Package 'iCheck'

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Type Package

Title QC Pipeline and Data Analysis Tools for High-Dimensional Illumina mRNA Expression Data

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Description QC pipeline and data analysis tools for high-dimensional Illumina mRNA expression data.

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Contents

`boxPlots` *Draw parallel plots for top results in whole-genome-wide analysis*

Description

Draw scatter plots for top results in whole-genome-wide analysis to test for the association of probes to a continuous-type phenotype variable.

Usage

```
boxPlots(
  resFrame,
  es,
  col.resFrame = c("probeIDs", "stats", "pval", "p.adj"),
  var.pheno = "sex",
  var.probe = "TargetID",
  var.gene = "Symbol",
  var.chr = "Chr",
  nTop = 20,
  myylab = "expression level",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "boxPlots.ps")
```

Arguments

`resFrame`	A data frame stores testing results, which must contain columns that indicate probe id, test statistic, p-value and optionally adjusted p-value.
`es`	An `ExpressionSet` object that used to run the whole genome-wide tests.
`col.resFrame`	A vector of characters indicating column names of `resFrame` corresponding to probe id, test statistic, p-value and optionally adjusted p-value.

var.pheno	character. the name of continuous-type phenotype variable that is used to test the association of this variable to probes.
var.probe	character. the name of feature variable indicating probe id.
var.gene	character. the name of feature variable indicating gene symbol.
var.chr	character. the name of feature variable indicating chromosome number.
nTop	integer. indicating how many top tests will be used to draw the scatter plot.
myylab	character. indicating y-axis label.
datExtrFunc	name of the function to extract genomic data. For an ExpressionSet object, you should set datExtrFunc=exprs; for a MethyLumiSet object, you should set datExtrFunc=betas.
fileFlag	logic. indicating if plot should be saved to an external figure file.
fileFormat	character. indicating the figure file type. Possible values are "ps", "pdf", or "jpeg". All other values will produce "png" file.
fileName	character. indicating figure file name (file extension should be specified). For example, you set fileFormat="pdf", then you can set fileName="test.pdf", but not fileName="test".

Value

Value 0 will be returned if no error occurs.

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)

res.limma = lmFitWrapper(
  es = es.sim,
  formula = ~as.factor(memSubj),
  pos.var.interest = 1,
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  verbose = TRUE)

boxPlots(
  resFrame=res.limma$frame,
```

```
  es=es.sim,
  col.resFrame = c("probeIDs", "stats", "pval"),
  var.pheno = "memSubj",
  var.probe = "probe",
  var.gene = "gene",
  var.chr = "chr",
  nTop = 20,
  myylab = "expression level",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "boxPlots.ps")
```

`densityPlots` *Draw estimated density plots for all arrays*

Description

Draw estimated density plots for all arrays.

Usage

```
densityPlots(
  es,
  requireLog2 = TRUE,
  myxlab = "expression level",
  mymain = "density plots",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "densityPlots.ps")
```

Arguments

`es`	An `ExpressionSet` object that used to run the whole genome-wide tests.
`requireLog2`	logic. indicating if log2 transformation is required before estimating densities.
`myxlab`	character. indicating x-axis label.
`mymain`	character. indicating title of the plot.
`datExtrFunc`	name of the function to extract genomic data. For an `ExpressionSet` object, you should set `datExtrFunc=exprs`; for a `MethyLumiSet` object, you should set `datExtrFunc=betas`.
`fileFlag`	logic. indicating if plot should be saved to an external figure file.
`fileFormat`	character. indicating the figure file type. Possible values are "ps", "pdf", or "jpeg". All other values will produce "png" file.
`fileName`	character. indicating figure file name (file extension should be specified). For example, you set `fileFormat="pdf"`, then you can set `fileName="test.pdf"`, but not `fileName="test"`.

Value

A list object, the i-th element is the object returned by function `density` for the i-th array.

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)

densityPlots(
  es = es.sim,
  requireLog2 = FALSE,
  myxlab = "expression level",
  mymain = "density plots",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "densityPlots.ps")
```

---

genExprSet *Generate an ExpressionSet object*

Description

Generate a simple ExpressionSet object.

