Package ‘metagenomeSeq’

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Title Statistical analysis for sparse high-throughput sequencing

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Description metagenomeSeq is designed to determine features (be it Operational Taxanomic Unit (OTU), species, etc.) that are differentially abundant between two or more groups of multiple samples. metagenomeSeq is designed to address the effects of both normalization and under-sampling of microbial communities on disease association detection and the testing of feature correlations.

License Artistic-2.0

Depends R(>= 3.0), Biobase, limma, glmnet, methods, RColorBrewer

Suggests annotate, BiocGenerics, biomformat, knitr, gss, testthat (>= 0.8), vegan, interactiveDisplay, IHW

Imports parallel, matrixStats, foreach, Matrix, gplots, graphics, grDevices, stats, utils, Wrench

VignetteBuilder knitr

URL https://github.com/nosson/metagenomeSeq/

BugReports https://github.com/nosson/metagenomeSeq/issues

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        Metagenomics, Normalization, Visualization, MultipleComparison,
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metagenomeSeq-package  Statistical analysis for sparse high-throughput sequencing

Description

metagenomeSeq is designed to determine features (be it Operational Taxonomic Unit (OTU), species, etc.) that are differentially abundant between two or more groups of multiple samples. metagenomeSeq is designed to address the effects of both normalization and under-sampling of microbial communities on disease association detection and the testing of feature correlations.

A user's guide is available, and can be opened by typing vignette("metagenomeSeq")

The metagenomeSeq package implements novel normalization and statistical methodology in the following papers.

Author(s)

Paulson, JN <jpaulson@umiacs.umd.edu>; Pop, M; Corrada Bravo, H

References


aggregateBySample  Aggregates a MRexperiment object or counts matrix to by a factor.

Description

Using the phenoData information in the MRexperiment, calling aggregateBySample on a MRexperiment and a particular phenoData column (i.e. 'diet') will aggregate counts using the aggfun function (default rowMeans). Possible aggfun alternatives include rowMeans and rowMedians.

Usage

aggregateBySample(obj, fct, aggfun = rowMeans, out = "MRexperiment")

aggSamp(obj, fct, aggfun = rowMeans, out = "MRexperiment")

Arguments

obj  A MRexperiment object or count matrix.

fct  phenoData column name from the MRexperiment object or if count matrix object a vector of labels.

aggfun  Aggregation function.

out  Either 'MRexperiment' or 'matrix'
aggregateByTaxonomy

Value
An aggregated count matrix or MRexperiment object where the new pData is a vector of 'fct' levels.

Examples

data(mouseData)
aggregateBySample(mouseData[1:100,],fct="diet",aggfun=rowSums)
# not run
# aggregateBySample(mouseData,fct="diet",aggfun=matrixStats::rowMedians)
# aggSamp(mouseData,fct='diet',aggfun=rowMaxs)

aggregateByTaxonomy  Aggregates a MRexperiment object or counts matrix to a particular level.

Description
Using the featureData information in the MRexperiment, calling aggregateByTaxonomy on a MRexperiment and a particular featureData column (i.e. 'genus') will aggregate counts to the desired level using the aggfun function (default colSums). Possible aggfun alternatives include colMeans and colMedians.

Usage
aggregateByTaxonomy(
  obj,
  lvl,
  alternate = FALSE,
  norm = FALSE,
  log = FALSE,
  aggfun = colSums,
  sl = 1000,
  featureOrder = NULL,
  returnFullHierarchy = TRUE,
  out = "MRexperiment"
)

aggTax(
  obj,
  lvl,
  alternate = FALSE,
  norm = FALSE,
  log = FALSE,
  aggfun = colSums,
  sl = 1000,
  featureOrder = NULL,
  returnFullHierarchy = TRUE,
Arguments

obj        A MRexperiment object or count matrix.
lvl        featureData column name from the MRexperiment object or if count matrix object a vector of labels.
alternate  Use the rowname for undefined OTUs instead of aggregating to "no_match".
norm       Whether to aggregate normalized counts or not.
log        Whether or not to log2 transform the counts - if MRexperiment object.
aggfun     Aggregation function.
s1         scaling value, default is 1000.
featureOrder    Hierarchy of levels in taxonomy as fData colnames
returnFullHierarchy  Boolean value to indicate return single column of fData or all columns of hierarchy
out        Either 'MRexperiment' or 'matrix'

Value
An aggregated count matrix.

Examples

data(mouseData)
aggregateByTaxonomy(mouseData[1:100,],lvl="class",norm=TRUE,aggfun=colSums)
# not run
# aggregateByTaxonomy(mouseData,lvl="class",norm=TRUE,aggfun=colMedians)
# aggTax(mouseData,lvl='phylum',norm=FALSE,aggfun=colSums)

biom2MRexperiment   Biom to MRexperiment objects

Description
Wrapper to convert biom files to MRexperiment objects.

Usage
biom2MRexperiment(obj)
calcNormFactors

Arguments

obj The biom object file.

Value

A MRexperiment object.

See Also

loadMeta loadPhenoData newMRexperiment loadBiom

Examples

library(biomformat)
rich_dense_file = system.file("extdata", "rich_dense_otu_table.biom", package = "biomformat")
x = biomformat::read_biom(rich_dense_file)
bio2MRexperiment(x)

calcNormFactors  Cumulative sum scaling (css) normalization factors

Description

Return a vector of the the sum up to and including a quantile.

Usage

calcNormFactors(obj, p = cumNormStatFast(obj))

Arguments

obj An MRexperiment object or matrix.

p The pth quantile.

Value

Vector of the sum up to and including a sample’s pth quantile.

See Also

fitZig cumNormStatFast cumNorm

Examples

data(mouseData)
head(calcNormFactors(mouseData))
calcPosComponent

**Description**
Fit the positive (log-normal) component

**Usage**
calcPosComponent(mat, mod, weights)

**Arguments**
- mat: A matrix of normalized counts
- mod: A model matrix
- weights: Weight matrix for samples and counts

**See Also**
- fitZeroLogNormal
- fitFeatureModel

---

calcShrinkParameters

**Description**
Calculate the shrunken variances and variance of parameters of interest across features.

**Usage**
calcShrinkParameters(fit, coef, mins2, exclude = NULL)

**Arguments**
- fit: A matrix of fits as outputted by calcZeroComponent or calcPosComponent
- coef: Coefficient of interest
- mins2: Minimum variance estimate
- exclude: Vector of features to exclude when shrinking

**See Also**
- fitZeroLogNormal
- fitFeatureModel
calcStandardError

---

**calcStandardError**  
*Calculate the zero-inflated log-normal statistic’s standard error*

---

**Description**  
Calculates the standard error for the model. Code modified from "Adjusting for covariates in zero-inflated gamma and zero-inflated log-normal models for semicontinuous data", ED Mills

**Usage**  
```
calcStandardError(mod, fitln, fitzero, coef = 2, exclude = NULL)
```

**Arguments**  
- `mod`: The zero component model matrix  
- `fitln`: A matrix with parameters from the log-normal fit  
- `fitzero`: A matrix with parameters from the logistic fit  
- `coef`: Coefficient of interest  
- `exclude`: List of features to exclude

**See Also**  
- `fitZeroLogNormal`  
- `fitFeatureModel`

---

**calculateEffectiveSamples**  
*Estimated effective samples per feature*

---

**Description**  
Calculates the number of estimated effective samples per feature from the output of a fitZig run. The estimated effective samples per feature is calculated as the sum_1^n (n = number of samples) 1-z_i where z_i is the posterior probability a feature belongs to the technical distribution.

**Usage**  
```
calculateEffectiveSamples(obj)
```

**Arguments**  
- `obj`: The output of fitZig run on a MReperiment object.

**Value**  
A list of the estimated effective samples per feature.
calcZeroComponent

See Also
fitZig MRcoefs MRfulltable

calcZeroAdjustment Calculate the zero-inflated component's adjustment factor

Description
Calculate the log ratio of average marginal probabilities for each sample having a positive count. This becomes the adjustment factor for the log fold change.

Usage
calcZeroAdjustment(fitln, fitzero, mod, coef, exclude = NULL)

Arguments
fitln A matrix with parameters from the log-normal fit
fitzero A matrix with parameters from the logistic fit
mod The zero component model matrix
coef Coefficient of interest
exclude List of features to exclude

See Also
fitZeroLogNormal fitFeatureModel

calcZeroComponent Zero component

Description
Fit the zero (logistic) component

Usage
calcZeroComponent(mat, mod, weights)

Arguments
mat A matrix of normalized counts
mod A model matrix
weights Weight matrix for samples and counts

See Also
fitZeroLogNormal fitFeatureModel
**correctIndices**  
Calculate the correct indices for the output of `correlationTest`

---

**Description**

Consider the upper triangular portion of a matrix of size nxn. Results from the `correlationTest` are output as the combination of two vectors, correlation statistic and p-values. The order of the output is 1vs2, 1vs3, 1vs4, etc. The `correctIndices` returns the correct indices to fill a correlation matrix or correlation-pvalue matrix.

**Usage**

`correctIndices(n)`

**Arguments**

- **n**  
The number of features compared by `correlationTest` (`nrow(mat)`).

**Value**

A vector of the indices for an upper triangular matrix.

**See Also**

- `correlationTest`

**Examples**

```r
data(mouseData)  
mat = MRcounts(mouseData)[55:60,]  
cors = correlationTest(mat)  
ind = correctIndices(nrow(mat))

cormat = as.matrix(dist(mat))  
cormat[cormat>0] = 0  
cormat[upper.tri(cormat)][ind] = cors[,1]  
table(cormat[1,-1] - cors[1:5,1])
```
Correlation of each row of a matrix or MRexperiment object

description

Calculates the (pairwise) correlation statistics and associated p-values of a matrix or the correlation of each row with a vector.

Usage

correlationTest(
  obj, 
  y = NULL, 
  method = "pearson", 
  alternative = "two.sided", 
  norm = TRUE, 
  log = TRUE, 
  cores = 1, 
  override = FALSE, 
  ...
)

Arguments

obj A MRexperiment object or count matrix.
y Vector of length ncol(obj) to compare to.
method One of 'pearson', 'spearman', or 'kendall'.
alternative Indicates the alternative hypothesis and must be one of 'two.sided', 'greater' (positive) or 'less'(negative). You can specify just the initial letter.
norm Whether to aggregate normalized counts or not - if MRexperiment object.
log Whether or not to log2 transform the counts - if MRexperiment object.
cores Number of cores to use.
override If the number of rows to test is over a thousand the test will not commence (unless override==TRUE).
...
Extra parameters for mclapply.

