a list.
sample.id	the id(s) of samples in the same order as file. If multiple sam files are given this arugment must be a list.
assembly	string that determines the genome assembly. Ex: mm9,hg18 etc. This is just a string for book keeping. It can be any string. Although, when using multiple files from the same assembly, this string should be consistent in each object.
save.folder	The folder which will be used to save methylation call files, if set to NULL no methylation call file will be saved as a text file. The files saved can be read into R in less time using methRead function in methylKit
save.context	A character vector consisting following strings: "CpG","CHG","CHH". The methylation percentages for these methylation contexts will be saved to save.folder
read.context	One of the 'CpG','CHG','CHH' or 'none' strings. Determines what type of methylation context will be read-in to the memory which can be immediately used for analysis. If given as 'none', processBismarkAln will not return any object, but if a save.folder argument given it will save the methylation percentage call files.
nolap	if set to TRUE and the SAM/BAM file has paired-end reads, the one read of the overlapping paired-end read pair will be ignored for methylation calling.
mincov	minimum read coverage to call a methylation status for a base.
minqual	minimum phred quality score to call a methylation status for a base.
phred64	logical (default: FALSE) you will not need to set this TRUE, Currently bismark gives only phred33 scale
treatment	treatment vector only to be used when location and sample.id parameters are lists and you are trying to read-in multiple samples that are related to eachother in down-stream analysis.

readMethylDB 65

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not (default: FALSE). With the default value, a text file containing methylation values will be saved. If TRUE, database will either be saved to location save.folder or if this is NULL, to a new folder in the current working directory named after this scheme: "methylDB <Date> <3randomlettersornum-

bers>"

verbose logical set verbosity of methCall (default: TRUE)

Value

methylRaw or methylRawList object

Note

SAM files should be sorted with samtools sort or unix sort. Other sorting methods can alter the order of fields(columns) in the SAM file and that will result in an error when using processBismarkAln().

Examples

```
# reading one bismark file:
my.file=system.file("extdata", "test.fastq_bismark.sorted.min.sam",
                              package = "methylKit")
obj=processBismarkAln(my.file, "test", assembly="hg18", save.folder=NULL,
                 save.context="CpG",read.context="CpG")
# reading multiple files
file.list2=list(system.file("extdata", "test.fastq_bismark.sorted.min.sam",
package = "methylKit"),
               system.file("extdata", "test.fastq_bismark.sorted.min.sam",
               package = "methylKit"),
              system.file("extdata", "test.fastq_bismark.sorted.min.sam",
              package = "methylKit"),
               system.file("extdata", "test.fastq_bismark.sorted.min.sam",
                package = "methylKit"))
 objs=processBismarkAln(location=file.list2
             , sample.id=list("test1", "test2", "ctrl1", "ctrl1"), assembly="hg18",
             save.folder=NULL, save.context=NULL, read.context="CpG",
             nolap=FALSE, mincov=10, minqual=20, phred64=FALSE,
             treatment=c(1,1,0,0))
```

readMethylDB

load tabix file with header to methylDB

Description

The function reads the header from a given tabix file and loads it into corresponding methylDB object.

66 reconstruct

Usage

```
readMethylDB(dbpath)
```

Arguments

dbpath

path to a tabix file with header

Value

an methylBaseDB,methylRawDB, methylRawListDB or an methylDiffDB object

Examples

```
## Not run:
data(methylKit)

baseDB.obj <- makeMethylDB(methylBase.obj,"my/path")
mydbpath <- getDBPath(baseDB.obj)
rm(baseDB.obj)
readMethylDB(mydbpath)

## End(Not run)</pre>
```

reconstruct

Reconstruct methylBase or methylBaseDB object based on a new methylation percentage matrix

Description

The function reconstructs a new methylBase object from an input methylBase object and percent methylation matrix. Basically, it uses the read coverages in the input methylBase object and deduces new number of methylated Cs and unmethylated Cs based on the input percent methylation matrix. It is ideally to be used to reconstruct methylBase objects after batch correction on percent methylation values. The percent methylation matrix rows must match methylBase object rows in order ,and in addition column order (the order of samples) in input methylBase must match the order in percent methylation matrix.

```
reconstruct(methMat, mBase, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'ANY,methylBase'
reconstruct(methMat, mBase, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'ANY,methylBaseDB'
reconstruct(methMat, mBase, chunk.size = 1e+06, save.db = TRUE, ...)
```

reconstruct 67

Arguments

methMat percent methylation matrix, row order and order of the samples same as the

methylBase object

mBase methylBase or methylBaseDB object to be reconstructed

chunk.size Number of rows to be taken as a chunk for processing the methylBaseDB objects

(default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_reconstructed" to current filename if database already exists or generate new file with filename "methyl-

Base_reconstructed"

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only

used for newly stored databases)

Value

new methylBase or methylBase object where methylation percentage matches input methMat and coverages matches input mBase

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylBaseDB, while being per default FALSE for methylBase. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Note

Batch effect correction (if any batch effect exists) is a tricky issue. We provide some simple ways to deal with it (see assocComp and removeComp), But if you can find other ways to correct for batch effects and want to create a methylBase object with the corrected percent methylation values, you can use this function.

Author(s)

Altuna Akalin

Examples

```
data(methylKit)
# get percent methylation
mat=percMethylation(methylBase.obj)

# do some changes in the matrix
# this is just a toy example
# ideally you want to correct the matrix
# for batch effects
mat[mat==100]=80

# reconstruct the methylBase from the corrected matrix
newobj=reconstruct(mat,methylBase.obj)
```