Usage

```
genExprSet(
  ex,
  pDat,
  fDat = NULL,
  annotation = "lumiHumanAll.db")
```

Arguments

`ex`	A matrix of expression levels. Rows are gene probes and columns are arrays.
`pDat`	A data frame describing arrays. Rows are arrays and columns are variables describing arrays. The row names of `pDat` must be the same as the column of `ex`.

fDat	A data frame describing gene probes. Rows are gene probes and columns are variables describing gene probes. The rownames of fDat must be the same as that of ex.
annotation	character string. Indicating the annotation library (e.g. lumiHumanAll.db for the gene probes.

Value

an ExpressionSet object.

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---

genSimData.BayesNormal

Generating simulated data set from conditional normal distributions

---

Description

Generating simulated data set from conditional normal distributions.

Usage

```
genSimData.BayesNormal(
  nCpGs,
  nCases,
  nControls,
  mu.n = -2,
  mu.c = 2,
  d0 = 20,
  s02 = 0.64,
  s02.c = 1.5,
  testPara = "var",
  outlierFlag = FALSE,
  eps = 0.001,
  applier = lapply)
```

Arguments

nCpGs	integer. Number of genes.
nCases	integer. Number of cases.
nControls	integer. Number of controls.
mu.n	numeric. mean of the conditional normal distribution for controls. See details.
mu.c	numeric. mean of the conditional normal distribution for cases. See details.
d0	integer. degree of freedom for scale-inverse chi squared distribution. See details.
s02	numeric. scaling parameter for scale-inverse chi squared distribution for controls. See details.

s02.c	numeric. scaling parameter for scale-inverse chi squared distribution for cases. See details.
testPara	character string. indicating if the test is for testing equal mean, equal variance, or both.
outlierFlag	logical. indicating if outliers would be generated. If outlierFlag=TRUE, then we followed Phipson and Oshlack's (2014) simulation studies to generate one outlier for each CpG site by replacing the DNA methylation level of one diseased subject by the maximum of the DNA methylation levels of all CpG sites.
eps	numeric. if $\|mean0 - mean1\| < eps$ then we regard $mean0 = mean1$. Similarly, if $\|var0 - var1\| < eps$ then we regard $var0 = var1$. $mean0$ and $var0$ are the mean and variance of the chi squared distribution for controls. $mean1$ and $var1$ are the mean and variance of the chi squared distribution for cases.
applier	function name to do apply operation.

Details

Based on Phipson and Oshlack's (2014) simulation algorithm. For each CpG site, variance of the DNA methylation was first sampled from an scaled inverse chi-squared distribution with degree of freedom d_0 and scaling parameter s_0^2: σ_i^2 $scale - inv\chi^2(d_0, s_0^2)$. M value for each CpG was then sampled from a normal distribution with mean μ_n and variance equal to the simulated variance σ_i^2. For cases, the variance was first generated from $\sigma_{i,c}^2$ $scale - inv\chi^2(d_0, s_{0,c}^2)$. M value for each CpG was then sampled from a normal distribution with mean μ_c and variance equal to the simulated variance $\sigma_{i,c}^2$.

Value

An ExpressionSet object. The phenotype data of the ExpressionSet object contains 2 columns: arrayID (array id) and memSubj (subject membership, i.e., case (memSubj=1) or control (memSubj=0)). The feature data of the ExpressionSet object contains 4 elements: probe (probe id), gene (psuedo gene symbol), chr (psuedo chromosome number), and memGenes (indicating if a gene is differentially expressed (when testPara="mean") or indicating if a gene is differentially variable (when testPara="var")).

