

# Package ‘RUVcorr’

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**Type** Package

**Title** Removal of unwanted variation for gene-gene correlations and related analysis

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**Description** RUVcorr allows to apply global removal of unwanted variation (ridged version of RUV) to real and simulated gene expression data.

**Imports** corplot, MASS, stats, lattice, grDevices, gridExtra, snowfall, psych, BiocParallel, grid, bladderbatch, reshape2, graphics

**License** GPL-2

**Suggests** knitr, hgu133a2.db, rmarkdown

**VignetteBuilder** knitr

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---

assessQuality                      *Quality assessment for cleaning procedures.*

---

**Description**

assessQuality allows to assess the quality of cleaning procedures in the context of correlations when the true underlying correlation structure is known.

**Usage**

```
assessQuality(
  est,
  true,
  index = "all",
  methods = c("all", "fnorm", "wrong.sign")
)
```

**Arguments**

est	A matrix of estimated gene expression values.
true	A matrix of true correlations.
index	A vector of indices of genes to be included in the assessment; if index="all" all genes are considered.
methods	The method used for quality assessment; if method="fnorm" the squared Frobenius norm is used; if method="wrong.sign" the percentage of wrongly estimated signs is calculated if method="all" both are calculated.

**Details**

The squared Frobenius norm used for `assessQuality` has the following structure

$$F = \frac{\|E - T\|^2}{s}$$

Here, the parameter  $E$  and the parameter  $T$  denote the lower triangles of the estimated and true Fisher transformed correlation matrices, respectively. The parameter  $s$  denotes the number of elements in  $E$  and  $T$ .

**Value**

`assessQuality` returns a vector of the requested quality assessments.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL,
Sigma.eps=0.1, 250, 100, intercept=FALSE, check.input=FALSE)
assessQuality(Y$Y, Y$Sigma, index=1:100, methods="wrong.sign")
assessQuality(Y$Y, Y$Sigma, index=1:100, method="fnorm")
```

---

background

*Randomly choose background genes.*


---

**Description**

`background` returns background genes for judging the quality of the cleaning. These genes are supposed to represent the majority of genes. The positive control and negative control genes should be excluded.

**Usage**

```
background(Y, nBG, exclude, nc_index)
```

**Arguments**

Y	A matrix of gene expression values or an object of the class simulateGEdata.
nBG	An integer setting the number of background genes.
exclude	A vector of indices of genes to exclude.
nc_index	A vector of indices of negative controls (also excluded from being background genes).

**Value**

background returns a vector of randomly chosen indices.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
background(Y, nBG=20, exclude=1:100, nc_index=251:500)
```

---

calculateThreshold     *Calculates the correlation threshold.*

---

**Description**

calculateThreshold returns the proportion of prioritised genes from a random selection for supplied threshold. Furthermore, this function also fits a loess curve to the estimated points. This allows the calculation of a threshold for prioritisation of genes.

**Usage**

```
calculateThreshold(
  X,
  exclude,
  index.ref,
  set.size = length(index.ref),
  Weights = NULL,
  thresholds = seq(0.05, 1, 0.05),
  anno = NULL,
  Factor = NULL,
  cpus = 1,
  parallel = FALSE
)
```

**Arguments**

X	A matrix of gene expression values.
exclude	A vector of indices of genes to exclude.
index.ref	A vector of indices of reference genes used for prioritisation.
set.size	An integer giving the size of the set of genes that are to be prioritised.
Weights	A object of class <code>Weights</code> or a list of weights. The weights should correspond to <code>Factor</code> . If <code>NULL</code> the unweighted correlations are used.
thresholds	A vector of thresholds; values should be in the range $[0, 1]$ .
anno	A dataframe or a matrix containing the annotation of arrays in X.
Factor	A character string corresponding to a column name of anno.
cpus	An integer giving the number of cores that are supposed to be used.
parallel	A logical value indicating whether parallel computing should be used.

**Details**

The proportion of prioritized random genes is estimated by drawing 1000 random sets of genes and calculating how many would be prioritised at every given threshold. A gene is prioritised if at least one correlation with a known reference gene is above the given threshold.

**Value**

`calculateThreshold` returns an object of class `Threshold`. An object of class `Threshold` is a list with the following components:

- `Prop.values` A vector of the proportion of prioritized genes.
- `Thresholds` A vector containing the values in threshold.
- `loess.estimate` An object of class `loess`.