regionCounts

Get regional counts for given GRanges or GRangesList object

Description

Convert methylRaw, methylRawDB, methylRawList, methylRawListDB, methylBase or methylBaseDB object into regional counts for a given GRanges or GRangesList object.

```
regionCounts(object,regions,cov.bases=0,strand.aware=FALSE,chunk.size,save.db,...)
## S4 method for signature 'methylRaw,GRanges'
regionCounts(
 object,
 regions,
 cov.bases = 0,
 strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylBase,GRanges'
regionCounts(
  object,
  regions,
 cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
```

```
)
## S4 method for signature 'methylRaw, GRangesList'
regionCounts(
  object,
 regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylBase,GRangesList'
regionCounts(
  object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylRawList,GRanges'
regionCounts(
  object,
 regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylRawList,GRangesList'
regionCounts(
 object,
 regions,
 cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = FALSE,
)
## S4 method for signature 'methylRawDB,GRanges'
regionCounts(
```

```
object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = TRUE,
)
## S4 method for signature 'methylRawDB,GRangesList'
regionCounts(
  object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = TRUE,
)
## S4 method for signature 'methylRawListDB,GRanges'
regionCounts(
 object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = TRUE,
)
## S4 method for signature 'methylRawListDB,GRangesList'
regionCounts(
  object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
  chunk.size = 1e+06,
  save.db = TRUE,
)
## S4 method for signature 'methylBaseDB,GRanges'
regionCounts(
  object,
  regions,
  cov.bases = 0,
  strand.aware = FALSE,
```

```
chunk.size = 1e+06,
    save.db = TRUE,
    ...
)

## S4 method for signature 'methylBaseDB,GRangesList'
regionCounts(
    object,
    regions,
    cov.bases = 0,
    strand.aware = FALSE,
    chunk.size = 1e+06,
    save.db = TRUE,
    ...
)
```

Arguments

 $object \\ a \ \text{methylRaw}, \\ \text{methylRawDB}, \\ \text{methylRawList}, \\ \text{methylRawListDB}, \\ \text{methylBase} \\$

or methylBaseDB object

NOTE: The given regions (Granges/GrangesList object) will be orderd based on chromosome and position before searching for overlaps, so the resulting methylKit object might have a different ording than expected. See details section for the reasoning of this choice and ways to still get custom ordering of

regions.

regions a GRanges or GRangesList object. Make sure that the GRanges objects are

unique in chr,start,end and strand columns. You can make them unique by using

unique() function.

cov.bases number minimum bases covered per region (Default:0). Only regions with base

coverage above this threshold are returned.

strand.aware if set to TRUE only CpGs that match the strand of the region will be summa-

rized. (default:FALSE)

chunk.size Number of rows to be taken as a chunk for processing the methylDB objects

(default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_regions" to current filename if database already exists or generate new file with filename "sampleID_regions"

or "methylBase_filtered" dependent on input object

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only

used for newly stored databases)

72 removeComp

Value

a new methylRaw,methylBase or methylRawList object. If strand. aware is set to FALSE (default). Even though the resulting object will have the strand information of regions it will still contain methylation information from both strands.

Details

The given regions (Granges/GrangesList object) will be orderd based on chromosome and position before searching for overlaps, so the resulting methylKit object might have a different ording than expected. We are doing this is to ensure that resulting output is consistent for in-memory and database based objects, as database based objects always have to be sorted to enable tabix indexing and providing fast random access.

If you to still want get a custom ordering of the output regions you can access the single regions in any object providing your indices to the select or extract functions.

The parameter chunk.size is only used when working with methylRawDB, methylBaseDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylRawDB, methylBaseDB or methylRawListDB, while being per default FALSE for methylRaw, methylBase or methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Examples

```
data(methylKit)

# get the windows of interest as a GRanges object, this can be any set
# of genomic locations
library(GenomicRanges)
my.win=GRanges(seqnames="chr21",
ranges=IRanges(start=seq(from=9764513,by=10000,length.out=20),width=5000) )

# getting counts per region
regional.methylRaw=regionCounts(object=methylRawList.obj, regions=my.win,
cov.bases=0,strand.aware=FALSE)
```

removeComp 73

Description

This function can remove a given principal componet from a given methylBase object. First, it calculates principal components from percent methylation matrix and removes the given component(s), reconstructs the methylation matrix then reconstructs number of methylated and unmethylated Cs per position based on the reconstructed percent methylation matrix, and finally returns a new methylBase object.

Usage

```
removeComp(mBase, comp = NULL, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'methylBase'
removeComp(mBase, comp = NULL, chunk.size = 1e+06, save.db = FALSE, ...)
## S4 method for signature 'methylBaseDB'
removeComp(mBase, comp = NULL, chunk.size = 1e+06, save.db = TRUE, ...)
```

Arguments

mBase	methylBase or methyl	lBaseDB object with no N	A values, that means all bases
-------	----------------------	--------------------------	--------------------------------

should be covered in all samples.

comp vector of component numbers to be removed

chunk.size Number of rows to be taken as a chunk for processing the methylBaseDB objects

(default: 1e6)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_reconstructed" to current filename if database already exists or generate new file with filename "methyl-

Base_reconstructed"

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

dbtype The type of the flat file database, currently only option "tabix"

Value

new methylBase or methylBaseDB object

Details

The parameter chunk.size is only used when working with methylBaseDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

74 reorganize

The parameter save db is per default TRUE for methylDB objects as methylBaseDB, while being per default FALSE for methylBase. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Examples

```
data(methylKit)
# remove 1st principal component
newObj=removeComp(methylBase.obj,comp=1)
# remove 3rd and 4th principal components
newObj=removeComp(methylBase.obj,comp=c(3,4))
```

reorganize

Reorganize methylKit objects by creating new objects from subset of samples

Description

The function creates a new methylRawList, methylRawListDB, methylBase or methylBaseDB object by selecting a subset of samples from the input object, which is a methylRawList or methylBase object. You can use the function to partition a large methylRawList or methylBase object to smaller object based on sample ids or when you want to reorder samples and/or give a new treatmet vector.

```
reorganize(
  methylObj,
  sample.ids,
  treatment,
  chunk.size = 1e+06,
  save.db = FALSE,
  ...
)

## S4 method for signature 'methylBase'
reorganize(
  methylObj,
  sample.ids,
  treatment,
  chunk.size = 1e+06,
  save.db = FALSE,
  ...
)
```

reorganize 75

```
## S4 method for signature 'methylRawList'
reorganize(
 methylObj,
  sample.ids,
  treatment,
  chunk.size = 1e+06,
 save.db = FALSE,
)
## S4 method for signature 'methylRawListDB'
reorganize(
 methylObj,
 sample.ids,
  treatment,
  chunk.size = 1e+06,
  save.db = TRUE,
)
## S4 method for signature 'methylBaseDB'
reorganize(
 methylObj,
  sample.ids,
  treatment,
  chunk.size = 1e+06,
  save.db = TRUE,
)
```

Arguments

methylObj	$a\ {\tt methylRawListDB}, {\tt methylBase}\ or\ {\tt methylBaseDB}\ object$
sample.ids	a vector for sample.ids to be subset. Order is important and the order should be similar to treatment. sample.ids should be a subset or reordered version of sample ids in the input object.
treatment	treatment vector, should be same length as sample.ids vector
chunk.size	Number of rows to be taken as a chunk for processing the methylBaseDB or methylRawListDB objects, default: 1e6
save.db	A Logical to decide whether the resulting object should be saved as flat file database or not, default: explained in Details sections
	optional Arguments used when save.db is TRUE
	suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: For "methylBase": The default

suffix is a 13-character random string appended to the fixed prefix "methylBase", e.g. "methylBase_16d3047c1a254.txt.bgz". For "methylRawList": ignored.