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References

Phipson B, Oshlack A. DiffVar: A new method for detecting differential variability with application to methylation in cancer and aging. *Genome Biol* 2014; 15:465

Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
```

```
  eps = 1.0e-3, applier = lapply)
print(es.sim)
```

`getPCAFunc` *Get principal components of arrays*

Description

Get principal components of arrays.

Usage

```
getPCAFunc(es,
           labelVariable = "subjID",
            hybName = "Hybridization_Name",
           requireLog2 = TRUE,
           corFlag = FALSE
)
```

Arguments

`es`	An `ExpressionSet` object
`labelVariable`	A character string. The name of a phenotype data variable use to label the arrays in the boxplots. By default, `labelVariable = "subjID"` which is equivalent to `labelVariable = "Hybridization_Name"`.
`hybName`	character string. indicating the phenotype variable `Hybridization_Name`.
`requireLog2`	logical. `requiredLog2=TRUE` indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
`corFlag`	logical. Indicating if correlation matrix (`corFlag=TRUE`) or covariance (`corFlag=FALSE`) is used to obtain principal components.

Value

A list with 3 elements:

`es.s`	An `ExpressionSet` object with the arrays sorted according to Batch_Run_Date, Chip_Barcode, and Chip_Address
`pcs`	An object returned by the function `prcomp` of the R package `stats`. It contans the following components. `sdev` (the square roots of the eigenvalues of the covariance/correlation matrix); `rotation` (a matrix whose columns contain the eigenvectors); `x` (a matrix whose columns contain principal components); `center` (the centering used or `FALSE`); `scale` (the scale used or `FALSE`)
`requireLog2`	logical. The same value as the input `requireLog2`.

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)

pca.obj = getPCAFunc(es = es.sim,
           labelVariable = "subjID",
           hybName = "memSubj",
           requireLog2 = FALSE,
           corFlag = FALSE
)
```

`glmWrapper` *Perform glm test for all gene probes*

Description

Perform glm test for all gene probes.

Usage

```
glmWrapper(es,
           formula = FEV1 ~ xi + age + gender,
           pos.var.interest = 1,
           family = gaussian,
           logit = FALSE,
           pvalAdjMethod = "fdr",
           alpha = 0.05,
           probeID.var = "ProbeID",
           gene.var = "Symbol",
           chr.var = "Chromosome",
           applier = lapply,
           verbose = TRUE)
```

Arguments

`es`	An LumiBatch object. `fData(es)` should contains information about probe ID, chromosome number and gene symbol.
`formula`	An object of class `formula`. The left handside of `~` is the response variable. Gene probe must be represented by the variable `xi`. For example, `xi~age+gender` (gene probe is the response variable); Or `FEV1~xi+age+gender` (gene probe is the predictor).
`pos.var.interest`	integer. Indicates which covariate in the right-hand-size of `~` of `formula` is of the interest. pos.var.interest $= 0$ means the intercept is of the interest. If the covariate of the interest is an factor or interaction term with more than 2 levels, the smallest p-value will represent the pvalue for the covariate of the interest.

family	By default is gaussian. refer to glm.
logit	logical. Indicate if the gene probes will be logit transformed. For example, for DNA methylation data, one might want to logit transformation for the beta-value $(methylated/(methylated + unmethylated))$.
pvalAdjMethod	One of p-value adjustment methods provided by the R function p.adjust in R package stats: "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none".
alpha	Significance level. A test is claimed to be significant if the adjusted p-value $<$ alpha.
probeID.var	character string. Name of the variable indicating probe ID in feature data set.
gene.var	character string. Name of the variable indicating gene symbol in feature data set.
chr.var	character string. Name of the variable indicating chromosome number in feature data set.
applier	By default, it is lapply. If the library multicore is available, can use mclapply to replace lappy.
verbose	logical. Determine if intermediate output need to be suppressed. By default verbose=TRUE, intermediate output will be printed.

Details

This function applies R function glm for each gene probe.

Value

A list with the following elements:

n.sig	Number of significant tests after p-value adjustment.
frame	A data frame containing test results sorted according to the ascending order of unadjusted p-values for the covariate of the interest. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (z-value), pval (p-values of the tests for the covariate of the interest), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).
statMat	A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the covariate of the interest.
pvalMat	A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the covariate of the interest.
pval.quantile	Quantiles (minimum, 25 for each covariate including intercept provided in the input argument formula.
frame.unsorted	A data frame containing test results. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (z-value for the covariate of the interest), pval (p-values of the tests for the covariate of the interest), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).

`statMat.unsorted`
: A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates.

