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Description mia implements tools for microbiome analysis based on the SummarizedExperiment, SingleCellExperiment and TreeSummarizedExperiment infrastructure. Data wrangling and analysis in the context of taxonomic data is the main scope. Additional functions for common task are implemented such as community indices calculation and summarization.

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Contents

`mia-package` `mia` *Package.*

Description

`mia` implements tools for microbiome analysis based on the `SummarizedExperiment`, `SingleCellExperiment` and `TreeSummarizedExperiment` infrastructure. Data wrangling and analysis in the context of taxonomic data is the main scope. Additional functions for common task are implemented such as community indices calculation and summarization.

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See Also

TreeSummarizedExperiment

addCluster *Clustering wrapper*

Description

This function returns a SummarizedExperiment with clustering information in its colData or rowData

Usage

```
addCluster(
  x,
  BLUSPARAM,
  assay.type = assay_name,
  assay_name = "counts",
  MARGIN = "features",
  full = FALSE,
  name = "clusters",
  clust.col = "clusters",
  ...
)

## S4 method for signature 'SummarizedExperiment'
addCluster(
  x,
  BLUSPARAM,
  assay.type = assay_name,
  assay_name = "counts",
  MARGIN = "features",
  full = FALSE,
  name = "clusters",
  clust.col = "clusters",
  ...
)
```

Arguments

x	A SummarizedExperiment object.
BLUSPARAM	A BlusterParam object specifying the algorithm to use.
assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
MARGIN	A single character value for specifying whether the transformation is applied sample (column) or feature (row) wise. (By default: MARGIN = "samples")
full	Logical scalar indicating whether the full clustering statistics should be returned for each method.

name	the name to store the result in metadata
clust.col	A single character value indicating the name of the rowData (or colData) where the data will be stored.
...	Additional parameters to use altExps for example

Details

This is a wrapper for the clusterRows function from the bluster package.

When setting full = TRUE, the clustering information will be stored in the metadata of the object.

By default, clustering is done on the features.

Value

addCluster returns an object of the same type as the x parameter with clustering information named clusters stored in colData or rowData.

Author(s)

Basil Courbayre

Examples

```
library(bluster)
data(GlobalPatterns, package = "mia")
tse <- GlobalPatterns

# Cluster on rows using Kmeans
tse <- addCluster(tse, KmeansParam(centers = 3))

# Clustering done on the samples using Hclust
tse <- addCluster(tse,
               MARGIN = "samples",
               HclustParam(metric = "bray", dist.fun = vegan::vegdist))

# Getting the clusters
colData(tse)$clusters
```

---

addDivergence *Estimate divergence*

Description

Estimate divergence against a given reference sample.

Usage

```
addDivergence(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  name = "divergence",
  reference = "median",
  FUN = vegan::vegdist,
  method = "bray",
  ...
)

## S4 method for signature 'SummarizedExperiment'
addDivergence(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  name = "divergence",
  reference = "median",
  FUN = vegan::vegdist,
  method = "bray",
  ...
)
```

Arguments

x	a SummarizedExperiment object.
assay.type	the name of the assay used for calculation of the sample-wise estimates.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
name	a name for the column of the colData the results should be stored in. By default, name is "divergence".
reference	a numeric vector that has length equal to number of features, or a non-empty character value; either 'median' or 'mean'. reference specifies the reference that is used to calculate divergence. by default, reference is "median".
FUN	a function for distance calculation. The function must expect the input matrix as its first argument. With rows as samples and columns as features. By default, FUN is vegan::vegdist.
method	a method that is used to calculate the distance. Method is passed to the function that is specified by FUN. By default, method is "bray".
...	optional arguments

Details

Microbiota divergence (heterogeneity / spread) within a given sample set can be quantified by the average sample dissimilarity or beta diversity with respect to a given reference sample.

This measure is sensitive to sample size. Subsampling or bootstrapping can be applied to equalize sample sizes between comparisons.

Value

x with additional colData named *name*

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

See Also

plotColData

- estimateRichness
- estimateEvenness
- estimateDominance

Examples

```
data(GlobalPatterns)
tse <- GlobalPatterns

# By default, reference is median of all samples. The name of column where results
# is "divergence" by default, but it can be specified.
tse <- addDivergence(tse)

# The method that are used to calculate distance in divergence and
# reference can be specified. Here, euclidean distance and dist function from
# stats package are used. Reference is the first sample.
tse <- addDivergence(tse, name = "divergence_first_sample",
                          reference = assays(tse)$counts[,1],
                          FUN = stats::dist, method = "euclidean")

# Reference can also be median or mean of all samples.
# By default, divergence is calculated by using median. Here, mean is used.
tse <- addDivergence(tse, name = "divergence_average", reference = "mean")

# All three divergence results are stored in colData.
colData(tse)
```

agglomerate-methods *Agglomerate or merge data using taxonomic information*

Description

Agglomeration functions can be used to sum-up data based on specific criteria such as taxonomic ranks, variables or prevalence.

`agglomerateByRanks` takes a `SummarizedExperiment`, splits it along the taxonomic ranks, aggregates the data per rank, converts the input to a `SingleCellExperiment` objects and stores the aggregated data as alternative experiments. `unsplitByRanks` takes these alternative experiments and flattens them again into a single `SummarizedExperiment`.

Usage

```
agglomerateByRank(x, ...)

agglomerateByVariable(x, ...)

## S4 method for signature 'SummarizedExperiment'
agglomerateByRank(
  x,
  rank = taxonomyRanks(x)[1],
  na.rm = TRUE,
  empty.fields = c(NA, "", " ", "\t", "-", "_"),
  ...
)

## S4 method for signature 'SummarizedExperiment'
agglomerateByVariable(x, MARGIN, f, ...)

## S4 method for signature 'TreeSummarizedExperiment'
agglomerateByVariable(
  x,
  MARGIN,
  f,
  update.tree = mergeTree,
  mergeTree = FALSE,
  ...
)

## S4 method for signature 'SingleCellExperiment'
agglomerateByRank(
  x,
  ...,
  altexp = NULL,
  altexp.rm = strip_altexp,
```

```
  strip_altexp = TRUE
)

## S4 method for signature 'TreeSummarizedExperiment'
agglomerateByRank(
  x,
  ...,
  update.tree = agglomerateTree,
  agglomerate.tree = agglomerateTree,
  agglomerateTree = FALSE
)

agglomerateByPrevalence(x, ...)

## S4 method for signature 'SummarizedExperiment'
agglomerateByPrevalence(
  x,
  rank = NULL,
  other.label = other_label,
  other_label = "Other",
  ...
)

agglomerateByRanks(x, ...)

## S4 method for signature 'SummarizedExperiment'
agglomerateByRanks(
  x,
  ranks = taxonomyRanks(x),
  na.rm = TRUE,
  as.list = FALSE,
  ...
)

## S4 method for signature 'SingleCellExperiment'
agglomerateByRanks(
  x,
  ranks = taxonomyRanks(x),
  na.rm = TRUE,
  as.list = FALSE,
  ...
)

## S4 method for signature 'TreeSummarizedExperiment'
agglomerateByRanks(
  x,
  ranks = taxonomyRanks(x),
  na.rm = TRUE,
```

```
  as.list = FALSE,
  ...
)

splitByRanks(x, ...)

unsplitByRanks(x, ...)

## S4 method for signature 'SingleCellExperiment'
unsplitByRanks(
  x,
  ranks = taxonomyRanks(x),
  keep.dimred = keep_reducedDims,
  keep_reducedDims = FALSE,
  ...
)

## S4 method for signature 'TreeSummarizedExperiment'
unsplitByRanks(
  x,
  ranks = taxonomyRanks(x),
  keep.dimred = keep_reducedDims,
  keep_reducedDims = FALSE,
  ...
)
```

Arguments

x	a SummarizedExperiment object
...	arguments passed to agglomerateByRank function for SummarizedExperiment objects and other functions. See agglomerateByRank for more details.
rank	a single character defining a taxonomic rank. Must be a value of taxonomyRanks() function.
na.rm	TRUE or FALSE: Should taxa with an empty rank be removed? Use it with caution, since results with NA on the selected rank will be dropped. This setting can be tweaked by defining empty.fields to your needs. (default: na.rm = TRUE)
empty.fields	a character value defining, which values should be regarded as empty. (Default: c(NA, "", " ", "\t")). They will be removed if na.rm = TRUE before agglomeration.
MARGIN	A character value for selecting if data is merged row-wise / for features ('rows') or column-wise / for samples ('cols'). Must be 'rows' or 'cols'.
f	A factor for merging. Must be the same length as nrow(x)/ncol(x). Rows/Cols corresponding to the same level will be merged. If length(levels(f)) == nrow(x)/ncol(x), x will be returned unchanged.
update.tree	TRUE or FALSE: Should rowTree() also be merged? (Default: update.tree = FALSE)

mergeTree
: Deprecated. Use update.tree instead.

altexp
: String or integer scalar specifying an alternative experiment containing the input data.

altexp.rm
: TRUE or FALSE: Should alternative experiments be removed prior to agglomeration? This prevents to many nested alternative experiments by default (default: altexp.rm = TRUE)

strip_altexp
: Deprecated. Use altexp.rm instead.

agglomerate.tree
: Deprecated. Use update.tree instead.

agglomerateTree
: Deprecated. Use update.tree instead.

other.label
: A single character valued used as the label for the summary of non-prevalent taxa. (default: other.label = "Other")

other_label
: Deprecated. use other.label instead.

ranks
: a character vector defining taxonomic ranks. Must all be values of taxonomyRanks() function.

as.list
: TRUE or FALSE: Should the list of SummarizedExperiment objects be returned by the function agglomerateByRanks as a SimpleList or stored in altExps? (default: as.list = FALSE)

keep.dimred
: TRUE or FALSE: Should the reducedDims(x) be transferred to the result? Please note, that this breaks the link between the data used to calculate the reduced dims. (default: keep.dimred = FALSE)

keep_reducedDims
: Deprecated. Use keep.dimred instead.

Details

agglomerateByRank can be used to sum up data based on associations with certain taxonomic ranks, as defined in rowData. Only available taxonomyRanks can be used.

agglomerateByVariable merges data on rows or columns of a SummarizedExperiment as defined by a factor alongside the chosen dimension. This function allows agglomeration of data based on other variables than taxonomy ranks. Metadata from the rowData or colData are retained as defined by archetype. assay are agglomerated, i.e. summed up. If the assay contains values other than counts or absolute values, this can lead to meaningless values being produced.

Agglomeration sums up the values of assays at the specified taxonomic level. With certain assays, e.g. those that include binary or negative values, this summing can produce meaningless values. In those cases, consider performing agglomeration first, and then applying the transformation afterwards.

agglomerateByVariable works similarly to sumCountsAcrossFeatures. However, additional support for TreeSummarizedExperiment was added and science field agnostic names were used. In addition the archetype argument lets the user select how to preserve row or column data.

For merge data of assays the function from scuttle are used.

agglomerateByPrevalence sums up the values of assays at the taxonomic level specified by rank (by default the highest taxonomic level available) and selects the summed results that exceed the

given population prevalence at the given detection level. The other summed values (below the threshold) are agglomerated in an additional row taking the name indicated by `other.label` (by default "Other").

`agglomerateByRanks` will use by default all available taxonomic ranks, but this can be controlled by setting `ranks` manually. `NA` values are removed by default, since they would not make sense, if the result should be used for `unsplitByRanks` at some point. The input data remains unchanged in the returned `SingleCellExperiment` objects.

`unsplitByRanks` will remove any `NA` value on each taxonomic rank so that no ambiguous data is created. In additional, a column `taxonomicLevel` is created or overwritten in the `rowData` to specify from which alternative experiment this originates from. This can also be used for `splitAltExps` to split the result along the same factor again. The input data from the base objects is not returned, only the data from the `altExp()`. Be aware that changes to `rowData` of the base object are not returned, whereas only the `colData` of the base object is kept.

Value

`agglomerateByRank` returns a taxonomically-agglomerated, optionally-pruned object of the same class as `x`. `agglomerateByVariable` returns an object of the same class as `x` with the specified entries merged into one entry in all relevant components. `agglomerateByRank` returns a taxonomically-agglomerated, optionally-pruned object of the same class as `x`.

`agglomerateByPrevalence` returns a taxonomically-agglomerated object of the same class as x and based on prevalent taxonomic results.

For `agglomerateByRanks`: If `as.list` = `TRUE` : `SummarizedExperiment` objects in a `SimpleList` If `as.list` = `FALSE` : The `SummarizedExperiment` passed as a parameter and now containing the `SummarizedExperiment` objects in its altExps

For `unsplitByRanks`: `x`, with `rowData` and `assay` data replaced by the unsplit data. `colData` of `x` is kept as well and any existing `rowTree` is dropped as well, since existing `rowLinks` are not valid anymore.

See Also

`splitOn` `unsplitOn` `agglomerateByVariable`, `sumCountsAcrossFeatures`, `agglomerateByRank`, `altExps`, `splitAltExps`

Examples

```
### Agglomerate data based on taxonomic information

data(GlobalPatterns)
# print the available taxonomic ranks
colnames(rowData(GlobalPatterns))
taxonomyRanks(GlobalPatterns)

# agglomerate at the Family taxonomic rank
x1 <- agglomerateByRank(GlobalPatterns, rank="Family")
## How many taxa before/after agglomeration?
nrow(GlobalPatterns)
nrow(x1)
```

```
# agglomerate the tree as well
x2 <- agglomerateByRank(GlobalPatterns, rank="Family",
                        update.tree = TRUE)
nrow(x2) # same number of rows, but
rowTree(x1) # ... different
rowTree(x2) # ... tree

# If assay contains binary or negative values, summing might lead to
# meaningless values, and you will get a warning. In these cases, you might
# want to do agglomeration again at chosen taxonomic level.
tse <- transformAssay(GlobalPatterns, method = "pa")
tse <- agglomerateByRank(tse, rank = "Genus")
tse <- transformAssay(tse, method = "pa")

# removing empty labels by setting na.rm = TRUE
sum(is.na(rowData(GlobalPatterns)$Family))
x3 <- agglomerateByRank(GlobalPatterns, rank="Family", na.rm = TRUE)
nrow(x3) # different from x2

# Because all the rownames are from the same rank, rownames do not include
# prefixes, in this case "Family:".
print(rownames(x3[1:3,]))

# To add them, use getTaxonomyLabels function.
rownames(x3) <- getTaxonomyLabels(x3, with.rank = TRUE)
print(rownames(x3[1:3,]))

# use 'empty.ranks.rm' to remove columns that include only NAs
x4 <- agglomerateByRank(GlobalPatterns, rank="Phylum",
                         empty.ranks.rm = TRUE)
head(rowData(x4))

# If the assay contains NAs, you might want to consider replacing them,
# since summing-up NAs lead to NA
x5 <- GlobalPatterns
# Replace first value with NA
assay(x5)[1,1] <- NA
x6 <- agglomerateByRank(x5, "Kingdom")
head( assay(x6) )
# Replace NAs with 0. This is justified when we are summing-up counts.
assay(x5)[ is.na(assay(x5)) ] <- 0
x6 <- agglomerateByRank(x5, "Kingdom")
head( assay(x6) )

## Look at enterotype dataset...
data(enterotype)
## Print the available taxonomic ranks. Shows only 1 available rank,
## not useful for agglomerateByRank
taxonomyRanks(enterotype)

### Merge TreeSummarizedExperiments on rows and columns

data(esophagus)
```

```
esophagus
plot(rowTree(esophagus))
# get a factor for merging
f <- factor(regmatches(rownames(esophagus),
                       regexpr("^[0-9]*_[0-9]*",rownames(esophagus))))
merged <- agglomerateByVariable(esophagus, MARGIN = "rows", f,
                                update.tree = TRUE)
plot(rowTree(merged))
#
data(GlobalPatterns)
GlobalPatterns
merged <- agglomerateByVariable(GlobalPatterns, MARGIN = "cols",
                                colData(GlobalPatterns)$SampleType)
merged
## Data can be aggregated based on prevalent taxonomic results
tse <- GlobalPatterns
tse <- agglomerateByPrevalence(tse,
                               rank = "Phylum",
                               detection = 1/100,
                               prevalence = 50/100,
                               as.relative = TRUE)

tse

# Here data is aggregated at the taxonomic level "Phylum". The five phyla
# that exceed the population prevalence threshold of 50/100 represent the
# five first rows of the assay in the aggregated data. The sixth and last row
# named by default "Other" takes the summed up values of all the other phyla
# that are below the prevalence threshold.

assay(tse)[,1:5]

data(GlobalPatterns)
# print the available taxonomic ranks
taxonomyRanks(GlobalPatterns)

# agglomerateByRanks
#
tse <- agglomerateByRanks(GlobalPatterns)
altExps(tse)
altExp(tse,"Kingdom")
altExp(tse,"Species")

# unsplitByRanks
tse <- unsplitByRanks(tse)
tse
```

---

calculateDMN *Dirichlet-Multinomial Mixture Model: Machine Learning for Microbiome Data*

Description

These functions are accessors for functions implemented in the DirichletMultinomial package

Usage

```
calculateDMN(x, ...)

## S4 method for signature 'ANY'
calculateDMN(
  x,
  k = 1,
  BPPARAM = SerialParam(),
  seed = runif(1, 0, .Machine$integer.max),
  ...
)

## S4 method for signature 'SummarizedExperiment'
calculateDMN(
  x,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  transposed = FALSE,
  ...
)

runDMN(x, name = "DMN", ...)

getDMN(x, name = "DMN", ...)

## S4 method for signature 'SummarizedExperiment'
getDMN(x, name = "DMN")

bestDMNFit(x, name = "DMN", type = c("laplace", "AIC", "BIC"), ...)

## S4 method for signature 'SummarizedExperiment'
bestDMNFit(x, name = "DMN", type = c("laplace", "AIC", "BIC"))

getBestDMNFit(x, name = "DMN", type = c("laplace", "AIC", "BIC"), ...)

## S4 method for signature 'SummarizedExperiment'
getBestDMNFit(x, name = "DMN", type = c("laplace", "AIC", "BIC"))

calculateDMNgroup(x, ...)

## S4 method for signature 'ANY'
calculateDMNgroup(
  x,
```

```
  variable,
  k = 1,
  seed = runif(1, 0, .Machine$integer.max),
  ...
)

## S4 method for signature 'SummarizedExperiment'
calculateDMNgroup(
  x,
  variable,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  transposed = FALSE,
  ...
)

performDMNgroupCV(x, ...)

## S4 method for signature 'ANY'
performDMNgroupCV(
  x,
  variable,
  k = 1,
  seed = runif(1, 0, .Machine$integer.max),
  ...
)

## S4 method for signature 'SummarizedExperiment'
performDMNgroupCV(
  x,
  variable,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  transposed = FALSE,
  ...
)
```

Arguments

x	a numeric matrix with samples as rows or a SummarizedExperiment object.
...	optional arguments not used.
k	the number of Dirichlet components to fit. See dmn
BPPARAM	A BiocParallelParam object specifying whether the UniFrac calculation should be parallelized.
seed	random number seed. See dmn

assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
exprs_values	a single character value for specifying which assay to use for calculation. (Please use assay.type instead.)
transposed	Logical scalar, is x transposed with samples in rows?
name	the name to store the result in metadata
type	the type of measure used for the goodness of fit. One of 'laplace', 'AIC' or 'BIC'.
variable	a variable from colData to use as a grouping variable. Must be a character of factor.