76 reorganize

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for already existing database

dbtype The type of the flat file database, currently only option "tabix"

Value

returns a methylRawList, methylRawListDB, methylBase or methylBaseDB object depending on the input object

Details

The parameter chunk.size is only used when working with methylBaseDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylBaseDB and methylRawListDB, while being per default FALSE for methylBase and methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

Examples

select 77

select

selects rows from of methylKit objects

Description

The function returns a subset of data contained in the methylKit objects.

Usage

```
select(x,i)
## S4 method for signature 'methylBase'
select(x, i)
## S4 method for signature 'methylRaw'
select(x, i)
## S4 method for signature 'methylDiff'
select(x, i)
## S4 method for signature 'methylRawDB'
select(x, i)
## S4 method for signature 'methylBaseDB'
select(x, i)
## S4 method for signature 'methylBaseDB'
select(x, i)
```

Arguments

i

 ${\bf x}$ an methylBase,methylBaseDB, methylRaw,methylRawDB or methylDiff object

a numeric or logical vector. This vector corresponds to bases or regions contained in methylKit objects. The vector is used to subset the data.

Value

a methylBase,methylRaw or methylDiff object depending on the input object.

Examples

78 selectByOverlap

```
methylBaseDB.obj=unite(methylRawList.obj,save.db=TRUE,dbdir="methylDB")

# selects first hundred rows, returns a methylRaw object
subset1=select(methylRawList.obj[[1]],1:100)
subset1=select(methylRawDB.obj,1:100)

# selects first hundred rows, returns a methylBase object
subset2=select(methylBaseOB.obj,1:100)
subset2=select(methylBaseDB.obj,1:100)

# selects first hundred rows, returns a methylDiff object
subset3=select(methylDiff.obj,1:100)

# remove Database again
rm(methylBaseDB.obj)
rm(methylRawDB.obj)
unlink("methylDB",recursive=TRUE)
```

selectByOverlap

selects records of methylDB objects lying inside a GRanges range

Description

The function selects records from any methylKit object that lie inside the regions given by ranges of class GRanges and returns an in-memory equivalent of this object

```
selectByOverlap(object,ranges)

## S4 method for signature 'methylRaw,GRanges'
selectByOverlap(object, ranges)

## S4 method for signature 'methylRawList,GRanges'
selectByOverlap(object, ranges)

## S4 method for signature 'methylBase,GRanges'
selectByOverlap(object, ranges)

## S4 method for signature 'methylDiff,GRanges'
selectByOverlap(object, ranges)

## S4 method for signature 'methylRawDB,GRanges'
```

selectByOverlap 79

```
selectByOverlap(object, ranges)
## S4 method for signature 'methylRawListDB,GRanges'
selectByOverlap(object, ranges)
## S4 method for signature 'methylBaseDB,GRanges'
selectByOverlap(object, ranges)
## S4 method for signature 'methylDiffDB,GRanges'
selectByOverlap(object, ranges)
```

Arguments

object an methylRaw,methylRawDB, methylRawList, methylRawListDB, methylBase,

methylBaseDB, methylDiff or methylDiffDB object

ranges a GRanges object specifying the regions of interest

Value

a methylBase,methylRaw, methylRawList or methylDiff object depending on the input object.

Author(s)

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Examples

```
data(methylKit)
file.list=list( system.file("extdata", "test1.myCpG.txt", package = "methylKit"),
                 system.file("extdata", "test2.myCpG.txt", package = "methylKit"),
                 system.file("extdata", "control1.myCpG.txt", package = "methylKit"),
system.file("extdata", "control2.myCpG.txt", package = "methylKit"))
methylRawListDB.obj=methRead(file.list,
                           sample.id=list("test1","test2","ctrl1","ctrl2"),
                           assembly="hg18", treatment=c(1,1,0,0),
                           dbtype = "tabix",dbdir = "methylDB")
methylBaseDB.obj=unite(methylRawListDB.obj)
methylDiffDB.obj = calculateDiffMeth(methylBaseDB.obj)
# define the windows of interest as a GRanges object, this can be any set
# of genomic locations
library(GenomicRanges)
my.win=GRanges(seqnames="chr21",
ranges=IRanges(start=seq(from=9764513,by=10000,length.out=20),width=5000) )
# selects the records that lie inside the regions
myRaw <- selectByOverlap(methylRawListDB.obj[[1]],my.win)</pre>
```

```
# selects the records that lie inside the regions
myBase <- selectByOverlap(methylBaseDB.obj,my.win)</pre>
# selects the records that lie inside the regions
myDiff <- selectByOverlap(methylDiffDB.obj,my.win)</pre>
# selects the records that lie inside the regions
myRaw2 <- selectByOverlap(methylRawList.obj[[1]],my.win)</pre>
# selects the records that lie inside the regions
myRawList2 <- selectByOverlap(methylRawList.obj,my.win)</pre>
# selects the records that lie inside the regions
myBase2 <- selectByOverlap(methylBase.obj,my.win)</pre>
# selects the records that lie inside the regions
myDiff2 <- selectByOverlap(methylDiff.obj,my.win)</pre>
rm(methylRawListDB.obj)
rm(methylBaseDB.obj)
rm(methylDiffDB.obj)
unlink("methylDB",recursive=TRUE)
```

show, methylBase-method

show method for methylKit classes

Description

 $The show method works for \verb|methylRaw|, methylRaw|DB|, methylRawList, methylRawListDB|, methylBase, methylBase, methylBase, methylDase, methylDase,$

```
## S4 method for signature 'methylBase'
show(object)

## S4 method for signature 'methylRaw'
show(object)

## S4 method for signature 'methylRawList'
show(object)

## S4 method for signature 'methylDiff'
show(object)
```

tileMethylCounts 81

```
## S4 method for signature 'methylRawDB'
show(object)

## S4 method for signature 'methylRawListDB'
show(object)

## S4 method for signature 'methylBaseDB'
show(object)

## S4 method for signature 'methylDiffDB'
show(object)
```