**Author(s)**

Saskia Freytag

**See Also**

[funcThresh](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
anno<-as.matrix(sample(1:4, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
weights<-findWeights(Y$Y, anno, "Factor")
calculateThreshold(Y$Y, exclude=seq(251,500,1), index.ref=seq_len(10),
Weights=weights, anno=anno, Factor="Factor")
```

---

compareRanks	<i>Compare ranking of known reference gene pairs.</i>
--------------	---

---

### Description

compareRanks allows to calculate the difference of the ranks of known reference gene pairs from two versions of the same data.

### Usage

```
compareRanks(Y, Y.hat, ref_index, no.random = 1000, exclude_index)
```

### Arguments

Y	A matrix of raw gene expression values.
Y.hat	A matrix of cleaned gene expression values.
ref_index	A vector of indices that are referring to genes of interest.
no.random	An integer giving the number of random genes.
exclude_index	A vector of indices to be excluded from the selection of random genes.

### Details

The correlations between all random genes and reference genes is calculated (including correlations between random and reference) using the two versions of the data. The correlations are then ranked according to their absolute value (highest to lowest). The ranks of the reference gene pairs are extracted. For a particular reference gene pair, the difference in the ranks between the two versions of the data is calculated: Rank in Y - Rank in Y.hat

### Value

compareRanks returns a vector of the differences in ranks of the correlations of reference gene pairs estimated using raw or cleaned data.

### Author(s)

Saskia Freytag

### Examples

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL,  
Sigma.eps=0.1, 250, 100, intercept=FALSE, check.input=FALSE)  
Y.hat<-RUVNaiveRidge(Y, center=TRUE, nu=0, kw=10)  
compareRanks(Y$Y, Y.hat, ref_index=1:30, no.random=100, exclude_index=c(31:100,251:500))
```

---

correlationPlot	<i>Correlation plot to compare estimated correlations with true correlations.</i>
-----------------	---

---

### Description

correlationPlot produces a correlation plot to compare true and estimated

### Usage

```
correlationPlot(  
  true,  
  est,  
  plot.genes = sample(seq_len(dim(true)[1]), 18),  
  boxes = TRUE,  
  title,  
  line = -1  
)
```

### Arguments

true	A matrix of true gene-gene correlation values.
est	A matrix of estimated gene expression values.
plot.genes	A vector of indices of genes used in plotting; the suggested length of this vector is 18.
boxes	A logical scalar to indicate whether boxes are drawn around sets of 6 genes; only available if plot.genes has length 18.
title	A character string describing the title of the plot.
line	on which MARgin line, starting at 0 counting outwards.

### Details

The upper triangle of the correlation plot shows the true gene-gene correlation values, while the lower triangle of the correlation plot shows the gene-gene correlation values calculated from the estimated gene expression values. This is possible because correlation matrices are symmetric.

### Value

correlationPlot returns a plot.

### Author(s)

Saskia Freytag

### See Also

[corrplot](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
correlationPlot(Y$Sigma, Y$Y, title="Raw",
plot.genes=c(sample(1:100, 6), sample(101:250, 6), sample(251:500, 6)))
```

---

ECDFPlot

---

*Plot empirical cumulative distribution function for correlations.*


---

**Description**

ECDFPlot generates empirical cumulative distribution functions (ECDF) for gene-gene correlation values.

**Usage**

```
ECDFPlot(X, Y, index = "all", col.X = "red", col.Y = "black", title, legend)
```

**Arguments**

X	A matrix or list of matrices of estimated gene-gene correlations.
Y	A matrix of reference gene-gene correlations (i.e. underlying known correlation structure).
index	A vector of indices of genes of interest.
col.X	The color or colors for ECDF as estimated from X.
col.Y	The color for ECDF as estimated from Y.
title	A character string describing title of plot.
legend	A vector describing X and Y.

**Value**

ECDFPlot returns a plot.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
Y.hat<-RUVNaiveRidge(Y, center=TRUE, nc_index=251:500, 0, 10, check.input=TRUE)
Y.hat.cor<-cor(Y.hat)
par(mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0, mfrow=c(1, 1))
ECDFPlot(Y.hat.cor, Y$Sigma, index=1:100, title="Simulated data",
legend=c("RUV", "Truth"))
ECDFPlot(list(Y.hat.cor, cor(Y$Y)), Y$Sigma, index=1:100,
title="Simulated data", legend=c("RUV", "Raw", "Truth"), col.Y="black")
```



---

eigenvaluePlot      *Plot eigenvalues of SVD of the negative controls.*

---

**Description**

eigenvaluePlot plots the ratio of the *i*th eigenvalue of the SVD of the negative controls to the eigenvalue total.

**Usage**

```
eigenvaluePlot(Y, nc_index, k = 10, center = TRUE, title = "Eigenvalue Plot")
```

**Arguments**

Y	A matrix of gene expressions.
nc_index	A vector of indices for the negative controls.
k	A numeric value giving the number of eigenvalues that should be displayed.
center	A logical character to indicate whether centering is needed.
title	A character string describing title.