`pvalMat.unsorted`
: A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates.

`memGenes`
: A numeric vector indicating the cluster membership of probes (unsorted). `memGenes[i]=1` if the i-th probe is significant (adjusted pvalue $<$ `alpha`) with positive z-value for the covariate of the interest; `memGenes[i]=2` if the i-th probe is nonsignificant ; `memGenes[i]=3` if the i-th probe is significant with negative z-value for the covariate of the interest;

`memGenes2`
: A numeric vector indicating the cluster membership of probes (unsorted). `memGenes2[i]=1` if the i-th probe is significant (adjusted pvalue $<$ `alpha`). `memGenes2[i]=0` if the i-th probe is nonsignificant.

`mu1`
: Mean expression levels for arrays for probe cluster 1 (average taking across all probes with `memGenes` value equal to 1.

`mu2`
: Mean expression levels for arrays for probe cluster 2 (average taking across all probes with `memGenes` value equal to 2.

`mu3`
: Mean expression levels for arrays for probe cluster 3 (average taking across all probes with `memGenes` value equal to 3.

`resMat`
: A matrix with $2p$ columns, where p is the number of covariates (including intercept; for a nominal variable with 3 levels say, there were 2 dummy covariates). The first p columns are p-values. The remaining p columns are test statistics.

Note

If the covariate of the interest is a factor or interaction term with more than 2 levels, then the p-value of the likelihood ratio test might be more appropriate than the smallest p-value for the covariate of the interest.

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Examples

```
  # generate simulated data set from conditional normal distribution
  set.seed(1234567)
  es.sim = genSimData.BayesNormal(nCpGs = 100,
    nCases = 20, nControls = 20,
    mu.n = -2, mu.c = 2,
    d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
    outlierFlag = FALSE,
    eps = 1.0e-3, applier = lapply)
  print(es.sim)

 res.glm = glmWrapper(
es = es.sim,
formula = xi~as.factor(memSubj),
pos.var.interest = 1,
family = gaussian,
```

```
  logit = FALSE,
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  applier = lapply,
  verbose = TRUE)
```

`lkhrWrapper` *Perform glm test for all gene probes*

Description

Perform glm test for all gene probes.

Usage

```
lkhrWrapper(es,
            formulaReduced = FEV1 ~ xi + gender,
            formulaFull =    FEV1 ~ xi + age + gender,
            family = gaussian,
            logit = FALSE,
            pvalAdjMethod = "fdr",
            alpha = 0.05,
            probeID.var = "ProbeID",
            gene.var = "Symbol",
            chr.var = "Chromosome",
            applier = lapply,
            verbose = TRUE)
```

Arguments

`es`	An LumiBatch object. `fData(es)` should contains information about probe ID, chromosome number and gene symbol.
`formulaReduced`	An object of class `formula`. Formula for reduced model. The left handside of `~` is the response variable. Gene probe must be represented by the variable `xi`. For example, `xi~gender` (gene probe is the response variable); Or `FEV1~xi+gender` (gene probe is the predictor).
`formulaFull`	An object of class `formula`. Formula for Full model. The left handside of `~` is the response variable. Gene probe must be represented by the variable `xi`. For example, `xi~age+gender` (gene probe is the response variable); Or `FEV1~xi+age+gender` (gene probe is the predictor).
`family`	By default is gaussian. refer to `glm`.
`logit`	logical. Indicate if the gene probes will be logit transformed. For example, for DNA methylation data, one might want to logit transformation for the beta-value $(methylated/(methylated + unmethylated))$.

pvalAdjMethod	One of p-value adjustment methods provided by the R function p.adjust in R package stats: "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none".
alpha	Significance level. A test is claimed to be significant if the adjusted p-value $<$ alpha.
probeID.var	character string. Name of the variable indicating probe ID in feature data set.
gene.var	character string. Name of the variable indicating gene symbol in feature data set.
chr.var	character string. Name of the variable indicating chromosome number in feature data set.
applier	By default, it is lapply. If the library multicore is available, can use mclapply to replace lappy.
verbose	logical. Determine if intermediate output need to be suppressed. By default verbose=TRUE, intermediate output will be printed.