Arguments

object any methylKit object

Examples

```
data(methylKit)
methylDiff.obj
show(methylDiff.obj)
```

tileMethylCounts

Get methylated/unmethylated base counts for tilling windows

Description

The function summarizes methylated/unmethylated base counts over tilling windows across genome. This function can be used when differential methylation analysis is preferable to tilling windows instead of base pairs.

```
tileMethylCounts(object,win.size=1000,step.size=1000,cov.bases=0,mc.cores=1,save.db,...)
## S4 method for signature 'methylRaw'
tileMethylCounts(
  object,
  win.size = 1000,
  step.size = 1000,
  cov.bases = 0,
  mc.cores = 1,
  save.db = FALSE,
  ...
)
```

82 tileMethylCounts

```
## S4 method for signature 'methylRawList'
tileMethylCounts(
  object,
 win.size = 1000,
 step.size = 1000,
 cov.bases = 0,
 mc.cores = 1,
 save.db = FALSE,
)
## S4 method for signature 'methylBase'
tileMethylCounts(
 object,
 win.size = 1000,
  step.size = 1000,
  cov.bases = 0,
 mc.cores = 1,
  save.db = FALSE,
)
## S4 method for signature 'methylRawDB'
tileMethylCounts(
 object,
 win.size = 1000,
 step.size = 1000,
 cov.bases = 0,
 mc.cores = 1,
  save.db = TRUE,
)
## S4 method for signature 'methylRawListDB'
tileMethylCounts(
 object,
 win.size = 1000,
 step.size = 1000,
 cov.bases = 0,
 mc.cores = 1,
  save.db = TRUE,
)
## S4 method for signature 'methylBaseDB'
tileMethylCounts(
 object,
```

tileMethylCounts 83

```
win.size = 1000,
step.size = 1000,
cov.bases = 0,
mc.cores = 1,
save.db = TRUE,
...
)
```

Arguments

object	methylRaw, methylRawDB, methylRawList, methylRawListDB, methylBase or methylBaseDB object containing base pair resolution methylation information
win.size	an integer for the size of the tiling windows
step.size	an integer for the step size of tiling windows
cov.bases	minimum number of bases to be covered in a given window
mc.cores	number of cores to use when processing methylDB objects, default: 1, but always 1 for Windows) $$
save.db	A Logical to decide whether the resulting object should be saved as flat file database or not, default: explained in Details sections
	optional Arguments used when save.db is TRUE suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: append "_tiled" to current filename if database already exists or generate new file with filename "sampleID_tiled" or "methylBase_tiled" dependent on input object dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for already existing database

Value

 ${\tt methylRaw,methylBase}\ or\ {\tt methylRawList}\ object$

Details

The parameter chunk.size is only used when working with methylRawDB, methylBaseDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

The parameter save.db is per default TRUE for methylDB objects as methylRawDB, methylBaseDB or methylRawListDB, while being per default FALSE for methylRaw, methylBase or methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might want to change the value of this parameter.

84 unite

Examples

unite

unite methylRawList to a single table

Description

This functions unites methylRawList and methylRawListDB objects that only bases with coverage from all samples are retained. The resulting object is either of class methylBase or methylBaseDB depending on input.

```
unite(
  object,
  destrand = FALSE,
 min.per.group = NULL,
  chunk.size = 1e+06,
 mc.cores = 1,
  save.db = FALSE,
)
## S4 method for signature 'methylRawList'
unite(
 object,
  destrand = FALSE,
 min.per.group = NULL,
  chunk.size = 1e+06,
 mc.cores = 1,
  save.db = FALSE,
)
## S4 method for signature 'methylRawListDB'
unite(
  object,
  destrand = FALSE,
 min.per.group = NULL,
  chunk.size = 1e+06,
 mc.cores = 1,
```

unite 85

```
save.db = TRUE,
...
)
```

Arguments

object a methylRawList or methylRawListDB object to be merged by common loca-

tions covered by reads

destrand if TRUE, reads covering both strands of a CpG dinucleotide will be merged, do

not set to TRUE if not only interested in CpGs (default: FALSE). If the methyl-RawList object contains regions rather than bases setting destrand to TRUE will

have no effect.

min.per.group an integer denoting minimum number of samples per replicate needed to cover

a region/base. By default only regions/bases that are covered in all samples are united as methylBase object, however by supplying an integer for this argument users can control how many samples needed to cover region/base to be united as methylBase object. For example, if min.per.group set to 2 and there are 3 replicates per condition, the bases/regions that are covered in at least 2 replicates will be united and missing data for uncovered bases/regions will appear as NAs.

chunk.size Number of rows to be taken as a chunk for processing the methylRawListDB

objects, default: 1e6

mc.cores number of cores to use when processing methylRawListDB objects, default: 1,

but always 1 for Windows)

save.db A Logical to decide whether the resulting object should be saved as flat file

database or not, default: explained in Details sections

... optional Arguments used when save.db is TRUE

suffix A character string to append to the name of the output flat file database, only used if save.db is true, default actions: The default suffix is a 13-character

random string appended to the fixed prefix "methylBase", e.g. "methylBase_16d3047c1a254.txt.bgz".

dbdir The directory where flat file database(s) should be stored, defaults to getwd(), working directory for newly stored databases and to same directory for

already existing database

dbtype The type of the flat file database, currently only option is "tabix" (only

used for newly stored databases)

Value

a methylBase or methylBaseDB object depending on input

Details

The parameter chunk.size is only used when working with methylRawDB or methylRawListDB objects, as they are read in chunk by chunk to enable processing large-sized objects which are stored as flat file database. Per default the chunk.size is set to 1M rows, which should work for most systems. If you encounter memory problems or have a high amount of memory available feel free to adjust the chunk.size.

86 updateMethObject

The parameter save.db is per default TRUE for methylDB objects as methylRawListDB, while being per default FALSE for methylRawList. If you wish to save the result of an in-memory-calculation as flat file database or if the size of the database allows the calculation in-memory, then you might change the value of this parameter.