**Value**

eigenvaluePlot returns a plot.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,  
250, 100, intercept=FALSE, check.input=FALSE)  
eigenvaluePlot(Y$Y, nc_index=251:500, k=20, center=TRUE)
```

---

empNegativeControls      *Empirically choose negative control genes.*

---

**Description**

empNegativeControls finds suitable negative controls in real or simulated data.

**Usage**

```
empNegativeControls(Y, exclude, smoothing = 0.1, nc)
```

```
## Default S3 method:
```

```
empNegativeControls(Y, exclude, smoothing = 0.1, nc)
```

```
## S3 method for class 'simulateGEdata'
```

```
empNegativeControls(Y, exclude, smoothing = 0.1, nc)
```

**Arguments**

Y	A matrix of gene expression values or an object of the class <code>simulateGEData</code> .
exclude	A vector of indices to be excluded from being chosen as negative controls.
smoothing	A numerical scalar determining the amount of smoothing to be applied.
nc	An integer setting the number of negative controls.

**Details**

First the mean of all genes (except the excluded genes) is calculated and genes are accordingly assigned to bins. The bins have the size of the smoothing parameter. In each bin the function picks a number of negative control genes proportional to the total number of genes in the bin. The picked genes in each bin have the lowest inter-quantile ranges of all genes in the respective bin.

**Value**

`empNegativeControls` returns a vector of indices of empirically chosen negative controls.

**Warning**

For simulated data it is advisable to use the known negative controls or restrict the empirical choice to the known negative controls by excluding all other genes.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEData(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=TRUE)
empNegativeControls(Y, exclude=1:100, nc=100)
```

---

findIQR

*Find the inter quantile range.*

---

**Description**

Internal function to find the inter quantile range.

**Usage**

```
findIQR(x)
```

**Arguments**

Vector of gene expression values.

**Value**

Numeric value.

**Author(s)**

Saskia Freytag

---

findMinmaxSamples	<i>Find minimum and maximum samples in gene expression data.</i>
-------------------	--

---

**Description**

Internal function that returns 5 samples with smallest inter-quantile range and 5 samples with highest inter-quantile range.

**Usage**

```
findMinmaxSamples(x)
```

**Arguments**

x	Matrix of gene expression values.
---	-----------------------------------

**Value**

Vector of indices.

**Author(s)**

Saskia Freytag

---

findWeights	<i>Finds weights of each level of a factor.</i>
-------------	---

---

**Description**

findWeights returns a list of variances and weights based on the correlation between genes for each level of a factor found in the annotation. This function is typically used to find the weights of each individual in the data set.

**Usage**

```
findWeights(X, anno, Factor)
```

**Arguments**

X	A matrix of gene expression values.
anno	A dataframe or a matrix containing the annotation of arrays in X.
Factor	A character string corresponding to a column name of anno. For all levels of this factor corresponding weights will be calculated.

**Details**

Note that because calculations of weights include finding correlations between all genes, this function might take some time. Hence, recalculation of weights is not advisable and should be avoided. However often the inverse variances can be used to calculate new weights. In particular, when  $W_i$  denotes the weight of the  $i^{th}$  level and  $V_i$  the variance as calculated from the gene-gene correlations:

$$W_i = \frac{\frac{1}{V_i}}{\sum_{i=1}^n \frac{1}{V_i}}$$

**Value**

findWeights returns output of the class `Weights`. An object of class `Weights` is a list with the following components:

- `Weights` A list containing the weights of each level of Factor.
- `Inv.Sigma` A list containing the inverse variances of each level of Factor.

**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
anno<-as.matrix(sample(1:4, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
findWeights(Y$Y, anno, "Factor")
```

---

funcPara

*Function to optimize parameters in parallel.*

---

**Description**

Internal function for parallel computing.

**Usage**

```
funcPara(x, Y, nc_index, center = TRUE, index, methods)
```

**Arguments**

x	Vector.
Y	simulateGE object.
nc_index	Vector.
center	Logical.
index	Vector.
methods	Vector.

**Value**

List.

**Author(s)**

Saskia Freytag

---

funcThresh

*Function to calculate correlation threshold in parallel.*

---

**Description**

Internal function for parallel computing.

**Usage**

```
funcThresh(.x, Y, Weights, Factor, anno, index.ref, thresholds, set.size)
```

**Arguments**

.x	Vector.
Y	Matrix.
Weights	A object of class Weights or a list of weights.
Factor	Character string.
anno	Dataframe.
index.ref	Vector.
thresholds	Vector.
set.size	Integer.

**Value**

Matrix.

**Author(s)**

Saskia Freytag

---

genePlot *Plot of means and inter-quantile ranges of all genes.*

---

### Description

genePlot plots the means vs. the inter-quantile ranges of the gene expression values of all genes with the possibility to highlight interesting sets of genes.

### Usage

```
genePlot(Y, index = NULL, legend = NULL, col.h = "red", title)
```

### Arguments

Y	A matrix of gene expression values or an object of the class <code>simulateGEData</code> .
index	A vector of indices of genes of interest to be displayed in a different color, if <code>index=NULL</code> no genes are highlighted.
legend	A character string describing the highlighted genes.
col.h	The color of the highlighted genes.
title	A character string describing the title of the plot.

### Value

genePlot returns a plot.

### Author(s)

Saskia Freytag

### Examples