Value

A matrix of size choose(number of rows, 2) by 2. The first column corresponds to the correlation value. The second column the p-value.

See Also

correctIndices
**cumNorm**

*Cumulative sum scaling normalization*

**Examples**

```r
# Pairwise correlation of raw counts
data(mouseData)
cors = correlationTest(mouseData[1:10,], norm=FALSE, log=FALSE)
head(cors)

mat = MRcounts(mouseData)[1:10,]
cormat = as.matrix(dist(mat)) # Creating a matrix
cormat[cormat>0] = 0 # Creating an empty matrix
ind = correctIndices(nrow(mat))
cormat[upper.tri(cormat)][ind] = cors[,1]
table(cormat[1,-1] - cors[1:9,1])

# Correlation of raw counts with a vector (library size in this case)
data(mouseData)
cors = correlationTest(mouseData[1:10,], libSize(mouseData), norm=FALSE, log=FALSE)
head(cors)
```

---

**Description**

Calculates each column’s quantile and calculates the sum up to and including that quantile.

**Usage**

```r
cumNorm(obj, p = cumNormStatFast(obj))
```

**Arguments**

- **obj**
  - An MRexperiment object.
- **p**
  - The pth quantile.

**Value**

Object with the normalization factors stored as a vector of the sum up to and including a sample’s pth quantile.

**See Also**

`fitZig`, `cumNormStat`

**Examples**

```r
data(mouseData)
mouseData <- cumNorm(mouseData)
head(normFactors(mouseData))
```
**cumNormMat**

*Cumulative sum scaling factors.*

**Description**

Calculates each column’s quantile and calculates the sum up to and including that quantile.

**Usage**

```r
cumNormMat(obj, p = cumNormStatFast(obj), sl = 1000)
```

**Arguments**

- `obj` A matrix or MRexperiment object.
- `p` The pth quantile.
- `sl` The value to scale by (default=1000).

**Value**

Returns a matrix normalized by scaling counts up to and including the pth quantile.

**See Also**

`fitZig`, `cumNorm`

**Examples**

```r
data(mouseData)
head(cumNormMat(mouseData))
```

---

**cumNormStat**

*Cumulative sum scaling percentile selection*

**Description**

Calculates the percentile for which to sum counts up to and scale by. `cumNormStat` might be deprecated one day. Deviates from methods in Nature Methods paper by making use row means for generating reference.

**Usage**

```r
cumNormStat(obj, qFlag = TRUE, pFlag = FALSE, rel = 0.1, ...)
```

**Examples**

```r
data(mouseData)
head(cumNormStat(mouseData))
```
cumNormStatFast

Arguments

- **obj**: A matrix or MRexperiment object.
- **qFlag**: Flag to either calculate the proper percentile using R’s step-wise quantile function or approximate function.
- **pFlag**: Plot the relative difference of the median deviance from the reference.
- **rel**: Cutoff for the relative difference from one median difference from the reference to the next.
- **...**: Applicable if pFlag == TRUE. Additional plotting parameters.

Value

Percentile for which to scale data

See Also

fitZig, cumNorm, cumNormStatFast

Examples

```r
data(mouseData)
p = round(cumNormStat(mouseData,pFlag=FALSE),digits=2)
```

---

**Description**

Calculates the percentile for which to sum counts up to and scale by. Faster version than available in cumNormStat. Deviates from methods described in Nature Methods by making use of ro means for reference.

**Usage**

cumNormStatFast(obj, pFlag = FALSE, rel = 0.1, ...)

**Arguments**

- **obj**: A matrix or MRexperiment object.
- **pFlag**: Plot the median difference quantiles.
- **rel**: Cutoff for the relative difference from one median difference from the reference to the next.
- **...**: Applicable if pFlag == TRUE. Additional plotting parameters.
doCountMStep

Value
Percentile for which to scale data

See Also
fitZig cumNorm cumNormStat

Examples

data(mouseData)
p = round(cumNormStatFast(mouseData,pFlag=FALSE),digits=2)

---
doCountMStep

**Compute the Maximization step calculation for features still active.**

Description
Maximization step is solved by weighted least squares. The function also computes counts residuals.

Usage
doCountMStep(z, y, mmCount, stillActive, fit2 = NULL, dfMethod = "modified")

Arguments
- **z**: Matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).
- **y**: Matrix (m x n) of count observations.
- **mmCount**: Model matrix for the count distribution.
- **stillActive**: Boolean vector of size M, indicating whether a feature converged or not.
- **fit2**: Previous fit of the count model.
- **dfMethod**: Either 'default' or 'modified' (by responsibilities)

Details
Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership $\delta_{ij}$ = 1 if $y_{ij}$ is generated from the zero point mass as latent indicator variables. The density is defined as $f_{\text{zig}}(y_{ij} = \pi_j(S_j)*f_0(y_{ij}) + (1-\pi_j(S_j)) * f_{\text{count}}(y_{ij};\mu_i,\sigma_i^2)$. The log-likelihood in this extended model is $(1-\delta_{ij}) \log f_{\text{count}}(y_{ij};\mu_i,\sigma_i^2) + \delta_{ij} \log \pi_j(S_j) + (1-\delta_{ij}) \log (1-\pi_j(s_j))$. The responsibilities are defined as $z_{ij} = \text{pr}(\delta_{ij}=1 | \text{data})$. 
doEStep

Value

Update matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).

See Also

fitZig

---

**doEStep**  Compute the Expectation step.

**Description**

Estimates the responsibilities $z_{ij} = \frac{\pi_j}{I_0(y_{ij} \pi_j) cdot I_0(y_{ij} + (1-\pi_j) cdot f_{count}(y_{ij})}

**Usage**

doEStep(countResiduals, zeroResiduals, zeroIndices)

**Arguments**

- **countResiduals**: Residuals from the count model.
- **zeroResiduals**: Residuals from the zero model.
- **zeroIndices**: Index (matrix m x n) of counts that are zero/non-zero.

**Details**

Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership $\delta_{ij} = 1$ if $y_{ij}$ is generated from the zero point mass as latent indicator variables. The density is defined as $f_{zigg}(y_{ij} = \pi_j(S_j) cdot f_0(y_{ij}) +(1-\pi_j (S_j)) cdot f_{count}(y_{ij};\mu_i,\sigma_i^2)$. The log-likelihood in this extended model is $\log f_{count}(y;\mu_i,\sigma_i^2)+\delta_{ij} \log \pi_j(s_j)+(1-\delta_{ij}) log (1-\pi_j (sj))$. The responsibilities are defined as $z_{ij} = pr(\delta_{ij}=1 | data)$.

**Value**

Updated matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).

**See Also**

fitZig
doZeroMStep  

**Compute the zero Maximization step.**

**Description**

Performs Maximization step calculation for the mixture components. Uses least squares to fit the parameters of the mean of the logistic distribution. \[ \pi_j = \sum_i^M \frac{1}{M} z_{ij} \] Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership \( \delta_{ij} = 1 \) if \( \delta_{ij} \) is generated from the zero point mass as latent indicator variables. The density is defined as \( f_{\text{zig}}(y_{ij} = \pi_j(S_j)) \cdot f_0(y_{ij}) + (1-\pi_j(S_j)) \cdot f_{\text{count}}(y_{ij}; \mu_i, \sigma_i^2) \). The log-likelihood in this extended model is \( (1-\delta_{ij}) \log f_{\text{count}}(y; \mu_i, \sigma_i^2) + \delta_{ij} \log \pi_j(S_j) + (1-\delta_{ij}) \log (1-\pi_j(S_j)) \). The responsibilities are defined as \( z_{ij} = pr(\delta_{ij}=1 | \text{data}) \).

**Usage**

\[ \text{doZeroMStep}(z, \text{zeroIndices}, \text{mmZero}) \]

**Arguments**

- \( z \)  
  Matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).
- \( \text{zeroIndices} \)  
  Index (matrix m x n) of counts that are zero/non-zero.
- \( \text{mmZero} \)  
  The zero model, the model matrix to account for the change in the number of OTUs observed as a linear effect of the depth of coverage.

**Value**

List of the zero fit (zero mean model) coefficients, variance - scale parameter (scalar), and normalized residuals of length sum(zeroIndices).

**See Also**

- fitZig

**exportMat**  

**Export the normalized MReXperiment dataset as a matrix.**

**Description**

This function allows the user to take a dataset of counts and output the dataset to the user’s workspace as a tab-delimited file, etc.
Usage

```r
exportMat(
  obj,
  log = TRUE,
  norm = TRUE,
  sep = "\t",
  file = "~/Desktop/matrix.tsv"
)
```

Arguments

- **obj**: A MRexperiment object or count matrix.
- **log**: Whether or not to log transform the counts - if MRexperiment object.
- **norm**: Whether or not to normalize the counts - if MRexperiment object.
- **sep**: Separator for writing out the count matrix.
- **file**: Output file name.

Value

NA

See Also

cumNorm

Examples

```r
data(lungData)
dataDirectory <- system.file("extdata", package="metagenomeSeq")
exportMat(lungData[,1:5],file.path(dataDirectory,"tmp.tsv"))
head(read.csv(file=file.path(dataDirectory,"tmp.tsv"),sep="\t"))
```

default

default

---

### exportStats

**Various statistics of the count data.**

Description

A matrix of values for each sample. The matrix consists of sample ids, the sample scaling factor, quantile value, the number identified features, and library size (depth of coverage).

Usage

```r
exportStats(obj, p = cumNormStat(obj), file = "~/Desktop/res.stats.tsv")
```
expSummary

Arguments

- **obj**: A MRexperiment object with count data.
- **p**: Quantile value to calculate the scaling factor and quantiles for the various samples.
- **file**: Output file name.

Value

None.

