

Package ‘TaxaNorm’

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Title Feature-Wise Normalization for Microbiome Sequencing Data

Version 2.4

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Description A novel feature-wise normalization method based on a zero-inflated negative binomial model. This method assumes that the effects of sequencing depth vary for each taxon on their mean and also incorporates a rational link of zero probability and taxon dispersion as a function of sequencing depth. Ziyue Wang, Dillon Lloyd, Shanshan Zhao, Alison Motsinger-Reif (2023) <[doi:10.1101/2023.10.31.563648](https://doi.org/10.1101/2023.10.31.563648)>.

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Depends R (>= 4.0.0), microbiome,

Imports phyloseq, stats, S4Vectors, BiocGenerics, vegan, methods, MASS, future, future.apply, matrixStats, pscl, parallelly, ggplot2, utils

URL <https://github.com/wangziyue57/TaxaNorm>

biocViews Sequencing, Microbiome, Metagenomics, Normalization, Visualization

Suggests rmarkdown, knitr

VignetteBuilder knitr

Encoding UTF-8

RoxygenNote 7.2.3

BugReports <https://github.com/wangziyue57/TaxaNorm/issues>

NeedsCompilation no

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Contents

TaxaNorm-datasets	2
TaxaNormGenerics	3
TaxaNorm_Model_Parameters-class	4
TaxaNorm_Model_QC	6
TaxaNorm_NMDS	6
TaxaNorm_Normalization	7
TaxaNorm_QC_Input	8
TaxaNorm_Results-class	8
TaxaNorm_Run_Diagnose	11

Index	13
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TaxaNorm-datasets	<i>TaxaNorm data objects</i>
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Description

Objects included in the TaxaNorm package, loaded with [utils::data](#)

Usage

```
data(TaxaNorm_Example_Input, package = "TaxaNorm")
```

```
data(TaxaNorm_Example_Output, package = "TaxaNorm")
```

TaxaNorm_Example_Input

Example data #'

TaxaNorm_Example_Output

Example output

Examples

```
data(TaxaNorm_Example_Input, package = "TaxaNorm")
  data(TaxaNorm_Example_Output, package = "TaxaNorm")
```

TaxaNormGenerics	<i>TaxaNorm package generics</i>
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Description

TaxaNorm package generics; see class man pages for associated methods

Usage

```
input_data(x, ...)  
input_data(x, ...) <- value  
rawdata(x, ...)  
rawdata(x, ...) <- value  
normdata(x, ...)  
normdata(x, ...) <- value  
ecdf(x, ...)  
ecdf(x, ...) <- value  
model_pars(x, ...)  
model_pars(x, ...) <- value  
converge(x, ...)  
converge(x, ...) <- value  
llk(x, ...)  
llk(x, ...) <- value  
final_df(x, ...)  
final_df(x, ...) <- value  
coefficients(x, ...)  
coefficients(x, ...) <- value  
mu(x, ...)
```

```

mu(x, ...) <- value

theta(x, ...)

theta(x, ...) <- value

pi(x, ...)

pi(x, ...) <- value

```

Arguments

x	TaxaNorm S4 object
...	Included for extendability; not currently used
value	Replacement value

Value

TaxaNorm generic functions return the specified slot of the TaxaNorm object given to the function

```

TaxaNorm_Model_Parameters-class
      TaxaNorm_Model_Parameters

```

Description

S4 class to store TaxaNorm Parameters

Usage

```

TaxaNorm_Model_Parameters(coefficients, mu, theta, pi)

## S4 method for signature 'TaxaNorm_Model_Parameters'
coefficients(x)

## S4 replacement method for signature 'TaxaNorm_Model_Parameters'
coefficients(x) <- value

## S4 method for signature 'TaxaNorm_Model_Parameters'
mu(x)

## S4 replacement method for signature 'TaxaNorm_Model_Parameters'
mu(x) <- value

## S4 method for signature 'TaxaNorm_Model_Parameters'
theta(x)