```
Y<-simulateGEData(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
  250, 100, intercept=FALSE, check.input=TRUE)
try(dev.off(), silent=TRUE)
par(mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0)
genePlot(Y, index=1:100, legend="Expressed genes", title="IQR-Mean Plot")
```

---

histogramPlot *Plot histogram of correlations.*

---

### Description

histogramPlot plots histograms of correlation values in expression data and its reference.

**Usage**

```
histogramPlot(  
  X,  
  Y,  
  legend,  
  breaks = 40,  
  title,  
  col.X = "red",  
  col.Y = "black",  
  line = NULL  
)
```

**Arguments**

X	A matrix or a list of matrices of estimated gene-gene correlations.
Y	A matrix of reference gene-gene correlations (i.e. known underlying correlation structure).
legend	A vector of character strings describing the data contained in X and Y.
breaks	one of: <ul style="list-style-type: none"><li>• a vector giving the breakpoints between histogram cells,</li><li>• a function to compute the vector of breakpoints,</li><li>• a single number giving the number of cells for the histogram,</li><li>• a character string naming an algorithm to compute the number of cells (see 'Details'),</li><li>• a function to compute the number of cells.</li></ul> In the last three cases the number is a suggestion only; as the breakpoints will be set to <code>pretty</code> values, the number is limited to 1e6 (with a warning if it was larger). If breaks is a function, the x vector is supplied to it as the only argument (and the number of breaks is only limited by the amount of available memory).
title	A character string describing title.
col.X	A vector or character string defining the color/colors associated with the data contained in X.
col.Y	The color associated with the data in Y.
line	A vector giving the line type.

**Details**

The default for breaks is "Sturges". Other names for which algorithms are supplied are "Scott" and "FD" / "Freedman-Diaconis" Case is ignored and partial matching is used. Alternatively, a function can be supplied which will compute the intended number of breaks or the actual breakpoints as a function of x.

**Value**

histogramPlot returns a plot.

**Author(s)**

Saskia Freytag

**Examples**

```

Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
Y.hat<-RUVNaiveRidge(Y, center=TRUE, nc_index=251:500, 0, 10, check.input=FALSE)
Y.hat.cor<-cor(Y.hat[,1:100])
try(dev.off(), silent=TRUE)
par(mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0, mfrow=c(1, 1))
histogramPlot(Y.hat.cor, Y$Sigma[1:100, 1:100], title="Simulated data",
legend=c("RUV", "Truth"))
try(dev.off(), silent=TRUE)
histogramPlot(list(Y.hat.cor, cor(Y$Y[, 1:100])), Y$Sigma[1:100, 1:100],
title="Simulated data", col.Y="black", legend=c("RUV", "Raw", "Truth"))

```

---

is.optimizeParameters *Checking optimizeParameters class.*

---

**Description**

is.optimizeParameters checks if object is of optimizeParameters class.

**Usage**

```
is.optimizeParameters(x)
```

**Arguments**

x                    An object.

**Value**

is.optimizeParameters returns a logical scalar; TRUE if the object is of the class optimizeParameters.

**Author(s)**

Saskia Freytag

**See Also**

[optimizeParameters](#)

**Examples**

```

Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
opt<-optimizeParameters(Y, kW.hat=c(1,5,10), nu.hat=c(100,1000),
nc_index=251:500, methods=c("fnorm"), cpus=1, parallel=FALSE)
opt
is.optimizeParameters(opt)

```



---

is.simulateGEdata      *Checking simulateGEdata class.*

---

**Description**

is.simulateGEdata checks if object is of simulateGEdata class.

**Usage**

```
is.simulateGEdata(x)
```

**Arguments**

x                      An object.

**Value**

is.simulateGEdata returns a logical scalar; TRUE if the object is of the class simulateGEdata.

**Author(s)**

Saskia Freytag

**See Also**

[simulateGEdata](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,  
250, 100, intercept=TRUE, check.input=TRUE)  
is.simulateGEdata(Y)
```

---

is.Threshold              *Checking Threshold class.*

---

**Description**

is.Threshold checks if object is of Threshold class.

**Usage**

```
is.Threshold(x)
```

**Arguments**

x                      An object.

**Value**

is.Threshold returns a logical scalar; TRUE if the object is of the class Threshold.

**Author(s)**

Saskia Freytag

**See Also**[calculateThreshold](#)

---

`is.Weights`*Checking Weights class.*

---

**Description**`is.Weights` checks if object is of `Weights` class.**Usage**`is.Weights(x)`**Arguments**`x` An object.**Value**`is.Weights` returns a logical scalar; TRUE if the object is of the class `Weights`.**Author(s)**

Saskia Freytag

**See Also**[findWeights](#)

---

`makePosSemiDef`*Makes square matrices positive semi-definite.*

---

**Description**

Internal function which returns closest positive semi-definite matrix to input matrix.