Value

calculateDMN and getDMN return a list of DMN objects, one element for each value of k provided.

bestDMNFit returns the index for the best fit and getBestDMNFit returns a single DMN object.

calculateDMNgroup returns a DMNGroup object

performDMNgroupCV returns a data.frame

See Also

DMN-class, DMNGroup-class, dmn, dmngroup, cvdmngroup , accessors for DMN objects

Examples

```
fl <- system.file(package="DirichletMultinomial", "extdata", "Twins.csv")
counts <- as.matrix(read.csv(fl, row.names=1))
fl <- system.file(package="DirichletMultinomial", "extdata", "TwinStudy.t")
pheno0 <- scan(fl)
lvls <- c("Lean", "Obese", "Overwt")
pheno <- factor(lvls[pheno0 + 1], levels=lvls)
colData <- DataFrame(pheno = pheno)

tse <- TreeSummarizedExperiment(assays = list(counts = counts),
                                colData = colData)

library(bluster)

# Compute DMM algorithm and store result in metadata
tse <- cluster(tse, name = "DMM", DmmParam(k = 1:3, type = "laplace"),
               MARGIN = "samples", full = TRUE)

# Get the list of DMN objects
metadata(tse)$DMM$dmm

# Get and display which objects fits best
bestFit <- metadata(tse)$DMM$best
bestFit
```

```
# Get the model that generated the best fit
bestModel <- metadata(tse)$DMM$dmm[[bestFit]]
bestModel

# Get the sample-cluster assignment probability matrix
head(metadata(tse)$DMM$prob)

# Get the weight of each component for the best model
bestModel@mixture$Weight
```

`calculateJSD` *Calculate the Jensen-Shannon Divergence*

Description

This function calculates the Jensen-Shannon Divergence (JSD) in a `SummarizedExperiment` object.

Usage

```
## S4 method for signature 'ANY'
calculateJSD(x, ...)

## S4 method for signature 'SummarizedExperiment'
calculateJSD(
  x,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  transposed = FALSE,
  ...
)

runJSD(x, BPPARAM = SerialParam(), chunkSize = nrow(x))
```

Arguments

`x`	a numeric matrix or a `SummarizedExperiment`.
`...`	optional arguments not used.
`assay.type`	a single `character` value for specifying which assay to use for calculation.
`assay_name`	a single `character` value for specifying which assay to use for calculation. (Please use `assay.type` instead. At some point `assay_name` will be disabled.)
`exprs_values`	a single `character` value for specifying which assay to use for calculation. (Please use `assay.type` instead.)
`transposed`	Logical scalar, is x transposed with cells in rows?

BPPARAM — A BiocParallelParam object specifying whether the JSD calculation should be parallelized.

chunkSize — an integer scalar, defining the size of data send to the individual worker. Only has an effect, if BPPARAM defines more than one worker. (default: chunkSize = nrow(x))

Value

a sample-by-sample distance matrix, suitable for NMDS, etc.

Author(s)

Susan Holmes <susan@stat.stanford.edu>. Adapted for phyloseq by Paul J. McMurdie. Adapted for mia by Felix G.M. Ernst

References

Jensen-Shannon Divergence and Hilbert space embedding. Bent Fuglede and Flemming Topsoe University of Copenhagen, Department of Mathematics http://www.math.ku.dk/~topsoe/ISIT2004JSD.pdf

See Also

http://en.wikipedia.org/wiki/Jensen-Shannon_divergence

Examples

```
data(enterotype)
library(scater)


jsd <- calculateJSD(enterotype)
class(jsd)
head(jsd)

enterotype <- runMDS(enterotype, FUN = calculateJSD, name = "JSD",
                     exprs_values = "counts")
head(reducedDim(enterotype))
head(attr(reducedDim(enterotype),"eig"))
attr(reducedDim(enterotype),"GOF")
```

---

calculateOverlap *Estimate overlap*

Description

This function calculates overlap for all sample-pairs in a SummarizedExperiment object.

Usage

```
calculateOverlap(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  detection = 0,
  ...
)

## S4 method for signature 'SummarizedExperiment'
calculateOverlap(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  detection = 0,
  ...
)

runOverlap(x, ...)

## S4 method for signature 'SummarizedExperiment'
runOverlap(x, name = "overlap", ...)
```

Arguments

x	a SummarizedExperiment object containing a tree.
assay.type	A single character value for selecting the assay to calculate the overlap.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
detection	A single numeric value for selecting detection threshold for absence/presence of features. Feature that has abundance under threshold in either of samples, will be discarded when evaluating overlap between samples.
...	Optional arguments not used.
name	A single character value specifying the name of overlap matrix that is stored in reducedDim(x).

Details

These function calculates overlap between all the sample-pairs. Overlap reflects similarity between sample-pairs.

When overlap is calculated using relative abundances, the higher the value the higher the similarity is, When using relative abundances, overlap value 1 means that all the abundances of features are equal between two samples, and 0 means that samples have completely different relative abundances.

Value

calculateOverlap returns sample-by-sample distance matrix. runOverlap returns x that includes overlap matrix in its reducedDim.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

See Also

calculateJSD calculateUnifrac

Examples

```
data(esophagus)
tse <- esophagus
tse <- transformAssay(tse, method = "relabundance")
overlap <- calculateOverlap(tse, assay_name = "relabundance")
overlap

# Store result to reducedDim
tse <- runOverlap(tse, assay.type = "relabundance", name = "overlap_between_samples")
head(reducedDims(tse)$overlap_between_samples)
```

---

calculateUnifrac *Calculate weighted or unweighted (Fast) Unifrac distance*

Description

This function calculates the Unifrac distance for all sample-pairs in a TreeSummarizedExperiment object. The function utilizes rbiom:unifrac().

Usage

```
calculateUnifrac(x, tree, ...)

## S4 method for signature 'ANY,phylo'
calculateUnifrac(x, tree, weighted = FALSE, ...)

## S4 method for signature 'TreeSummarizedExperiment,missing'
calculateUnifrac(
  x,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  tree.name = tree_name,
  tree_name = "phylo",
```

```
  transposed = FALSE,
  ...
)

runUnifrac(
  x,
  tree,
  weighted = FALSE,
  node.label = nodeLab,
  nodeLab = NULL,
  ...
)
```

Arguments

x	a numeric matrix or a TreeSummarizedExperiment object containing a tree. Please note that runUnifrac expects a matrix with samples per row and not per column. This is implemented to be compatible with other distance calculations such as dist as much as possible.
tree	if x is a matrix, a phylo object matching the matrix. This means that the phylo object and the columns should relate to the same type of features (aka. microorganisms).
...	optional arguments not used.
weighted	TRUE or FALSE: Should use weighted-Unifrac calculation? Weighted-Unifrac takes into account the relative abundance of species/taxa shared between samples, whereas unweighted-Unifrac only considers presence/absence. Default is FALSE, meaning the unweighted-Unifrac distance is calculated for all pairs of samples.
assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
exprs_values	a single character value for specifying which assay to use for calculation. (Please use assay.type instead.)
tree.name	a single character value for specifying which tree will be used in calculation. (By default: tree.name = "phylo")
tree_name	Deprecated. Use tree.name instead.
transposed	Logical scalar, is x transposed with cells in rows, i.e., is Unifrac distance calculated based on rows (FALSE) or columns (TRUE). (By default: transposed = FALSE)
node.label	if x is a matrix, a character vector specifying links between rows/columns and tips of tree. The length must equal the number of rows/columns of x. Furthermore, all the node labs must be present in tree.
nodeLab	Deprecated. Use node.label instead.

Details

Please note that if `calculateUnifrac` is used as a `FUN` for `runMDS`, the argument `ntop` has to be set to `nrow(x)`.

Value

a sample-by-sample distance matrix, suitable for NMDS, etc.

References

http://bmf.colorado.edu/unifrac/

See also additional descriptions of Unifrac in the following articles:

Lozupone, Hamady and Knight, "Unifrac - An Online Tool for Comparing Microbial Community Diversity in a Phylogenetic Context.", BMC Bioinformatics 2006, 7:371

Lozupone, Hamady, Kelley and Knight, "Quantitative and qualitative (beta) diversity measures lead to different insights into factors that structure microbial communities." Appl Environ Microbiol. 2007

Lozupone C, Knight R. "Unifrac: a new phylogenetic method for comparing microbial communities." Appl Environ Microbiol. 2005 71 (12):8228-35.

Examples

```
data(esophagus)
library(scater)
calculateUnifrac(esophagus, weighted = FALSE)
calculateUnifrac(esophagus, weighted = TRUE)
# for using calculateUnifrac in conjunction with runMDS the tree argument
# has to be given separately. In addition, subsetting using ntop must
# be disabled
esophagus <- runMDS(esophagus, FUN = calculateUnifrac, name = "Unifrac",
                    tree = rowTree(esophagus),
                    assay.type = "counts",
                    ntop = nrow(esophagus))
reducedDim(esophagus)
```

---

deprecate *These functions will be deprecated. Please use other functions instead.*

Description

These functions will be deprecated. Please use other functions instead.

Usage

```
cluster(x, ...)

## S4 method for signature 'SummarizedExperiment'
cluster(x, ...)

addTaxonomyTree(x, ...)

## S4 method for signature 'SummarizedExperiment'
addTaxonomyTree(x, ...)

taxonomyTree(x, ...)

## S4 method for signature 'SummarizedExperiment'
taxonomyTree(x, ...)

mergeRows(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeRows(x, ...)

## S4 method for signature 'TreeSummarizedExperiment'
mergeRows(x, ...)

mergeCols(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeCols(x, ...)

## S4 method for signature 'TreeSummarizedExperiment'
mergeCols(x, ...)

mergeFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeFeatures(x, ...)

## S4 method for signature 'TreeSummarizedExperiment'
mergeFeatures(x, ...)

mergeSamples(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeSamples(x, ...)

## S4 method for signature 'TreeSummarizedExperiment'
mergeSamples(x, ...)
```

```
mergeFeaturesByRank(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeFeaturesByRank(x, ...)

## S4 method for signature 'SingleCellExperiment'
mergeFeaturesByRank(x, ...)

mergeFeaturesByPrevalence(x, ...)

## S4 method for signature 'SummarizedExperiment'
mergeFeaturesByPrevalence(x, ...)

getExperimentCrossAssociation(x, ...)

## S4 method for signature 'MultiAssayExperiment'
getExperimentCrossAssociation(x, ...)

## S4 method for signature 'SummarizedExperiment'
getExperimentCrossAssociation(x, ...)

## S4 method for signature 'TreeSummarizedExperiment'
mergeFeaturesByRank(x, ...)

testExperimentCrossAssociation(x, ...)

## S4 method for signature 'ANY'
testExperimentCrossAssociation(x, ...)

testExperimentCrossCorrelation(x, ...)

## S4 method for signature 'ANY'
testExperimentCrossCorrelation(x, ...)

getExperimentCrossCorrelation(x, ...)

## S4 method for signature 'ANY'
getExperimentCrossCorrelation(x, ...)

loadFromBiom(...)

loadFromQIIME2(...)

readQZA(...)

loadFromMothur(...)

loadFromMetaphlan(...)
```

```
loadFromHumann(...)

countDominantFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
countDominantFeatures(x, ...)

subsetByRareTaxa(x, ...)

## S4 method for signature 'ANY'
subsetByRareTaxa(x, ...)

subsetByRareFeatures(x, ...)

## S4 method for signature 'ANY'
subsetByRareFeatures(x, ...)

subsetByPrevalentTaxa(x, ...)

## S4 method for signature 'ANY'
subsetByPrevalentTaxa(x, ...)

subsetByPrevalentFeatures(x, ...)

## S4 method for signature 'ANY'
subsetByPrevalentFeatures(x, ...)

countDominantTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
countDominantTaxa(x, ...)

full_join(x, ...)

## S4 method for signature 'ANY'
full_join(x, ...)

inner_join(x, ...)

## S4 method for signature 'ANY'
inner_join(x, ...)

left_join(x, ...)

## S4 method for signature 'ANY'
left_join(x, ...)
```

```
right_join(x, ...)

## S4 method for signature 'ANY'
right_join(x, ...)

plotNMDS(x, ...)

estimateDivergence(x, ...)

## S4 method for signature 'SummarizedExperiment'
estimateDivergence(x, ...)

meltAssay(x, ...)

## S4 method for signature 'SummarizedExperiment'
meltAssay(x, ...)

transformSamples(x, ...)

## S4 method for signature 'SummarizedExperiment'
transformSamples(x, ...)

ZTransform(x, ...)

## S4 method for signature 'SummarizedExperiment'
ZTransform(x, ...)

relAbundanceCounts(x, ...)

## S4 method for signature 'SummarizedExperiment'
relAbundanceCounts(x, ...)

transformCounts(x, ...)

transformFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
transformFeatures(x, ...)

getUniqueFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
getUniqueFeatures(x, ...)

getUniqueTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
getUniqueTaxa(x, ...)
```

```
getTopFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
getTopFeatures(x, ...)

getTopTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
getTopTaxa(x, ...)

getRareFeatures(x, ...)

## S4 method for signature 'ANY'
getRareFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
getRareFeatures(x, ...)

getRareTaxa(x, ...)

## S4 method for signature 'ANY'
getRareTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
getRareTaxa(x, ...)

getPrevalentFeatures(x, ...)

## S4 method for signature 'ANY'
getPrevalentFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
getPrevalentFeatures(x, ...)

getPrevalentTaxa(x, ...)

## S4 method for signature 'ANY'
getPrevalentTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
getPrevalentTaxa(x, ...)

subsampleCounts(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsampleCounts(x, ...)
```

```
addPerSampleDominantFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
addPerSampleDominantFeatures(x, ...)

addPerSampleDominantTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
addPerSampleDominantTaxa(x, ...)

perSampleDominantFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
perSampleDominantFeatures(x, ...)

perSampleDominantTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
perSampleDominantTaxa(x, ...)
```

Arguments

x	A SummarizedExperiment object.
...	Additional parameters. See dedicated function.

---

dmn_se *dmn_se*

Description

dmn_se is a dataset on twins' microbiome where samples are stratified by their community composition through Dirichlet Multinomial Mixtures (DMM). It was derived from the **DirichletMultinomial** package.

Usage

```
data(dmn_se)
```

Format

A SummarizedExperiment with 130 features and 278 samples. The rowData contains no taxonomic information. The colData includes:

pheno participant's weight condition (Lean, Overwt and Obese)

Author(s)

Turnbaugh, PJ et al.

References

Holmes I, Harris K, Quince C (2012). Dirichlet Multinomial Mixtures: Generative Models for Microbial Metagenomics. PLoS ONE 7(2): e30126. https://doi.org/10.1371/journal.pone.0030126

Turnbaugh PJ, Hamady M, Yatsunenko T, Cantarel BL, Duncan A, et al. (2009). A core gut microbiome in obese and lean twins. Nature 457: 480–484. https://doi.org/10.1038/nature07540

See Also

mia-datasets calculateDMN

`enterotype` *enterotype*

Description

The enterotype data of the human gut microbiome includes taxonomic profiling for 280 fecal samples from 22 subjects based on shotgun DNA sequencing. The authors claimed that the data naturally clumps into three community-level clusters, or "enterotypes", that are not immediately explained by sequencing technology or demographic features of the subjects. In a later addendum from 2014 the authors stated that enterotypes should not be seen as discrete clusters, but as a way of stratifying samples to reduce complexity. It was converted into a TreeSummarizedExperiment from the **phyloseq** package.

Usage

```
data(enterotype)
```

Format

A TreeSummarizedExperiment with 553 features and 280 samples. The rowData contains taxonomic information at Genus level. The colData includes:

Enterotype enterotype the sample belongs to (1, 2 and 3)

Sample_ID sample ID of samples from all studies

SeqTech sequencing technology

SampleID sample ID of complete samples

Project original project from which sample was obtained (gill06, turnbaugh09, MetaHIT, MicroObes, MicroAge and kurokawa07)

Nationality participant's nationality (american, danish, spanish, french, italian and japanese)

Gender participant's gender (F or M)

Age participant's age (0.25 – 87)

ClinicalStatus participant's clinical status (healthy, obese, CD, UC and elderly)

Author(s)

Arumugam, M., Raes, J., et al.

Source

http://www.bork.embl.de/Docu/Arumugam_et_al_2011/downloads.html

References

Arumugam, M., et al. (2011). Enterotypes of the human gut microbiome. Nature, 473(7346), 174-180. https://doi.org/10.1038/nature09944

Arumugam, M., et al. (2014). Addendum: Enterotypes of the human gut microbiome. Nature 506, 516 (2014). https://doi.org/10.1038/nature13075

See Also

mia-datasets

---

esophagus *esophagus*

Description

This small dataset from a human esophageal community includes 3 samples from 3 human adults based on biopsies analysed with 16S rDNA PCR. The 16S rRNA sequence processing is provided in the mothur wiki from the link below. It was converted into a TreeSummarizedExperiment from the **phyloseq** package.

Usage

```
data(esophagus)
```

Format

A TreeSummarizedExperiment with 58 features and 3 samples. The rowData contains no taxonomic information. The colData is empty.

Author(s)

Pei et al. <zhiheng.pei@med.nyu.edu>.

Source

http://www.mothur.org/wiki/Esophageal_community_analysis

References

Pei, Z., Bini, E. J., Yang, L., Zhou, M., Francois, F., & Blaser, M. J. (2004). Bacterial biota in the human distal esophagus. Proceedings of the National Academy of Sciences of the United States of America, 101(12), 4250-4255. https://doi.org/10.1073/pnas.0306398101

McMurdie, J. & Holmes, S. (2013) *phyloseq*: An R Package for reproducible interactive analysis and graphics of microbiome census data. PLoS ONE. 8(4):e61217. https://doi.org/10.1371/journal.pone.0061217

See Also

mia-datasets

`estimateDiversity` *Estimate (alpha) diversity measures*

Description

Several functions for calculating (alpha) diversity indices, including the vegan package options and some others.

Usage

```
estimateDiversity(
  x,
  assay.type = "counts",
  assay_name = NULL,
  index = c("coverage", "fisher", "gini_simpson", "inverse_simpson",
    "log_modulo_skewness", "shannon"),
  name = index,
  ...
)

## S4 method for signature 'SummarizedExperiment'
estimateDiversity(
  x,
  assay.type = "counts",
  assay_name = NULL,
  index = c("coverage", "fisher", "gini_simpson", "inverse_simpson",
    "log_modulo_skewness", "shannon"),
  name = index,
  ...,
  BPPARAM = SerialParam()
)

## S4 method for signature 'TreeSummarizedExperiment'
estimateDiversity(
```

```
  x,
  assay.type = "counts",
  assay_name = NULL,
  index = c("coverage", "faith", "fisher", "gini_simpson", "inverse_simpson",
    "log_modulo_skewness", "shannon"),
  name = index,
  tree.name = tree_name,
  tree_name = "phylo",
  ...,
  BPPARAM = SerialParam()
)

estimateFaith(
  x,
  tree = "missing",
  assay.type = "counts",
  assay_name = NULL,
  name = "faith",
  ...
)

## S4 method for signature 'SummarizedExperiment,phylo'
estimateFaith(
  x,
  tree,
  assay.type = "counts",
  assay_name = NULL,
  name = "faith",
  node.label = node_lab,
  node_lab = NULL,
  ...
)

## S4 method for signature 'TreeSummarizedExperiment,missing'
estimateFaith(
  x,
  assay.type = "counts",
  assay_name = NULL,
  name = "faith",
  tree.name = tree_name,
  tree_name = "phylo",
  ...
)
```

Arguments

x	a SummarizedExperiment object or TreeSummarizedExperiment. The latter is recommended for microbiome data sets and tree-based alpha diversity indices.

assay.type	the name of the assay used for calculation of the sample-wise estimates.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
index	a character vector, specifying the diversity measures to be calculated.
name	a name for the column(s) of the colData the results should be stored in. By default this will use the original names of the calculated indices.
...	optional arguments: • threshold: A numeric value in the unit interval, determining the threshold for coverage index. By default, threshold is 0.9. • quantile: Arithmetic abundance classes are evenly cut up to to this quantile of the data. The assumption is that abundances higher than this are not common, and they are classified in their own group. By default, quantile is 0.5. • nclasses: The number of arithmetic abundance classes from zero to the quantile cutoff indicated by quantile. By default, nclasses is 50. • num_of_classes Deprecated. Use nclasses instead. • only.tips: A boolean value specifying whether to remove internal nodes when Faith's index is calculated. When only.tips=TRUE, those rows that are not tips of tree are removed. (By default: only.tips=FALSE)
BPPARAM	A BiocParallelParam object specifying whether calculation of estimates should be parallelized.
tree.name	a single character value for specifying which rowTree will be used to calculate faith index. (By default: tree.name = "phylo")
tree_name	Deprecated. Use tree.name isntead.
tree	A phylogenetic tree that is used to calculate 'faith' index. If x is a TreeSummarizedExperiment, rowTree(x) is used by default.
node.label	NULL or a character vector specifying the links between rows and node labels of tree. If a certain row is not linked with the tree, missing instance should be noted as NA. When NULL, all the rownames should be found from the tree. (By default: node.label = NULL)
node_lab	Deprecated. Use node.label instead.