See Also

cumNorm, quantile

Examples

data(lungData)
dataDirectory <- system.file("extdata", package="metagenomeSeq")
exportStats(lungData[,1:5],file=file.path(dataDirectory,"tmp.tsv"))
head(read.csv(file=file.path(dataDirectory,"tmp.tsv"),sep="\t"))

Description

The expSummary vectors represent the column (sample specific) sums of features, i.e. the total number of reads for a sample, libSize and also the normalization factors, normFactor.

Usage

expSummary(obj)

Arguments

- **obj**: a MRexperiment object.

Value

Experiment summary table

Author(s)

Joseph N. Paulson, jpaulson@umiacs.umd.edu
extractMR

Examples

data(mouseData)
expSummary(mouseData)

extractMR

Extract the essentials of an MReperiment.

Description

Extract the essentials of an MReperiment.

Usage

extractMR(obj)

Arguments

obj MRexperiment-class object.

Value

A list containing:

  counts : Count data
  • librarySize : The column sums / library size / sequencing depth
  • normFactors : The normalization scaling factors
  • pheno : phenotype table
  • feat : feature table

Examples

data(mouseData)
head(metagenomeSeq::extractMR(mouseData))
filterData

Filter datasets according to no. features present in features with at least a certain depth.

**Description**

Filter the data based on the number of present features after filtering samples by depth of coverage. There are many ways to filter the object, this is just one way.

**Usage**

```r
filterData(obj, present = 1, depth = 1000)
```

**Arguments**

- `obj`: A MRexperiment object or count matrix.
- `present`: Features with at least 'present' positive samples.
- `depth`: Samples with at least this much depth of coverage.

**Value**

A MRexperiment object.

**Examples**

```r
data(mouseData)
filterData(mouseData)
```

fitDO

Wrapper to calculate Discovery Odds Ratios on feature values.

**Description**

This function returns a data frame of p-values, odds ratios, lower and upper confidence limits for every row of a matrix. The discovery odds ratio is calculated as using Fisher’s exact test on actual counts. The test’s hypothesis is whether or not the discovery of counts for a feature (of all counts) is found in greater proportion in a particular group.

**Usage**

```r
fitDO(obj, cl, norm = TRUE, log = TRUE, adjust.method = "fdr", cores = 1, ...)
```
fitFeatureModel

 Computes differential abundance analysis using a zero-inflated log-normal model

Description

Wrapper to actually run zero-inflated log-normal model given a MRexperiment object and model matrix. User can decide to shrink parameter estimates.

Usage

fitFeatureModel(obj, mod, coef = 2, B = 1, szero = FALSE, spos = TRUE)
Arguments

- **obj**: A MRexperiment object with count data.
- **mod**: The model for the count distribution.
- **coef**: Coefficient of interest to grab log fold-changes.
- **B**: Number of bootstraps to perform if >1. If >1 performs permutation test.
- **szero**: TRUE/FALSE, shrink zero component parameters.
- **spos**: TRUE/FALSE, shrink positive component parameters.

Value

A list of objects including:

- call - the call made to fitFeatureModel
- fitZeroLogNormal - list of parameter estimates for the zero-inflated log normal model
- design - model matrix
- taxa - taxa names
- counts - count matrix
- pvalues - calculated p-values
- permuttedfits - permutted z-score estimates under the null

See Also

cumNorm

Examples

data(lungData)
lungData = lungData[-which(is.na(pData(lungData)$SmokingStatus))]
lungData=filterData(lungData,present=30,depth=1)
lungData <- cumNorm(lungData, p=.5)
s <- normFactors(lungData)
pd <- pData(lungData)
mod <- model.matrix(~1+SmokingStatus, data=pd)
lungres1 = fitFeatureModel(lungData,mod)
**fitLogNormal**

**Slots**
- call: the call made to fitFeatureModel
- fitZeroLogNormal: list of parameter estimates for the zero-inflated log normal model
- design: model matrix
- taxa: taxa names
- counts: count matrix
- pvalues: calculated p-values
- permuttedFits: permuted z-score estimates under the null

---

**fitLogNormal** *Computes a log-normal linear model and permutation based p-values.*

**Description**
Wrapper to perform the permutation test on the t-statistic. This is the original method employed by metastats (for non-sparse large samples). We include CSS normalization though (optional) and log2 transform the data. In this method the null distribution is not assumed to be a t-dist.

**Usage**

```r
fitLogNormal(obj, mod, useCSSoffset = TRUE, B = 1000, coef = 2, sl = 1000)
```

**Arguments**
- `obj`: A MRexperiment object with count data.
- `mod`: The model for the count distribution.
- `useCSSoffset`: Boolean, whether to include the default scaling parameters in the model or not.
- `B`: Number of permutations.
- `coef`: The coefficient of interest.
- `sl`: The value to scale by (default=1000).

**Value**
Call made, fit object from lmFit, t-statistics and p-values for each feature.

**Examples**

```r
# This is a simple demonstration
data(lungData)
k = grep("Extraction.Control", pData(lungData)$SampleType)
lungTrim = lungData[, -k]
k = which(rowSums(MRcounts(lungTrim) > 0) < 30)
lungTrim = cumNorm(lungTrim)[k,
lungTrim = lungTrim[-k,]
```
smokingStatus = pData(lungTrim)$SmokingStatus
mod = model.matrix(~smokingStatus)
fit = fitLogNormal(obj = lungTrim, mod=mod, B=1)

fitMultipleTimeSeries  Discover differentially abundant time intervals for all bacteria

Description

Calculate time intervals of significant differential abundance over all bacteria of a particularly specified level (lvl). If not lvl is specified, all OTUs are analyzed. Warning, function can take a while

Usage

fitMultipleTimeSeries(obj, lvl = NULL, B = 1, featureOrder = NULL, ...)

Arguments

obj  metagenomeSeq MRexperiment-class object.
lvl  Vector or name of column in featureData of MRexperiment-class object for aggregating counts (if not OTU level).
B  Number of permutations to perform.
featureOrder  Hierarchy of levels in taxonomy as fData colnames
...  Options for fitTimeSeries, except feature.

Value

List of lists of matrices of time point intervals of interest, Difference in abundance area and p-value, fit, area permutations.

A list of lists for which each includes:

- timeIntervals - Matrix of time point intervals of interest, area of differential abundance, and pvalue.
- data - Data frame of abundance, class indicator, time, and id input.
- fit - Data frame of fitted values of the difference in abundance, standard error estimates and timepoints interpolated over.
- perm - Differential abundance area estimates for each permutation.
- call - Function call.

See Also

cumNorm fitSSTimeSeries fitTimeSeries
Examples

```r
data(mouseData)
res = fitMultipleTimeSeries(obj=mouseData,lvl='phylum',class='status',
id='mouseID',time='relativeTime',B=1)
```

**fitPA**

`Wrapper to run fisher's test on presence/absence of a feature.`

**Description**

This function returns a data frame of p-values, odds ratios, lower and upper confidence limits for every row of a matrix.

**Usage**

```r
fitPA(obj, cl, thres = 0, adjust.method = "fdr", cores = 1, 
      ...)
```

**Arguments**

- `obj`: A MRexperiment object with a count matrix, or a simple count matrix.
- `cl`: Group comparison
- `thres`: Threshold for defining presence/absence.
- `adjust.method`: Method to adjust p-values by. Default is "FDR". Options include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". See `p.adjust` for more details.
- `cores`: Number of cores to use.
- `...`: Extra parameters for `makeCluster`

**Value**

Matrix of odds ratios, p-values, lower and upper confidence intervals

**See Also**

`cumNorm fitZig fitDO fitMeta`

**Examples**

```r
data(lungData)
k = grep("Extraction.Control",pData(lungData)$SampleType)
lungTrim = lungData[,,-k]
lungTrim = lungTrim[-which(rowSums(MRcounts(lungTrim)>0)<20),]
res = fitPA(lungTrim,pData(lungTrim)$SmokingStatus);
head(res)
```
Description

Calculate time intervals of interest using SS-Anova fitted models. Fitting is performed uses Smoothing Spline ANOVA (SS-Anova) to find interesting intervals of time. Given observations at different time points for two groups, fitSSTimeSeries calculates a function that models the difference in abundance between two groups across all time. Using permutations we estimate a null distribution of areas for the time intervals of interest and report significant intervals of time. Use of the function for analyses should cite: "Finding regions of interest in high throughput genomics data using smoothing splines" Talukder H, Paulson JN, Bravo HC. (In preparation)

Usage

```r
fitSSTimeSeries(
  obj,
  formula,
  feature,
  class,
  time,
  id,
  lvl = NULL,
  include = c("class", "time:class"),
  C = 0,
  B = 1000,
  norm = TRUE,
  log = TRUE,
  sl = 1000,
  featureOrder = NULL,
  ...
)
```

Arguments

- **obj**: metagenomeSeq MRexperiment-class object.
- **formula**: Formula for ssanova. Of the form: abundance ~ ... where ... includes any pData slot value.
- **feature**: Name or row of feature of interest.
- **class**: Name of column in phenoData of MRexperiment-class object for class membership.
- **time**: Name of column in phenoData of MRexperiment-class object for relative time.
- **id**: Name of column in phenoData of MRexperiment-class object for sample id.
- **lvl**: Vector or name of column in featureData of MRexperiment-class object for aggregating counts (if not OTU level).
fitTimeSeries

include | Parameters to include in prediction.
C       | Value for which difference function has to be larger or smaller than (default 0).
B       | Number of permutations to perform
norm    | When aggregating counts to normalize or not.
log     | Log2 transform.
s1      | Scaling value.
featureOrder | Hierarchy of levels in taxonomy as fData colnames
...     | Options for ssanova

Value

List of matrix of time point intervals of interest, Difference in abundance area and p-value, fit, area permutations, and call.

A list of objects including:

- timeIntervals - Matrix of time point intervals of interest, area of differential abundance, and pvalue.
- data - Data frame of abundance, class indicator, time, and id input.
- fit - Data frame of fitted values of the difference in abundance, standard error estimates and timepoints interpolated over.
- perm - Differential abundance area estimates for each permutation.
- call - Function call.