Examples

```
data(methylKit)
## Following
my.methylBase=unite(methylRawList.obj)
my.methylBase=unite(methylRawList.obj,destrand=TRUE)
```

updateMethObject

update methylKit objects The method updates object from earlier versions (<v0.9.1) to latest object.

Description

update methylKit objects

The method updates object from earlier versions (<v0.9.1) to latest object.

Usage

```
updateMethObject(object)
```

Arguments

object

a methylKit object: methylRaw, methylRawList, methylBase or methylDiff

Value

```
{\tt methylRaw,methylDiff,methylBase}\ or\ {\tt methylRawList}\ object
```

@export @docType methods @rdname updateMethObject

Index

[,methylBase,ANY,ANY,ANY-method	bedgraph,methylRawListDB-method
(extract), 18	(bedgraph), 6
[,methylBaseDB,ANY,ANY,ANY-method	
(extract), 18	calculateDiffMeth, 9, 48, 49
[,methylDiff,ANY,ANY,ANY-method	calculateDiffMeth,methylBase-method
(extract), 18	(calculateDiffMeth), 9
[,methylDiffDB,ANY,ANY,ANY-method	calculateDiffMeth,methylBaseDB-method
(extract), 18	(calculateDiffMeth), 9
[,methylRaw,ANY,ANY,ANY-method	calculateDiffMethDSS, 12
(extract), 18	$\verb calculateDiffMethDSS , \verb methylBase-method \\$
[,methylRawDB,ANY,ANY,ANY-method	(calculateDiffMethDSS), 12
(extract), 18	clusterSamples, 13
(6,61,600), 10	clusterSamples,methylBase-method
adjust.methylC(methylKit-defunct), 51	(clusterSamples), 13
adjustMethylC, 3	clusterSamples,methylBaseDB-method
adjustMethylC,methylRaw,methylRaw-method	(clusterSamples), 13
(adjustMethylC), 3	
adjustMethylC,methylRawDB,methylRawDB-method	data.frame, 10, 28, 46, 48, 52
	dataSim, <i>12</i> , 15
<pre>(adjustMethylC), 3 adjustMethylC, methylRawList, methylRawList-me (adjustMethylC), 3</pre>	densityMclust, <i>43</i> thod
(adjustMethylC), 3	diffMethPerChr, 17
<pre>(adjustMethylC), 3 adjustMethylC, methylRawListDB, methylRawListDB (adjustMethylC), 3</pre>	diffMethPerChr,methylDiff-method B-method
(adjustMethylC), 3	
annotate.WithFeature	diffMethPerChr,methylDiffDB-method
(methylKit-defunct), 51	(diffMethPerChr), 17
annotate.WithGenicParts	10.73
(methylKit-defunct), 51	extract, 18, 72
as, 46, 48–50, 52, 53	extract, methylBase, ANY-method
assocComp, 5, 67	(extract), 18
assoccomp, 5, 67	extract, methylBaseDB, ANY-method
barplot, 18	(extract), 18
bedgraph, 6	extract, methylDiff, ANY-method
bedgraph, wethylDiff-method (bedgraph), 6	(extract), 18
bedgraph, methylDiffDB-method	extract, methylDiffDB, ANY-method
(bedgraph), 6	(extract), 18
bedgraph, methylRaw-method (bedgraph), 6	<pre>extract, methylRaw, ANY-method (extract),</pre>
	18
bedgraph, methylRawDB-method (bedgraph),	extract, methylRawDB, ANY-method
6	(extract), 18
bedgraph, methylRawList-method	footoog 12 12
(bedgraph), 6	fastseg, <i>42</i> , <i>43</i>

0.17.	
filterByCoverage, 20	<pre>getData, methylBaseDB-method (getData),</pre>
filterByCoverage, methylRaw-method	28
(filterByCoverage), 20	getData, methylDiff-method (getData), 28
filterByCoverage, methylRawDB-method	<pre>getData, methylDiffDB-method (getData),</pre>
(filterByCoverage), 20	28
filterByCoverage, methylRawList-method	getData, methylRaw-method (getData), 28
(filterByCoverage), 20	<pre>getData, methy1RawDB-method (getData), 28</pre>
filterByCoverage,methylRawListDB-method	getDBPath, 29
(filterByCoverage), 20	<pre>getDBPath,methylBaseDB-method (getDBPath), 29</pre>
<pre>get.methylDiff(methylKit-defunct), 51</pre>	getDBPath,methylDiffDB-method
getAssembly, 22, 46, 47, 49, 50, 52, 53	(getDBPath), 29
<pre>getAssembly,methylBase-method</pre>	getDBPath,methylRawDB-method
(getAssembly), 22	(getDBPath), 29
<pre>getAssembly,methylBaseDB-method</pre>	getDBPath,methylRawListDB-method
(getAssembly), 22	(getDBPath), 29
<pre>getAssembly,methylDiff-method</pre>	getFeatsWithTargetsStats
(getAssembly), 22	(methylKit-defunct), 51
<pre>getAssembly,methylDiffDB-method</pre>	
(getAssembly), 22	getFlanks (methylKit-defunct), 51
getAssembly,methylRaw-method	getMembers (methylKit-defunct), 51
(getAssembly), 22	getMethylationStats, 30
<pre>getAssembly,methylRawDB-method</pre>	getMethylationStats, methylRaw-method
(getAssembly), 22	(getMethylationStats), 30
getContext, 24, 46, 47, 49, 50, 52, 53	<pre>getMethylationStats,methylRawDB-method</pre>
getContext, methylBase-method	(getMethylationStats), 30
(getContext), 24	getMethylDiff, 31
getContext, methylBaseDB-method	<pre>getMethylDiff,methylDiff-method</pre>
(getContext), 24	(getMethylDiff), 31
getContext, methylDiff-method	<pre>getMethylDiff,methylDiffDB-method</pre>
(getContext), 24	(getMethylDiff), 31
getContext, methylDiffDB-method	getSampleID, 33
(getContext), 24	getSampleID,methylBase-method
getContext, methylRaw-method	(getSampleID), 33
(getContext), 24	<pre>getSampleID,methylBaseDB-method</pre>
getContext, methylRawDB-method	(getSampleID), 33
(getContext), 24	<pre>getSampleID,methylDiff-method</pre>
getCorrelation, 25	(getSampleID), 33
getCorrelation,methylBase-method	<pre>getSampleID,methylDiffDB-method</pre>
(getCorrelation), 25	(getSampleID), 33
getCorrelation, methylBaseDB-method	<pre>getSampleID,methylRaw-method</pre>
(getCorrelation), 25	(getSampleID), 33
getCoverageStats, 26	getSampleID,methylRawDB-method
getCoverageStats, methylRaw-method	(getSampleID), 33
(getCoverageStats), 26	getSampleID,methylRawList-method
getCoverageStats, methylRawDB-method	(getSampleID), 33
(getCoverageStats), 26	getSampleID, methylRawListDB-method
getData, 19, 28, 46, 47, 49, 50, 52, 53	(getSampleID), 33
getData, methylBase-method (getData), 28	getSampleID<- (getSampleID), 33
Bottata, motification (Bottata), 20	Personal (Personal Ferry), 22