Details

The available indices include the 'Coverage', 'Faith's phylogenetic diversity', 'Fisher alpha', 'Gini-Simpson', 'Inverse Simpson', 'log-modulo skewness', and 'Shannon' indices. See details for more information and references.

Alpha diversity is a joint quantity that combines elements or community richness and evenness. Diversity increases, in general, when species richness or evenness increase.

By default, this function returns all indices.

- 'coverage': Number of species needed to cover a given fraction of the ecosystem (50 percent by default). Tune this with the threshold argument.

- 'faith': Faith's phylogenetic alpha diversity index measures how long the taxonomic distance is between taxa that are present in the sample. Larger values represent higher diversity. Using this index requires rowTree. (Faith 1992)

  If the data includes features that are not in tree's tips but in internal nodes, there are two options. First, you can keep those features, and prune the tree to match features so that each tip can be found from the features. Other option is to remove all features that are not tips. (See `only.tips` parameter)

- 'fisher': Fisher's alpha; as implemented in `vegan::fisher.alpha`. (Fisher et al. 1943)

- 'gini_simpson': Gini-Simpson diversity i.e. $1 - lambda$, where $lambda$ is the Simpson index, calculated as the sum of squared relative abundances. This corresponds to the diversity index 'simpson' in `vegan::diversity`. This is also called Gibbs–Martin, or Blau index in sociology, psychology and management studies. The Gini-Simpson index (1-lambda) should not be confused with Simpson's dominance (lambda), Gini index, or inverse Simpson index (1/lambda).

- 'inverse_simpson': Inverse Simpson diversity: $1/lambda$ where $lambda = sum(p^2)$ and p refers to relative abundances. This corresponds to the diversity index 'invsimpson' in vegan::diversity. Don't confuse this with the closely related Gini-Simpson index

- 'log_modulo_skewness': The rarity index characterizes the concentration of species at low abundance. Here, we use the skewness of the frequency distribution of arithmetic abundance classes (see Magurran & McGill 2011). These are typically right-skewed; to avoid taking log of occasional negative skews, we follow Locey & Lennon (2016) and use the log-modulo transformation that adds a value of one to each measure of skewness to allow logarithmization.

- 'shannon': Shannon diversity (entropy).

Value

x with additional `colData` named `*name*`

Author(s)

Leo Lahti and Tuomas Borman. Contact: `microbiome.github.io`

References

Beisel J-N. et al. (2003) A Comparative Analysis of Diversity Index Sensitivity. *Internal Rev. Hydrobiol.* 88(1):3-15. https://portais.ufg.br/up/202/o/2003-comparative_evennes_index.pdf

Bulla L. (1994) An index of diversity and its associated diversity measure. *Oikos* 70:167–171

Faith D.P. (1992) Conservation evaluation and phylogenetic diversity. *Biological Conservation* 61(1):1-10.

Fisher R.A., Corbet, A.S. & Williams, C.B. (1943) The relation between the number of species and the number of individuals in a random sample of animal population. *Journal of Animal Ecology 12*, 42-58.

Locey K.J. & Lennon J.T. (2016) Scaling laws predict global microbial diversity. *PNAS* 113(21):5970-5975.

Magurran A.E., McGill BJ, eds (2011) Biological Diversity: Frontiers in Measurement and Assessment. (Oxford Univ Press, Oxford), Vol 12.

Smith B. & Wilson JB. (1996) A Consumer's Guide to Diversity Indices. *Oikos* 76(1):70-82.

See Also

plotColData

- estimateRichness
- estimateEvenness
- estimateDominance
- diversity
- estimateR

Examples

```
data(GlobalPatterns)
tse <- GlobalPatterns

# All index names as known by the function
index <- c("shannon","gini_simpson","inverse_simpson", "coverage", "fisher",
"faith",  "log_modulo_skewness")

# Corresponding polished names
name <- c("Shannon","GiniSimpson","InverseSimpson", "Coverage", "Fisher",
"Faith",  "LogModSkewness")

# Calculate diversities
tse <- estimateDiversity(tse, index = index)

# The colData contains the indices with their code names by default
colData(tse)[, index]

# Removing indices
colData(tse)[, index] <- NULL

# 'threshold' can be used to determine threshold for 'coverage' index
tse <- estimateDiversity(tse, index = "coverage", threshold = 0.75)
# 'quantile' and 'nclasses' can be used when
# 'log_modulo_skewness' is calculated
tse <- estimateDiversity(tse, index = "log_modulo_skewness",
       quantile = 0.75, nclasses = 100)

# It is recommended to specify also the final names used in the output.
tse <- estimateDiversity(tse,
  index = c("shannon", "gini_simpson", "inverse_simpson", "coverage",
              "fisher", "faith", "log_modulo_skewness"),
   name = c("Shannon", "GiniSimpson",  "InverseSimpson",  "Coverage",
              "Fisher", "Faith", "LogModSkewness"))

# The colData contains the indices by their new names provided by the user
```

```
colData(tse)[, name]

# Compare the indices visually
pairs(colData(tse)[, name])

# Plotting the diversities - use the selected names
library(scater)
plotColData(tse, "Shannon")
# ... by sample type
plotColData(tse, "Shannon", "SampleType")

# combining different plots
library(patchwork)
plot_index <- c("Shannon","GiniSimpson")
plots <- lapply(plot_index,
               plotColData,
               object = tse,
               x = "SampleType",
               colour_by = "SampleType")
plots <- lapply(plots,"+",
   theme(axis.text.x = element_text(angle=45,hjust=1)))
names(plots) <- plot_index
plots$Shannon + plots$GiniSimpson + plot_layout(guides = "collect")
```

`estimateDominance` *Estimate dominance measures*

Description

This function calculates community dominance indices. This includes the 'Absolute', 'Berger-Parker', 'Core abundance', 'Gini', 'McNaughton's', 'Relative', and 'Simpson's' indices.

Usage

```
estimateDominance(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  index = c("absolute", "dbp", "core_abundance", "gini", "dmn", "relative",
    "simpson_lambda"),
  ntaxa = 1,
  aggregate = TRUE,
  name = index,
  ...,
  BPPARAM = SerialParam()
)

## S4 method for signature 'SummarizedExperiment'
```

```
estimateDominance(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  index = c("absolute", "dbp", "core_abundance", "gini", "dmn", "relative",
    "simpson_lambda"),
  ntaxa = 1,
  aggregate = TRUE,
  name = index,
  ...,
  BPPARAM = SerialParam()
)
```

Arguments

x	a SummarizedExperiment object
assay.type	A single character value for selecting the assay to calculate the sample-wise estimates.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
index	a character vector, specifying the indices to be calculated.
ntaxa	Optional and only used for the Absolute and Relative dominance indices: The n-th position of the dominant taxa to consider (default: ntaxa = 1). Disregarded for the indices "dbp", "core_abundance", "Gini", "dmn", and "Simpson".
aggregate	Optional and only used for the Absolute, dbp, Relative, and dmn dominance indices: Aggregate the values for top members selected by ntaxa or not. If TRUE, then the sum of relative abundances is returned. Otherwise the relative abundance is returned for the single taxa with the indicated rank (default: aggregate = TRUE). Disregarded for the indices "core_abundance", "gini", "dmn", and "simpson".
name	A name for the column(s) of the colData where the calculated Dominance indices should be stored in.
...	additional arguments currently not used.
BPPARAM	A BiocParallelParam object specifying whether calculation of estimates should be parallelized. (Currently not used)

Details

A dominance index quantifies the dominance of one or few species in a community. Greater values indicate higher dominance.

Dominance indices are in general negatively correlated with alpha diversity indices (species richness, evenness, diversity, rarity). More dominant communities are less diverse.

estimateDominance calculates the following community dominance indices:

- 'absolute': Absolute index equals to the absolute abundance of the most dominant n species of the sample (specify the number with the argument ntaxa). Index gives positive integer values.

- 'dbp': Berger-Parker index (See Berger & Parker 1970) calculation is a special case of the 'relative' index. dbp is the relative abundance of the most abundant species of the sample. Index gives values in interval 0 to 1, where bigger value represent greater dominance.

$$dbp = \frac{N_1}{N_{tot}}$$

where N_1 is the absolute abundance of the most dominant species and N_{tot} is the sum of absolute abundances of all species.

- 'core_abundance': Core abundance index is related to core species. Core species are species that are most abundant in all samples, i.e., in whole data set. Core species are defined as those species that have prevalence over 50\ species must be prevalent in 50\ calculate the core abundance index. Core abundance index is sum of relative abundances of core species in the sample. Index gives values in interval 0 to 1, where bigger value represent greater dominance.

$$core_abundance = \frac{N_{core}}{N_{tot}}$$

where N_{core} is the sum of absolute abundance of the core species and N_{tot} is the sum of absolute abundances of all species.

- 'gini': Gini index is probably best-known from socio-economic contexts (Gini 1921). In economics, it is used to measure, for example, how unevenly income is distributed among population. Here, Gini index is used similarly, but income is replaced with abundance.

  If there is small group of species that represent large portion of total abundance of microbes, the inequality is large and Gini index closer to 1. If all species has equally large abundances, the equality is perfect and Gini index equals 0. This index should not be confused with Gini-Simpson index, which quantifies diversity.

- 'dmn': McNaughton's index is the sum of relative abundances of the two most abundant species of the sample (McNaughton & Wolf, 1970). Index gives values in the unit interval:

$$dmn = (N_1 + N_2)/N_tot$$

where N_1 and N_2 are the absolute abundances of the two most dominant species and N_{tot} is the sum of absolute abundances of all species.

- 'relative': Relative index equals to the relative abundance of the most dominant n species of the sample (specify the number with the argument `ntaxa`). This index gives values in interval 0 to 1.

$$relative = N_1/N_tot$$

where N_1 is the absolute abundance of the most dominant species and N_{tot} is the sum of absolute abundances of all species.

- 'simpson_lambda': Simpson's (dominance) index or Simpson's lambda is the sum of squared relative abundances. This index gives values in the unit interval. This value equals the probability that two randomly chosen individuals belongs to the same species. The higher the probability, the greater the dominance (See e.g. Simpson 1949).

$$lambda = \sum(p^2)$$

where p refers to relative abundances.

There is also a more advanced Simpson dominance index (Simpson 1949). However, this is not provided and the simpler squared sum of relative abundances is used instead as the alternative index is not in the unit interval and it is highly correlated with the simpler variant implemented here.

Value

x with additional `colData` named `*name*`

Author(s)

Leo Lahti and Tuomas Borman. Contact: `microbiome.github.io`

References

Berger WH & Parker FL (1970) Diversity of Planktonic Foraminifera in Deep-Sea Sediments. *Science* 168(3937):1345-1347. doi: 10.1126/science.168.3937.1345

Gini C (1921) Measurement of Inequality of Incomes. *The Economic Journal* 31(121): 124-126. doi: 10.2307/2223319

McNaughton, SJ and Wolf LL. (1970). Dominance and the niche in ecological systems. *Science* 167:13, 1–139

Simpson EH (1949) Measurement of Diversity. *Nature* 163(688). doi: 10.1038/163688a0

See Also

- `estimateRichness`
- `estimateEvenness`
- `estimateDiversity`

Examples

```
data(esophagus)

# Calculates Simpson's lambda (can be used as a dominance index)
esophagus <- estimateDominance(esophagus, index="simpson_lambda")

# Shows all indices
colData(esophagus)

# Indices must be written correctly (e.g. dbp, not dbp), otherwise an error
# gets thrown
esophagus <- estimateDominance(esophagus, index="dbp")
# Calculates dbp and Core Abundance indices
esophagus <- estimateDominance(esophagus, index=c("dbp", "core_abundance"))
# Shows all indices
colData(esophagus)
# Shows dbp index
colData(esophagus)$dbp
```

```
# Deletes dbp index
colData(esophagus)$dbp <- NULL
# Shows all indices, dbp is deleted
colData(esophagus)
# Deletes all indices
colData(esophagus) <- NULL

# Calculates all indices
esophagus <- estimateDominance(esophagus)
# Shows all indices
colData(esophagus)
# Deletes all indices
colData(esophagus) <- NULL

# Calculates all indices with explicitly specified names
esophagus <- estimateDominance(esophagus,
    index = c("dbp", "dmn", "absolute", "relative",
              "simpson_lambda", "core_abundance", "gini"),
    name  = c("BergerParker", "McNaughton", "Absolute", "Relative",
              "SimpsonLambda", "CoreAbundance", "Gini")
)
# Shows all indices
colData(esophagus)
```

`estimateEvenness` *Estimate Evenness measures*

Description

This function calculates community evenness indices. These include the 'Camargo', 'Pielou', 'Simpson', 'Evar' and 'Bulla' evenness measures. See details for more information and references.

Usage

```
estimateEvenness(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  index = c("pielou", "camargo", "simpson_evenness", "evar", "bulla"),
  name = index,
  ...
)

## S4 method for signature 'SummarizedExperiment'
estimateEvenness(
  x,
  assay.type = assay_name,
  assay_name = "counts",
```

```
  index = c("camargo", "pielou", "simpson_evenness", "evar", "bulla"),
  name = index,
  ...,
  BPPARAM = SerialParam()
)
```

Arguments

x	a SummarizedExperiment object
assay.type	A single character value for selecting the assay used for calculation of the sample-wise estimates.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
index	a character vector, specifying the evenness measures to be calculated.
name	a name for the column(s) of the colData the results should be stored in.
...	optional arguments: • threshold: a numeric threshold. assay values below or equal to this threshold will be set to zero.
BPPARAM	A BiocParallelParam object specifying whether calculation of estimates should be parallelized.

Details

Evenness is a standard index in community ecology, and it quantifies how evenly the abundances of different species are distributed. The following evenness indices are provided:

By default, this function returns all indices.

The available evenness indices include the following (all in lowercase):

- 'camargo': Camargo's evenness (Camargo 1992)
- 'simpson_evenness': Simpson's evenness is calculated as inverse Simpson diversity (1/lambda) divided by observed species richness S: (1/lambda)/S.
- 'pielou': Pielou's evenness (Pielou, 1966), also known as Shannon or Shannon-Weaver/Wiener/Weiner evenness; H/ln(S). The Shannon-Weaver is the preferred term; see Spellerberg and Fedor (2003).
- 'evar': Smith and Wilson's Evar index (Smith & Wilson 1996).
- 'bulla': Bulla's index (O) (Bulla 1994).

Desirable statistical evenness metrics avoid strong bias towards very large or very small abundances; are independent of richness; and range within the unit interval with increasing evenness (Smith & Wilson 1996). Evenness metrics that fulfill these criteria include at least camargo, simpson, smith-wilson, and bulla. Also see Magurran & McGill (2011) and Beisel et al. (2003) for further details.

Value

x with additional colData named *name*

References

Beisel J-N. et al. (2003) A Comparative Analysis of Evenness Index Sensitivity. *Internal Rev. Hydrobiol.* 88(1):3-15. URL: https://portais.ufg.br/up/202/o/2003-comparative_evennes_index.pdf

Bulla L. (1994) An index of evenness and its associated diversity measure. *Oikos* 70:167–171.

Camargo, JA. (1992) New diversity index for assessing structural alterations in aquatic communities. *Bull. Environ. Contam. Toxicol.* 48:428–434.

Locey KJ and Lennon JT. (2016) Scaling laws predict global microbial diversity. *PNAS* 113(21):5970-5975; doi:10.1073/pnas.1521291113.

Magurran AE, McGill BJ, eds (2011) Biological Diversity: Frontiers in Measurement and Assessment (Oxford Univ Press, Oxford), Vol 12.

Pielou, EC. (1966) The measurement of diversity in different types of biological collections. *J Theoretical Biology* 13:131–144.

Smith B and Wilson JB. (1996) A Consumer's Guide to Evenness Indices. *Oikos* 76(1):70-82.

Spellerberg and Fedor (2003). A tribute to Claude Shannon (1916 –2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. *Alpha Ecology & Biogeography* 12, 177–197.

See Also

plotColData

- estimateRichness
- estimateDominance
- estimateDiversity

Examples

```
data(esophagus)
tse <- esophagus

# Specify index and their output names
index <- c("pielou", "camargo", "simpson_evenness", "evar", "bulla")
name  <- c("Pielou", "Camargo", "SimpsonEvenness",  "Evar", "Bulla")

# Estimate evenness and give polished names to be used in the output
tse <- estimateEvenness(tse, index = index, name = name)

# Check the output
head(colData(tse))
```

`estimateRichness` *Estimate richness measures*

Description

Several functions for calculation of community richness indices available via wrapper functions. They are implemented via the vegan package.

Usage

```
estimateRichness(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  index = c("ace", "chao1", "hill", "observed"),
  name = index,
  detection = 0,
  ...,
  BPPARAM = SerialParam()
)

## S4 method for signature 'SummarizedExperiment'
estimateRichness(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  index = c("ace", "chao1", "hill", "observed"),
  name = index,
  detection = 0,
  ...,
  BPPARAM = SerialParam()
)
```

Arguments

`x`	a `SummarizedExperiment` object.
`assay.type`	the name of the assay used for calculation of the sample-wise estimates.
`assay_name`	a single `character` value for specifying which assay to use for calculation. (Please use `assay.type` instead. At some point `assay_name` will be disabled.)
`index`	a `character` vector, specifying the richness measures to be calculated.
`name`	a name for the column(s) of the colData the results should be stored in.
`detection`	a numeric value for selecting detection threshold for the abundances. The default detection threshold is 0.
`...`	additional parameters passed to `estimateRichness`
`BPPARAM`	A `BiocParallelParam` object specifying whether calculation of estimates should be parallelized.

Details

These include the 'ace', 'Chao1', 'Hill', and 'Observed' richness measures. See details for more information and references.

The richness is calculated per sample. This is a standard index in community ecology, and it provides an estimate of the number of unique species in the community. This is often not directly observed for the whole community but only for a limited sample from the community. This has led to alternative richness indices that provide different ways to estimate the species richness.

Richness index differs from the concept of species diversity or evenness in that it ignores species abundance, and focuses on the binary presence/absence values that indicate simply whether the species was detected.

The function takes all index names in full lowercase. The user can provide the desired spelling through the argument `name` (see examples).

The following richness indices are provided.

- 'ace': Abundance-based coverage estimator (ACE) is another nonparametric richness index that uses sample coverage, defined based on the sum of the probabilities of the observed species. This method divides the species into abundant (more than 10 reads or observations) and rare groups in a sample and tends to underestimate the real number of species. The ACE index ignores the abundance information for the abundant species, based on the assumption that the abundant species are observed regardless of their exact abundance. We use here the bias-corrected version (O'Hara 2005, Chiu et al. 2014) implemented in `estimateR`. For an exact formulation, see `estimateR`. Note that this index comes with an additional column with standard error information.
- 'chao1': This is a nonparametric estimator of species richness. It assumes that rare species carry information about the (unknown) number of unobserved species. We use here the bias-corrected version (O'Hara 2005, Chiu et al. 2014) implemented in `estimateR`. This index implicitly assumes that every taxa has equal probability of being observed. Note that it gives a lower bound to species richness. The bias-corrected for an exact formulation, see `estimateR`. This estimator uses only the singleton and doubleton counts, and hence it gives more weight to the low abundance species. Note that this index comes with an additional column with standard error information.
- 'hill': Effective species richness aka Hill index (see e.g. Chao et al. 2016). Currently only the case 1D is implemented. This corresponds to the exponent of Shannon diversity. Intuitively, the effective richness indicates the number of species whose even distribution would lead to the same diversity than the observed community, where the species abundances are unevenly distributed.
- 'observed': The *observed richness* gives the number of species that is detected above a given `detection` threshold in the observed sample (default 0). This is conceptually the simplest richness index. The corresponding index in the **vegan** package is "richness".