See Also
cumNorm ssFit ssIntervalCandidate ssPerm ssPermAnalysis plotTimeSeries

Examples

data(mouseData)
res = fitSSTimeSeries(obj=mouseData,feature="Actinobacteria",
class="status",id="mouseID",time="relativeTime",lvl='class',B=2)
Usage

```r
fitTimeSeries(
  obj,
  formula,
  feature,
  class,
  time,
  id,
  method = c("ssanova"),
  lvl = NULL,
  include = c("class", "time:class"),
  C = 0,
  B = 1000,
  norm = TRUE,
  log = TRUE,
  sl = 1000,
  featureOrder = NULL,
  ...
)
```

Arguments

- **obj**: metagenomeSeq MRexperiment-class object.
- **formula**: Formula for ssanova. Of the form: abundance ~ ... where ... includes any pData slot value.
- **feature**: Name or row of feature of interest.
- **class**: Name of column in phenoData of MRexperiment-class object for class membership.
- **time**: Name of column in phenoData of MRexperiment-class object for relative time.
- **id**: Name of column in phenoData of MRexperiment-class object for sample id.
- **method**: Method to estimate time intervals of differentially abundant bacteria (only ssanova method implemented currently).
- **lvl**: Vector or name of column in featureData of MRexperiment-class object for aggregating counts (if not OTU level).
- **include**: Parameters to include in prediction.
- **C**: Value for which difference function has to be larger or smaller than (default 0).
- **B**: Number of permutations to perform.
- **norm**: When aggregating counts to normalize or not.
- **log**: Log2 transform.
- **sl**: Scaling value.
- **featureOrder**: Hierarchy of levels in taxonomy as fData colnames
- **...**: Options for ssanova
fitZeroLogNormal

Value

List of matrix of time point intervals of interest, Difference in abundance area and p-value, fit, area permutations, and call.

A list of objects including:

- timeIntervals - Matrix of time point intervals of interest, area of differential abundance, and pvalue.
- data - Data frame of abundance, class indicator, time, and id input.
- fit - Data frame of fitted values of the difference in abundance, standard error estimates and timepoints interpolated over.
- perm - Differential abundance area estimates for each permutation.
- call - Function call.

See Also

cumNorm fitSSTimeSeries plotTimeSeries

Examples

data(mouseData)
res = fitTimeSeries(obj=mouseData,feature="Actinobacteria",class="status",id="mouseID",time="relativeTime",lvl='class',B=2)

---

fitZeroLogNormal  Compute the log fold-change estimates for the zero-inflated log-normal model

Description

Run the zero-inflated log-normal model given a MRexperiment object and model matrix. Not for the average user, assumes structure of the model matrix.

Usage

fitZeroLogNormal(obj, mod, coef = 2, szero = TRUE, spos = TRUE)

Arguments

obj  A MRexperiment object with count data.
mod  The model for the count distribution.
coef  Coefficient of interest to grab log fold-changes.
szero  TRUE/FALSE, shrink zero component parameters.
spos  TRUE/FALSE, shrink positive component parameters.
Value

A list of objects including:

- logFC - the log fold-change estimates
- adjFactor - the adjustment factor based on the zero component
- se - standard error estimates
- fitln - parameters from the log-normal fit
- fitzero - parameters from the logistic fit
- zeroRidge - output from the ridge regression
- posRidge - output from the ridge regression
- tauPos - estimated tau^2 for positive component
- tauZero - estimated tau^2 for zero component
- exclude - features to exclude for various reasons, e.g. all zeros
- zeroExclude - features to exclude for various reasons, e.g. all zeros

See Also

cumNorm fitFeatureModel

---

fitZig

Computes the weighted fold-change estimates and t-statistics.

Description

Wrapper to actually run the Expectation-maximization algorithm and estimate $f_{count}$ fits. Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership $\delta_{ij} = 1$ if $y_{ij}$ is generated from the zero point mass as latent indicator variables. The density is defined as $f_{zig}(y_{ij} = p_i_j(S_j)*f_0(y_{ij}) + (1-p_i_j(S_j)) * f_{count}(y_{ij}; \mu_i, \sigma_i^2)$. The log-likelihood in this extended model is: $(1-\delta_{ij}) log f_{count}(y;\mu_i,\sigma_i^2) + \delta_{ij} log p_i_j(S_j) + (1-\delta_{ij}) log (1-p_i_j(S_j))$. The responsibilities are defined as $z_{ij} = pr(\delta_{ij}=1 | data)$.

Usage

```r
fitZig(
  obj,
  mod,
  zeroMod = NULL,
  useCSSoffset = TRUE,
  control = zigControl(),
  useMixedModel = FALSE,
  ...
)
```
Arguments

- **obj**: A MRexperiment object with count data.
- **mod**: The model for the count distribution.
- **zeroMod**: The zero model, the model to account for the change in the number of OTUs observed as a linear effect of the depth of coverage.
- **useCSSoffset**: Boolean, whether to include the default scaling parameters in the model or not.
- **control**: The settings for fitZig.
- **useMixedModel**: Estimate the correlation between duplicate features or replicates using duplicateCorrelation.
  
  Additional parameters for duplicateCorrelation.

Value

A list of objects including:

- call - the call made to fitZig
- fit - 'MLArrayLM' Limma object of the weighted fit
- countResiduals - standardized residuals of the fit
- z - matrix of the posterior probabilities
- eb - output of eBayes, moderated t-statistics, moderated F-statistics, etc
- taxa - vector of the taxa names
- counts - the original count matrix input
- zeroMod - the zero model matrix
- zeroCoef - the zero model fitted results
- stillActive - convergence
- stillActiveNLL - nll at convergence
- dupcor - correlation of duplicates

See Also

cumNorm zigControl

Examples

```r
# This is a simple demonstration
data(lungData)
k = grep("Extraction.Control", pData(lungData)$SampleType)
lungTrim = lungData[,-k]
k = which(rowSums(MRcounts(lungTrim)>0)<30)
lungTrim = cumNorm(lungTrim)
lungTrim = lungTrim[-k,]
smokingStatus = pData(lungTrim)$SmokingStatus
mod = model.matrix(~smokingStatus)
# The maxit is not meant to be 1 - this is for demonstration/speed
settings = zigControl(maxit=1,verbose=FALSE)
fit = fitZig(obj = lungTrim, mod=mod, control=settings)
```
**fitZigResults-class**  
Class "fitZigResults" – a formal class for storing results from a fitZig call.

**Description**

This class contains all of the same information expected from a fitZig call, but it is defined in the S4 style as opposed to being stored as a list.

**Slots**

- **call** the call made to fitZig  
- **fit** 'MLArrayLM' Limma object of the weighted fit  
- **countResiduals** standardized residuals of the fit  
- **z** matrix of the posterior probabilities. It is defined as $z_{ij} = pr(\delta_{ij}=1 \mid data)$  
- **zUsed** used in getZ  
- **eBayes** output of eBayes, moderated t-statistics, moderated F-statistics, etc  
- **taxa** vector of the taxa names  
- **counts** the original count matrix input  
- **zeroMod** the zero model matrix  
- **zeroCoef** the zero model fitted results  
- **stillActive** convergence  
- **stillActiveNLL** nll at convergence  
- **dupcor** correlation of duplicates

---

**getCountDensity**

*Compute the value of the count density function from the count model residuals.*

**Description**

Calculate density values from a normal: $f(x) = 1/(\sqrt{2\pi} \sigma) e^{-(x - \mu)^2/(2\sigma^2)}$. Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership $\delta_{ij} = 1$ if $y_{ij}$ is generated from the zero point mass as latent indicator variables. The density is defined as $f_{\text{zig}}(y_{ij} = \pi_j(S_j) \cdot f_0(y_{ij}) + (1-\pi_j(S_j)) \cdot f_{\text{count}}(y_{ij};\mu_{ij},\sigma_{ij}^2)$. The log-likelihood in this extended model is $(1-\delta_{ij}) \log f_{\text{count}}(y_{ij};\mu_{ij},\sigma_{ij}^2) + \delta_{ij} \log \pi_j(s_j) + (1-\delta_{ij}) \log (1-\pi_j(s_j))$. The responsibilities are defined as $z_{ij} = pr(\delta_{ij}=1 \mid data)$.

**Usage**

```r
getCountDensity(residuals, log = FALSE)
```
Arguments

residuals  Residuals from the count model.
log        Whether or not we are calculating from a log-normal distribution.

Value

Density values from the count model residuals.

See Also

fitZig

gEpsilon

Get Epsilon

Arguments

nll         Vector of size M with the current negative log-likelihoods.
nllOld      Vector of size M with the previous iterations negative log-likelihoods.

Value

Vector of size M of the relative differences between the previous and current iteration nll.

See Also

fitZig
getNegativeLogLikelihoods

Calculate the negative log-likelihoods for the various features given the residuals.

Description

Maximum-likelihood estimates are approximated using the EM algorithm where we treat mixture membership \( \delta_{ij} = 1 \) if \( y_{ij} \) is generated from the zero point mass as latent indicator variables. The log-likelihood in this extended model is \( (1-\delta_{ij}) \log f_{\text{count}}(y;\mu_i,\sigma_i^2) + \delta_{ij} \log \pi_j(s_j) + (1-\delta_{ij}) \log (1-\pi_j(s_j)) \). The responsibilities are defined as \( z_{ij} = \text{pr}(\delta_{ij}=1 | \text{data and current values}) \).

Usage

generateNegativeLogLikelihoods(z, countResiduals, zeroResiduals)

Arguments

- **z**: Matrix \((m \times n)\) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).
- **countResiduals**: Residuals from the count model.
- **zeroResiduals**: Residuals from the zero model.

Value

Vector of size \( M \) of the negative log-likelihoods for the various features.

See Also

- fitZig

getPi

Calculate the mixture proportions from the zero model / spike mass model residuals.

Description

\( F(x) = 1 / (1 + \exp(-(x-m)/s)) \) (the CDF of the logistic distribution). Provides the probability that a real-valued random variable \( X \) with a given probability distribution will be found at a value less than or equal to \( x \). The output are the mixture proportions for the samples given the residuals from the zero model.

Usage

generatePi(residuals)
getZ

Arguments

residuals Residuals from the zero model.

Value

Mixture proportions for each sample.