(getSampleID), 33hist, 27, 31getSampleIDx-, methylBaseBB-method (getSampleID), 33joinSegmentNeighbours, 36, 44getSampleIDx-, methylDifffmethod (getSampleID, 33list, 40, 54, 55getSampleIDx-, methylRaw-method (getSampleID), 33makeMethylDB, 37getSampleIDx-, methylRaw-method (getSampleID), 33makeMethylDB, methylBase-method (makeMethylDB), 37getSampleIDx-, methylRawList-method (getSampleID), 33makeMethylDB, methylBase-method (makeMethylDB), 37getSampleIDx-, methylRawListDB-method (getSampleID), 33makeMethylDB, methylDiff-method (makeMethylDB), 37getTreatment, 35makeMethylDB, methylDiff-method (makeMethylDB), 37getTreatment, getTreatment, methylDiffDB-method (getTreatment), 35makeMethylDB, methylRaw-method (makeMethylDB), 37getTreatment, methylBase-method (getTreatment), 35makeMethylDB, methylRawList-method (makeMethylDB), 37getTreatment, methylDiffDB-method (getTreatment), 35makeMethylDB, methylRawList-methods (makeMethylDB), 37getTreatment, methylDiffDB-method (getTreatment), 35methRead, 38, 54, 55getTreatment, methylDiffDB-method (getTreatment), 35methRead, 38, 54, 55getTreatment, methylDiffDB-method (getTreatment), 35methRead, 38, 54, 55getTreatment, methylDiffDB-method (getTreatment), 35methRead, character, charact
(getSampleID), 33joinSegmentNeighbours, 36, 44getSampleID,methylDiff-method(getSampleID,asgetSampleID,methylDiffDB-method(getSampleID), 33makeMethylDB, 37getSampleID,methylRaw-method(getSampleID), 33(makeMethylDB), 37getSampleID,methylRawDB-method(getSampleID),as(getSampleID,asgetSampleID,methylRawList-method(getSampleID),as(getSampleID),asgetTargetAnnotationStats(methylKit-defunct)(methylKit-defunct),asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,asgetTreatment,as(getTreatment,asgetTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as(getTreatment,as
getSampleID<-,methylDiffDB-method
getSampleID<-,methylDiffDB-method
getSampleID<-,methylDiffDB-method
getSampleID<-,methylDiffDB-method
(getSampleID), 33makeMethylDB, 37getSampleID<-, methylRaw-method (getSampleID), 33makeMethylDB, methylBase-method (makeMethylDB), 37getSampleID<-, methylRawDB-method (getSampleID), 33makeMethylDB, methylBase-methods (makeMethylDB), 37getSampleID<-, methylRawList-method (getSampleID), 33makeMethylDB, methylDiff-method (makeMethylDB), 37getSampleID<-, methylRawListDB-method (getSampleID), 33(makeMethylDB, methylDiff-methods (makeMethylDB), 37getTargetAnnotationStats (methylKit-defunct), 51 getTreatment, 35 getTreatment, getTreatment, methylDiffDB-method (getTreatment, methylBase-method (getTreatment), 35makeMethylDB, methylRaw-methods (makeMethylDB), 37getTreatment, methylBase-method (getTreatment, methylBaseDB-method (getTreatment, methylDiff-method (getTreatment), 35makeMethylDB, methylRawList-methods (makeMethylDB), 37getTreatment, methylDiff-method (getTreatment), 35makeMethylDB, methylRawList-methods (makeMethylDB), 37getTreatment, methylDiff-method (getTreatment), 35methRead, 38, 54, 55getTreatment, methylDiffDB-method (getTreatment), 35methRead, 38, 54, 55methRead, 38, 54, 55methRead, character, ANY, ANY-methodgetTreatment, methylDiffDB-method (getTreatment, methylDiffDB-method)(methRead), 38
getSampleID<-,methylRaw-method (getSampleID), 33 getSampleID<-,methylRawDB-method (getSampleID), 33 getSampleID<-,methylRawList-method (getSampleID), 33 getSampleID<-,methylRawList-method (getSampleID), 33 getSampleID<-,methylRawListDB-method (getSampleID), 33 getSampleID<-,methylRawListDB-method (getSampleID), 33 getTargetAnnotationStats (methylKit-defunct), 51 (methylKit-defunct), 51 getTreatment, 35 getTreatment, getTreatment, methylDiffDB-method (getTreatment), 35 getTreatment, methylBase-method (getTreatment), 35 getTreatment, methylBase-method (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-methods (makeMethylDB, methylRawList-methods (makeMethylDB, methylRawList-methods (makeMethylDB, 37 makeMethylDB, methylRawList-methods (makeMethylDB, 37 makeMethylDB, methylRawList-methods (makeMethylDB, 37 makeMethylDB, methylRawList-method (makeMethylDB, 37 makeMethylDB, methylRawList-method (makeMethylDB, 37 makeMethylDB, methylRawList-method (makeMethylDB, 37 makeMethylDB, methylRawList-method (makeMethylDB, 37 makeMethylDB,
(getSampleID), 33 getSampleID<-, methylRawDB-method (getSampleID), 33 getSampleID<-, methylRawList-method (getSampleID), 33 getSampleID<-, methylRawListDB-method (getSampleID), 33 getSampleID<-, methylRawListDB-method (getSampleID), 33 getSampleID<-, methylRawListDB-method (getSampleID), 33 getTargetAnnotationStats (methylKit-defunct), 51 getTreatment, 35 getTreatment, getTreatment, methylDiffDB-method (getTreatment), 35 getTreatment, methylBase-method (getTreatment), 35 getTreatment, methylBase-method (makeMethylDB), 37 makeMethylDB, methylRaw-methods (makeMethylDB), 37 makeMethylDB, methylRaw-methods (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB), 37 makeMethylDB, methylRawList-methods (makeMethylDB), 37 makeMethylDB, methylDB, 37 makeMethylDB, methylDB, 37 makeMethylDB, methylDB, 37 makeMethylDB, methylDB, 37 makeMethylDB, 37 makeMethylDB, methylDB, 37 makeMethylDB, 37 makeMethylDB, methylDB, 37 makeMethylDB, 37 make
getSampleID<-,methylRawDB-method
(getSampleID), 33 getSampleID<-, methylRawList-method (getSampleID), 33 getSampleID<-, methylRawListDB-method (getSampleID), 33 getSampleID<-, methylRawListDB-method (getSampleID), 33 getTargetAnnotationStats (methylKit-defunct), 51 getTreatment, 35 getTreatment, getTreatment, methylDiffDB-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylDiffDB-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiffDB-method (makeMethylDB, methylRawList-methods (makeMethylDB), 37 makeMethylDB, methylRawList-methods (makeMethylDB), 37 makeMethylDB, methylRawList-methods (makeMethylDB), 37 makeMethylDB, methylRawList-methods (makeMethylDB), 37 makeMethylDB, methylRawList-method (makeMethylDB, methylR
getSampleID<-,methylRawList-method
(getSampleID), 33 getSampleID<-, methylRawListDB-method
getSampleID<-,methylRawListDB-method
(getSampleID), 33 getTargetAnnotationStats
getTargetAnnotationStats
(methylKit-defunct), 51(makeMethylDB), 37getTreatment, 35makeMethylDB, methylRaw-methodsgetTreatment, getTreatment, methylDiffDB-method(makeMethylDB), 37(getTreatment), 35makeMethylDB, methylRawList-methodgetTreatment, methylBase-method(makeMethylDB, methylRawList-methods(getTreatment, methylBaseDB-method(makeMethylDB, methylRawList-methods(getTreatment), 35Mclust, 43getTreatment, methylDifff-methodmethRead, 38, 54, 55(getTreatment, methylDiffDB-methodmethRead, character, ANY, ANY-methodgetTreatment, methylDiffDB-method(methRead), 38
getTreatment, 35 getTreatment, getTreatment, methylDiffDB-method (makeMethylDB, methylRaw-methods (makeMethylDB), 37 (getTreatment), 35 getTreatment, methylBase-method (makeMethylDB, methylRawList-method) (makeMethylDB), 37 (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiff-method getTreatment, methylDiffDB-method (methRead, 38, 54, 55 methRead, character, ANY, ANY-method getTreatment, methylDiffDB-method (methRead), 38
getTreatment, getTreatment, methylDiffDB-method (makeMethylDB), 37 (getTreatment), 35
(getTreatment), 35 getTreatment, methylBase-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylBaseDB-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 getTreatment, methylDiffDB-method (getTreatment), 35
getTreatment, methylBase-method (makeMethylDB), 37 (getTreatment), 35 getTreatment, methylBaseDB-method (makeMethylDB, methylRawList-methods (makeMethylDB), 37 (getTreatment), 35 getTreatment, methylDiff-method (methRead, 38, 54, 55) (getTreatment), 35 getTreatment, methylDiffDB-method (methRead), 38
(getTreatment), 35 getTreatment, methylBaseDB-method
getTreatment, methylBaseDB-method (makeMethylDB), 37 (getTreatment), 35 getTreatment, methylDiff-method methRead, 38, 54, 55 (getTreatment), 35 getTreatment, methylDiffDB-method (methRead), 38
(getTreatment), 35 getTreatment, methylDiff-method (getTreatment), 35 (getTreatment), 35 methRead, 38, 54, 55 methRead, character, ANY, ANY-method getTreatment, methylDiffDB-method (methRead), 38
getTreatment, methylDiff-method methRead, 38, 54, 55 (getTreatment), 35 methRead, character, ANY, ANY-method getTreatment, methylDiffDB-method (methRead), 38
(getTreatment), 35 methRead, character, ANY, ANY-method getTreatment, methylDiffDB-method (methRead), 38
getTreatment, methylDiffDB-method (methRead), 38
getTreatment, methylRawList-method (methRead), 38
(getTreatment), 35 methRead, character-method (methRead), 38
getTreatment, methylRawListDB-method methRead, list, ANY, ANY-method
(getTreatment), 35 (methRead), 38
<pre>getTreatment<- (getTreatment), 35 methRead, list, list, character-method</pre>
<pre>getTreatment<-,methylBase-method (methRead), 38</pre>
(getTreatment), 35 methSeg, $37, 42, 45$
<pre>getTreatment<-,methylBaseDB-method methSeg2bed, 44, 44</pre>
(getTreatment), 35 methylBase, 5, 10, 19, 23, 24, 28, 33, 35, 37,
getTreatment<-,methylDiff-method 47, 48, 62, 67, 68, 71, 73, 77, 79, 83,
(getTreatment), 35
<pre>getTreatment<-,methylDiffDB-method methylBase (methylBase-class), 45</pre>
(getTreatment), 35 methylBase-class, 45
<pre>getTreatment<-,methylRawList-method methylBase.obj, 46</pre>
(getTreatment), 35 methylBaseDB, 5, 10, 19, 23, 24, 28, 29,
(getTreatment), 35
(8001104,000
GRanges, 37, 43–46, 48–50, 52, 53, 68, 78 methylBaseDB (methylBaseDB-class), 47