Details

This function applies R functions lrtest in R package lmtest and glm for each gene probe.

Value

A list with the following elements:

frame	A data frame containing test results sorted according to the ascending order of unadjusted p-values for the covariate of the interest. The data frame contains 8 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), Chisq (chi square test statistic), Df (degree of freedom of the chisquare test statistic), pval (p-values of the tests for the covariate of the interest), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix). The rows are ordered based on the descending order of chisquare test statistic.
frame.unsorted	A data frame containing test results. unordered frame.

Author(s)

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Examples

```
    # generate simulated data set from conditional normal distribution
    set.seed(1234567)
    es.sim = genSimData.BayesNormal(nCpGs = 100,
      nCases = 20, nControls = 20,
      mu.n = -2, mu.c = 2,
      d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
      outlierFlag = FALSE,
      eps = 1.0e-3, applier = lapply)
    print(es.sim)

set.seed(1234567)
es.sim$age = rnorm(ncol(es.sim), mean=50, sd=5)
```

```
res.lkh = lkhrWrapper(
  es = es.sim,
  formulaReduced = xi ~ memSubj,
  formulaFull =    xi ~ memSubj + age,
  family = gaussian(),
  logit = FALSE,
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  applier = lapply,
  verbose = TRUE)
```

`lmFitPaired` *A wrapper function for the function 'lmFit' of the R Bioconductor package 'limma' for paired data*

Description

A wrapper function for the function 'lmFit' of the R Bioconductor package 'limma' for paired data.

Usage

```
lmFitPaired(
    esDiff,
    formula = ~1,
    pos.var.interest = 0,
    pvalAdjMethod = "fdr",
    alpha = 0.05,
    probeID.var="ProbeID",
    gene.var = "Symbol",
    chr.var = "Chromosome",
    verbose = TRUE)
```

Arguments

`esDiff`	An LumiBatch object containing log2 difference between cases and controls. `fData(esDiff)` should contains information about probe ID, chromosome number and gene symbol.
`formula`	An object of class `formula`. The intercept measures the effect of treatment. Other covariates measure the effects of their interaction and treatment. The p-values for the intercept will be output. No left handside of ~ should be specified since the response variable will be the expression level.
`pos.var.interest`	integer. Indicates which covariate on the right-hand-side of ~ in `formula` is the covariate of the interest. By default, it is the intercept `pos.var.interest=0`.
`pvalAdjMethod`	One of p-value adjustment methods provided by the R function `p.adjust` in R package `stats`: "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none".

alpha	Significance level. A test is claimed to be significant if the adjusted p-value $<$ alpha.
probeID.var	character string. Name of the variable indicating probe ID in feature data set.
gene.var	character string. Name of the variable indicating gene symbol in feature data set.
chr.var	character string. Name of the variable indicating chromosome number in feature data set.
verbose	logical. Determine if intermediate output need to be suppressed. By default verbose=TRUE, intermediate output will be printed.

Details

This is a wrapper function of R Bioconductor functions lmFit and eBayes for paired data to make it easier to input design and output list of significant results.

Value

A list with the following elements:

n.sig	Number of significant tests after p-value adjustment.
frame	A data frame containing test results sorted according to the ascending order of unadjusted p-values for the intercept. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (moderated t-statistics for the intercept), pval (p-values of the tests for the intercept), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).
statMat	A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the intercept.
pvalMat	A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the intercept.
pval.quantile	Quantiles (minimum, 25 for all covariates including intercept provided in the input argument formula.
frame.unsorted	A data frame containing test results. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (moderated t-statistics for the intercept), pval (p-values of the tests for the intercept), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).
statMat.unsorted	A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates.
pvalMat.unsorted	A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates.
memGenes	A numeric vector indicating the cluster membership of probes (unsorted). memGenes[i]=1 if the i-th probe is significant (adjusted pvalue $<$ alpha) with positive moderated t-statistic; memGenes[i]=2 if the i-th probe is nonsignificant ; memGenes[i]=3 if the i-th probe is significant with negative moderated t-statistic;