See Also

fitZig

getZ Calculate the current Z estimate responsibilities (posterior probabilities)

Description

Calculate the current \( Z \) estimate responsibilities (posterior probabilities)

Usage

getZ(z, zUsed, stillActive, nll, nllUSED)

Arguments

z Matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0).
zUsed Matrix (m x n) of estimate responsibilities (probabilities that a count comes from a spike distribution at 0) that are actually used (following convergence).
stillActive A vector of size M booleans saying if a feature is still active or not.
nll Vector of size M with the current negative log-likelihoods.
nllUSED Vector of size M with the converged negative log-likelihoods.

Value

A list of updated zUsed and nllUSED.

See Also

fitZig
isItStillActive  
*Function to determine if a feature is still active.*

**Description**

In the Expectation Maximization routine features posterior probabilities routinely converge based on a tolerance threshold. This function checks whether or not the feature’s negative log-likelihood (measure of the fit) has changed or not.

**Usage**

```r
isItStillActive(eps, tol, stillActive, stillActiveNLL, nll)
```

**Arguments**

- **eps**: Vector of size M (features) representing the relative difference between the new nll and old nll.
- **tol**: The threshold tolerance for the difference
- **stillActive**: A vector of size M booleans saying if a feature is still active or not.
- **stillActiveNLL**: A vector of size M recording the negative log-likelihoods of the various features, updated for those still active.
- **nll**: Vector of size M with the current negative log-likelihoods.

**Value**

None.

**See Also**

- `fitZig`

---

**libSize**  
*Access sample depth of coverage from MRexperiment object*

**Description**

Access the libSize vector represents the column (sample specific) sums of features, i.e. the total number of reads for a sample or depth of coverage. It is used by `fitZig`.

**Usage**

```r
libSize(object)
```
Arguments

object             a MRexperiment object

Value

Library sizes

Author(s)

Joseph N. Paulson

Examples

```r
data(lungData)
head(libSize(lungData))
```

---

libSize<-  
 Replace the library sizes in a MRexperiment object

Description

Function to replace the scaling factors, aka the library sizes, of samples in a MRexperiment object.

Usage

```r
## S4 replacement method for signature 'MRexperiment,numeric'
libSize(object) <- value
```

Arguments

object             a MRexperiment object
value              vector of library sizes

Value

vector library sizes

Author(s)

Joseph N. Paulson

Examples

```r
data(lungData)
head(libSize(lungData) <- rnorm(1))
```
loadBiom

Load objects organized in the Biom format.

Description

Wrapper to load Biom formatted object.

Usage

loadBiom(file)

Arguments

file

The biom object filepath.

Value

A MRexperiment object.

See Also

loadMeta loadPhenoData newMRexperiment biom2MRexperiment

Examples

#library(biomformat)
rich_dense_file = system.file("extdata", "rich_dense_otu_table.biom", package = "biomformat")
x = loadBiom(rich_dense_file)
x

loadMeta

Load a count dataset associated with a study.

Description

Load a matrix of OTUs in a tab delimited format.

Usage

loadMeta(file, sep = "\t")

Arguments

file

Path and filename of the actual data file.

sep

File delimiter.
**loadMetaQ**

Value

A list with objects 'counts' and 'taxa'.

See Also

`loadPhenoData`

Examples

```r
dataDirectory <- system.file("extdata", package="metagenomeSeq")
lung = loadMeta(file.path(dataDirectory,"CHK_NAME.otus.count.csv"))
```

---

**loadMetaQ**  
*Load a count dataset associated with a study set up in a Qiime format.*

Description

Load a matrix of OTUs in Qiime's format

Usage

```r
loadMetaQ(file)
```

Arguments

- `file`  
  Path and filename of the actual data file.

Value

An list with 'counts' containing the count data, 'taxa' containing the otu annotation, and 'otus'.

See Also

`loadMeta`  
`loadPhenoData`

Examples

```r
# see vignette
```
loadPhenoData  

*Load a clinical/phenotypic dataset associated with a study.*

**Description**

Load a matrix of metadata associated with a study.

**Usage**

```r
loadPhenoData(file, tran = TRUE, sep = "\t")
```

**Arguments**

- `file`: Path and filename of the actual clinical file.
- `tran`: Boolean. If the covariates are along the columns and samples along the rows, then `tran` should equal TRUE.
- `sep`: The separator for the file.

**Value**

The metadata as a dataframe.

**See Also**

`loadMeta`

**Examples**

```r
dataDirectory <- system.file("extdata", package="metagenomeSeq")
clin = loadPhenoData(file.path(dataDirectory,"CHK_clinical.csv"),tran=TRUE)
```

---

lungData  

*OTU abundance matrix of samples from a smoker/non-smoker study*

**Description**

This is a list with a matrix of OTU counts, OTU names, taxa annotations for each OTU, and phenotypic data. Samples along the columns and OTUs along the rows.

**Format**

A list of OTU matrix, taxa, otus, and phenotypes
**makeLabels**

**Value**

MRexperiment-class object of 16S lung samples.

**References**


---

**Description**

Beginning to transition to better axes for plots

**Usage**

```r
makeLabels(x = "samples", y = "abundance", norm, log)
```

**Arguments**

- **x**
  - string for the x-axis
- **y**
  - string for the y-axis
- **norm**
  - is the data normalized?
- **log**
  - is the data logged?

**Value**

vector of x,y labels

**Examples**

```r
metagenomeSeq::makeLabels(norm=TRUE, log=TRUE)
```
mergeMRexperiments  Merge two MRexperiment objects together

Description
This function will take two MRexperiment objects and merge them together finding common OTUs. If there are OTUs not found in one of the two MRexperiments then a message will announce this and values will be coerced to zero for the second table.

Usage
mergeMRexperiments(x, y)

Arguments
x  MRexperiment-class object 1.
y  MRexperiment-class object 2.

Value
Merged MRexperiment-class object.

Examples
data(mouseData)
newobj = mergeMRexperiments(mouseData,mouseData)
newobj

# let me know if people are interested in an option to merge by keys instead of row names.
data(lungData)
newobj = mergeMRexperiments(mouseData,lungData)
newobj

mergeTable  Merge two tables

Description
Merge two tables

Usage
mergeTable(x, y)
**Arguments**

- **x**  
  For assignment operators, the object that will undergo a replacement (object inside parenthesis).
- **value**  
  For assignment operators, the value to replace with (the right side of the assignment).
- **...**  
  For functions other than assignment operators, parameters to be passed to the modern version of the function (see table).

**Value**

Merged table

---

**Description**

These functions may be removed completely in the next release.

**Usage**

```
deprecated_metagenomeSeq_function(x, value, ...)
```
MRcoefs

Table of top-ranked features from fitZig or fitFeatureModel

Description

Extract a table of the top-ranked features from a linear model fit. This function will be updated soon to provide better flexibility similar to limma's topTable.

Usage

MRcoefs(
obj,
by = 2,
coef = NULL,
number = 10,
taxa = obj@taxa,
uniqueNames = FALSE,
adjustMethod = "fdr",
alpha = 0.1,

Arguments

obj Output of fitFeatureModel or fitZig.
by Column number or column name specifying which coefficient or contrast of the linear model is of interest.
coef Column number(s) or column name(s) specifying which coefficient or contrast of the linear model to display.
number The number of bacterial features to pick out.
taxa Taxa list.
uniqueNames Number the various taxa.
adjustMethod Method to adjust p-values by. Default is "FDR". Options include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". See p.adjust for more details. Additionally, options using independent hypothesis weighting (IHW) are available. See MRihw for more details.
alpha Value for p-value significance threshold when running IHW. The default is set to 0.1.
MRcounts

Accessor for the counts slot of a MRexperiment object

Description

The counts slot holds the raw count data representing (along the rows) the number of reads annotated for a particular feature and (along the columns) the sample.

Usage

MRcounts(obj, norm = FALSE, log = FALSE, sl = 1000)
Arguments

- **obj**: a `MRexperiment` object.
- **norm**: logical indicating whether or not to return normalized counts.
- **log**: TRUE/FALSE whether or not to log2 transform scale.
- **sl**: The value to scale by (default=1000).

Value

Normalized or raw counts

Author(s)

Joseph N. Paulson, jpaulson@umiacs.umd.edu

Examples

```r
data(lungData)
head(MRcounts(lungData))
```

**MRexperiment**

`Class "MRexperiment" – a modified eSet object for the data from high-throughput sequencing experiments`

Description

This is the main class for metagenomeSeq.

Objects from the Class

Objects should be created with calls to `newMRexperiment`.

Extends

Class `eSet` (package `Biobase`), directly. Class `VersionedBiobase` (package `Biobase`), by class "eSet", distance 2. Class `Versioned` (package `Biobase`), by class "eSet", distance 3.

Methods

Class-specific methods.

- Subset operation, taking two arguments and indexing the sample and variable. Returns an `MRexperiment` object, including relevant metadata. Setting `drop=TRUE` generates an error. Subsetting the data, the experiment summary slot is repopulated and pData is repopulated after calling factor (removing levels not present).
MRexperiment2biom

Note

Note: This is a summary for reference. For an explanation of the actual usage, see the vignette.

MRexperiments are the main class in use by metagenomeSeq. The class extends eSet and provides additional slots which are populated during the analysis pipeline.

MRexperiment dataset are created with calls to newMRexperiment. MRexperiment datasets contain raw count matrices (integers) accessible through MRcounts. Similarly, normalized count matrices can be accessed (following normalization) through MRcounts by calling norm=TRUE. Following an analysis, a matrix of posterior probabilities for counts is accessible through posteriorProbs.

The normalization factors used in analysis can be recovered by normFactors, as can the library sizes of samples (depths of coverage), libSize.

Similarly to other RNASeq bioconductor packages available, the rows of the matrix correspond to a feature (be it OTU, species, gene, etc.) and each column an experimental sample. Pertinent clinical information and potential confounding factors are stored in the phenoData slot (accessed via pData).

To populate the various slots in an MRexperiment several functions are run. 1) cumNormStat calculates the proper percentile to calculate normalization factors. The cumNormStat slot is populated. 2) cumNorm calculates the actual normalization factors using p = cumNormStat.

Other functions will place subsequent matrices (normalized counts (cumNormMat), posterior probabilities (posteriorProbs))

As mentioned above, MRexperiment is derived from the virtual class, eSet and thereby has a phenoData slot which allows for sample annotation. In the phenoData data frame factors are stored. The normalization factors and library size information is stored in a slot called expSummary that is an annotated data frame and is repopulated for subsetted data.