```

```
## S4 replacement method for signature 'TaxaNorm_Model_Parameters'
theta(x) <- value

## S4 method for signature 'TaxaNorm_Model_Parameters'
pi(x)

## S4 replacement method for signature 'TaxaNorm_Model_Parameters'
pi(x) <- value
```

Arguments

coefficients	Passed to coefficients slot
mu	Passed to mu slot
theta	Passed to theta slot
pi	Passed to pi slot
x	TaxaNorm_Model_Parameters object
value	Replacement value

Details

Parameters for TaxaNorm Method

Functions

- coefficients(TaxaNorm_Model_Parameters): Return coefficients slot
- mu(TaxaNorm_Model_Parameters): Return mu slot
- theta(TaxaNorm_Model_Parameters): Return theta slot
- pi(TaxaNorm_Model_Parameters): Return pi slot

Slots

```
coefficients matrix coefficients
mu matrix mu
theta matrix theta
pi matrix pi
```

Examples

```
coefficients <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
mu <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
theta <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
pi <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
TaxaNorm_Model_Parameters(coefficients = coefficients,mu = mu,theta = theta,pi = pi)
```

TaxaNorm_Model_QC *Function to QC TaxNorm algorithm*

Description

Function to QC TaxNorm algorithm

Usage

```
TaxaNorm_Model_QC(TaxaNormResults)
```

Arguments

TaxaNormResults
Input data; Results from TaxaNorm normalization

Value

a list containing qc taxnorm object

Examples

```
data("TaxaNorm_Example_Output", package = "TaxaNorm")  
TaxaNorm_Model_QC(TaxaNormResults = TaxaNorm_Example_Output)
```

TaxaNorm_NMDS *Function for TaxNorm NMDS*

Description

Function for TaxNorm NMDS

Usage

```
TaxaNorm_NMDS(TaxaNormResults, group_column)
```

Arguments

TaxaNormResults
(Required) Input data; should be either a phyloseq object or a count matrix
group_column column to cluster on

Value

NMDS Plot

Examples

```
data("TaxaNorm_Example_Output", package = "TaxaNorm")
TaxaNorm_NMDS(TaxaNorm_Example_Output, group_column = "body_site")
```

TaxaNorm_Normalization

Function to run TaxaNorm algorithm

Description

Function to run TaxaNorm algorithm

Usage

```
TaxaNorm_Normalization(
  data,
  depth = NULL,
  group = NULL,
  meta.data = NULL,
  filter.cell.num = 10,
  filter.taxa.count = 0,
  random = FALSE,
  ncores = NULL
)
```

Arguments

data	(Required) Input data; should be either a phyloseq object or a count matrix
depth	sequencing depth if pre-calculated. It should be a vector with the same length and order as the column of the count data
group	condition variables if samples are from multiple groups; should be correspond to the column of the count data. default is NULL, where no grouping is considered
meta.data	meta data for Taxa
filter.cell.num	taxa with "filter.cell.num" in more than the value provided will be filtered
filter.taxa.count	"filter.taxa.count" samples will be removed before testing. default is keep taxa appear in at least 10 samples within each group
random	calculate randomized normal quantile residual
ncores	whether multiple cores is used for parallel computing; default is max(1, detectCores() - 1)

Value

a TaxaNorm Object containing the normalized count values and accessory information

Examples

```
data("TaxaNorm_Example_Input", package = "TaxaNorm")
Normalized_Data <- TaxaNorm_Normalization(data= TaxaNorm_Example_Input,
                                          depth = NULL,
                                          group = sample_data(TaxaNorm_Example_Input)$body_site,
                                          meta.data = NULL,
                                          filter.cell.num = 10,
                                          filter.taxa.count = 0,
                                          random = FALSE,
                                          ncores = 1)
```