memGenes2	A numeric vector indicating the cluster membership of probes (unsorted). memGenes2[i]=1 if the i-th probe is significant (adjusted pvalue $<$ alpha). memGenes2[i]=0 if the i-th probe is nonsignificant.
mu1	Mean expression levels for arrays for probe cluster 1 (average taking across all probes with memGenes value equal to 1.
mu2	Mean expression levels for arrays for probe cluster 2 (average taking across all probes with memGenes value equal to 2.
mu3	Mean expression levels for arrays for probe cluster 3 (average taking across all probes with memGenes value equal to 3.
ebFit	object returned by R Bioconductor function eBayes.

Author(s)

Weiliang Qiu <stwxq@channing.harvard.edu>, Brandon Guo <brandowonder@gmail.com>, Christopher Anderson <christopheranderson84@gmail.com>, Barbara Klanderman <BKLANDERMAN@partners.org>, Vincent Carey <stvjc@channing.harvard.edu>, Benjamin Raby <rebar@channing.harvard.edu>

Examples

```
    # generate simulated data set from conditional normal distribution
    set.seed(1234567)
    es.sim = genSimData.BayesNormal(nCpGs = 100,
      nCases = 20, nControls = 20,
      mu.n = -2, mu.c = 2,
      d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
      outlierFlag = FALSE,
      eps = 1.0e-3, applier = lapply)
    print(es.sim)

  # although the generated data is not from
  # paired design, we use it to illusrate the
  # usage of the function lmFitPaired


res.limma = lmFitPaired(
  es = es.sim,
  formula = ~as.factor(memSubj),
  pos.var.interest = 0, # the intercept is what we are interested
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  verbose = TRUE)
```

---

lmFitWrapper *A wrapper function for the function 'lmFit' of the R Bioconductor package 'limma'*

Description

A wrapper function for the function 'lmFit' of the R Bioconductor package 'limma'.

Usage

```
lmFitWrapper(
    es,
    formula = ~as.factor(gender),
    pos.var.interest = 1,
    pvalAdjMethod = "fdr",
    alpha = 0.05,
    probeID.var = "ProbeID",
    gene.var = "Symbol",
    chr.var = "Chromosome",
    verbose = TRUE)
```

Arguments

es	An LumiBatch object. fData(es) should contains information about chromosome number and gene symbol.
formula	An object of class formula. No left handside of ~ should be specified since the response variable will be the expression level.
pos.var.interest	integer. Indicates which covariate on the right-hand-side of ~ in formula is the covariate of the interest. By default, it is the first covariate pos.var.interest=1.
pvalAdjMethod	One of p-value adjustment methods provided by the R function p.adjust in R package stats: "holm", "hochberg", "hommel", "bonferroni", "BH", "BY", "fdr", "none".
alpha	Significance level. A test is claimed to be significant if the adjusted p-value $<$ alpha.
probeID.var	character string. Name of the variable indicating probe ID in feature data set.
gene.var	character string. Name of the variable indicating gene symbol in feature data set.
chr.var	character string. Name of the variable indicating chromosome number in feature data set.
verbose	logical. Determine if intermediate output need to be suppressed. By default verbose=TRUE, intermediate output will be printed.

Details

This is a wrapper function of R Bioconductor functions lmFit and eBayes to make it easier to input design and output list of significant results.

Value

A list with the following elements:

n.sig	Number of significant tests after p-value adjustment.
frame	A data frame containing test results sorted according to the ascending order of unadjusted p-values for the covariate of the interest. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (moderated t-statistics for the covariate of interest, i.e. the first covariate), \ codepval (p-values of the tests for the covariate of interest, i.e. the first

covariate), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).

statMat — A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the covariate of the interest.

pvalMat — A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates. The rows are ordered according to the ascending order of unadjusted p-values for the covariate of the interest.

pval.quantile — Quantiles (minimum, 25 for all covariates including intercept provided in the input argument formula.