Examples

# See vignette

<table>
<thead>
<tr>
<th>MRexperiment2biom</th>
<th>MRexperiment to biom objects</th>
</tr>
</thead>
</table>

Description

Wrapper to convert MRexperiment objects to biom objects.

Usage

MRexperiment2biom(
  obj,
  id = NULL,
  norm = FALSE,
  log = FALSE,
  sl = 1000,
  qiimeVersion = TRUE
)
Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>obj</td>
<td>The MRexperiment object.</td>
</tr>
<tr>
<td>id</td>
<td>Optional id for the biom matrix.</td>
</tr>
<tr>
<td>norm</td>
<td>normalize count table</td>
</tr>
<tr>
<td>log</td>
<td>log2 transform count table</td>
</tr>
<tr>
<td>sl</td>
<td>scaling factor for normalized counts.</td>
</tr>
<tr>
<td>qiimeVersion</td>
<td>Format fData according to QIIME specifications (assumes only taxonomy in fData).</td>
</tr>
</tbody>
</table>

Value

A biom object.

See Also

loadMeta, loadPhenoData, newMRexperiment, loadBiom, biom2MRexperiment

MRfulltable

Table of top microbial marker gene from linear model fit including sequence information

Description

Extract a table of the top-ranked features from a linear model fit. This function will be updated soon to provide better flexibility similar to limma’s topTable. This function differs from link{MRcoefs} in that it provides other information about the presence or absence of features to help ensure significant features called are moderately present.

Usage

MRfulltable(
  obj,
  by = 2,
  coef = NULL,
  number = 10,
  taxa = obj@taxa,
  uniqueNames = FALSE,
  adjustMethod = "fdr",
  group = 0,
  eff = 0,
  numberEff = FALSE,
  ncounts = 0,
  file = NULL
)
**Arguments**

obj
Output of fitFeatureModel or fitZig.

by
Column number or column name specifying which coefficient or contrast of the linear model is of interest.

coeff
Column number(s) or column name(s) specifying which coefficient or contrast of the linear model to display.

number
The number of bacterial features to pick out.

taxa
Taxa list.

uniqueNames
Number the various taxa.

adjustMethod
Method to adjust p-values by. Default is "FDR". Options include "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". See `p.adjust` for more details.

group
One of five choices: 0, 1, 2, 3, 4. 0: the sort is ordered by a decreasing absolute value coefficient fit. 1: the sort is ordered by the raw coefficient fit in decreasing order. 2: the sort is ordered by the raw coefficient fit in increasing order. 3: the sort is ordered by the p-value of the coefficient fit in increasing order. 4: no sorting.

eff
Filter features to have at least a "eff" quantile or number of effective samples.

numberEff
Boolean, whether eff should represent quantile (default/FALSE) or number.

ncounts
Filter features to those with at least 'counts' counts.

file
Name of output file, including location, to save the table.

**Value**
Table of the top-ranked features determined by the linear fit's coefficient.

**See Also**

`fitZig` `fitFeatureModel` `MRcoefs` `MRtable` `fitPA`

**Examples**

data(lungData)
k = grep("Extraction.Control",pData(lungData)$SampleType)
lungTrim = lungData[-k]
lungTrim=filterData(lungTrim,present=30)
lungTrim=cumNorm(lungTrim,p=0.5)
smokingStatus = pData(lungTrim)$SmokingStatus
mod = model.matrix(~smokingStatus)
fit = fitZig(obj = lungTrim,mod=mod)
head(MRfulltable(fit))
####
fit = fitFeatureModel(obj = lungTrim,mod=mod)
head(MRfulltable(fit))
MRihw, fitFeatureModelResults-method

MRihw runs IHW within a MRcoefs() call

Description

Function used in MRcoefs() when "IHW" is set as the p value adjustment method

Usage

MRihw(obj, ...)

Arguments

<table>
<thead>
<tr>
<th>obj</th>
<th>Either a fitFeatureModelResults or fitZigResults object</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>other parameters</td>
</tr>
</tbody>
</table>

MRihw, fitFeatureModelResults-method

MRihw runs IHW within a MRcoefs() call

Description

Function used in MRcoefs() when "IHW" is set as the p value adjustment method

Usage

## S4 method for signature 'fitFeatureModelResults'
MRihw(obj, p, adjustMethod, alpha)

Arguments

<table>
<thead>
<tr>
<th>obj</th>
<th>Either a fitFeatureModelResults or fitZigResults object</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>a vector of pvalues extracted from obj</td>
</tr>
<tr>
<td>adjustMethod</td>
<td>Value specifying which adjustment method and which covariate to use for IHW pvalue adjustment. For obj of class fitFeatureModelResults-class, options are &quot;ihw-abundance&quot; (median feature count per row) and &quot;ihw-ubiquity&quot; (number of non-zero features per row). For obj of class fitZigResults-class, options are &quot;ihw-abundance&quot; (weighted mean per feature) and &quot;ihw-ubiquity&quot; (number of non-zero features per row).</td>
</tr>
<tr>
<td>alpha</td>
<td>pvalue significance level specified for IHW call. Default is 0.1</td>
</tr>
</tbody>
</table>
MRihw.runs IHW within a MRcoefs() call

Description
Function used in MRcoefs() when "IHW" is set as the p value adjustment method

Usage
## S4 method for signature 'fitZigResults'
MRihw(obj, p, adjustMethod, alpha)

Arguments

  obj 
  Either a fitFeatureModelResults or fitZigResults object

  p 
  a vector of pvalues extracted from obj

  adjustMethod 
  Value specifying which adjustment method and which covariate to use for IHW pvalue adjustment. For obj of class fitFeatureModelResults-class, options are "ihw-abundance" (median feature count per row) and "ihw-ubiquity" (number of non-zero features per row). For obj of class fitZigResults-class, options are "ihw-abundance" (weighted mean per feature) and "ihw-ubiquity" (number of non-zero features per row).

  alpha 
  pvalue significance level specified for IHW call. Default is 0.1

MRtable
Table of top microbial marker gene from linear model fit including sequence information

Description
Extract a table of the top-ranked features from a linear model fit. This function will be updated soon to provide better flexibility similar to limma’s topTable. This function differs from link{MRcoefs} in that it provides other information about the presence or absence of features to help ensure significant features called are moderately present.

Usage
MRtable(
  obj, 
  by = 2, 
  coef = NULL, 
  number = 10, 
  taxa = obj@taxa,
uniqueNames = FALSE,
adjustMethod = "fdr",
group = 0,
    eff = 0,
    numberEff = FALSE,
ncounts = 0,
    file = NULL
)

Arguments

obj          Output of fitFeatureModel or fitZig.
by           Column number or column name specifying which coefficient or contrast of the
linear model is of interest.
coef         Column number(s) or column name(s) specifying which coefficient or contrast
of the linear model to display.
number        The number of bacterial features to pick out.
taxa         Taxa list.
uniqueNames  Number the various taxa.
adjustMethod  Method to adjust p-values by. Default is "FDR". Options include "holm",
              "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none". See p.adjust
              for more details.
group        One of five choices, 0,1,2,3,4. 0: the sort is ordered by a decreasing absolute
              value coefficient fit. 1: the sort is ordered by the raw coefficient fit in decreasing
              order. 2: the sort is ordered by the raw coefficient fit in increasing order. 3:
              the sort is ordered by the p-value of the coefficient fit in increasing order. 4: no
              sorting.
eff          Filter features to have at least a "eff" quantile or number of effective samples.
numberEff    Boolean, whether eff should represent quantile (default/FALSE) or number.
ncounts      Filter features to have at least 'counts' of counts.
file         Name of file, including location, to save the table.

Value

Table of the top-ranked features determined by the linear fit’s coefficient.

See Also

    fitZig  fitFeatureModel  MRcoefs  MRfulltable

Examples

data(lungData)
k = grep("Extraction.Control",pData(lungData)$SampleType)
lungTrim = lungData[-k]
lungTrim=filterData(lungTrim,present=30)
newMRexperiment

Description

This function creates a MRexperiment object from a matrix or data frame of count data.

Usage

newMRexperiment(
  counts,
  phenoData = NULL,
  featureData = NULL,
  libSize = NULL,
  normFactors = NULL
)

Arguments

counts A matrix or data frame of count data. The count data is representative of the number of reads annotated for a feature (be it gene, OTU, species, etc). Rows should correspond to features and columns to samples.

phenoData An AnnotatedDataFrame with pertinent sample information.

featureData An AnnotatedDataFrame with pertinent feature information.

libSize libSize, library size, is the total number of reads for a particular sample.

normFactors normFactors, the normalization factors used in either the model or as scaling factors of sample counts for each particular sample.

Details

See MRexperiment-class and eSet (from the Biobase package) for the meaning of the various slots.

Value

an object of class MRexperiment
**Description**

Function to access the scaling factors, aka the normalization factors, of samples in a MRexperiment object.

**Usage**

```r
normFactors(object)
```

**Arguments**

- `object` a MRexperiment object

**Value**

Normalization scaling factors

**Author(s)**

Joseph N. Paulson

**Examples**

```r
cnts = matrix(abs(rnorm(1000)),nc=10)
obj <- newMRexperiment(cnts)

head(normFactors(lungData))
```
normFactors <- Replace the normalization factors in a MReperiment object

Description

Function to replace the scaling factors, aka the normalization factors, of samples in a MReperiment object.

Usage

```r
## S4 replacement method for signature 'MReperiment,numeric'
normFactors(object) <- value
```

Arguments

- `object`: a MReperiment object
- `value`: vector of normalization scaling factors

Value

Normalization scaling factors

Author(s)

Joseph N. Paulson

Examples

```r
data(lungData)
head(normFactors(lungData) <- rnorm(1))
```

plotBubble Basic plot of binned vectors.