methylDiff, 6, 8, 11, 17-19, 23, 24, 28,	pool, methylBaseDB-method (pool), 61
31–33, 35, 37, 43, 50, 77, 79, 86	prcomp, 58
methylDiff (methylDiff-class), 48	processBismarkAln, 63
methylDiff-class, 48	processBismarkAln, character, character, character-method
methylDiff.obj, 49	(processBismarkAln), 63
methylDiffDB, 6, 8, 29, 31–35, 37, 43, 66, 79	processBismarkAln,list,list,character-method
•	
methylDiffDB (methylDiffDB-class), 49	(processBismarkAln), 63
methylDiffDB-class, 49	qvalue, 10, 13
methylKit-defunct, 51	qvaiue, 10, 13
methylRaw, 6, 8, 19, 23, 24, 28, 33, 37, 43, 53,	read, <i>53</i>
54, 68, 71, 77, 79, 83, 86	read (methylKit-defunct), 51
methylRaw (methylRaw-class), 51	read.table, 40
methylRaw-class, 51	readMethylDB, 65
methylRawDB, 6, 8, 19, 23, 24, 28, 29, 33, 37,	reconstruct, 66
43, 55, 66, 68, 71, 77, 79, 83	
methylRawDB (methylRawDB-class), 53	reconstruct, ANY, methylBase-method
methylRawDB-class, 53	(reconstruct), 66
methylRawList, 6, 8, 33, 35, 37, 68, 71, 79,	reconstruct, ANY, methylBaseDB-method
83, 86	(reconstruct), 66
methylRawList (methylRawList-class), 54	reconstruct, methylBase-method
methylRawList-class, 54	(reconstruct), 66
methylRawList.obj, 55	reconstruct, methylBaseDB-method
methylRawListDB, 6, 8, 29, 33-35, 37, 66, 68,	(reconstruct), 66
71, 79, 83	regionCounts, 68
methylRawListDB	regionCounts, methylBase, GRanges-method
(methylRawListDB-class), 55	(regionCounts), 68
methylRawListDB-class, 55	regionCounts,methylBase,GRangesList-method
	(regionCounts), 68
normalizeCoverage, 56	regionCounts, methylBaseDB, GRanges-method
normalizeCoverage,methylRawList-method	(regionCounts), 68
(normalizeCoverage), 56	regionCounts,methylBaseDB,GRangesList-method
normalizeCoverage,methylRawListDB-method	(regionCounts), 68
(normalizeCoverage), 56	regionCounts,methylRaw,GRanges-method
	(regionCounts), 68
p.adjust, <i>10</i> , <i>13</i>	regionCounts,methylRaw,GRangesList-method
PCASamples, 58	(regionCounts), 68
PCASamples, methylBase-method	regionCounts,methylRawDB,GRanges-method
(PCASamples), 58	(regionCounts), 68
PCASamples, methylBaseDB-method	regionCounts,methylRawDB,GRangesList-method
(PCASamples), 58	(regionCounts), 68
percMethylation, 60	regionCounts,methylRawList,GRanges-method
percMethylation,methylBase-method	(regionCounts), 68
(percMethylation), 60	regionCounts,methylRawList,GRangesList-method
percMethylation,methylBaseDB-method	(regionCounts), 68
(percMethylation), 60	regionCounts,methylRawListDB,GRanges-method
plotTargetAnnotation	(regionCounts),68
<pre>(methylKit-defunct), 51</pre>	regionCounts,methylRawListDB,GRangesList-method
pool, <i>12</i> , 61	(regionCounts), 68
pool, methylBase-method (pool), 61	removeComp, 67, 72