frame.unsorted — A data frame containing test results. The data frame contains 7 columns: probeIDs, geneSymbols (gene symbols of the genes where the probes come from), chr (numbers of chromosomes where the probes locate), stats (moderated t-statistics for the covariate of the interest), pval (p-values of the tests for the covariate of the interest), p.adj (adjusted p-values), pos (row numbers of the probes in the expression data matrix).

statMat.unsorted — A matrix containing test statistics for all covariates and for all probes. Rows are probes and columns are covariates.

pvalMat.unsorted — A matrix containing pvalues for all covariates and for all probes. Rows are probes and columns are covariates.

memGenes — A numeric vector indicating the cluster membership of probes (unsorted). memGenes[i]=1 if the i-th probe is significant (adjusted pvalue $<$ alpha) with positive moderated t-statistic; memGenes[i]=2 if the i-th probe is nonsignificant ; memGenes[i]=3 if the i-th probe is significant with negative moderated t-statistic;

memGenes2 — A numeric vector indicating the cluster membership of probes (unsorted). memGenes2[i]=1 if the i-th probe is significant (adjusted pvalue $<$ alpha). memGenes2[i]=0 if the i-th probe is nonsignificant.

mu1 — Mean expression levels for arrays for probe cluster 1 (average taking across all probes with memGenes value equal to 1.

mu2 — Mean expression levels for arrays for probe cluster 2 (average taking across all probes with memGenes value equal to 2.

mu3 — Mean expression levels for arrays for probe cluster 3 (average taking across all probes with memGenes value equal to 3.

ebFit — object returned by R Bioconductor function eBayes.

Author(s)

Weiliang Qiu <stwxq@channing.harvard.edu>, Brandon Guo <brandowonder@gmail.com>, Christopher Anderson <christopheranderson84@gmail.com>, Barbara Klanderman <BKLANDERMAN@partners.org>, Vincent Carey <stvjc@channing.harvard.edu>, Benjamin Raby <rebar@channing.harvard.edu>

Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
```

```
    d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
    outlierFlag = FALSE,
    eps = 1.0e-3, applier = lapply)
  print(es.sim)


res.limma = lmFitWrapper(
  es = es.sim,
  formula = ~as.factor(memSubj),
  pos.var.interest = 1,
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  verbose = TRUE)
```

`LumiBatch2Table` *Output slots (exprs, pData, fData) of an LumiBatch object into 3 text files*

Description

Output slots (exprs, pData, fData) of an LumiBatch object into 3 text files.

Usage

```
LumiBatch2Table(
  es,
  probeID.var="ProbeID",
  gene.var="Symbol",
  chr.var="Chromosome",
  sep = ",",
  quote = FALSE,
  filePrefix = "test",
  fileExt = "csv")
```

Arguments

`es`	An LumiBatch object
`probeID.var`	character string. Name of the variable indicating probe ID in feature data set.
`gene.var`	character string. Name of the variable indicating gene symbol in feature data set.
`chr.var`	character string. Name of the variable indicating chromosome number in feature data set.
`sep`	Field delimiter for the output text files
`quote`	logical. Indicating if any character or factor. See also `write.table`.
`filePrefix`	Prefix of the names of the output files.
`fileExt`	File extension of the names of the output files.

Details

Suppose `filePrefix="test"` and `fileExt=".csv"`. Then, the file names of the 3 output files are: "test_exprs.csv", "test_pDat.csv", and "test_fDat.csv", respectively.

Value

None.

Author(s)

Weiliang Qiu <stwxq@channing.harvard.edu>, Brandon Guo <brandowonder@gmail.com>, Christopher Anderson <christopheranderson84@gmail.com>, Barbara Klanderman <BKLANDERMAN@partners.org>, Vincent Carey <stvjc@channing.harvard.edu>, Benjamin Raby <rebar@channing.harvard.edu>

Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)

LumiBatch2Table(
 es = es.sim,
 probeID.var="probe",
 gene.var="gene",
 chr.var="chr",
 sep = ",",
 quote = FALSE,
 filePrefix = "test",
 fileExt = "csv")
```

`pca2DPlot` *Scatter plot of first 2 principal components*

Description

Scatter plot of first 2 principal components.