Value

`x` with additional `colData` named `*name*`

Author(s)

Leo Lahti. Contact: `microbiome.github.io`

References

Chao A. (1984) Non-parametric estimation of the number of classes in a population. *Scand J Stat.* 11:265–270.

Chao A, Chun-Huo C, Jost L (2016). Phylogenetic Diversity Measures and Their Decomposition: A Framework Based on Hill Numbers. Biodiversity Conservation and Phylogenetic Systematics, Springer International Publishing, pp. 141–172, doi:10.1007/978-3-319-22461-9_8.

Chiu, C.H., Wang, Y.T., Walther, B.A. & Chao, A. (2014). Improved nonparametric lower bound of species richness via a modified Good-Turing frequency formula. *Biometrics* 70, 671-682.

O'Hara, R.B. (2005). Species richness estimators: how many species can dance on the head of a pin? *J. Anim. Ecol.* 74, 375-386.

See Also

plotColData

- estimateR

Examples

```
data(esophagus)

# Calculates all richness indices by default
esophagus <- estimateRichness(esophagus)

# Shows all indices
colData(esophagus)

# Shows Hill index
colData(esophagus)$hill

# Deletes hill index
colData(esophagus)$hill <- NULL

# Shows all indices, hill is deleted
colData(esophagus)

# Delete the remaining indices
colData(esophagus)[, c("observed", "chao1", "ace")] <- NULL

# Calculates observed richness index and saves them with specific names
esophagus <- estimateRichness(esophagus,
    index = c("observed", "chao1", "ace", "hill"),
     name = c("Observed", "Chao1", "ACE", "Hill"))

# Show the new indices
colData(esophagus)

# Deletes all colData (including the indices)
colData(esophagus) <- NULL
```

```
# Calculate observed richness excluding singletons (detection limit 1)
esophagus <- estimateRichness(esophagus, index="observed", detection = 1)

# Deletes all colData (including the indices)
colData(esophagus) <- NULL

# Indices must be written correctly (all lowercase), otherwise an error
# gets thrown
esophagus <- estimateRichness(esophagus, index="ace")

# Calculates Chao1 and ACE indices only
esophagus <- estimateRichness(esophagus, index=c("chao1", "ace"),
                                          name=c("Chao1", "ACE"))

# Deletes all colData (including the indices)
colData(esophagus) <- NULL

# Names of columns can be chosen arbitrarily, but the length of arguments
# must match.
esophagus <- estimateRichness(esophagus,
                              index = c("ace", "chao1"),
                              name = c("index1", "index2"))
# Shows all indices
colData(esophagus)
```

`getCrossAssociation` *Calculate correlations between features of two experiments.*

Description

Calculate correlations between features of two experiments.

Usage

```
getCrossAssociation(x, ...)

## S4 method for signature 'MultiAssayExperiment'
getCrossAssociation(
  x,
  experiment1 = 1,
  experiment2 = 2,
  assay.type1 = assay_name1,
  assay_name1 = "counts",
  assay.type2 = assay_name2,
  assay_name2 = "counts",
  altexp1 = NULL,
  altexp2 = NULL,
  col.var1 = colData_variable1,
```

```
  colData_variable1 = NULL,
  col.var2 = colData_variable2,
  colData_variable2 = NULL,
  MARGIN = 1,
  method = c("kendall", "spearman", "categorical", "pearson"),
  mode = "table",
  p.adj.method = p_adj_method,
 p_adj_method = c("fdr", "BH", "bonferroni", "BY", "hochberg", "holm", "hommel", "none"),
  p.adj.threshold = p_adj_threshold,
  p_adj_threshold = NULL,
  cor.threshold = cor_threshold,
  cor_threshold = NULL,
  sort = FALSE,
  filter.self.cor = filter_self_correlations,
  filter_self_correlations = FALSE,
  verbose = TRUE,
  test.signif = test_significance,
  test_significance = FALSE,
  show.warnings = show_warnings,
  show_warnings = TRUE,
  paired = FALSE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getCrossAssociation(x, experiment2 = x, ...)
```

Arguments

x	A MultiAssayExperiment or SummarizedExperiment object.
...	Additional arguments: • symmetric: A single boolean value for specifying if measure is symmetric or not. When symmetric = TRUE, associations are calculated only for unique variable-pairs, and they are assigned to corresponding variable-pair. This decreases the number of calculations in 2-fold meaning faster execution. (By default: symmetric = FALSE) • association.fun: A function that is used to calculate (dis-)similarity between features. Function must take matrix as an input and give numeric values as an output. Adjust method and other parameters correspondingly. Supported functions are, for example, stats::dist and vegan::vegdist.
experiment1	A single character or numeric value for selecting the experiment 1 from experiments(x) of MultiassayExperiment object. (By default: experiment1 = 1)
experiment2	A single character or numeric value for selecting the experiment 2 fromexperiments(x) of MultiAssayExperiment object or altExp(x) of TreeSummarizedExperiment object. Alternatively, experiment2 can also be TreeSE object when x is TreeSE object. (By default: experiment2 = 2 when x is MAE and experiment2 = x when x is TreeSE)

assay.type1 A single character value for selecting the assay of experiment 1 to be transformed. (By default: assay.type1 = "counts")

assay_name1 Deprecated. Use assay.type1 instead.

assay.type2 A single character value for selecting the assay of experiment 2 to be transformed. (By default: assay.type2 = "counts")

assay_name2 Deprecated. Use assay.type2 instead.

altexp1 A single numeric or character value specifying alternative experiment from the altExp of experiment 1. If NULL, then the experiment is itself and altExp option is disabled. (By default: altexp1 = NULL)

altexp2 A single numeric or character value specifying alternative experiment from the altExp of experiment 2. If NULL, then the experiment is itself and altExp option is disabled. (By default: altexp2 = NULL)

col.var1 A character value specifying column(s) from colData of experiment 1. If col.var1 is used, assay.type1 is disabled. (By default: col.var1 = NULL)

colData_variable1
Deprecated. Use col.var1 instead.

col.var2 A character value specifying column(s) from colData of experiment 2. If col.var2 is used, assay.type2 is disabled. (By default: col.var2 = NULL)

colData_variable2
Deprecated. Use col.var2 instead.

MARGIN A single numeric value for selecting if association are calculated row-wise / for features (1) or column-wise / for samples (2). Must be 1 or 2. (By default: MARGIN = 1)

method A single character value for selecting association method ('kendall', pearson', or 'spearman' for continuous/numeric; 'categorical' for discrete) (By default: method = "kendall")

mode A single character value for selecting output format Available formats are 'table' and 'matrix'. (By default: mode = "table")

p.adj.method A single character value for selecting adjustment method of p-values. Passed to p.adjust function. (By default: p.adj.method = "fdr")

p_adj_method Deprecated. Use p.adj.method isntead.

p.adj.threshold
A single numeric value (from 0 to 1) for selecting adjusted p-value threshold for filtering. (By default: p.adj.threshold = NULL)

p_adj_threshold
Deprecated. Use p.dj.threshold instead.

cor.threshold A single numeric absolute value (from 0 to 1) for selecting correlation threshold for filtering. (By default: cor.threshold = NULL)

cor_threshold Deprecated. Use cor.threshold instead.

sort A single boolean value for selecting whether to sort features or not in result matrices. Used method is hierarchical clustering. (By default: sort = FALSE)

`filter.self.cor`
: A single boolean value for selecting whether to filter out correlations between identical items. Applies only when correlation between experiment itself is tested, i.e., when assays are identical. (By default: `filter.self.cor = FALSE`)

`filter_self_correlations`
: Deprecated. Use `filter.self.cor` instead.

`verbose`
: A single boolean value for selecting whether to get messages about progress of calculation.

`test.signif`
: A single boolean value for selecting whether to test statistical significance of associations. (By default: `test.signif = FALSE`)

`test_significance`
: Deprecated. Use `test.signif` instead.

`show.warnings`
: A single boolean value for selecting whether to show warnings that might occur when correlations and p-values are calculated.

`show_warnings`
: Deprecated. use `show.warnings` instead.

`paired`
: A single boolean value for specifying if samples are paired or not. `colnames` must match between twp experiments. `paired` is disabled when `MARGIN = 1`. (By default: `paired = FALSE`)

Details

The function `getCrossAssociation` calculates associations between features of two experiments. By default, it not only computes associations but also tests their significance. If desired, setting `test.signif` to FALSE disables significance calculation.

We recommend the non-parametric Kendall's tau as the default method for association analysis. Kendall's tau has desirable statistical properties and robustness at lower sample sizes. Spearman rank correlation can provide faster solutions when running times are critical.

Value

This function returns associations in table or matrix format. In table format, returned value is a data frame that includes features and associations (and p-values) in columns. In matrix format, returned value is a one matrix when only associations are calculated. If also significances are tested, then returned value is a list of matrices.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

Examples

```
data(HintikkaXOData)
mae <- HintikkaXOData

# Subset so that less observations / quicker to run, just for example
mae[[1]] <- mae[[1]][1:20, 1:10]
mae[[2]] <- mae[[2]][1:20, 1:10]
# Several rows in the counts assay have a standard deviation of zero
```

```
# Remove them, since they do not add useful information about cross-association
mae[[1]] <- mae[[1]][rowSds(assay(mae[[1]])) > 0, ]
# Transform data
mae[[1]] <- transformAssay(mae[[1]], method = "rclr")

# Calculate cross-correlations
result <- getCrossAssociation(mae, method = "pearson", assay.type2 = "nmr")
# Show first 5 entries
head(result, 5)

# Use altExp option to specify alternative experiment from the experiment
altExp(mae[[1]], "Phylum") <- agglomerateByRank(mae[[1]], rank = "Phylum")
# Transform data
altExp(mae[[1]], "Phylum") <- transformAssay(altExp(mae[[1]], "Phylum"), method = "relabundance")
# When mode = "matrix", the return value is a matrix
result <- getCrossAssociation(mae, experiment2 = 2,
                                    assay.type1 = "relabundance", assay.type2 = "nmr",
                                      altexp1 = "Phylum",
                                      method = "pearson", mode = "matrix")
# Show first 5 entries
head(result, 5)

# If test.signif = TRUE, then getCrossAssociation additionally returns
# significances
# filter.self.cor = TRUE filters self correlations
# p.adj.threshold can be used to filter those features that do not
# have any correlations whose p-value is lower than the threshold
result <- getCrossAssociation(mae[[1]], experiment2 = mae[[1]], method = "pearson",
                                       filter.self.cor = TRUE,
                                       p.adj.threshold = 0.05,
                                       test.signif = TRUE)
# Show first 5 entries
head(result, 5)

# Returned value is a list of matrices
names(result)

# Calculate Bray-Curtis dissimilarity between samples. If dataset includes
# paired samples, you can use paired = TRUE.
result <- getCrossAssociation(mae[[1]], mae[[1]], MARGIN = 2, paired = FALSE,
                                       association.fun = vegan::vegdist,
                                       method = "bray")


# If experiments are equal and measure is symmetric (e.g., taxa1 vs taxa2 == taxa2 vs taxa1),
# it is possible to speed-up calculations by calculating association only for unique
# variable-pairs. Use "symmetric" to choose whether to measure association for only
# other half of of variable-pairs.
result <- getCrossAssociation(mae, experiment1 = "microbiota",
                                  experiment2 = "microbiota",
                                  assay.type1 = "counts",
                                  assay.type2 = "counts",
                                  symmetric = TRUE)
```

```
# For big data sets, the calculations might take a long time.
# To speed them up, you can take a random sample from the data.
# When dealing with complex biological problems, random samples can be
# enough to describe the data. Here, our random sample is 30 % of whole data.
sample_size <- 0.3
tse <- mae[[1]]
tse_sub <- tse[ sample( seq_len( nrow(tse) ), sample_size * nrow(tse) ), ]
result <- getCrossAssociation(tse_sub)

# It is also possible to choose variables from colData and calculate association
# between assay and sample metadata or between variables of sample metadata
mae[[1]] <- estimateDiversity(mae[[1]])
# colData_variable works similarly to assay.type. Instead of fetching an assay
# named assay.type from assay slot, it fetches a column named colData_variable
# from colData.
result <- getCrossAssociation(mae[[1]], assay.type1 = "counts",
                                col.var2 = c("shannon", "coverage"),
                                test.signif = TRUE)
```

---

getDominant *Get dominant taxa*

Description

These functions return information about the most dominant taxa in a SummarizedExperiment object.

Usage

```
getDominant(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  rank = NULL,
  other.name = "Other",
  n = NULL,
  complete = TRUE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getDominant(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  rank = NULL,
  other.name = "Other",
```

```
  n = NULL,
  complete = TRUE,
  ...
)

addDominant(x, name = "dominant_taxa", other.name = "Other", n = NULL, ...)

## S4 method for signature 'SummarizedExperiment'
addDominant(
  x,
  name = "dominant_taxa",
  other.name = "Other",
  n = NULL,
  complete = FALSE,
  ...
)
```

Arguments

x	A SummarizedExperiment object.
assay.type	A single character value for selecting the assay to use for identifying dominant taxa.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
rank	A single character defining a taxonomic rank. Must be a value of the output of taxonomyRanks().
other.name	A name for features that are not included in n the most frequent dominant features in the data. Default is "Other".
n	The number of features that are the most frequent dominant features. Default is NULL, which defaults that each sample is assigned a dominant taxon.
complete	A boolean value to manage multiple dominant taxa for a sample. Default for getDominant is TRUE to include all equally dominant taxa for each sample. complete = FALSE samples one taxa for the samples that have multiple. Default for addDominant is FALSE to add a column with only one dominant taxon assigned for each sample into colData. complete = TRUE adds a list that includes all dominant taxa for each sample into colData.
...	Additional arguments passed on to agglomerateByRank() when rank is specified.
name	A name for the column of the colData where the dominant taxa will be stored in when using addDominant.

Details

addDominant extracts the most abundant taxa in a SummarizedExperiment object, and stores the information in the colData. It is a wrapper for getDominant.

With rank parameter, it is possible to agglomerate taxa based on taxonomic ranks. E.g. if 'Genus' rank is used, all abundances of same Genus are added together, and those families are returned. See agglomerateByRank() for additional arguments to deal with missing values or special characters.

Value

getDominant returns a named character vector x while addDominant returns SummarizedExperiment with additional column in colData named *name*.

Author(s)

Leo Lahti, Tuomas Borman and Sudarshan A. Shetty.

Examples

```
data(GlobalPatterns)
x <- GlobalPatterns

# Finds the dominant taxa.
sim.dom <- getDominant(x, rank="Genus")

# Add information to colData
x <- addDominant(x, rank = "Genus", name="dominant_genera")
colData(x)
```

---

getMediation *Perform mediation analysis*

Description

getMediation and addMediation provide a wrapper of mediate for SummarizedExperiment.

Usage

```
addMediation(x, ...)

## S4 method for signature 'SummarizedExperiment'
addMediation(
  x,
  outcome,
  treatment,
  name = "mediation",
  mediator = NULL,
  assay.type = NULL,
  dimred = NULL,
  family = gaussian(),
  covariates = NULL,
  p.adj.method = "holm",
```

```
  add.metadata = FALSE,
  verbose = TRUE,
  ...
)

getMediation(x, ...)

## S4 method for signature 'SummarizedExperiment'
getMediation(
  x,
  outcome,
  treatment,
  mediator = NULL,
  assay.type = NULL,
  dimred = NULL,
  family = gaussian(),
  covariates = NULL,
  p.adj.method = "holm",
  add.metadata = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

x	a SummarizedExperiment.
...	additional parameters that can be passed to mediate.
outcome	A single character value indicating the colData variable used as outcome in the model.
treatment	A single character value indicating the colData variable used as treatment in the model.
name	A single character value to name the metadata element and avoid overwriting other metadata slots. It is supported only by addMediation. (default: name = "mediation")
mediator	A single character value indicating the colData variable used as mediator in the model. (default: mediator = NULL)
assay.type	A single character value indicating the assay used for feature-wise mediation analysis. (default: assay.type = NULL)
dimred	A single character value indicating the reduced dimension result in reducedDims(object) for component-wise mediation analysis. (default: dimred = NULL)
family	A specification for the outcome model link function. (default: family = gaussian("identity"))
covariates	Single character value or list indicating the colData variables used as covariates in the model. (default: covariates = NULL)
p.adj.method	A single character value for selecting adjustment method of p-values. Passed to p.adjust function. (default: p.adj.method = "holm")

add.metadata	TRUE or FALSE, should the model metadata be returned. (default: add.metadata = FALSE)
verbose	TRUE or FALSE, should execution messages be printed. (default: verbose = TRUE)

Details

This wrapper of mediate for SummarizedExperiment provides a simple method to analyse the effect of a treatment variable on an outcome variable found in colData(se) through the mediation of either another variable in colData (argument mediator) or an assay (argument assay.type) or a reducedDim (argument dimred). Importantly, those three arguments are mutually exclusive.

Value

getMediation returns a data.frame of adjusted p-values and effect sizes for the ACMEs and ADEs of every mediator given as input, whereas addMediation returns an updated SummarizedExperiment instance with the same data.frame stored in the metadata as "mediation". Its columns include:

Mediator the mediator variable

ACME_estimate the Average Causal Mediation Effect (ACME) estimate

ADE_estimate the Average Direct Effect (ADE) estimate

ACME_pval the adjusted p-value for the ACME estimate

ADE_pval the adjusted p-value for the ADE estimate

Examples

```
## Not run:
# Import libraries
library(mia)
library(scater)

# Load dataset
data(hitchip1006, package = "miaTime")
tse <- hitchip1006

# Agglomerate features by family (merely to speed up execution)
tse <- agglomerateByRank(tse, rank = "Phylum")
# Convert BMI variable to numeric
tse$bmi_group <- as.numeric(tse$bmi_group)

# Analyse mediated effect of nationality on BMI via alpha diversity
# 100 permutations were done to speed up execution, but ~1000 are recommended
med_df <- getMediation(tse,
                       outcome = "bmi_group",
                       treatment = "nationality",
                       mediator = "diversity",
                       covariates = c("sex", "age"),
                       treat.value = "Scandinavia",
                       control.value = "CentralEurope",
                       boot = TRUE, sims = 100,
```

```
                      add.metadata = TRUE)

 # Visualise model statistics for 1st mediator
 plot(attr(med_df, "metadata")[[1]])

# Apply clr transformation to counts assay
tse <- transformAssay(tse,
                      method = "clr",
                      pseudocount = 1)

# Analyse mediated effect of nationality on BMI via clr-transformed features
# 100 permutations were done to speed up execution, but ~1000 are recommended
tse <- addMediation(tse, name = "assay_mediation",
                    outcome = "bmi_group",
                    treatment = "nationality",
                    assay.type = "clr",
                    covariates = c("sex", "age"),
                    treat.value = "Scandinavia",
                    control.value = "CentralEurope",
                    boot = TRUE, sims = 100,
                    p.adj.method = "fdr")

# Show results for first 5 mediators
head(metadata(tse)$assay_mediation, 5)

# Perform ordination
tse <- runMDS(tse, name = "MDS",
              method = "euclidean",
              assay.type = "clr",
              ncomponents = 3)

# Analyse mediated effect of nationality on BMI via NMDS components
# 100 permutations were done to speed up execution, but ~1000 are recommended
tse <- addMediation(tse, name = "reddim_mediation",
                    outcome = "bmi_group",
                    treatment = "nationality",
                    dimred = "MDS",
                    covariates = c("sex", "age"),
                    treat.value = "Scandinavia",
                    control.value = "CentralEurope",
                    boot = TRUE, sims = 100,
                    p.adj.method = "fdr")

# Show results for first 5 mediators
head(metadata(tse)$reddim_mediation, 5)

## End(Not run)
```

---

getPrevalence *Calculation prevalence information for features across samples*

Description

These functions calculate the population prevalence for taxonomic ranks in a SummarizedExperiment-class object.

Usage

```
getPrevalence(x, ...)