Description

This function plots takes two vectors, calculates the contingency table and plots circles sized by the contingency table value. Optional significance vectors of the values significant will shade the circles by proportion of significance.
plotBubble

Usage

plotBubble(
  yvector,
  xvector,
  sigvector = NULL,
  nbreaks = 10,
  ybreak = quantile(yvector, p = seq(0, 1, length.out = nbreaks)),
  xbreak = quantile(xvector, p = seq(0, 1, length.out = nbreaks)),
  scale = 1,
  local = FALSE,
  ...
)

Arguments

yvector A vector of values represented along y-axis.
xvector A vector of values represented along x-axis.
sigvector A vector of the names of significant features (names should match x/yvector).
nbreaks Number of bins to break yvector and xvector into.
ybreak The values to break the yvector at.
xbreak The values to break the xvector at.
scale Scaling of circle bin sizes.
local Boolean to shade by significant bin numbers (TRUE) or overall proportion (FALSE).
... Additional plot arguments.

Value

A matrix of features along rows, and the group membership along columns.

See Also

plotMRheatmap

Examples

data(mouseData)
mouseData = mouseData[which(rowSums(mouseData)>139),]
sparsity = rowMeans(MRcounts(mouseData)==0)
lor = log(fitPA(mouseData,cl=pData(mouseData)[,3])$oddsRatio)
plotBubble(lor,sparsity,main="lor ~ sparsity")
# Example 2
x = runif(100000)
y = runif(100000)
plotBubble(y,x)
plotClassTimeSeries  

Plot abundances by class

Description

Plot the abundance of values for each class using a spline approach on the estimated full model.

Usage

plotClassTimeSeries(
  res,
  formula, 
  xlab = "Time",
  ylab = "Abundance",
  color0 = "black",
  color1 = "red",
  include = c("1", "class", "time:class"),
  ...
)

Arguments

res            Output of fitTimeSeries function
formula        Formula for ssanova. Of the form: abundance ~ ... where ... includes any pData
               slot value.
xlab           X-label.
ylab           Y-label.
color0         Color of samples from first group.
color1         Color of samples from second group.
include        Parameters to include in prediction.
...            Extra plotting arguments.

Value

Plot for abundances of each class using a spline approach on estimated null model.

See Also

fitTimeSeries

Examples

data(mouseData)
res = fitTimeSeries(obj=mouseData, feature="Actinobacteria",
  class="status", id="mouseID", time="relativeTime", lvl='class', B=10)
plotClassTimeSeries(res, pch=21, bg=res$data$class, ylim=c(0,8))
plotCorr

Basic correlation plot function for normalized or unnormalized counts.

Description

This function plots a heatmap of the "n" features with greatest variance across rows.

Usage

plotCorr(obj, n, norm = TRUE, log = TRUE, fun = cor, ...)

Arguments

- obj: A MRexperiment object with count data.
- n: The number of features to plot. This chooses the "n" features with greatest variance.
- norm: Whether or not to normalize the counts - if MRexperiment object.
- log: Whether or not to log2 transform the counts - if MRexperiment object.
- fun: Function to calculate pair-wise relationships. Default is pearson correlation.
- ...: Additional plot arguments.

Value

plotted correlation matrix

See Also

cumNormMat

Examples

data(mouseData)
plotCorr(obj=mouseData,n=200,cexRow = 0.4,cexCol = 0.4,trace="none",dendrogram="none", col = colorRampPalette(brewer.pal(9, "RdBu"))(50))
plotFeature

Basic plot function of the raw or normalized data.

Description

This function plots the abundance of a particular OTU by class. The function is the typical manhattan plot of the abundances.

Usage

plotFeature(
  obj,
  otuIndex,
  classIndex,
  col = "black",
  sort = TRUE,
  sortby = NULL,
  norm = TRUE,
  log = TRUE,
  sl = 1000,
  ...
)

Arguments

  obj                  A MRexperiment object with count data.
  otuIndex             The row to plot
  classIndex           A list of the samples in their respective groups.
  col                  A vector to color samples by.
  sort                 Boolean, sort or not.
  sortby               Default is sort by library size, alternative vector for sorting
  norm                 Whether or not to normalize the counts - if MRexperiment object.
  log                  Whether or not to log2 transform the counts - if MRexperiment object.
  sl                   Scaling factor - if MRexperiment and norm=TRUE.
  ...                  Additional plot arguments.

Value

  counts and classindex

See Also

cumNorm
Examples

```r
data(mouseData)
classIndex=list(Western=which(pData(mouseData)$diet=="Western"))
classIndex$BK=which(pData(mouseData)$diet=="BK")

par(mfrow=c(2,1))
dates = pData(mouseData)$date
plotFeature(mouseData,norm=FALSE,log=FALSE,otuIndex,classIndex,
            col=dates,sortby=dates,ylab="Raw reads")
```

---

**plotGenus**

*Basic plot function of the raw or normalized data.*

Description

This function plots the abundance of a particular OTU by class. The function uses the estimated posterior probabilities to make technical zeros transparent.

Usage

```r
plotGenus(
  obj,
  otuIndex,
  classIndex,
  norm = TRUE,
  log = TRUE,
  no = 1:length(otuIndex),
  labs = TRUE,
  xlab = NULL,
  ylab = NULL,
  jitter = TRUE,
  jitter.factor = 1,
  pch = 21,
  ...
)
```

Arguments

- **obj**: An MRexperiment object with count data.
- **otuIndex**: A list of the otus with the same annotation.
- **classIndex**: A list of the samples in their respective groups.
- **norm**: Whether or not to normalize the counts - if MRexperiment object.
- **log**: Whether or not to log2 transform the counts - if MRexperiment object.
- **no**: Which of the otuIndex to plot.
plotMRheatmap

Description

This function plots a heatmap of the 'n' features with greatest variance across rows (or other statistic).

Usage

plotMRheatmap(obj, n, norm = TRUE, log = TRUE, fun = sd, ...)

Arguments

obj  A MRexperiment object with count data.

n  The number of features to plot. This chooses the 'n' features of greatest positive statistic.

norm  Whether or not to normalize the counts - if MRexperiment object.

log  Whether or not to log2 transform the counts - if MRexperiment object.

fun  Function to select top 'n' features.

...  Additional plot arguments.
plotOrd

Plot of either PCA or MDS coordinates for the distances of normalized or unnormalized counts.

Description

This function plots the PCA / MDS coordinates for the "n" features of interest. Potentially uncovering batch effects or feature relationships.

Usage

plotOrd(
  obj,
  tran = TRUE,
  comp = 1:2,
  norm = TRUE,
  log = TRUE,
  usePCA = TRUE,
  useDist = FALSE,
  distfun = stats::dist,
  dist.method = "euclidian",
  n = NULL,
  ...
)

Value

plotted matrix

See Also

cumNormMat

Examples

data(mouseData)
trials = pData(mouseData)$diet
heatmapColColors=brewer.pal(12,"Set3") [as.integer(factor(trials))];
heatmapCols = colorRampPalette(brewer.pal(9, "RdBu"))(50)
### version using sd
plotMRheatmap(obj=mouseData,n=200,cexRow = 0.4,cexCol = 0.4,trace="none",
             col = heatmapCols,ColSideColors = heatmapColColors)
### version using MAD
plotMRheatmap(obj=mouseData,n=50,fun=mad,cexRow = 0.4,cexCol = 0.4,trace="none",
              col = heatmapCols,ColSideColors = heatmapColColors)
plotOTU

Arguments

- **obj**: A MRexperiment object or count matrix.
- **tran**: Transpose the matrix.
- **comp**: Which components to display.
- **norm**: Whether or not to normalize the counts - if MRexperiment object.
- **log**: Whether or not to log2 the counts - if MRexperiment object.
- **usePCA**: TRUE/FALSE whether to use PCA or MDS coordinates (TRUE is PCA).
- **useDist**: TRUE/FALSE whether to calculate distances.
- **distfun**: Distance function, default is stats::dist.
- **dist.method**: If useDist==TRUE, what method to calculate distances.
- **n**: Number of features to make use of in calculating your distances.
- **...**: Additional plot arguments.

Value

coordinates

See Also

cumNormMat

Examples

data(mouseData)
c1 = pData(mouseData)[,3]
plotOrd(mouseData,tran=TRUE,useDist=TRUE,pch=21,bg=factor(c1),usePCA=FALSE)

plotOTU

Basic plot function of the raw or normalized data.

Description

This function plots the abundance of a particular OTU by class. The function uses the estimated posterior probabilities to make technical zeros transparent.

Usage

plotOTU(
  obj,
  otu,
  classIndex,
  log = TRUE,
  norm = TRUE,
jitter.factor = 1,
pch = 21,
labs = TRUE,
xlab = NULL,
ylab = NULL,
jitter = TRUE,
...
)

Arguments

obj          A MRexperiment object with count data.

otu          The row number/OTU to plot.

classIndex   A list of the samples in their respective groups.

log          Whether or not to log2 transform the counts - if MRexperiment object.

norm         Whether or not to normalize the counts - if MRexperiment object.

jitter.factor Factor value for jitter.

pch          Standard pch value for the plot command.

labs         Whether to include group labels or not. (TRUE/FALSE)

xlab         xlabel for the plot.

ylab         ylabel for the plot.

jitter       Boolean to jitter the count data or not.

...          Additional plot arguments.

Value

Plotted values

See Also

cumNorm

Examples

data(mouseData)
classIndex=list(controls=which(pData(mouseData)$diet=="BK"))
classIndex$cases=which(pData(mouseData)$diet=="Western")
# you can specify whether or not to normalize, and to what level
plotOTU(mouseData,otu=9083,classIndex,norm=FALSE,main="9083 feature abundances")
plotRare  

Plot of rarefaction effect

Description

This function plots the number of observed features vs. the depth of coverage.

Usage

plotRare(obj, cl = NULL, ...)

Arguments

obj A MRexperiment object with count data or matrix.
cl Vector of classes for various samples.
... Additional plot arguments.

Value

Library size and number of detected features

See Also

plotOrd, plotMRheatmap, plotCorr, plotOTU, plotGenus

Examples

data(mouseData)
c1 = factor(pData(mouseData)[,3])
res = plotRare(mouseData, cl=c1, pch=21, bg=c1)
tmp=lapply(levels(cl), function(lv) lm(res[,"ident"]~res[,"libSize"]-1, subset=cl==lv))
for(i in 1:length(levels(cl))){
  abline(tmp[[i]], col=i)
}
legend("topleft", c("Diet 1","Diet 2"), text.col=c(1,2), box.col=NA)
plotTimeSeries  Plot difference function for particular bacteria

**Description**

Plot the difference in abundance for significant features.