**Usage**`makePosSemiDef(a, offset = 0)`**Arguments**`a` Square matrix.`offset` Offset.

**Value**

Positive semi-definite matrix.

**Author(s)**

Saskia Freytag

---

makeRankedList	<i>Make ranked list of correlations.</i>
----------------	--

---

**Description**

Internal function.

**Usage**

```
makeRankedList(Data)
```

**Arguments**

Data	matrix of gene-gene correlations.
------	-----------------------------------

**Value**

Matrix.

**Author(s)**

Saskia Freytag

---

mashUp	<i>Joining two correlation matrices by diagonal.</i>
--------	--

---

**Description**

Internal function that joins two matrices at their diagonal.

**Usage**

```
mashUp(true, est, plot.genes)
```

**Arguments**

true	Matrix.
est	Matrix.
plot.genes	Vector of indices.

**Value**

Matrix.

**Author(s)**

Saskia Freytag

---

 optimizeParameters     *Optimize parameters of removal of unwanted variation.*


---

**Description**

optimizeParameters returns the optimal parameters to be used in the removal of unwanted variation procedure when using simulated data.

**Usage**

```
optimizeParameters(
  Y,
  kW.hat = seq(5, 25, 5),
  nu.hat = c(0, 10, 100, 1000, 10000),
  nc_index,
  methods = c("all", "fnorm", "wrong.sign"),
  cpus = 1,
  parallel = FALSE,
  check.input = FALSE
)
```

**Arguments**

Y	An object of the class <code>simualteGEdata</code> .
kW.hat	A vector of integers for kW in <code>RUVNaiveRidge</code> .
nu.hat	A vector of values for nu in <code>RUVNaiveRidge</code> .
nc_index	A vector of indices of the negative controls used in <code>RUVNaiveRidge</code> .
methods	The method used for quality assessment; if <code>method="fnorm"</code> the squared Frobenius norm is used; if <code>method="wrong.sign"</code> the percentage of wrongly estimated signs is calculated if <code>method="all"</code> both are calculated.
cpus	A number specifying how many workers to use for parallel computing.
parallel	Logical: if TRUE parallel computing is used.
check.input	Logical; if TRUE all input is checked; not advisable for large simulations.

**Details**

The simulated data is cleaned using removal of unwanted variation with all combinations of the input parameters. The quality of each cleaning is judged by the Frobenius Norm of the correlation as estimated from the cleaned data and the known data or the percentage of correlations with estimated to have the wrong sign.

**Value**

`optimizeParameters` returns output of the class `optimizeParameters`. An object of class `optimizeParameters` is a list containing the following components:

`All.results` A matrix of output of the quality assessment for all combinations of input parameters.

`Compare.raw` A vector of the quality assessment for the uncorrected data.

`Optimal.parameter` A matrix or a vector giving the optimal parameter combination.

**Author(s)**

Saskia Freytag

**See Also**

[assessQuality](#), [RUVNaiveRidge](#), [funcPara](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
opt<-optimizeParameters(Y, kW.hat=c(1,5,10), nu.hat=c(100,1000), nc_index=251:500,
methods=c("fnorm"), cpus=1, parallel=FALSE, check.input=TRUE)
opt
```

---

PCAPlot

*Plot principle component analysis for gene expression data.*

---

**Description**

PCAPlot generates principle component plots for with the possibility to color arrays according to a known factor.

**Usage**

```
PCAPlot(
  Y,
  comp = c(1, 2),
  anno = NULL,
  Factor = NULL,
  numeric = FALSE,
  new.legend = NULL,
  title
)
```

**Arguments**

Y	A matrix of gene expression values or an object of class prcomp.
comp	A vector of length 2 specifying which principle components to be used.
anno	A dataframe or a matrix containing the annotation of the arrays.
Factor	A character string describing the column name of anno used for coloring.
numeric	A logical scalar indicating whether Factor is numerical.
new.legend	A vector describing the names used for labelling; if NULL labels in Factor are used.
title	A character string giving the title.

**Value**

PCAPlot returns a plot.

**Author(s)**

Saskia Freytag

**See Also**

[prcomp](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
PCAPlot(Y$Y, title="")

## Create random annotation file
anno<-as.matrix(sample(1:4, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
try(dev.off(), silent=TRUE)
par(mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0, mfrow=c(1, 1))
PCAPlot(Y$Y, anno=anno, Factor="Factor", numeric=TRUE, title="")
```

---

plot.optimizeParameters

*Plots an object of class optimizeParameters.*

---

**Description**

plot.optimizeParameters generates a heatmap of the quality assessment values stored in the object of class optimizeParameters .

**Usage**

```
## S3 method for class 'optimizeParameters'
plot(
  x,
  main = colnames(opt$All.results)[seq(3, dim(opt$All.results)[2], 1)],
  ...
)
```

**Arguments**

x	An object of the class optimizeParameters.
main	A character string describing title of plot.
...	Further arguments passed to or from other methods.