## S4 method for signature 'ANY'
getPrevalence(
  x,
  detection = 0,
  include.lowest = include_lowest,
  include_lowest = FALSE,
  sort = FALSE,
  na.rm = TRUE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getPrevalence(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  as.relative = as_relative,
  as_relative = FALSE,
  rank = NULL,
  ...
)

getPrevalent(x, ...)

## S4 method for signature 'ANY'
getPrevalent(
  x,
  prevalence = 50/100,
  include.lowest = include_lowest,
  include_lowest = FALSE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getPrevalent(
  x,
  rank = NULL,
  prevalence = 50/100,
  include.lowest = include_lowest,
  include_lowest = FALSE,
```

```
  ...
)

getRare(x, ...)

## S4 method for signature 'ANY'
getRare(
  x,
  prevalence = 50/100,
  include.lowest = include_lowest,
  include_lowest = FALSE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getRare(
  x,
  rank = NULL,
  prevalence = 50/100,
  include.lowest = include_lowest,
  include_lowest = FALSE,
  ...
)

subsetByPrevalent(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsetByPrevalent(x, rank = NULL, ...)

subsetByRare(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsetByRare(x, rank = NULL, ...)

getPrevalentAbundance(
  x,
  assay.type = assay_name,
  assay_name = "relabundance",
  ...
)

## S4 method for signature 'ANY'
getPrevalentAbundance(
  x,
  assay.type = assay_name,
  assay_name = "relabundance",
  ...
)
```

```
## S4 method for signature 'SummarizedExperiment'
getPrevalentAbundance(x, assay.type = assay_name, assay_name = "counts", ...)
```

Arguments

x	a SummarizedExperiment object
...	additional arguments • If !is.null(rank) arguments are passed on to agglomerateByRank. See ?agglomerateByRank for more details. Note that you can specify whether to remove empty ranks with agg.na.rm instead of na.rm. (default: FALSE) • for getPrevalent, getRare, subsetByPrevalent and subsetByRare additional parameters passed to getPrevalence • for getPrevalentAbundance additional parameters passed to getPrevalent
detection	Detection threshold for absence/presence. If as_relative = FALSE, it sets the counts threshold for a taxon to be considered present. If as_relative = TRUE, it sets the relative abundance threshold for a taxon to be considered present. (default: detection = 0)
include.lowest	logical scalar: Should the lower boundary of the detection and prevalence cutoffs be included? (default: FALSE)
include_lowest	Deprecated. Use include.lowest instead.
sort	logical scalar: Should the result be sorted by prevalence? (default: FALSE)
na.rm	logical scalar: Should NA values be omitted when calculating prevalence? (default: na.rm = TRUE)
assay.type	A single character value for selecting the assay to use for prevalence calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
as.relative	logical scalar: Should the detection threshold be applied on compositional (relative) abundances? (default: FALSE)
as_relative	Deprecated. Use as.relative instead.
rank	a single character defining a taxonomic rank. Must be a value of taxonomyRanks() function.
prevalence	Prevalence threshold (in 0 to 1). The required prevalence is strictly greater by default. To include the limit, set include.lowest to TRUE.

Details

getPrevalence calculates the relative frequency of samples that exceed the detection threshold. For SummarizedExperiment objects, the prevalence is calculated for the selected taxonomic rank, otherwise for the rows. The absolute population prevalence can be obtained by multiplying the prevalence by the number of samples (ncol(x)). If as.relative = FALSE the relative frequency (between 0 and 1) is used to check against the detection threshold.

The core abundance index from getPrevalentAbundance gives the relative proportion of the core species (in between 0 and 1). The core taxa are defined as those that exceed the given population prevalence threshold at the given detection level as set for getPrevalent.

subsetPrevalent and subsetRareFeatures return a subset of x. The subset includes the most prevalent or rare taxa that are calculated with getPrevalent or getRare respectively.

getPrevalent returns taxa that are more prevalent with the given detection threshold for the selected taxonomic rank.

getRare returns complement of getPrevalent.

Value

subsetPrevalent and subsetRareFeatures return subset of x.

All other functions return a named vectors:

- getPrevalence returns a numeric vector with the names being set to either the row names of x or the names after agglomeration.
- getPrevalentAbundance returns a numeric vector with the names corresponding to the column name of x and include the joint abundance of prevalent taxa.
- getPrevalent and getRare return a character vector with only the names exceeding the threshold set by prevalence, if the rownames of x is set. Otherwise an integer vector is returned matching the rows in x.

Author(s)

Leo Lahti For getPrevalentAbundance: Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

References

A Salonen et al. The adult intestinal core microbiota is determined by analysis depth and health status. Clinical Microbiology and Infection 18(S4):16 20, 2012. To cite the R package, see citation('mia')

See Also

agglomerateByRank, getTop

Examples

```
data(GlobalPatterns)
tse <- GlobalPatterns
# Get prevalence estimates for individual ASV/OTU
prevalence.frequency <- getPrevalence(tse,
                                      detection = 0,
                                      sort = TRUE,
                                      as.relative = TRUE)
head(prevalence.frequency)

# Get prevalence estimates for phylums
```

```
# - the getPrevalence function itself always returns population frequencies
prevalence.frequency <- getPrevalence(tse,
                                      rank = "Phylum",
                                      detection = 0,
                                      sort = TRUE,
                                      as.relative = TRUE)
head(prevalence.frequency)

# - to obtain population counts, multiply frequencies with the sample size,
# which answers the question "In how many samples is this phylum detectable"
prevalence.count <- prevalence.frequency * ncol(tse)
head(prevalence.count)

# Detection threshold 1 (strictly greater by default);
# Note that the data (GlobalPatterns) is here in absolute counts
# (and not compositional, relative abundances)
# Prevalence threshold 50 percent (strictly greater by default)
prevalent <- getPrevalent(tse,
                          rank = "Phylum",
                          detection = 10,
                          prevalence = 50/100,
                          as.relative = FALSE)
head(prevalent)

# Gets a subset of object that includes prevalent taxa
altExp(tse, "prevalent") <- subsetByPrevalent(tse,
                                              rank = "Family",
                                              detection = 0.001,
                                              prevalence = 0.55,
                                              as.relative = TRUE)
altExp(tse, "prevalent")

# getRare returns the inverse
rare <- getRare(tse,
                    rank = "Phylum",
                    detection = 1/100,
                    prevalence = 50/100,
                    as.relative = TRUE)
head(rare)

# Gets a subset of object that includes rare taxa
altExp(tse, "rare") <- subsetByRare(tse,
                                    rank = "Class",
                                    detection = 0.001,
                                    prevalence = 0.001,
                                    as.relative = TRUE)
altExp(tse, "rare")

# Names of both experiments, prevalent and rare, can be found from slot
# altExpNames
tse

data(esophagus)
```

```
getPrevalentAbundance(esophagus, assay.type = "counts")
```

`GlobalPatterns` *GlobalPatterns*

Description

GlobalPatterns compared the microbial communities from 25 environmental samples and three known "mock communities" at a an average depth of 3.1 million reads per sample. Authors reproduced diversity patterns seen in many other published studies, while investigating technical bias by applying the same techniques to simulated microbial communities of known composition. Special thanks are given to J. Gregory Caporaso for providing the OTU-clustered data files for inclusion in the **phyloseq** package, from which this data was converted to `TreeSummarizedExperiment`.

Usage

```
data(GlobalPatterns)
```

Format

A TreeSummarizedExperiment with 19216 features and 26 samples. The rowData contains taxonomic information at Kingdom, Phylum, Class, Order, Family, Genus and Species levels. The colData includes:

X.SampleID Sample ID taken from the corresponding study

Primer primer used for sequencing

Final_Barcode final barcode (6 nucleotides)

Barcode_truncated_plus_T truncated barcode with an added tyrosine (6 nucleotides)

Barcode_full_length complete barcode with a length of 11 nucleotides

SampleType sampling type by collection site (Soil, Feces, Skin, Tongue, Freshwater, Creek Freshwater, Ocean, Estuary Sediment and Mock)

Description additional information (sampling location, environmental factors and study type)

Author(s)

Caporaso, J. G., et al.

References

Caporaso, J. G., et al. (2011). Global patterns of 16S rRNA diversity at a depth of millions of sequences per sample. PNAS, 108, 4516-4522. https://doi.org/10.1073/pnas.1000080107

See Also

mia-datasets

hierarchy-tree *Calculate hierarchy tree*

Description

These functions generate a hierarchy tree using taxonomic information from a SummarizedExperiment object and add this hierarchy tree into the rowTree.

Usage

```
getHierarchyTree(x, ...)

## S4 method for signature 'SummarizedExperiment'
getHierarchyTree(x, ...)

addHierarchyTree(x, ...)

## S4 method for signature 'SummarizedExperiment'
addHierarchyTree(x, ...)
```

Arguments

x	a SummarizedExperiment object
...	optional arguments not used currently.

Details

addHierarchyTree calculates a hierarchy tree from the available taxonomic information and add it to rowTree.

getHierarchyTree generates a hierarchy tree from the available taxonomic information. Internally it uses toTree and resolveLoop to sanitize data if needed.

Please note that a hierarchy tree is not an actual phylogenetic tree. A phylogenetic tree represents evolutionary relationships among features. On the other hand, a hierarchy tree organizes species into a hierarchical structure based on their taxonomic ranks.

Value

- addHierarchyTree: a TreeSummarizedExperiment whose phylo tree represents the hierarchy among available taxonomy information.
- getHierarchyTree: a phylo tree representing the hierarchy among available taxonomy information.

Examples

```
# Generate a tree based on taxonomic rank hierarchy (a hierarchy tree).
data(GlobalPatterns)
tse <- GlobalPatterns
getHierarchyTree(tse)

# Add a hierarchy tree to a TreeSummarizedExperiment.
# Please note that any tree already stored in rowTree() will be overwritten.
tse <- addHierarchyTree(tse)
tse
```

`HintikkaXOData` *HintikkaXOData*

Description

HintikkaXO is a multiomics dataset from a rat experiment studying effect of fat and prebiotics in diet. It contains high-throughput profiling data from 40 rat samples, including 39 biomarkers, 38 metabolites (NMR), and 12706 OTUs from 318 species, measured from Cecum. This is diet comparison study with High/Low fat diet and xylo-oligosaccaride supplementation. Column metadata is common for all experiments (microbiota, metabolites, biomarkers) and is described below.

Usage

```
data(HintikkaXOData)
```

Format

A MultiAssayExperiment with 3 experiments (microbiota, metabolites and biomarkers). rowData of the microbiota experiment contains taxonomic information at Phylum, Class, Order, Family, Genus, Species and OTU levels. The metabolites and biomarkers experiments contain 38 NMR metabolites and 39 biomarkers, respectively. The colData includes:

Sample Sample ID (character)

Rat Rat ID (factor)

Site Site of measurement ("Cecum"); single value

Diet Diet group (factor; combination of the Fat and XOS fields)

Fat Fat in Diet (factor; Low/High)

XOS XOS Diet Supplement (numeric; 0/1)

Author(s)

Hintikka L et al.

References

Hintikka L et al. (2021): Xylo-oligosaccharides in prevention of hepatic steatosis and adipose tissue inflammation: associating taxonomic and metabolomic patterns in fecal microbiota with biclustering. International Journal of Environmental Research and Public Health 18(8):4049. https://doi.org/10.3390/ijerph18084049

See Also

mia-datasets

`importHUMAnN` *Import HUMAnN results to* `TreeSummarizedExperiment`

Description

Import HUMAnN results to `TreeSummarizedExperiment`

Arguments

`file`	a single `character` value defining the file path of the HUMAnN file. The file must be in merged HUMAnN format.
`col.data`	a DataFrame-like object that includes sample names in rownames, or a single `character` value defining the file path of the sample metadata file. The file must be in `tsv` format (default: `col.data = NULL`).
`colData`	Deprecated. Use `col.data` instead.
`...`	additional arguments: • `assay.type`: A single character value for naming `assay` (default: `assay.type = "counts"`) • `prefix.rm`: `TRUE` or `FALSE`: Should taxonomic prefixes be removed? (default: `prefix.rm = FALSE`) • `remove.suffix`: `TRUE` or `FALSE`: Should suffixes of sample names be removed? HUMAnN pipeline adds suffixes to sample names. Suffixes are formed from file names. By selecting `remove.suffix = TRUE`, you can remove pattern from end of sample names that is shared by all. (default: `remove.suffix = FALSE`)

Details

Import HUMAnN (currently version 3.0 supported) results of functional predictions based on metagenome composition (e.g. pathways or gene families). The input must be in merged HUMAnN format. (See the HUMAnN documentation and `humann_join_tables` method.)

The function parses gene/pathway information along with taxonomy information from the input file. This information is stored to `rowData`. Abundances are stored to `assays`.

Usually the workflow includes also taxonomy data from Metaphlan. See importMetaPhlAn to load the data to `TreeSE`.

Value

A TreeSummarizedExperiment object

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

References

Beghini F, McIver LJ, Blanco-Míguez A, Dubois L, Asnicar F, Maharjan S, Mailyan A, Manghi P, Scholz M, Thomas AM, Valles-Colomer M, Weingart G, Zhang Y, Zolfo M, Huttenhower C, Franzosa EA, & Segata N (2021) Integrating taxonomic, functional, and strain-level profiling of diverse microbial communities with bioBakery 3. *eLife*. 10:e65088.

See Also

importMetaPhlAn makeTreeSEFromPhyloseq makeTreeSEFromBiom makeTreeSEFromDADA2 importQIIME2 importMothur

Examples

```
# File path
file_path <- system.file("extdata", "humann_output.tsv", package = "mia")
# Import data
tse <- importHUMAnN(file_path)
tse
```

---

importMetaPhlAn *Import Metaphlan results to* TreeSummarizedExperiment

---

Description

Import Metaphlan results to TreeSummarizedExperiment

Arguments

file	a single character value defining the file path of the Metaphlan file. The file must be in merged Metaphlan format.
col.data	a DataFrame-like object that includes sample names in rownames, or a single character value defining the file path of the sample metadata file. The file must be in tsv format (default: col.data = NULL).
colData	Deprecated. use col.data instead.
sample_meta	Deprecated. Use col.data instead.
tree.file	a single character value defining the file path of the phylogenetic tree. (default: tree.file = NULL).

phy_tree — Deprecated. Use tree.file instead.

... — additional arguments:

- assay.type: A single character value for naming assay (default: assay.type = "counts")
- assay_name: A single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
- prefix.rm: TRUE or FALSE: Should taxonomic prefixes be removed? (default: prefix.rm = FALSE)
- remove.suffix: TRUE or FALSE: Should suffixes of sample names be removed? Metaphlan pipeline adds suffixes to sample names. Suffixes are formed from file names. By selecting remove.suffix = TRUE, you can remove pattern from end of sample names that is shared by all. (default: remove.suffix = FALSE)
- set.ranks: TRUE or FALSE: Should the columns in the rowData that are treated as taxonomy ranks be updated according to the ranks found in the imported data? (default: set.ranks = FALSE)

Details

Import Metaphlan (versions 2, 3 and 4 supported) results. Input must be in merged Metaphlan format. (See the Metaphlan documentation and merge_metaphlan_tables method.) Data is imported so that data at the lowest rank is imported as a TreeSummarizedExperiment object. Data at higher rank is imported as a SummarizedExperiment objects which are stored to altExp of TreeSummarizedExperiment object.

Currently Metaphlan versions 2, 3, and 4 are supported.

Value

A TreeSummarizedExperiment object

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

References

Beghini F, McIver LJ, Blanco-Míguez A, Dubois L, Asnicar F, Maharjan S, Mailyan A, Manghi P, Scholz M, Thomas AM, Valles-Colomer M, Weingart G, Zhang Y, Zolfo M, Huttenhower C, Franzosa EA, & Segata N (2021) Integrating taxonomic, functional, and strain-level profiling of diverse microbial communities with bioBakery 3. *eLife*. 10:e65088. doi: 10.7554/eLife.65088

See Also

importHUMAnN makeTreeSEFromPhyloseq makeTreeSEFromBiom makeTreeSEFromDADA2 importQIIME2 importMothur

Examples

```
# (Data is from tutorial
# https://github.com/biobakery/biobakery/wiki/metaphlan3#merge-outputs)

# File path
file_path <- system.file("extdata", "merged_abundance_table.txt", package = "mia")
# Import data
tse <- importMetaPhlAn(file_path)
# Data at the lowest rank
tse
# Data at higher rank is stored in altExp
altExps(tse)
# Higher rank data is in SE format, for example, Phylum rank
altExp(tse, "Phylum")
```

`importMothur` *Import Mothur results as a* `TreeSummarizedExperiment`

Description

This method creates a `TreeSummarizedExperiment` object from `Mothur` files provided as input.

Usage

```
importMothur(
  assay.file = sharedFile,
  sharedFile,
  taxonomyFile = NULL,
  row.file = taxonomyFile,
  designFile = NULL,
  col.file = designFile
)
```

Arguments

`assay.file`	a single `character` value defining the file path of the feature table to be imported. The File has to be in `shared file` format as defined in Mothur documentation.
`sharedFile`	Deprecated. Use `assay.file` instead.
`taxonomyFile`	Deprecated. Use `row.file` instead.
`row.file`	a single `character` value defining the file path of the taxonomy table to be imported. The File has to be in `taxonomy file` or `constaxonomy file` format as defined in Mothur documentation. (default: `row.file = NULL`).
`designFile`	Deprecated. Use `col.file` instead.
`col.file`	a single `character` value defining the file path of the sample metadata to be imported. The File has to be in `desing file` format as defined in Mothur documentation. (default: `col.file = NULL`).

Details

Results exported from Mothur can be imported as a SummarizedExperiment using importMothur. Except for the assay.file, the other data types, row.file, and col.file, are optional, but are highly encouraged to be provided.

Value

A TreeSummarizedExperiment object

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

References

https://mothur.org/ https://mothur.org/wiki/shared_file/ https://mothur.org/wiki/taxonomy_file/ https://mothur.org/wiki/constaxonomy_file/ https://mothur.org/wiki/design_file/

See Also

makeTreeSEFromPhyloseq makeTreeSEFromBiom makeTreeSEFromDADA2 importQIIME2

Examples

```
# Abundance table
counts <- system.file("extdata", "mothur_example.shared", package = "mia")
# Taxa table (in "cons.taxonomy" or "taxonomy" format)
taxa <- system.file("extdata", "mothur_example.cons.taxonomy", package = "mia")
#taxa <- system.file("extdata", "mothur_example.taxonomy", package = "mia")
# Sample meta data
meta <- system.file("extdata", "mothur_example.design", package = "mia")

# Creates se object from files
se <- importMothur(assay.file = counts, row.file = taxa, col.file = meta)
# Convert SE to TreeSE
tse <- as(se, "TreeSummarizedExperiment")
tse
```

---

importQIIME2 *Import QIIME2 results to* TreeSummarizedExperiment

---

Description

Results exported from QIMME2 can be imported as a TreeSummarizedExperiment using importQIIME2. Except for the assay.file, the other data types, row.file, refseq.file and tree.file, are optional, but are highly encouraged to be provided.

Import the QIIME2 artifacts to R.

Usage