TaxaNorm_QC_Input *Function for TaxNorm input data*

Description

Function for TaxNorm input data

Usage

```
TaxaNorm_QC_Input(data)
```

Arguments

data (Required) Input data; should be either a phyloseq object or a count matrix

Value

QC PLOTS

Examples

```
data("TaxaNorm_Example_Input", package = "TaxaNorm")
qc_data <- TaxaNorm_QC_Input(TaxaNorm_Example_Input)
```

TaxaNorm_Results-class
TaxaNorm Results

Description

S4 class to store TaxaNorm Results

Usage

```
TaxaNorm_Results(  
  input_data,  
  rawdata,  
  normdata,  
  ecdf,  
  model_pars,  
  converge,  
  llk,  
  final_df  
)  
  
## S4 method for signature 'TaxaNorm_Results'  
input_data(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
input_data(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
rawdata(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
rawdata(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
normdata(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
normdata(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
ecdf(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
ecdf(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
model_pars(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
model_pars(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
converge(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
converge(x) <- value
```

```
## S4 method for signature 'TaxaNorm_Results'  
llk(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
llk(x) <- value  
  
## S4 method for signature 'TaxaNorm_Results'  
final_df(x)  
  
## S4 replacement method for signature 'TaxaNorm_Results'  
final_df(x) <- value
```

Arguments

input_data	passed to input_data slot
rawdata	Passed to rawdata slot
normdata	Passed to normdata slot
ecdf	Passed to ecdf slot
model_pars	Passed to model_pars slot
converge	Passed to converge slot
llk	Passed to llk slot
final_df	Passed to final_df slot
x	TaxaNorm_Results object
value	Replacement value

Details

All results from the TaxaNorm method and what was used to get those results

Functions

- `input_data(TaxaNorm_Results)`: Return input_data slot
- `rawdata(TaxaNorm_Results)`: Return rawdata slot
- `normdata(TaxaNorm_Results)`: Return normdata slot
- `ecdf(TaxaNorm_Results)`: Return ecdf slot
- `model_pars(TaxaNorm_Results)`: Return model_pars slot
- `converge(TaxaNorm_Results)`: Return converge slot
- `llk(TaxaNorm_Results)`: Return llk slot
- `final_df(TaxaNorm_Results)`: Return final_df slot

Slots

input_data ANY phyloseq input data
 rawdata data.frame Data frame of counts to use
 normdata data.frame Normalized Data
 ecdf data.frame ecdf
 model_pars [TaxaNorm_Model_Parameters](#) list of model parameters
 converge vector(<logical>) converge
 llk ANY llk
 final_df ANY final_df

Examples

```
coefficients <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
mu <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
theta <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
pi <- matrix(c(1,2,3,4,5,6,7,8,9),nrow=3,ncol=3,byrow=TRUE)
model_pars <- TaxaNorm_Model_Parameters(coefficients = coefficients,mu = mu,theta = theta,pi = pi)
data("TaxaNorm_Example_Input", package = "TaxaNorm")
rawdata <- data.frame(Taxa1 = c(1,2,3),Taxa2 = c(3,4,5),Taxa3 = c(6,7,8))
normdata <- data.frame(Taxa1 = c(-1.4,-1.09,-0.73),
  Taxa2 = c(-0.36,0,0.36), Taxa3 = c(0.73,1.09,1.46))
ecdf <- data.frame(0.05,0.23,0.89)
converge <- c(TRUE,TRUE,FALSE)
llk <- c(1,1.5,0.5)
final_df <- data.frame(Taxa1 = c(1,2,3),Taxa2 = c(3,4,5),Taxa3 = c(6,7,8))
TaxaNorm_Results(input_data = TaxaNorm_Example_Input,
  rawdata = rawdata,
  normdata = normdata,
  ecdf = ecdf,
  model_pars = model_pars,
  converge = converge,
  llk = llk,
  final_df = final_df)
```

TaxaNorm_Run_Diagnose *Function to run TaxNorm algorithm*

Description

Function to run TaxNorm algorithm

Usage

```
TaxaNorm_Run_Diagnose(Normalized_Results, prev = TRUE, equiv = TRUE, group)
```