**Details**

The black point in the heatmap denotes the optimal parameter combination.

**Value**

plot.optimizeParameters returns a plot.

**Author(s)**

Saskia Freytag

**See Also**

[optimizeParameters](#)

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=2, Sigma.eps=0.1,
  250, 100, intercept=FALSE, check.input=FALSE)
opt<-optimizeParameters(Y, kW.hat=c(1,5,10), nu.hat=c(100,100000),
  nc_index=seq(251,500,1), methods=c("fnorm"), cpus=1, parallel=FALSE)
try(dev.off(), silent=TRUE)
plot(opt, main="Heatmap Plot")
```

---

plotDesign

*Plot nested design structure.*

---

**Description**

plotDesign returns a plot with different color strips representing different factors relating to the study design. genes.

**Usage**

```
plotDesign(anno, Factors, anno.names = Factors, orderby = NULL)
```

**Arguments**

anno	A dataframe or matrix containing the annotation of the study.
Factors	A vector of factors that should be plotted.
anno.names	A vector containing the names, the default Factors.
orderby	A character describing an element in Factor by which the data should be ordered.

**Value**

plotDesign returns a plot.

**Author(s)**

Saskia Freytag

**Examples**

```
library(bladderbatch)
data(bladderdata)
expr.meta <- pData(bladderEset)
plotDesign(expr.meta, c("cancer", "outcome", "batch"),
c("Diagnosis", "Outcome", "Batch"), orderby="batch")
```

---

plotThreshold	<i>Plots an object of class Threshold.</i>
---------------	--

---

**Description**

plotThreshold plots the objects of class Threshold.

**Usage**

```
plotThreshold(x, main = "", legend, col = NULL, ...)
```

**Arguments**

x	An object of class Threshold or a list of objects of class Threshold.
main	A character string describing the title of the plot.
legend	A vector of character strings describing the different Threshold objects in x; only applicable when x is a list.
col	A vector giving the colors, if NULL colors are generated automatically.
...	Further arguments passed to or from other methods.

**Value**

plotThreshold returns a plot.

**Author(s)**

Saskia Freytag

**See Also**

[calculateThreshold](#)



**Examples**

```

Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
anno<-as.matrix(sample(1:4, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
weights<-findWeights(Y$Y, anno, "Factor")
Thresh<-calculateThreshold(Y$Y, exclude=1:100, index.ref=1:10,
Weights=weights, anno=anno, Factor="Factor")
plotThreshold(Thresh)

```

---

```
print.simulateGEdata Print an object of class simulateGEdata.
```

---

**Description**

print.simulateGEdata is the print generic for object of the class simulateGEdata.

**Usage**

```

## S3 method for class 'simulateGEdata'
print(x, ...)

```

**Arguments**

x	An object of the class simulateGEdata.
...	Further arguments passed to or from other methods.

**Value**

print.simulateGEdata returns the information about simulation and the first 5 rows and 5 columns of all matrices.

**Author(s)**

Saskia Freytag

**See Also**

[simulateGEdata](#)

**Examples**

```

Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=TRUE, check.input=FALSE)
Y

```

---

prioritise

*Prioritising candidate genes.*

---

### Description

prioritise returns a set of genes from a candidate set of genes that are correlated above a provided threshold with at least one of the provided reference genes.

### Usage

```
prioritise(X, ref_index, cand_index, anno, Factor, Weights, threshold)
```

### Arguments

X	A matrix of gene expression values.
ref_index	A vector of indices of reference genes.
cand_index	A vector of indices of candidate genes.
anno	A dataframe or a matrix containing the annotation of arrays in X.
Factor	A character string corresponding to a column name of anno; this should be the same used to generate Weights.
Weights	An object of class Weights or a list of weights. If NULL the unweighted correlation is used.
threshold	A value in the range [0, 1].

### Value

prioritise returns a matrix with three columns. The first column gives the names of the genes that were prioritised, while the second column gives the number of correlations above the threshold for the gene in question. The third column gives the sum of the absolute value of all correlations with reference genes above the threshold.

### Author(s)

Saskia Freytag

### Examples

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
  250, 100, intercept=FALSE, check.input=TRUE)
colnames(Y$Y)<-1:dim(Y$Y)[2]
anno<-as.matrix(sample(1:5, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
weights<-findWeights(Y$Y, anno, "Factor")
prioritise(Y$Y, 1:10, 51:150, anno, "Factor", weights, 0.6)
```

**Description**

RLEPlot generates three different types of relative log expression plots for high-dimensional data.