```
importQIIME2(
  assay.file = featureTableFile,
  featureTableFile,
  row.file = taxonomyTableFile,
  taxonomyTableFile = NULL,
  col.file = sampleMetaFile,
  sampleMetaFile = NULL,
  as.refseq = featureNamesAsRefSeq,
  featureNamesAsRefSeq = TRUE,
  refseq.file = refSeqFile,
  refSeqFile = NULL,
  tree.file = phyTreeFile,
  phyTreeFile = NULL,
  ...
)

importQZA(file, temp.dir = temp, temp = tempdir(), ...)
```

Arguments

assay.file	a single character value defining the file path of the feature table to be imported.
featureTableFile	Deprecated. use assay.file instead.
row.file	a single character value defining the file path of the taxonomy table to be imported. (default: row.file = NULL).
taxonomyTableFile	Deprecated. use row.file instead.
col.file	a single character value defining the file path of the sample metadata to be imported. The file has to be in tsv format. (default: col.file = NULL).
sampleMetaFile	Deprecated. Use col.file instead.
as.refseq	TRUE or FALSE: Should the feature names of the feature table be regarded as reference sequences? This setting will be disregarded, if refseq.file is not NULL. If the feature names do not contain valid DNA characters only, the reference sequences will not be set.
featureNamesAsRefSeq	Deprecated. Use as.refseq instead.
refseq.file	a single character value defining the file path of the reference sequences for each feature. (default: refseq.file = NULL).
refSeqFile	Deprecated. Use refseq.file instead.
tree.file	a single character value defining the file path of the phylogenetic tree. (default: tree.file = NULL).
phyTreeFile	Deprecated. Use tree.file isntead.
...	additional arguments:

- temp.dir: the temporary directory used for decompressing the data. (default: tempdir())
- prefix.rm: TRUE or FALSE: Should taxonomic prefixes be removed? (default: prefix.rm = FALSE)

file — character, path of the input qza file. Only files in format of BIOMV210DirFmt (feature table), TSVTaxonomyDirectoryFormat (taxonomic table), NewickDirectoryFormat (phylogenetic tree) and DNASequencesDirectoryFormat (representative sequences) are supported right now.

temp.dir — character, a temporary directory in which the qza file will be decompressed to, default tempdir().

temp — Deprecated. Use temp.dir isntead.

Details

Both arguments as.refseq and refseq.file can be used to define reference sequences of features. as.refseq is only taken into account, if refseq.file is NULL. No reference sequences are tried to be created, if featureNameAsRefSeq is FALSE and refseq.file is NULL.

Value

A TreeSummarizedExperiment object

matrix object for feature table, DataFrame for taxonomic table, ape::phylo object for phylogenetic tree, Biostrings::DNAStringSet for representative sequences of taxa.

Author(s)

Yang Cao

References

Bolyen E et al. 2019: Reproducible, interactive, scalable and extensible microbiome data science using QIIME 2. Nature Biotechnology 37: 852–857. https://doi.org/10.1038/s41587-019-0209-9

https://qiime2.org

See Also

makeTreeSEFromPhyloseq makeTreeSEFromBiom makeTreeSEFromDADA2 importMothur

Examples

```
assay.file <- system.file("extdata", "table.qza", package = "mia")
row.file <- system.file("extdata", "taxonomy.qza", package = "mia")
col.file <- system.file("extdata", "sample-metadata.tsv", package = "mia")
tree.file <- system.file("extdata", "tree.qza", package = "mia")
refseq.file <- system.file("extdata", "refseq.qza", package = "mia")
tse <- importQIIME2(
  assay.file = assay.file,
  row.file = row.file,
  col.file = col.file,
```

```
  refseq.file = refseq.file,
  tree.file = tree.file
)

tse
# Read individual files
assay.file <- system.file("extdata", "table.qza", package = "mia")
row.file <- system.file("extdata", "taxonomy.qza", package = "mia")
col.file <- system.file("extdata", "sample-metadata.tsv", package = "mia")

assay <- importQZA(assay.file)
rowdata <- importQZA(row.file, prefix.rm = TRUE)
coldata <- read.table(col.file, header = TRUE, sep = "\t", comment.char = "")

# Assign rownames
rownames(coldata) <- coldata[, 1]
coldata[, 1] <- NULL

# Order coldata based on assay
coldata <- coldata[match(colnames(assay), rownames(coldata)), ]

# Create SE from individual files
se <- SummarizedExperiment(assays = list(assay), rowData = rowdata, colData = coldata)
se
```

`isContaminant` *decontam functions*

Description

The `decontam` functions `isContaminant` and `isNotContaminant` are made available for `SummarizedExperiment` objects.

Usage

```
## S4 method for signature 'SummarizedExperiment'
isContaminant(
  seqtab,
  assay.type = assay_name,
  assay_name = "counts",
  name = "isContaminant",
  concentration = NULL,
  control = NULL,
  batch = NULL,
  threshold = 0.1,
  normalize = TRUE,
  detailed = TRUE,
  ...
```

```
)

## S4 method for signature 'SummarizedExperiment'
isNotContaminant(
  seqtab,
  assay.type = assay_name,
  assay_name = "counts",
  name = "isNotContaminant",
  control = NULL,
  threshold = 0.5,
  normalize = TRUE,
  detailed = FALSE,
  ...
)

addContaminantQC(x, name = "isContaminant", ...)

## S4 method for signature 'SummarizedExperiment'
addContaminantQC(x, name = "isContaminant", ...)

addNotContaminantQC(x, name = "isNotContaminant", ...)

## S4 method for signature 'SummarizedExperiment'
addNotContaminantQC(x, name = "isNotContaminant", ...)
```

Arguments

seqtab, x	a SummarizedExperiment
assay.type	A single character value for selecting the assay to use.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
name	A name for the column of the colData in which the contaminant information should be stored.
concentration	NULL or a single character value. Defining a column with numeric values from the colData to use as concentration information. (default: concentration = NULL)
control	NULL or a single character value. Defining a column with logical values from the colData to define control and non-control samples. (default: control = NULL)
batch	NULL or a single character value. Defining a column with values interpretable as a factor from the colData to use as batch information. (default: batch = NULL)
threshold	numeric scalar. See decontam:isContaminant or decontam:isNotContaminant
normalize, detailed	logical scalar. See decontam:isContaminant or decontam:isNotContaminant
...	• for isContaminant/ isNotContaminant: arguments passed on to decontam:isContaminant or decontam:isNotContaminant

- for addContaminantQC/addNotContaminantQC: arguments passed on to isContaminant/ isNotContaminant

Value

for isContaminant/ isNotContaminant a DataFrame or for addContaminantQC/addNotContaminantQC a modified object of class(x)

See Also

decontam:isContaminant, decontam:isNotContaminant

Examples

```
data(esophagus)
# setup of some mock data
colData(esophagus)$concentration <- c(1,2,3)
colData(esophagus)$control <- c(FALSE,FALSE,TRUE)

isContaminant(esophagus,
              method = "frequency",
              concentration = "concentration")
esophagus <- addContaminantQC(esophagus,
                              method = "frequency",
                              concentration = "concentration")
colData(esophagus)

isNotContaminant(esophagus, control = "control")
esophagus <- addNotContaminantQC(esophagus, control = "control")
colData(esophagus)
```

---

makePhyloseqFromTreeSE

Create a phyloseq object from a TreeSummarizedExperiment object

---

Description

This function creates a phyloseq object from a TreeSummarizedExperiment object. By using assay.type, it is possible to specify which table from assay is added to the phyloseq object.

Usage

```
makePhyloseqFromTreeSE(x, ...)

## S4 method for signature 'SummarizedExperiment'
makePhyloseqFromTreeSE(x, assay.type = "counts", assay_name = NULL, ...)

## S4 method for signature 'TreeSummarizedExperiment'
makePhyloseqFromTreeSE(x, tree.name = tree_name, tree_name = "phylo", ...)
```

```
makePhyloseqFromTreeSummarizedExperiment(x, ...)

## S4 method for signature 'ANY'
makePhyloseqFromTreeSummarizedExperiment(x, ...)
```

Arguments

x	a TreeSummarizedExperiment object
...	additional arguments
assay.type	A single character value for selecting the assay to be included in the phyloseq object that is created. (By default: assay.type = "counts")
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
tree.name	a single character value for specifying which tree will be included in the phyloseq object that is created, (By default: tree.name = "phylo")
tree_name	Deprecated. Use tree.name instead.

Details

makePhyloseqFromTreeSE is used for creating a phyloseq object from TreeSummarizedExperiment object.

Value

An object of class Phyloseq object.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

Examples

```
# Get tse object
data(GlobalPatterns)
tse <- GlobalPatterns

# Create a phyloseq object from it
phy <- makePhyloseqFromTreeSE(tse)
phy

# By default the chosen table is counts, but if there are other tables,
# they can be chosen with assay.type.

# Counts relative abundances table
tse <- transformAssay(tse, method = "relabundance")
phy2 <- makePhyloseqFromTreeSE(tse, assay.type = "relabundance")
phy2
```

makeTreeSEFromBiom *Loading a biom file*

Description

For convenience a few functions are available to convert data from a 'biom' file or object into a TreeSummarizedExperiment

Usage

```
importBIOM(file, ...)

makeTreeSEFromBiom(
  x,
  prefix.rm = removeTaxaPrefixes,
  removeTaxaPrefixes = FALSE,
  rank.from.prefix = rankFromPrefix,
  rankFromPrefix = FALSE,
  artifact.rm = remove.artifacts,
  remove.artifacts = FALSE,
  ...
)

makeTreeSummarizedExperimentFromBiom(x, ...)
```

Arguments

file	biom file location
...	additional arguments • patter: character value specifying artifacts to be removed. If patterns = "auto", special characters are removed. (default: pattern = "auto")
x	object of type biom
prefix.rm	TRUE or FALSE: Should taxonomic prefixes be removed? The prefixes is removed only from detected taxa columns meaning that rank.from.prefix should be enabled in the most cases. (default prefix.rm = FALSE)
removeTaxaPrefixes	Deprecated. Use prefix.rm instead.
rank.from.prefix	TRUE or FALSE: If file does not have taxonomic ranks on feature table, should they be scraped from prefixes? (default rank.from.prefix = FALSE)
rankFromPrefix	Deprecated.Use rank.from.prefix instead.
artifact.rm	TRUE or FALSE: If file have some taxonomic character naming artifacts, should they be removed. (default artifact.rm = FALSE)
remove.artifacts	Deprecated. Use artifact.rm instead.

Value

An object of class TreeSummarizedExperiment

See Also

makeTreeSEFromPhyloseq makeTreeSEFromDADA2 importQIIME2 importMothur

Examples

```
# Load biom file
library(biomformat)
biom_file <- system.file("extdata", "rich_dense_otu_table.biom",
                         package = "biomformat")

# Make TreeSE from biom file
tse <- importBIOM(biom_file)

# Make TreeSE from biom object
biom_object <- biomformat::read_biom(biom_file)
tse <- makeTreeSEFromBiom(biom_object)

# Get taxonomyRanks from prefixes and remove prefixes
tse <- importBIOM(biom_file,
                  rank.from.prefix = TRUE,
                  prefix.rm = TRUE)

# Load another biom file
biom_file <- system.file("extdata/testdata", "Aggregated_humanization2.biom",
                         package = "mia")

# Clean artifacts from taxonomic data
tse <- importBIOM(biom_file,
                  artifact.rm = TRUE)
```

---

makeTreeSEFromDADA2 *Coerce 'DADA2' results to* TreeSummarizedExperiment

---

Description

makeTreeSEFromDADA2 is a wrapper for the mergePairs function from the dada2 package.

Usage

```
makeTreeSEFromDADA2(...)

makeTreeSummarizedExperimentFromDADA2(...)
```

Arguments

...	See mergePairs function for more details.

Details

A count matrix is constructed via `makeSequenceTable(mergePairs(...))` and rownames are dynamically created as `ASV(N)` with `N` from 1 to `nrow` of the count tables. The colnames and rownames from the output of `makeSequenceTable` are stored as `colnames` and in the `referenceSeq` slot of the `TreeSummarizedExperiment`, respectively.

Value

An object of class `TreeSummarizedExperiment`

See Also

`makeTreeSEFromPhyloseq` `makeTreeSEFromBiom` `importQIIME2` `importMothur`

Examples

```
if(requireNamespace("dada2")) {
  fnF <- system.file("extdata", "sam1F.fastq.gz", package="dada2")
  fnR = system.file("extdata", "sam1R.fastq.gz", package="dada2")
  dadaF <- dada2::dada(fnF, selfConsist=TRUE)
  dadaR <- dada2::dada(fnR, selfConsist=TRUE)

  tse <- makeTreeSEFromDADA2(dadaF, fnF, dadaR, fnR)
  tse
}
```

---

makeTreeSEFromPhyloseq

Coerce a `phyloseq` *object to a* `TreeSummarizedExperiment`

Description

`makeTreeSEFromPhyloseq` converts `phyloseq` objects into `TreeSummarizedExperiment` objects.

Usage

```
makeTreeSEFromPhyloseq(x)

makeTreeSummarizedExperimentFromPhyloseq(x)

## S4 method for signature 'ANY'
makeTreeSummarizedExperimentFromPhyloseq(x)
```

Arguments

`x`	a `phyloseq` object

Details

All data stored in a phyloseq object is transferred.

Value

An object of class TreeSummarizedExperiment

See Also

makeTreeSEFromBiom makeTreeSEFromDADA2 importQIIME2 importMothur

Examples

```
if (requireNamespace("phyloseq")) {
    data(GlobalPatterns, package="phyloseq")
    makeTreeSEFromPhyloseq(GlobalPatterns)
    data(enterotype, package="phyloseq")
    makeTreeSEFromPhyloseq(enterotype)
    data(esophagus, package="phyloseq")
    makeTreeSEFromPhyloseq(esophagus)
}
```

---

meltSE *Converting a SummarizedExperiment object into a long data.frame*

Description

meltSE Converts a SummarizedExperiment object into a long data.frame which can be used for tidyverse-tools.

Usage

```
meltSE(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  add.row = add_row_data,
  add_row_data = NULL,
  add.col = add_col_data,
  add_col_data = NULL,
  row.name = feature_name,
  feature_name = "FeatureID",
  col.name = sample_name,
  sample_name = "SampleID",
  ...
)

## S4 method for signature 'SummarizedExperiment'
```

```
meltSE(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  add.row = add_row_data,
  add_row_data = NULL,
  add.col = add_col_data,
  add_col_data = NULL,
  row.name = feature_name,
  feature_name = "FeatureID",
  col.name = sample_name,
  sample_name = "SampleID",
  ...
)
```

Arguments

x	A numeric matrix or a SummarizedExperiment
assay.type	a character value to select an assayNames
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
add.row	NULL, TRUE or a character vector to select information from the rowData to add to the molten assay data. If add.row = NULL no data will be added, if add.row = TRUE all data will be added and if add.row is a character vector, it will be used to subset to given column names in rowData. (default: add.row = NULL)
add_row_data	Deprecated. Use add.row instead.
add.col	NULL, TRUE or a character vector to select information from the colData to add to the molten assay data. If add.col = NULL no data will be added, if add.col = TRUE all data will be added and if add.col is a character vector, it will be used to subset to given column names in colData. (default: add.col = NULL)
add_col_data	Deprecated. Use add.col instead.
row.name	a character scalar to use as the output's name for the feature identifier. (default: row.name = "FeatureID")
feature_name	Deprecated. Use row.name instead.
col.name	a character scalar to use as the output's name for the sample identifier. (default: col.name = "SampleID")
sample_name	Deprecated. Use col.name instead.
...	optional arguments: • check_names: A boolean value passed to data.frame function's check.name argument. Determines if sample names are checked that they are syntactically valid variable names and are not duplicated. If they are not, sample names are modified. (default: check_names = TRUE)

Details

If the colData contains a column "SampleID" or the rowData contains a column "FeatureID", they will be renamed to "SampleID_col" and "FeatureID_row", if row names or column names are set.

Value

A `tibble` with the molten data. The assay values are given in a column named like the selected assay `assay.type`. In addition, a column "FeatureID" will contain the rownames, if set, and analogously a column "SampleID" with the colnames, if set

Author(s)

Sudarshan A. Shetty

Examples

```
data(GlobalPatterns)
molten_tse <- meltSE(GlobalPatterns,
                        assay.type = "counts",
                        add.row = TRUE,
                        add.col = TRUE
                        )
molten_tse
```

`mergeSEs` *Merge SE objects into single SE object.*

Description

Merge SE objects into single SE object.

Usage

```
mergeSEs(x, ...)

## S4 method for signature 'SimpleList'
mergeSEs(
  x,
  assay.type = "counts",
  assay_name = NULL,
  join = "full",
  missing.values = missing_values,
  missing_values = NA,
  collapse.cols = collapse_samples,
  collapse_samples = FALSE,
  collapse.rows = collapse_features,
  collapse_features = TRUE,
  verbose = TRUE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
```

```
mergeSEs(x, y = NULL, ...)