**Usage**

```r
plotTimeSeries(
  res,
  C = 0,
  xlab = "Time",
  ylab = "Difference in abundance",
  main = "SS difference function prediction",
  ...
)
```

**Arguments**

- `res`: Output of `fitTimeSeries` function
- `C`: Value for which difference function has to be larger or smaller than (default 0).
- `xlab`: X-label.
- `ylab`: Y-label.
- `main`: Main label.
- `...`: Extra plotting arguments.

**Value**

Plot of difference in abundance for significant features.

**See Also**

`fitTimeSeries`

**Examples**

```r
data(mouseData)
res = fitTimeSeries(obj=mouseData, feature="Actinobacteria",
                    class="status", id="mouseID", time="relativeTime", lvl='class', B=10)
plotTimeSeries(res)
```
posteriorProbs

Description

Accessing the posterior probabilities following a run through fitZig

Usage

posteriorProbs(obj)

Arguments

obj  a MRexperiment object.

Value

Matrix of posterior probabilities

Author(s)

Joseph N. Paulson

Examples

# This is a simple demonstration
data(lungData)
k = grep("Extraction.Control", pData(lungData)$SampleType)
lungTrim = lungData[-k]
k = which(rowSums(MRcounts(lungTrim)>0)<30)
lungTrim = cumNorm(lungTrim)
lungTrim = lungTrim[-k,]
smokingStatus = pData(lungTrim)$SmokingStatus
mod = model.matrix(~smokingStatus)
# The maxit is not meant to be 1 -- this is for demonstration/speed
settings = zigControl(maxit=1,verbose=FALSE)
fit = fitZig(obj = lungTrim,mod=mod,control=settings)
head(posteriorProbs(lungTrim))
### returnAppropriateObj

**Check if MRexperiment or matrix and return matrix**

**Description**

Function to check if object is a MRexperiment class or matrix

**Usage**

```r
returnAppropriateObj(obj, norm, log, sl = 1000)
```

**Arguments**

- **obj**: a MRexperiment or matrix object
- **norm**: return a normalized MRexperiment matrix
- **log**: return a log transformed MRexperiment matrix
- **sl**: scaling value

**Value**

Matrix

**Examples**

```r
data(lungData)
head(returnAppropriateObj(lungData, norm=FALSE, log=FALSE))
```

### ssFit

**smoothing-splines anova fit**

**Description**

Sets up a data-frame with the feature abundance, class information, time points, sample ids and returns the fitted values for the fitted model.

**Usage**

```r
ssFit(
    formula,
    abundance,
    class,
    time,
    id,
    include = c("class", "time:class"),
    pd,
    ...
)
```
ssIntervalCandidate

Arguments

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>formula</td>
<td>Formula for ssanova. Of the form: abundance ~ ... where ... includes any pData slot value.</td>
</tr>
<tr>
<td>abundance</td>
<td>Numeric vector of abundances.</td>
</tr>
<tr>
<td>class</td>
<td>Class membership (factor of group membership).</td>
</tr>
<tr>
<td>time</td>
<td>Time point vector of relative times (same length as abundance).</td>
</tr>
<tr>
<td>id</td>
<td>Sample / patient id.</td>
</tr>
<tr>
<td>include</td>
<td>Parameters to include in prediction.</td>
</tr>
<tr>
<td>pd</td>
<td>Extra variable.</td>
</tr>
<tr>
<td>...</td>
<td>Extra parameters for ssanova function (see ?ssanova).</td>
</tr>
</tbody>
</table>

Value

A list containing:

- data : Inputed data
- fit : The interpolated / fitted values for timePoints
- se : The standard error for CI intervals
- timePoints : The time points interpolated over

See Also

cumNorm fitTimeSeries ssPermAnalysis ssPerm ssIntervalCandidate

Examples

# Not run

ssIntervalCandidate(fit, standardError, timePoints, positive = TRUE, C = 0)
Arguments

- **fit**: SS-Anova fits.
- **standardError**: SS-Anova se estimates.
- **timePoints**: Time points interpolated over.
- **positive**: Positive region or negative region (difference in abundance is positive/negative).
- **C**: Value for which difference function has to be larger or smaller than (default 0).

Value

Matrix of time point intervals of interest

See Also

cumNorm fitTimeSeries ssFit ssPerm ssPermAnalysis

Examples

```r
# Not run
```

### ssPerm

**class permutations for smoothing-spline time series analysis**

Description

Creates a list of permuted class memberships for the time series permutation tests.

Usage

```r
ssPerm(df, B)
```

Arguments

- **df**: Data frame containing class membership and sample/patient id label.
- **B**: Number of permutations.

Value

A list of permuted class memberships

See Also

cumNorm fitTimeSeries ssFit ssPermAnalysis ssIntervalCandidate

Examples

```r
# Not run
```
Description

Calculates the fit for each permutation and estimates the area under the null (permuted) model for interesting time intervals of differential abundance.

Usage

ssPermAnalysis(
  data,
  formula,
  permList,
  intTimes,
  timePoints,
  include = c("class", "time:class"),
  ...
)

Arguments

  data          Data used in estimation.
  formula       Formula for ssanova. Of the form: abundance ~ ... where ... includes any pData slot value.
  permList      A list of permuted class memberships
  intTimes      Interesting time intervals.
  timePoints    Time points to interpolate over.
  include       Parameters to include in prediction.
  ...           Options for ssanova

Value

A matrix of permuted area estimates for time intervals of interest.

See Also

cumNorm fitTimeSeries ssFit ssPerm ssIntervalCandidate

Examples

# Not run
trapz  \hspace{1cm} \textit{Trapezoidal Integration}

**Description**

Compute the area of a function with values \(y\) at the points \(x\). Function comes from the pracma package.

**Usage**

\[
\text{trapz}(x, y)
\]

**Arguments**

- \(x\) \hspace{1cm} x-coordinates of points on the x-axis
- \(y\) \hspace{1cm} y-coordinates of function values

**Value**

Approximated integral of the function from \(\min(x)\) to \(\max(x)\). Or a matrix of the same size as \(y\).

**Examples**

```r
# Calculate the area under the sine curve from 0 to pi:
n <- 101
x <- seq(0, pi, len = n)
y <- sin(x)
trapz(x, y) \implies 1.999835504

# Use a correction term at the boundary: \(-h^2/12 \times (f'(b) - f'(a))\)
h <- x[2] - x[1]
ca <- (y[2] - y[1]) / h
cb <- (y[n] - y[n-1]) / h
trapz(x, y) - h^2/12 \times (cb - ca) \implies 1.999999969
```

**ts2MRexperiment**

*With a list of fitTimeSeries results, generate an MRexperiment that can be plotted with metaviz*

**Description**

With a list of fitTimeSeries results, generate an MRexperiment that can be plotted with metavizr
Usage

ts2MRexperiment(
  obj,
  sampleNames = NULL,
  sampleDescription = "timepoints",
  taxonomyLevels = NULL,
  taxonomyHierarchyRoot = "bacteria",
  taxonomyDescription = "taxonomy",
  featuresOfInterest = NULL,
  featureDataOfInterest = NULL
)

Arguments

  obj          Output of fitMultipleTimeSeries
  sampleNames  Sample names for plot
  sampleDescription  Description of samples for plot axis label
  taxonomyLevels Feature names for plot
  taxonomyHierarchyRoot  Root of feature hierarchy for MReperiment
  taxonomyDescription Description of features for plot axis label
  featuresOfInterest The features to select from the fitMultipleTimeSeries output
  featureDataOfInterest featureData for the resulting MReperiment

Value

MReperiment that contains fitTimeSeries data, featureData, and phenoData

See Also

fitTimeSeries fitMultipleTimeSeries

Examples

data(mouseData)
res = fitMultipleTimeSeries(obj=mouseData,lvl='phylum',class="status",
                          id="mouseID",time="relativeTime",B=1)
obj = ts2MRexperiment(res)
obj
**uniqueFeatures**

Table of features unique to a group

**Description**

Creates a table of features, their index, number of positive samples in a group, and the number of reads in a group. Can threshold features by a minimum no. of reads or no. of samples.

**Usage**

```r
uniqueFeatures(obj, cl, nsamples = 0, nreads = 0)
```

**Arguments**

- **obj**: Either a MRexperiment object or matrix.
- **cl**: A vector representing assigning samples to a group.
- **nsamples**: The minimum number of positive samples.
- **nreads**: The minimum number of raw reads.

**Value**

Table of features unique to a group

**Examples**

```r
data(mouseData)
head(uniqueFeatures(mouseData[1:100,], cl=pData(mouseData)[,3]))
```

---

**wrenchNorm**

Computes normalization factors using wrench instead of cumNorm

**Description**

Calculates normalization factors using method published by M. Sentil Kumar et al. (2018) to compute normalization factors which considers compositional bias introduced by sequencers.

**Usage**

```r
wrenchNorm(obj, condition)
```

**Arguments**

- **obj**: an MRexperiment object
- **condition**: case control label that wrench uses to calculate normalization factors
Value

an MRexperiment object with updated normalization factors. Accessible by `normFactors`.

See Also

cumNorm fitZig

Examples

data(mouseData)
mouseData <- wrenchNorm(mouseData, condition = mouseData$diet)
head(normFactors(mouseData))

zigControl

Settings for the fitZig function

Description

Settings for the fitZig function

Usage

```r
zigControl(
  tol = 1e-04,
  maxit = 10,
  verbose = TRUE,
  dfMethod = "modified",
  pvalMethod = "default"
)
```

Arguments

tol The tolerance for the difference in negative log likelihood estimates for a feature to remain active.

maxit The maximum number of iterations for the expectation-maximization algorithm.

verbose Whether to display iterative step summary statistics or not.

dfMethod Either 'default' or 'modified' (by responsibilities).

pvalMethod Either 'default' or 'bootstrap'.

Value

The value for the tolerance, maximum no. of iterations, and the verbose warning.

Note

`fitZig` makes use of `zigControl`. 
See Also
fitZig cumNorm plotOTU

Examples
control = zigControl(tol=1e-10,maxit=10,verbose=FALSE)
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