**Usage**

```
RLEPlot(
  X,
  Y,
  center = TRUE,
  name,
  title,
  method = c("IQR.points", "IQR.boxplots", "minmax"),
  anno = NULL,
  Factor = NULL,
  numeric = FALSE,
  new.legend = NULL,
  outlier = FALSE
)
```

**Arguments**

X	A matrix of gene expression values.
Y	A matrix of gene expression values.
center	A logical scalar; TRUE if centering should be applied.
name	A vector of characters describing the data contained in X and Y.
title	A character string describing the title of the plot.
method	The type of RLE plot to be displayed; possible inputs are "IQR.points", "IQR.boxplots" and "minmax" (for information see details).
anno	A dataframe or a matrix containing the annotation of arrays in X and Y (only applicable for method="IQR.points"); if anno=NULL data points are not colored.
Factor	A character string corresponding to a column name of anno to be used for coloring.
numeric	A logical scalar indicating whether Factor is numerical.
new.legend	A vector describing the names used for labelling; if NULL labels in Factor are used.
outlier	A logical indicating whether outliers should be plotted; only applicable when method="minmax".

**Details**

There are three different RLE plots that can be generated using RLEPlot:

"IQR.points" Median expression vs. inter-quantile range of every array.

"IQR.boxplots" Boxplots of the 25% and 75% quantile of all arrays.

"Minmax" Ordinary RLE plots for the 5 arrays with the smallest and largest inter-quantile ranges.

Note that normal RLE plots are not supplied as they are not very suitable for high-dimensional data.

**Value**

RLEPlot returns a plot.

**Author(s)**

Saskia Freytag, Terry Speed

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
Y.hat<-RUVNaiveRidge(Y, center=TRUE, nc_index=251:500, 0, 10, check.input=TRUE)
try(dev.off(), silent=TRUE)
par(mar=c(5.1, 4.1, 4.1, 2.1), mgp=c(3, 1, 0), las=0)
RLEPlot(Y$Y, Y.hat, name=c("Raw", "RUV"), title="", method="IQR.points")
try(dev.off(), silent=TRUE)
par(mfrow=c(1, 1))
RLEPlot(Y$Y, Y.hat, name=c("Raw", "RUV"), title="", method="IQR.boxplots")
try(dev.off(), silent=TRUE)
RLEPlot(Y$Y, Y.hat, name=c("Raw", "RUV"), title="", method="minmax")

#Create a random annotation file
anno<-as.matrix(sample(1:4, dim(Y.hat)[1], replace=TRUE))
colnames(anno)<-"Factor"
try(dev.off(), silent=TRUE)
RLEPlot(Y$Y, Y.hat, name=c("Raw", "RUV"), title="", method="IQR.points",
anno=anno, Factor="Factor", numeric=TRUE)
```

---

RUVcorr

*Removal of unwanted variation for gene-gene correlations.*


---

**Description**

**RUVcorr** allows to apply global removal of unwanted variation (ridged version of RUV) to real and simulated gene expression data.

**Details**

All gene expression data are assumed to be in the following format:

- Rows correspond to arrays.
- Columns correspond to genes.

**Author(s)**

Saskia Freytag

---

RUVNaiveRidge	<i>Removal of unwanted variation for gene correlations.</i>
---------------	---

---

### Description

RUVNaiveRidge applies the ridged version of global removal of unwanted variation to simulated or real gene expression data.

### Usage

```
RUVNaiveRidge(Y, center = TRUE, nc_index, nu, kW, check.input = FALSE)
```

```
## Default S3 method:
```

```
RUVNaiveRidge(Y, center = TRUE, nc_index, nu, kW, check.input = FALSE)
```

```
## S3 method for class 'simulateGEdata'
```

```
RUVNaiveRidge(Y, center = TRUE, nc_index, nu, kW, check.input = FALSE)
```

### Arguments

Y	A matrix of gene expression values or an object of class simulateGEdata.
center	A logical scalar; if TRUE the data is centered, if FALSE data is assumed to be already centered.
nc_index	A vector of indices of negative controls.
nu	A numeric scalar value of $\nu \geq 0$ .
kW	An integer setting the number of dimensions for the estimated noise.
check.input	A logical scalar; if TRUE all input is checked (not advisable for large simulations).

### Details

The parameter kW controls how much noise is cleaned, whereas the parameter nu controls the amount of ridging to deal with possible dependence of the noise and the factor of interest.

### Value

RUVNaiveRidge returns a matrix of the cleaned (RUV-treated) centered gene expression values.

### Author(s)

Saskia Freytag, Laurent Jacob

### References

Jacob L., Gagnon-Bartsch J., Speed T. Correcting gene expression data when neither the unwanted variation nor the factor of interest are observed. Berkley Technical Reports (2012).

**Examples**