removeComp, methylBase-method	selectByOverlap, methylRawList-method
(removeComp), 72	(selectByOverlap), 78
removeComp,methylBaseDB-method	selectByOverlap, methylRawListDB, GRanges-method
(removeComp), 72	(selectByOverlap), 78
reorganize, 12, 74	selectByOverlap, methylRawListDB-method
reorganize,methylBase-method	(selectByOverlap), 78
(reorganize), 74	show, methylBase
reorganize,methylBaseDB-method	(show, methylBase-method), 80
(reorganize), 74	show, methylBase-method, 80
reorganize,methylRawList-method	show,methylBaseDB
(reorganize), 74	(show, methylBase-method), 80
reorganize,methylRawListDB-method	show, methylBaseDB-method
(reorganize), 74	(show, methylBase-method), 80
	show, methylDiff
select, 72, 77	(show, methylBase-method), 80
select, methylBase-method (select), 77	show, methylDiff-method
select, methylBaseDB-method (select), 77	(show, methylBase-method), 80
select, methylDiff-method (select), 77	show,methylDiffDB
select, methylDiffDB-method (select), 77	$({\sf show}, {\sf methylBase-method}), 80$
select, methylRaw-method (select), 77	show, methylDiffDB-method
select, methylRawDB-method (select), 77	(show, methylBase-method), 80
selectByOverlap, 78	show, methylRaw
selectByOverlap, methylBase, GRanges-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRaw-method
selectByOverlap, methylBase-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawDB
selectByOverlap, methylBaseDB, GRanges-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawDB-method
selectByOverlap, methylBaseDB-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawList
selectByOverlap, methylDiff, GRanges-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawList-method
selectByOverlap, methylDiff-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawListDB
selectByOverlap, methylDiffDB, GRanges-method	(show, methylBase-method), 80
(selectByOverlap), 78	show, methylRawListDB-method
selectByOverlap, methylDiffDB-method	(show, methylBase-method), 80
(selectByOverlap), 78	tileMethylCounts, 81
selectByOverlap, methylRaw, GRanges-method	tileMethylCounts, methylBase-method
(selectByOverlap), 78	(tileMethylCounts), 81
selectByOverlap, methylRaw-method	tileMethylCounts, methylBaseDB-method
(selectByOverlap), 78	(tileMethylCounts), 81
selectByOverlap, methylRawDB, GRanges-method	tileMethylCounts, methylRaw-method
(selectByOverlap), 78	(tileMethylCounts), 81
selectByOverlap, methylRawDB-method	tileMethylCounts, methylRawDB-method
(selectByOverlap), 78	(tileMethylCounts), 81
selectByOverlap, methylRawList, GRanges-method	· · · · · · · · · · · · · · · · · · ·
(selectByOverlap), 78	(tileMethylCounts), 81
(Setectorovertab), /o	(titelie tily i couli to), oi

```
tileMethylCounts,methylRawListDB-method
          (tileMethylCounts), 81
unite, 45, 47, 84
```

 $\begin{tabular}{ll} unite, methylRawList-method (unite), 84\\ unite, methylRawListDB-method (unite), 84\\ updateMethObject, 86\\ \end{tabular}$