Arguments

Normalized_Results
(Required) Input results from from run_norm()
prev run prev test
equiv run equiv test
group group used for taxanorm normalization

Value

a list containing the normalized count values

Examples

```
data("TaxaNorm_Example_Input", package = "TaxaNorm")
data("TaxaNorm_Example_Output", package = "TaxaNorm")
Diagnose_Data <- TaxaNorm_Run_Diagnose(Normalized_Results = TaxaNorm_Example_Output,
                                       prev = TRUE,
                                       equiv = TRUE,
                                       group = sample_data(TaxaNorm_Example_Input)$body_site)
```

Index

coefficients (TaxaNormGenerics), 3
coefficients, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4
coefficients<- (TaxaNormGenerics), 3
coefficients<-, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4
converge (TaxaNormGenerics), 3
converge, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
converge<- (TaxaNormGenerics), 3
converge<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

ecdf (TaxaNormGenerics), 3
ecdf, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
ecdf<- (TaxaNormGenerics), 3
ecdf<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

final_df (TaxaNormGenerics), 3
final_df, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
final_df<- (TaxaNormGenerics), 3
final_df<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

input_data (TaxaNormGenerics), 3
input_data, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
input_data<- (TaxaNormGenerics), 3
input_data<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

llk (TaxaNormGenerics), 3
llk, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
llk<- (TaxaNormGenerics), 3
llk<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

model_pars (TaxaNormGenerics), 3
model_pars, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
model_pars<- (TaxaNormGenerics), 3
model_pars<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
mu (TaxaNormGenerics), 3
mu, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4
mu<- (TaxaNormGenerics), 3
mu<-, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4

normdata (TaxaNormGenerics), 3
normdata, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
normdata<- (TaxaNormGenerics), 3
normdata<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

pi (TaxaNormGenerics), 3
pi, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4
pi<- (TaxaNormGenerics), 3
pi<-, TaxaNorm_Model_Parameters-method
(TaxaNorm_Model_Parameters-class),
4

rawdata (TaxaNormGenerics), 3
rawdata, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8
rawdata<- (TaxaNormGenerics), 3
rawdata<-, TaxaNorm_Results-method
(TaxaNorm_Results-class), 8

TaxaNorm-datasets, 2
 TaxaNorm_Example_Input
 (TaxaNorm-datasets), 2
 TaxaNorm_Example_Output
 (TaxaNorm-datasets), 2
 TaxaNorm_Model_Parameters, 11
 TaxaNorm_Model_Parameters
 (TaxaNorm_Model_Parameters-class),
 4
 TaxaNorm_Model_Parameters-class, 4
 TaxaNorm_Model_Parameters-coefficients
 (TaxaNorm_Model_Parameters-class),
 4
 TaxaNorm_Model_Parameters-mu
 (TaxaNorm_Model_Parameters-class),
 4
 TaxaNorm_Model_Parameters-pi
 (TaxaNorm_Model_Parameters-class),
 4
 TaxaNorm_Model_Parameters-theta
 (TaxaNorm_Model_Parameters-class),
 4
 TaxaNorm_Model_QC, 6
 TaxaNorm_NMDS, 6
 TaxaNorm_Normalization, 7
 TaxaNorm_QC_Input, 8
 TaxaNorm_Results
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-class, 8
 TaxaNorm_Results-converge
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-ecdf
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-final_df
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-input_data
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-llk
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-model_pars
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-normdata
 (TaxaNorm_Results-class), 8
 TaxaNorm_Results-rawdata
 (TaxaNorm_Results-class), 8
 TaxaNorm_Run_Diagnose, 11
 TaxaNormGenerics, 3
 theta (TaxaNormGenerics), 3
 theta, TaxaNorm_Model_Parameters-method
 (TaxaNorm_Model_Parameters-class),
 4
 theta<- (TaxaNormGenerics), 3
 theta<- , TaxaNorm_Model_Parameters-method
 (TaxaNorm_Model_Parameters-class),
 4
 utils::data, 2