```

Y<-simulateGEData(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=TRUE, check.input=FALSE)
Y
Y.hat<-RUVNaiveRidge(Y, center=TRUE, nc_index=251:500, 0, 9, check.input=TRUE)
cor(Y.hat[,1:5])
Y$Sigma[1:5,1:5]
Y.hat<-RUVNaiveRidge(Y, center=FALSE, nc_index=251:500, 0, 10, check.input=TRUE)
cor(Y.hat[,1:5])
Y$Sigma[1:5,1:5]

```

simulateGEData

*Simulate gene expression data.***Description**

simulateGEData returns simulated noisy gene expression values of specified size and its underlying gene-gene correlation.

**Usage**

```

simulateGEData(
  n,
  m,
  k,
  size.alpha,
  corr.strength,
  g = NULL,
  Sigma.eps = 0.1,
  nc,
  ne,
  intercept = TRUE,
  check.input = FALSE
)

```

**Arguments**

n	An integer setting the number of genes.
m	An integer setting the number of arrays.
k	An integer setting number of dimensions of noise term, controls dimension of $W$ and $\alpha$ .
size.alpha	A numeric scalar giving the maximal and minimal absolute value of $\alpha$ .
corr.strength	An integer controlling the dimension of $X$ and $\beta$ .
g	An integer value between $[1, \min(k, \text{corr.strength})]$ giving the correlation between $X$ and $W$ or NULL for independence.
Sigma.eps	A numeric scalar setting the amount of random variation in $\epsilon$ ; $\text{Sigma.eps} > 0$ .
nc	An integer setting the number of negative controls.
ne	An integer setting the number of strongly expressed genes.
intercept	An logical value indicating whether the systematic noise has an intercept.
check.input	A logical scalar; if TRUE all input is checked (not advisable for large simulations).

## Details

This function generates log2-transformed expression values of  $n$  genes in  $m$  arrays. The expression values consist of true expression and noise:

$$Y = X\beta + W\alpha + \epsilon$$

The dimensions of the matrices  $X$  and  $\beta$  are used to control the size of the correlation between the genes. It is possible to simulate three different classes of genes:

- correlated genes expressed with true log2-transformed values from 0 to 16
- correlated genes expressed with true log2-transformed values with mean 0
- uncorrelated genes with true log2-transformed expression equal to 0 (negative controls)

The negative control are always the last  $nc$  genes in the data, whereas the strongly expressed genes are always the first  $ne$  genes in the data. The parameter `intercept` controls whether the systematic noise has an offset or not. Note that the intercept is one dimension of  $W$ . It is possible to either simulate data where  $W$  and  $X$  are independent by setting `g` to `NULL`, or increasing correlation  $bWX$  between  $W$  and  $X$  by increasing `g`.

## Value

`simulateGEdata` returns output of the class `simulateGEdata`. An object of class `simulateGEdata` is a list with the following components:

- Truth A matrix containing the values of  $X\beta$ .
- Y A matrix containing the values in  $Y$ .
- Noise A matrix containing the values in  $W\alpha$ .
- Sigma A matrix containing the true gene-gene correlations, as defined by  $X\beta$ .
- Info A matrix containing some of the general information about the simulation.

## Author(s)

Saskia Freytag, Johann Gagnon-Bartsch

## References

Jacob L., Gagnon-Bartsch J., Speed T. Correcting gene expression data when neither the unwanted variation nor the factor of interest are observed. Berkley Technical Reports (2012).

## Examples

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=TRUE, check.input=TRUE)
Y
Y<-simulateGEdata(500, 500, 10, 2, 5, g=3, Sigma.eps=0.1,
250, 100, intercept=TRUE, check.input=TRUE)
Y
```

---

splitByFactor	<i>Splitting a data set by a particular factor.</i>
---------------	---

---

**Description**

Internal function that splits a data set according to a particular factor.

**Usage**

```
splitByFactor(X, anno, Factor)
```

**Arguments**

X	A matrix containing gene expressions.
anno	A dataframe or a matrix containing the annotation of arrays in X.
Factor	A character string corresponding to a column name of anno to be used for splitting.

**Value**

splitByFactor returns a list object.

**Author(s)**

Saskia Freytag

---

wcor	<i>Calculate weighted correlations.</i>
------	---

---

**Description**

wcor returns correlations weighted according to a provided object of class Weights.

**Usage**

```
wcor(X, anno, Factor, Weights)
```

**Arguments**

X	A matrix of gene expression values.
anno	A dataframe or a matrix containing the annotation of arrays in X.
Factor	A character string corresponding to a column name of anno; this should be the same used to generate Weights.
Weights	An object of class Weights or a list of weights.

**Value**

wcor returns a matrix.



**Author(s)**

Saskia Freytag

**Examples**

```
Y<-simulateGEdata(500, 500, 10, 2, 5, g=NULL, Sigma.eps=0.1,
250, 100, intercept=FALSE, check.input=FALSE)
anno<-as.matrix(sample(1:5, dim(Y$Y)[1], replace=TRUE))
colnames(anno)<-"Factor"
weights<-findWeights(Y$Y, anno, "Factor")
wcor(Y$Y[,1:5], anno, "Factor", weights)
```

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