## S4 method for signature 'list'
mergeSEs(x, ...)
```

Arguments

x	a SummarizedExperiment object or a list of SummarizedExperiment objects.
...	optional arguments (not used).
assay.type	A character value for selecting the assay to be merged. (By default: assay.type = "counts")
assay_name	(Deprecated) alias for assay.type.
join	A single character value for selecting the joining method. Must be 'full', 'inner', 'left', or 'right'. 'left' and 'right' are disabled when more than two objects are being merged. (By default: join = "full")
missing.values	NA, 0, or a single character values specifying the notation of missing values. (By default: missing.values = NA)
missing_values	Deprecated. Use missing.values instead.
collapse.cols	A boolean value for selecting whether to collapse identically named samples to one. (By default: collapse.cols = FALSE)
collapse_samples	Deprecated. Use collapse.cols instead.
collapse.rows	A boolean value for selecting whether to collapse identically named features to one. Since all taxonomy information is taken into account, this concerns rownames-level (usually strain level) comparison. Often OTU or ASV level is just an arbitrary number series from sequencing machine meaning that the OTU information is not comparable between studies. With this option, it is possible to specify whether these strains are combined if their taxonomy information along with OTU number matches. (By default: collapse.rows = TRUE)
collapse_features	Deprecated. Use collapse.rows instead.
verbose	A single boolean value to choose whether to show messages. (By default: verbose = TRUE)
y	a SummarizedExperiment object when x is a SummarizedExperiment object. Disabled when x is a list.

Details

This function merges multiple SummarizedExperiment objects. It combines rowData, assays, and colData so that the output includes each unique row and column ones. The merging is done based on rownames and colnames. rowTree and colTree are preserved if linkage between rows/cols and the tree is found.

Equally named rows are interpreted as equal. Further matching based on rowData is not done. For samples, collapsing is disabled by default meaning that equally named samples that are stored in

different objects are interpreted as unique. Collapsing can be enabled with `collapse.cols = TRUE` when equally named samples describe the same sample.

If, for example, all rows are not shared with individual objects, there are missing values in `assays`. The notation of missing can be specified with the `missing.values` argument. If input consists of `TreeSummarizedExperiment` objects, also `rowTree`, `colTree`, and `referenceSeq` are preserved if possible. The data is preserved if all the rows or columns can be found from it.

Compared to `cbind` and `rbind` `mergeSEs` allows more freely merging since `cbind` and `rbind` expect that rows and columns are matching, respectively.

You can choose joining methods from `'full'`, `'inner'`, `'left'`, and `'right'`. In all the methods, all the samples are included in the result object. However, with different methods, it is possible to choose which rows are included.

- `full` – all unique features
- `inner` – all shared features
- `left` – all the features of the first object
- `right` – all the features of the second object

The output depends on the input. If the input contains `SummarizedExperiment` object, then the output will be `SummarizedExperiment`. When all the input objects belong to `TreeSummarizedExperiment`, the output will be `TreeSummarizedExperiment`.

Value

A single `SummarizedExperiment` object.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

See Also

- `TreeSummarizedExperiment::cbind`
- `TreeSummarizedExperiment::rbind`
- `full_join`
- `inner_join`
- `left_join`
- `right_join`

Examples

```
data(GlobalPatterns)
data(esophagus)
data(enterotype)

# Take only subsets so that it wont take so long
tse1 <- GlobalPatterns[1:100, ]
tse2 <- esophagus
```

```
tse3 <- enterotype[1:100, ]

# Merge two TreeSEs
tse <- mergeSEs(tse1, tse2)

# Merge a list of TreeSEs
list <- SimpleList(tse1, tse2, tse3)
tse <- mergeSEs(list, assay.type = "counts", missing.values = 0)
tse

# With 'join', it is possible to specify the merging method. Subsets are used
# here just to show the functionality
tse_temp <- mergeSEs(tse[1:10, 1:10], tse[5:100, 11:20], join = "left")
tse_temp

# If your objects contain samples that describe one and same sample,
# you can collapse equally named samples to one by specifying 'collapse.cols'
tse_temp <- mergeSEs(list(tse[1:10, 1], tse[1:20, 1], tse[1:5, 1]),
                     collapse.cols = TRUE,
                     join = "inner")
tse_temp

# Merge all available assays
tse <- transformAssay(tse, method="relabundance")
ts1 <- transformAssay(tse1, method="relabundance")
tse_temp <- mergeSEs(tse, tse1, assay.type = assayNames(tse))
```

`mia-datasets` *mia datasets*

Description

mia provides various datasets derived from independent experimental studies. The datasets represent instances of the TreeSummarizedExperiment and MultiAssayExperiment containers and can serve as tools to practice the mia functionality.

Details

Currently, the following datasets are available:

- `dmn_se`: A SummarizedExperiment with 130 features and 278 samples
- `enterotype`: A TreeSummarizedExperiment with 553 features and 280 samples
- `esophagus`: A TreeSummarizedExperiment with 58 features and 3 samples
- `GlobalPatterns`: A TreeSummarizedExperiment with 19216 features and 26 samples
- `HintikkaXOData`: A MultiAssayExperiment with 3 experiments (microbiota, metabolites and biomarkers)
- `peerj13075`: A TreeSummarizedExperiment with 674 features and 58 samples
- `Tengeler2020`: A TreeSummarizedExperiment with 151 features and 27 samples

Examples

```
# Load dataset from mia
library(mia)
data("GlobalPatterns", package = "mia")

# In this case, the dataset is a TreeSE, so it is renamed as tse
tse <- GlobalPatterns

# Print summary
tse
```

`peerj13075` *peerj13075*

Description

peerj13075 includes skin microbial profiles of 58 volunteers with multiple factors. 16S r-RNA sequencing of V3-V4 regions was done to generate millions of read using illumina platform. A standard bioinformatic and statistical analysis done to explore skin bacterial diversity and its association with age, diet, geographical locations. The authors investigated significant association of skin microbiota with individual's geographical location.

Usage

```
data(peerj13075)
```

Format

A TreeSummarizedExperiment with 674 features and 58 samples. The rowData contains taxonomic information at kingdom, phylum, class, order, family and genus level. The colData includes:

Sample sample ID

Geographical_location city where participant lives (Ahmednagar, Pune and Nashik)

Gender participant's gender (Male or Female)

Age participant's age group (Middle_age, Adult and Elderly)

Diet participant's diet (Veg or Mixed)

Author(s)

Potbhare, R., et al.

References

Potbhare, R., RaviKumar, A., Munukka, E., Lahti, L., & Ashma, R. (2022). Skin microbiota diversity among genetically unrelated individuals of Indian origin. PeerJ, 10, e13075. https://doi.org/10.7717/peerj.13075 Supplemental information includes OTU table and taxonomy table publicly-accessible from: https://www.doi.org/10.7717/peerj.13075/supp-1 https://www.doi.org/10.7717/peerj.13075/supp-2

See Also

mia-datasets

---

rarefyAssay *Subsample Counts*

Description

rarefyAssay randomly subsamples counts within a SummarizedExperiment object and returns a new SummarizedExperiment containing the original assay and the new subsampled assay.

Usage

```
rarefyAssay(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  sample = min_size,
  min_size = min(colSums2(assay(x))),
  replace = TRUE,
  name = "subsampled",
  verbose = TRUE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
rarefyAssay(
  x,
  assay.type = assay_name,
  assay_name = "counts",
  sample = min_size,
  min_size = min(colSums2(assay(x))),
  replace = TRUE,
  name = "subsampled",
  verbose = TRUE,
  ...
)
```

Arguments

x	A SummarizedExperiment object.
assay.type	A single character value for selecting the SummarizedExperiment assay used for random subsampling. Only counts are useful and other transformed data as input will give meaningless output.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)

sample	A single integer value equal to the number of counts being simulated this can equal to lowest number of total counts found in a sample or a user specified number.
min_size	Deprecated. Use sample instead.
replace	Logical Default is TRUE. The default is with replacement (replace=TRUE). See phyloseq::rarefy_even_depth for details on implications of this parameter.
name	A single character value specifying the name of transformed abundance table that will be added to the new SummarizedExperiment.
verbose	Logical Default is TRUE. When TRUE an additional message about the random number used is printed.
...	additional arguments not used

Details

Although the subsampling approach is highly debated in microbiome research, we include the rarefyAssay function because there may be some instances where it can be useful. Note that the output of rarefyAssay is not the equivalent as the input and any result have to be verified with the original dataset. To maintain the reproducibility, please define the seed using set.seed() before implement this function.

Value

rarefyAssay return x with subsampled data.

Author(s)

Sudarshan A. Shetty and Felix G.M. Ernst

References

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Examples

```
# When samples in TreeSE are less than specified sample, they will be removed.
# If after subsampling features are not present in any of the samples,
# they will be removed.
data(GlobalPatterns)
tse <- GlobalPatterns
set.seed(123)
tse.subsampled <- rarefyAssay(tse,
                                  sample = 60000,
```

```
                                    name = "subsampled"
                                    )
tse.subsampled
dim(tse)
dim(assay(tse.subsampled, "subsampled"))
```

---

relabundance *Getter / setter for relative abundance data*

Description

This function is being deprecated and will be removed in future releases. Please use `assay(x, "relabundance")` instead, which provides a more flexible and robust way to access and modify relative abundance data stored in the assay slot of a `TreeSummarizedExperiment` object.

Usage

```
relabundance(x, ...)

relabundance(x) <- value

## S4 method for signature 'SummarizedExperiment'
relabundance(x)

## S4 replacement method for signature 'SummarizedExperiment'
relabundance(x) <- value
```

Arguments

x	a `TreeSummarizedExperiment` object
...	optional arguments not used currently.
value	a matrix to store as the 'relabundance' assay

Value

For `relabundance`, the matrix stored with the name "relabundance".

Examples

```
data(GlobalPatterns)
# Calculates relative abundances
GlobalPatterns <- transformAssay(GlobalPatterns, method="relabundance")
# Fetches calculated relative abundances
# head(assay(GlobalPatterns, "relabundance"))
```

runCCA *Canonical Correspondence Analysis and Redundancy Analysis*

Description

These functions perform Canonical Correspondence Analysis on data stored in a SummarizedExperiment.

Usage

```
getCCA(x, ...)

addCCA(x, ...)

getRDA(x, ...)

addRDA(x, ...)

## S4 method for signature 'ANY'
getCCA(x, ...)

## S4 method for signature 'SummarizedExperiment'
getCCA(
  x,
  formula,
  variables,
  test.signif = TRUE,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  scores = "wa",
  ...
)

calculateCCA(x, ...)

## S4 method for signature 'SingleCellExperiment'
addCCA(x, formula, variables, altexp = NULL, name = "CCA", ...)

runCCA(x, ...)

## S4 method for signature 'ANY'
getRDA(x, ...)

## S4 method for signature 'SummarizedExperiment'
getRDA(
  x,
  formula,
```

```
  variables,
  test.signif = TRUE,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  scores = "wa",
  ...
)

calculateRDA(x, ...)

## S4 method for signature 'SingleCellExperiment'
addRDA(x, formula, variables, altexp = NULL, name = "RDA", ...)

runRDA(x, ...)
```

Arguments

x	For `calculate*` a `SummarizedExperiment` or a numeric matrix with columns as samples For `run*` a `SingleCellExperiment` or a derived object.
...	additional arguments passed to vegan::cca or vegan::dbrda and other internal functions. • `method` a dissimilarity measure to be applied in dbRDA and possible following homogeneity test. (By default: `method="euclidean"`) • `scale` a logical scalar, should the expression values be standardized? `scale` is disabled when using `*RDA` functions. Please scale before performing RDA. (By default: `scale=TRUE`) • `full` a logical scalar, should all the results from the significance calculations be returned. When `full=FALSE`, only summary tables are returned. (By default: `full=FALSE`) • `homogeneity.test` a single `character` value for specifying the significance test used to analyse `vegan::betadisper` results. Options include 'permanova' (`vegan::permutest`), 'anova' (`stats::anova`) and 'tukeyhsd' (`stats::TukeyHSD`). (By default: `homogeneity.test="permanova"`)
formula	If `x` is a `SummarizedExperiment` a formula can be supplied. Based on the right-hand side of the given formula `colData` is subset to `variables`. `variables` and `formula` can be missing, which turns the CCA analysis into a CA analysis and dbRDA into PCoA/MDS.
variables	When `x` is a `SummarizedExperiment`, `variables` can be used to specify variables from `colData`. When `x` is a matrix, `variables` is a `data.frame` or an object coercible to one containing the variables to use. All variables are used. Please subset, if you want to consider only some of them. `variables` and `formula` can be missing, which turns the CCA analysis into a CA analysis and dbRDA into PCoA/MDS.

test.signif	a logical scalar, should the PERMANOVA and analysis of multivariate homogeneity of group dispersions be performed. (By default: test.signif = TRUE)
assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
exprs_values	a single character value for specifying which assay to use for calculation. (Please use assay.type instead.)
scores	A string specifying scores to be returned. Must be 'wa' (site scores found as weighted averages (cca) or weighted sums (rda) of v with weights Xbar, but the multiplying effect of eigenvalues removed) or 'u' ((weighted) orthonormal site scores). (By default: scores='wa')
altexp	String or integer scalar specifying an alternative experiment containing the input data.
name	String specifying the name to be used to store the result in the reducedDims of the output.

Details

*CCA functions utilize vegan:cca and *RDA functions vegan:dbRDA. By default dbRDA is done with euclidean distances which equals to RDA.

Significance tests are done with vegan:anova.cca (PERMANOVA). Group dispersion, i.e., homogeneity within groups is analyzed with vegan:betadisper (multivariate homogeneity of groups dispersions (variances)) and statistical significance of homogeneity is tested with a test specified by homogeneity.test parameter.

Value

For getCCA a matrix with samples as rows and CCA dimensions as columns. Attributes include calculated cca/rda object and significance analysis results.

For addCCA a modified x with the results stored in reducedDim as the given name.

See Also

For more details on the actual implementation see cca and dbrda

Examples

```
library(scater)
data(GlobalPatterns)
GlobalPatterns <- addCCA(GlobalPatterns, data ~ SampleType)
plotReducedDim(GlobalPatterns,"CCA", colour_by = "SampleType")

# Fetch significance results
attr(reducedDim(GlobalPatterns, "CCA"), "significance")

GlobalPatterns <- addRDA(GlobalPatterns, data ~ SampleType)
plotReducedDim(GlobalPatterns,"CCA", colour_by = "SampleType")
```

```
# Specify dissimilarity measure
GlobalPatterns <- transformAssay(GlobalPatterns, method = "relabundance")
GlobalPatterns <- addRDA(
    GlobalPatterns, data ~ SampleType, assay.type = "relabundance",  method = "bray")

# To scale values when using *RDA functions, use transformAssay(MARGIN = "features", ...)
tse <- GlobalPatterns
tse <- transformAssay(tse, MARGIN = "features", method = "z")
# Data might include taxa that do not vary. Remove those because after z-transform
# their value is NA
tse <- tse[ rowSums( is.na( assay(tse, "z") ) ) == 0, ]
# Calculate RDA
tse <- addRDA(tse, formula = data ~ SampleType,
              assay.type = "z", name = "rda_scaled", na.action = na.omit)
# Plot
plotReducedDim(tse,"rda_scaled", colour_by = "SampleType")
# A common choice along with PERMANOVA is ANOVA when statistical significance
# of homogeneity of groups is analysed. Moreover, full signficance test results
# can be returned.
 tse <- addRDA(tse, data ~ SampleType, homogeneity.test = "anova", full = TRUE)
```

---

runDPCoA *Calculation of Double Principal Correspondance analysis*

Description

Double Principal Correspondance analysis is made available via the ade4 package in typical fashion. Results are stored in the reducedDims and are available for all the expected functions.

Usage

```
getDPCoA(x, y, ...)

## S4 method for signature 'ANY,ANY'
getDPCoA(
  x,
  y,
  ncomponents = 2,
  ntop = NULL,
  subset.row = subset_row,
  subset_row = NULL,
  scale = FALSE,
  transposed = FALSE,
  ...
)

## S4 method for signature 'TreeSummarizedExperiment,missing'
getDPCoA(
```

```
  x,
  ...,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  tree.name = tree_name,
  tree_name = "phylo"
)

calculateDPCoA(x, ...)

addDPCoA(x, ..., altexp = NULL, name = "DPCoA")

runDPCoA(x, ...)
```

Arguments

x	For getDPCoA, a numeric matrix of expression values where rows are features and columns are cells. Alternatively, a TreeSummarizedExperiment containing such a matrix. For addDPCoA a TreeSummarizedExperiment containing the expression values as well as a rowTree to calculate y using cophenetic.phylo.
y	a dist or a symmetric matrix compatible with ade4:dpcoa
...	Currently not used.
ncomponents	Numeric scalar indicating the number of DPCoA dimensions to obtain.
ntop	Numeric scalar specifying the number of features with the highest variances to use for dimensionality reduction. Alternatively NULL, if all features should be used. (default: ntop = NULL)
subset.row	Vector specifying the subset of features to use for dimensionality reduction. This can be a character vector of row names, an integer vector of row indices or a logical vector.
subset_row	Deprecated. Use subset.row instead.
scale	Logical scalar, should the expression values be standardized?
transposed	Logical scalar, is x transposed with cells in rows?
assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
exprs_values	a single character value for specifying which assay to use for calculation. (Please use assay.type instead.)
tree.name	a single character value for specifying which rowTree will be used in calculation. (By default: tree.name = "phylo")
tree_name	Deprecated. Use tree.name instead.
altexp	String or integer scalar specifying an alternative experiment containing the input data.
name	String specifying the name to be used to store the result in the reducedDims of the output.

Details

In addition to the reduced dimension on the features, the reduced dimension for samples are returned as well as `sample_red` attribute. `eig`, `feature_weights` and `sample_weights` are returned as attributes as well.

Value

For `getDPCoA` a matrix with samples as rows and CCA dimensions as columns

For `addDPCoA` a modified `x` with the results stored in `reducedDim` as the given `name`

See Also

`plotReducedDim` `reducedDims`

Examples

```
data(esophagus)
dpcoa <- getDPCoA(esophagus)
head(dpcoa)

esophagus <- addDPCoA(esophagus)
reducedDims(esophagus)

library(scater)
plotReducedDim(esophagus, "DPCoA")
```

`runNMDS` *Perform non-metric MDS on sample-level data*

Description

Perform non-metric multi-dimensional scaling (nMDS) on samples, based on the data in a `SingleCellExperiment` object.

Usage

```
getNMDS(x, ...)

## S4 method for signature 'ANY'
getNMDS(
  x,
  FUN = vegdist,
  nmds.fun = nmdsFUN,
  nmdsFUN = c("isoMDS", "monoMDS"),
  ncomponents = 2,
  ntop = 500,
  subset.row = subset_row,
```

```
  subset_row = NULL,
  scale = FALSE,
  transposed = FALSE,
  keep.dist = keep_dist,
  keep_dist = FALSE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getNMDS(
  x,
  ...,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  FUN = vegdist
)

## S4 method for signature 'SingleCellExperiment'
getNMDS(
  x,
  ...,
  assay.type = assay_name,
  assay_name = exprs_values,
  exprs_values = "counts",
  dimred = NULL,
  ndimred = n_dimred,
  n_dimred = NULL,
  FUN = vegdist
)

calculateNMDS(x, ...)

addNMDS(x, ..., altexp = NULL, name = "NMDS")

runNMDS(x, ...)
```

Arguments

x	For getNMDS, a numeric matrix of expression values where rows are features and columns are cells. Alternatively, a TreeSummarizedExperiment containing such a matrix. For addNMDS a SingleCellExperiment
...	additional arguments to pass to FUN and nmds.fun.
FUN	a function or character value with a function name returning a dist object
nmds.fun	a character value to choose the scaling implementation, either "isoMDS" for MASS::isoMDS or "monoMDS" for vegan::monoMDS
nmdsFUN	Deprecated. Use nmds.fun instead.

ncomponents	Numeric scalar indicating the number of NMDS dimensions to obtain.
ntop	Numeric scalar specifying the number of features with the highest variances to use for dimensionality reduction.
subset.row	Vector specifying the subset of features to use for dimensionality reduction. This can be a character vector of row names, an integer vector of row indices or a logical vector.
subset_row	Deprecated. Use subset.row instead.
scale	Logical scalar, should the expression values be standardized?
transposed	Logical scalar, is x transposed with cells in rows?
keep.dist	Logical scalar indicating whether the dist object calculated by FUN should be stored as 'dist' attribute of the matrix returned/stored by getNMDS/ addNMDS.
keep_dist	Deprecated. Use keep.dist instead.
assay.type	a single character value for specifying which assay to use for calculation.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
exprs_values	a single character value for specifying which assay to use for calculation. (Please use assay.type instead.)
dimred	String or integer scalar specifying the existing dimensionality reduction results to use.
ndimred	Integer scalar or vector specifying the dimensions to use if dimred is specified.
n_dimred	Deprecated. Use ndimred instead.
altexp	String or integer scalar specifying an alternative experiment containing the input data.
name	String specifying the name to be used to store the result in the reducedDims of the output.

Details

Either MASS::isoMDS or vegan::monoMDS are used internally to compute the NMDS components. If you supply a custom FUN, make sure that the arguments of FUN and nmds.fun do not collide.

Value

For getNMDS, a matrix is returned containing the MDS coordinates for each sample (row) and dimension (column).

Author(s)

Felix Ernst

See Also

MASS::isoMDS, vegan::monoMDS for NMDS component calculation.

plotMDS, to quickly visualize the results.

Examples

```
# generate some example data
mat <- matrix(1:60, nrow = 6)
df <- DataFrame(n = c(1:6))
tse <- TreeSummarizedExperiment(assays = list(counts = mat),
                                rowData = df)
#
getNMDS(tse)

#
data(esophagus)
esophagus <- addNMDS(esophagus, FUN = vegan::vegdist, name = "BC")
esophagus <- addNMDS(esophagus, FUN = vegan::vegdist, name = "euclidean",
                     method = "euclidean")
reducedDims(esophagus)
```

---

splitOn *Split* TreeSummarizedExperiment *column-wise or row-wise based on grouping variable*

Description

Split TreeSummarizedExperiment column-wise or row-wise based on grouping variable

Usage

```
splitOn(x, ...)

## S4 method for signature 'SummarizedExperiment'
splitOn(x, f = NULL, ...)

## S4 method for signature 'SingleCellExperiment'
splitOn(x, f = NULL, ...)

## S4 method for signature 'TreeSummarizedExperiment'
splitOn(x, f = NULL, update.tree = update_rowTree, update_rowTree = FALSE, ...)

unsplitOn(x, ...)

## S4 method for signature 'list'
unsplitOn(x, update.tree = update_rowTree, update_rowTree = FALSE, ...)

## S4 method for signature 'SimpleList'
unsplitOn(x, update.tree = update_rowTree, update_rowTree = FALSE, ...)

## S4 method for signature 'SingleCellExperiment'
unsplitOn(
  x,
```

```
  altexp = altExpNames,
  altExpNames = names(altExps(x)),
  keep.dimred = keep_reducedDims,
  keep_reducedDims = FALSE,
  ...
)
```

Arguments

x	A SummarizedExperiment object or a list of SummarizedExperiment objects.
...	Arguments passed to agglomerateByVariable function for SummarizedExperiment objects and other functions. See agglomerateByVariable for more details. • use.names A single boolean value to select whether to name elements of list by their group names.
f	A single character value for selecting the grouping variable from rowData or colData or a factor or vector with the same length as one of the dimensions. If f matches with both dimensions, MARGIN must be specified. Split by cols is not encouraged, since this is not compatible with storing the results in altExps.
update.tree	TRUE or FALSE: Should the rowTree be updated based on splitted data? Option is enabled when x is a TreeSummarizedExperiment object or a list of such objects. (By default: update.tree = FALSE)
update_rowTree	Deprecated. Use update.tree instead.
altexp	a character vector specifying the alternative experiments to be unsplit. (By default: altexp = names(altExps(x)))
altExpNames	Deprecated. Use altexp instead.
keep.dimred	TRUE or FALSE: Should the reducedDims(x) be transferred to the result? Please note, that this breaks the link between the data used to calculate the reduced dims. (By default: keep.dimred = FALSE)
keep_reducedDims	Deprecated. Use keep.dimred instead.

Details

splitOn split data based on grouping variable. Splitting can be done column-wise or row-wise. The returned value is a list of SummarizedExperiment objects; each element containing members of each group.

Value

For splitOn: SummarizedExperiment objects in a SimpleList.

For unsplitOn: x, with rowData and assay data replaced by the unsplit data. colData of x is kept as well and any existing rowTree is dropped as well, since existing rowLinks are not valid anymore.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

See Also

agglomerateByRanks agglomerateByVariable, sumCountsAcrossFeatures, agglomerateByRank, altExps, splitAltExps

Examples

```
data(GlobalPatterns)
tse <- GlobalPatterns
# Split data based on SampleType.
se_list <- splitOn(tse, f = "SampleType")

# List of SE objects is returned.
se_list

# Create arbitrary groups
rowData(tse)$group <- sample(1:3, nrow(tse), replace = TRUE)
colData(tse)$group <- sample(1:3, ncol(tse), replace = TRUE)

# Split based on rows
# Each element is named based on their group name. If you don't want to name
# elements, use use_name = FALSE. Since "group" can be found from rowdata and colData
# you must use MARGIN.
se_list <- splitOn(tse, f = "group", use.names = FALSE, MARGIN = 1)

# When column names are shared between elements, you can store the list to altExps
altExps(tse) <- se_list

altExps(tse)

# If you want to split on columns and update rowTree, you can do
se_list <- splitOn(tse, f = colData(tse)$group, update.tree = TRUE)

# If you want to combine groups back together, you can use unsplitBy
unsplitOn(se_list)
```

---

subsetSamples *Subset functions*

Description

To make a transition from phyloseq easier, the subsetSamples and subsetFeatures functions are implemented. To avoid name clashes they are named differently.

Usage

```
subsetSamples(x, ...)

subsetFeatures(x, ...)
```

```
subsetTaxa(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsetSamples(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsetFeatures(x, ...)

## S4 method for signature 'SummarizedExperiment'
subsetTaxa(x, ...)
```

Arguments

x	a SummarizedExperiment object
...	See subset. drop is not supported.

Details

However, the use of these functions is discouraged since subsetting using [works on both dimension at the same time, is more flexible and is used throughout R to subset data with two or more dimension. Therefore, these functions will be removed in Bioconductor release 3.15 (April, 2022).

Value

A subset of x

Examples

```
data(GlobalPatterns)
subsetSamples(GlobalPatterns, colData(GlobalPatterns)$SampleType == "Soil")
# Vector that is used to specify subset must not include NAs
subsetFeatures(GlobalPatterns, rowData(GlobalPatterns)$Phylum == "Actinobacteria" &
               !is.na(rowData(GlobalPatterns)$Phylum))
```

---

summaries *Summarizing microbiome data*

Description

To query a SummarizedExperiment for interesting features, several functions are available.

Usage

```
getTop(
  x,
  top = 5L,
  method = c("mean", "sum", "median"),
  assay.type = assay_name,
  assay_name = "counts",
  na.rm = TRUE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
getTop(
  x,
  top = 5L,
  method = c("mean", "sum", "median", "prevalence"),
  assay.type = assay_name,
  assay_name = "counts",
  na.rm = TRUE,
  ...
)

getUnique(x, ...)

## S4 method for signature 'SummarizedExperiment'
getUnique(x, rank = NULL, ...)

summarizeDominance(x, group = NULL, name = "dominant_taxa", ...)

## S4 method for signature 'SummarizedExperiment'
summarizeDominance(x, group = NULL, name = "dominant_taxa", ...)

## S4 method for signature 'SummarizedExperiment'
summary(object, assay.type = assay_name, assay_name = "counts")
```

Arguments

x	A SummarizedExperiment object.
top	Numeric value, how many top taxa to return. Default return top five taxa.
method	Specify the method to determine top taxa. Either sum, mean, median or prevalence. Default is 'mean'.
assay.type	a character value to select an assayNames By default it expects count data.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
na.rm	For getTop logical argument for calculation method specified to argument method. Default is TRUE.

...	Additional arguments passed on to agglomerateByRank() when rank is specified for summarizeDominance.
rank	A single character defining a taxonomic rank. Must be a value of the output of taxonomyRanks().
group	With group, it is possible to group the observations in an overview. Must be one of the column names of colData.
name	The column name for the features. The default is 'dominant_taxa'.
object	A SummarizedExperiment object.

Details

The getTop extracts the most top abundant "FeatureID"s in a SummarizedExperiment object.

The getUnique is a basic function to access different taxa at a particular taxonomic rank.

summarizeDominance returns information about most dominant taxa in a tibble. Information includes their absolute and relative abundances in whole data set.

The summary will return a summary of counts for all samples and features in SummarizedExperiment object.

Value

The getTop returns a vector of the most top abundant "FeatureID"s

The getUnique returns a vector of unique taxa present at a particular rank

The summarizeDominance returns an overview in a tibble. It contains dominant taxa in a column named *name* and its abundance in the data set.

The summary returns a list with two tibbles

Author(s)

Leo Lahti, Tuomas Borman and Sudarshan A. Shetty

See Also

getPrevalent

perCellQCMetrics, perFeatureQCMetrics, addPerCellQC, addPerFeatureQC, quickPerCellQC

Examples

```
data(GlobalPatterns)
top_taxa <- getTop(GlobalPatterns,
                       method = "mean",
                       top = 5,
                       assay.type = "counts")
top_taxa

# Use 'detection' to select detection threshold when using prevalence method
top_taxa <- getTop(GlobalPatterns,
                       method = "prevalence",
```

```
                      top = 5,
                      assay_name = "counts",
                      detection = 100)
top_taxa

# Top taxa os specific rank
getTop(agglomerateByRank(GlobalPatterns,
                           rank = "Genus",
                           na.rm = TRUE))

# Gets the overview of dominant taxa
dominant_taxa <- summarizeDominance(GlobalPatterns,
                                    rank = "Genus")
dominant_taxa

# With group, it is possible to group observations based on specified groups
# Gets the overview of dominant taxa
dominant_taxa <- summarizeDominance(GlobalPatterns,
                                    rank = "Genus",
                                    group = "SampleType",
                                    na.rm = TRUE)

dominant_taxa

# Get an overview of sample and taxa counts
summary(GlobalPatterns, assay_name= "counts")

# Get unique taxa at a particular taxonomic rank
# sort = TRUE means that output is sorted in alphabetical order
# With na.rm = TRUE, it is possible to remove NAs
# sort and na.rm can also be used in function getTop
getUnique(GlobalPatterns, "Phylum", sort = TRUE)
```

---

taxonomy-methods *Functions for accessing taxonomic data stored in* rowData.

Description

These function work on data present in rowData and define a way to represent taxonomic data alongside the features of a SummarizedExperiment.

Usage

```
TAXONOMY_RANKS

taxonomyRanks(x)

## S4 method for signature 'SummarizedExperiment'
taxonomyRanks(x)
```

```
taxonomyRankEmpty(
  x,
  rank = taxonomyRanks(x)[1L],
  empty.fields = c(NA, "", " ", "\t", "-", "_")
)

## S4 method for signature 'SummarizedExperiment'
taxonomyRankEmpty(
  x,
  rank = taxonomyRanks(x)[1],
  empty.fields = c(NA, "", " ", "\t", "-", "_")
)

checkTaxonomy(x, ...)

## S4 method for signature 'SummarizedExperiment'
checkTaxonomy(x)

setTaxonomyRanks(ranks)

getTaxonomyRanks()

getTaxonomyLabels(x, ...)

## S4 method for signature 'SummarizedExperiment'
getTaxonomyLabels(
  x,
  empty.fields = c(NA, "", " ", "\t", "-", "_"),
  with.rank = with_rank,
  with_rank = FALSE,
  make.unique = make_unique,
  make_unique = TRUE,
  resolve.loops = resolve_loops,
  resolve_loops = FALSE,
  ...
)

mapTaxonomy(x, ...)

## S4 method for signature 'SummarizedExperiment'
mapTaxonomy(
  x,
  taxa = NULL,
  from = NULL,
  to = NULL,
  use.grepl = use_grepl,
  use_grepl = FALSE
```

```
)

IdTaxaToDataFrame(from)
```

Arguments

x	a SummarizedExperiment object
rank	a single character defining a taxonomic rank. Must be a value of taxonomyRanks() function
empty.fields	a character value defining, which values should be regarded as empty. (Default: c(NA, "", " ", "\t")). They will be removed if na.rm = TRUE before agglomeration
...	optional arguments not used currently.
ranks	Avector of ranks to be set
with.rank	TRUE or FALSE: Should the level be add as a suffix? For example: "Phylum:Crenarchaeota" (default: with.rank = FALSE)
with_rank	Deprecated. Use with.rank instead.
make.unique	TRUE or FALSE: Should the labels be made unique, if there are any duplicates? (default: make.unique = TRUE)
make_unique	Deprecated. Use make.unique instead.
resolve.loops	TRUE or FALSE: Should resolveLoops be applied to the taxonomic data? Please note that has only an effect, if the data is unique. (default: resolve.loops = TRUE)
resolve_loops	Deprecated. Use resolve.loops instead.
taxa	a character vector, which is used for subsetting the taxonomic information. If no information is found,NULL is returned for the individual element. (default: NULL)
from	• For mapTaxonomy: a scalar character value, which must be a valid taxonomic rank. (default: NULL) • otherwise a Taxa object as returned by IdTaxa
to	a scalar character value, which must be a valid taxonomic rank. (default: NULL)
use.grepl	TRUE or FALSE: should pattern matching via grepl be used? Otherwise literal matching is used. (default: FALSE)
use_grepl	Deprecated. Use use.grepl instead.

Format

a character vector of length 8 containing the taxonomy ranks recognized. In functions this is used as case insensitive.

Details

taxonomyRanks returns, which columns of rowData(x) are regarded as columns containing taxonomic information.

taxonomyRankEmpty checks, if a selected rank is empty of information.

checkTaxonomy checks, if taxonomy information is valid and whether it contains any problems. This is a soft test, which reports some diagnostic and might mature into a data validator used upon object creation.

getTaxonomyLabels generates a character vector per row consisting of the lowest taxonomic information possible. If data from different levels, is to be mixed, the taxonomic level is prepended by default.

IdTaxaToDataFrame extracts taxonomic results from results of IdTaxa.

mapTaxonomy maps the given features (taxonomic groups; taxa) to the specified taxonomic level (to argument) in rowData of the SummarizedExperiment data object (i.e. rowData(x)[,taxonomyRanks(x)]). If the argument to is not provided, then all matching taxonomy rows in rowData will be returned. This function allows handy conversions between different

Taxonomic information from the IdTaxa function of DECIPHER package are returned as a special class. With as(taxa,"DataFrame") the information can be easily converted to a DataFrame compatible with storing the taxonomic information a rowData. Please note that the assigned confidence information are returned as metatdata and can be accessed using metadata(df)$confidence.

Value

- taxonomyRanks: a character vector with all the taxonomic ranks found in colnames(rowData(x))
- taxonomyRankEmpty: a logical value
- mapTaxonomy: a list per element of taxa. Each element is either a DataFrame, a character or NULL. If all character results have the length of one, a single character vector is returned.

See Also

agglomerateByRank, toTree, resolveLoop

Examples

```
data(GlobalPatterns)
GlobalPatterns
taxonomyRanks(GlobalPatterns)

checkTaxonomy(GlobalPatterns)

table(taxonomyRankEmpty(GlobalPatterns,"Kingdom"))
table(taxonomyRankEmpty(GlobalPatterns,"Species"))

getTaxonomyLabels(GlobalPatterns[1:20,])

# mapTaxonomy
## returns the unique taxonomic information
mapTaxonomy(GlobalPatterns)
```

```
# returns specific unique taxonomic information
mapTaxonomy(GlobalPatterns, taxa = "Escherichia")
# returns information on a single output
mapTaxonomy(GlobalPatterns, taxa = "Escherichia",to="Family")

# setTaxonomyRanks
tse <- GlobalPatterns
colnames(rowData(tse))[1] <- "TAXA1"

setTaxonomyRanks(colnames(rowData(tse)))
# Taxonomy ranks set to: taxa1 phylum class order family genus species

# getTaxonomyRanks is to get/check if the taxonomic ranks is set to "TAXA1"
getTaxonomyRanks()
```

`Tengeler2020` *Tengeler2020*

Description

Tengeler2020 includes gut microbiota profiles of 27 persons with ADHD. A standard bioinformatic and statistical analysis done to demonstrate that altered microbial composition could be a driver of altered brain structure and function and concomitant changes in the animals' behavior. This was investigated by colonizing young, male, germ-free C57BL/6JOlaHsd mice with microbiota from individuals with and without ADHD.

Usage

```
data(Tengeler2020)
```

Format

A TreeSummarizedExperiment with 151 features and 27 samples. The rowData contains taxonomic information at Kingdom, Phylum, Class, Order, Family and Genus level. The colData includes:

patient_status clinical status of the patient (ADHD or Control)

cohort cohort to which the patient belongs (Cohort_1, Cohort_2 and Cohort_3)

patient_status_vs_cohort combination of patient_status and cohort

sample_name unique sample ID

Author(s)

A.C. Tengeler, et al.

References

Tengeler, A.C., Dam, S.A., Wiesmann, M. et al. Gut microbiota from persons with attention-deficit/hyperactivity disorder affects the brain in mice. Microbiome 8, 44 (2020). https://doi.org/10.1186/s40168-020-00816-x

Supplemental information includes Home-cage activity, methods, results and imaging parameters and publicly-accessible from: https://static-content.springer.com/esm/art%3A10.1186%2Fs40168-020-00816-x/MediaObjects/40168_2020_816_MOESM1_ESM.docx https://static-content.springer.com/esm/art%3A10.1186%2Fs40168-020-00816-x/MediaObjects/40168_2020_816_MOESM2_ESM.docx https://static-content.springer.com/esm/art%3A10.1186%2Fs40168-020-00816-x/MediaObjects/40168_2020_816_MOESM3_ESM.docx

See Also

mia-datasets

`transformAssay` *Transform assay*

Description

Variety of transformations for abundance data, stored in `assay`. See details for options.

Usage

```
transformAssay(
  x,
  assay.type = "counts",
  assay_name = NULL,
 method = c("alr", "chi.square", "clr", "frequency", "hellinger", "log", "log10",
  "log2", "max", "normalize", "pa", "range", "rank", "rclr", "relabundance", "rrank",
    "standardize", "total", "z"),
  MARGIN = "samples",
  name = method,
  pseudocount = FALSE,
  ...
)

## S4 method for signature 'SummarizedExperiment'
transformAssay(
  x,
  assay.type = "counts",
  assay_name = NULL,
 method = c("alr", "chi.square", "clr", "frequency", "hellinger", "log", "log10",
  "log2", "max", "normalize", "pa", "range", "rank", "rclr", "relabundance", "rrank",
    "standardize", "total", "z"),
  MARGIN = "samples",
```

```
  name = method,
  pseudocount = FALSE,
  ...
)
```

Arguments

x	A SummarizedExperiment object.
assay.type	A single character value for selecting the assay to be transformed.
assay_name	a single character value for specifying which assay to use for calculation. (Please use assay.type instead. At some point assay_name will be disabled.)
method	A single character value for selecting the transformation method.
MARGIN	A single character value for specifying whether the transformation is applied sample (column) or feature (row) wise. (By default: MARGIN = "samples")
name	A single character value specifying the name of transformed abundance table.
pseudocount	TRUE, FALSE, or a numeric value. When TRUE, automatically adds the minimum positive value of assay.type. When FALSE, does not add any pseudocount (pseudocount = 0). Alternatively, a user-specified numeric value can be added as pseudocount.
...	additional arguments passed on to vegan:decostand: • reference: A single value which will be used to fill reference sample's column in returned assay when calculating alr. (default: reference = NA) • ref_vals Deprecated. Use reference instead.

Details

These transformCount function provides a variety of options for transforming abundance data. The transformed data is calculated and stored in a new assay. The previously available wrappers transformSamples, transformFeatures ZTransform, and relAbundanceCounts have been deprecated.

The transformAssay provides sample-wise (column-wise) or feature-wise (row-wise) transformation to the abundance table (assay) based on specified MARGIN.

The available transformation methods include:

- 'alr', 'chi.square', 'clr', 'frequency', 'hellinger', 'log', 'normalize', 'pa', 'rank', 'rclr' 'relabundance', 'rrank', 'standardize', 'total': please refer to decostand for details.
- 'log10': log10 transformation can be used for reducing the skewness of the data.

$$log10 = \log_{10} x$$

  where x is a single value of data.
- 'log2': log2 transformation can be used for reducing the skewness of the data.

$$log2 = \log_2 x$$

  where x is a single value of data.

Value

transformAssay returns the input object x, with a new transformed abundance table named name added in the assay.

Author(s)

Leo Lahti and Tuomas Borman. Contact: microbiome.github.io

Examples

```
data(esophagus, package="mia")
tse <- esophagus

# By specifying 'method', it is possible to apply different transformations,
# e.g. compositional transformation.
tse <- transformAssay(tse, method = "relabundance")

# The target of transformation can be specified with "assay.type"
# Pseudocount can be added by specifying 'pseudocount'.

# Perform CLR with smallest positive value as pseudocount
tse <- transformAssay(tse, assay.type = "relabundance", method = "clr",
                      pseudocount = TRUE
                      )

head(assay(tse, "clr"))

# With MARGIN, you can specify the if transformation is done for samples or
# for features. Here Z-transformation is done feature-wise.
tse <- transformAssay(tse, method = "z", MARGIN = "features")
head(assay(tse, "z"))

# Name of the stored table can be specified.
tse <- transformAssay(tse, method="hellinger", name="test")
head(assay(tse, "test"))

# pa returns presence absence table.
tse <- transformAssay(tse, method = "pa")
head(assay(tse, "pa"))

# rank returns ranks of taxa.
tse <- transformAssay(tse, method = "rank")
head(assay(tse, "rank"))

# In order to use other ranking variants, modify the chosen assay directly:
assay(tse, "rank_average", withDimnames = FALSE) <- colRanks(assay(tse, "counts"),
                                                             ties.method="average",
                                                             preserveShape = TRUE)
```

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