Usage

```
pca2DPlot(pcaObj,
          plot.dim = c(1,2),
          labelVariable = "subjID",
          hybName = "Hybridization_Name",
          outFileName = "test_pca_raw.pdf",
          title = "Scatter plot of pcas",
          plotOutPutFlag = FALSE,
```

```
mar = c(5, 4, 4, 2) + 0.1,
lwd = 1.5,
equalRange = TRUE,
xlab = NULL,
ylab = NULL,
xlim = NULL,
ylim = NULL,
cex.legend = 1.5,
cex = 1.5,
cex.lab = 1.5,
cex.axis = 1.5,
legendPosition = "topright",
...)
```

Arguments

pcaObj	An object returned by the function pca of the R package pcaMethods.
plot.dim	A vector of 2 positive-integer-value integer specifying which 2 pcas will be plot.
labelVariable	The name of a column of the phenotype data matrix. The elements of the column will replace the column names of the expression data matrix.
hybName	character string. indicating the phenotype variable Hybridization_Name.
outFileName	Name of the figure file to be created.
title	Title of the scatter plot.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
equalRange	logical. Indicating if the x-axis and y-axis have the same range.
xlab	Label of x axis.
ylab	Label of y axis.
xlim	Range of x axis.
ylim	Range of y axis.
cex.legend	Font size for legend.
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
cex.lab	The magnification to be used for x and y labels relative to the current setting of cex.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.
legendPosition	Position of legend. Possible values are "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right" and "center".
...	Arguments to be passed to plot.

Value

A matrix of PCA scores. Each column corresponds to a principal component.

Author(s)

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Examples

```
    # generate simulated data set from conditional normal distribution
    set.seed(1234567)
    es.sim = genSimData.BayesNormal(nCpGs = 100,
      nCases = 20, nControls = 20,
      mu.n = -2, mu.c = 2,
      d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
      outlierFlag = FALSE,
      eps = 1.0e-3, applier = lapply)
    print(es.sim)

    pca.obj = getPCAFunc(es = es.sim,
                     labelVariable = "subjID",
                     hybName = "memSubj",
                     requireLog2 = FALSE,
                     corFlag = FALSE
)

pca2DPlot(pcaObj = pca.obj,
          plot.dim = c(1,2),
          labelVariable = "subjID",
          hybName = "memSubj",
          plotOutPutFlag = FALSE,
          cex.legend = 0.5,
          legendPosition = "topright")
```

`pca3DPlot` *Scatter plot of 3 specified principal components*

Description

Scatter plot of 3 specified principal components.

Usage

```
pca3DPlot(pcaObj,
          plot.dim = c(1,2, 3),
          labelVariable = "subjID",
           hybName = "Hybridization_Name",
          outFileName = "test_pca_raw.pdf",
          title = "Scatter plot of pcas",
          plotOutPutFlag = FALSE,
```

```
mar = c(5, 4, 4, 2) + 0.1,
lwd = 1.5,
equalRange = TRUE,
xlab = NULL,
ylab = NULL,
zlab = NULL,
xlim = NULL,
ylim = NULL,
zlim = NULL,
cex.legend = 1.5,
cex = 1.5,
cex.lab = 1.5,
cex.axis = 1.5,
legendPosition = "topright",
...)
```

Arguments

pcaObj	An object returned by the function pca of the R package pcaMethods.
plot.dim	A vector of 3 positive-integer-value integer specifying which 3 pcas will be plot.
labelVariable	The name of a column of the phenotype data matrix. The elements of the column will replace the column names of the expression data matrix.
hybName	character string. indicating the phenotype variable Hybridization_Name.
outFileName	Name of the figure file to be created.
title	Title of the scatter plot.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
equalRange	logical. Indicating if the x-axis and y-axis have the same range.
xlab	Label of x axis.
ylab	Label of y axis.
zlab	Label of z axis.
xlim	Range of x axis.
ylim	Range of y axis.
zlim	Range of z axis.
cex.legend	Font size for legend.
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
cex.lab	The magnification to be used for x and y labels relative to the current setting of cex.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.
legendPosition	Position of legend. Possible values are "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right" and "center".
...	Arguments to be passed to plot.

Value

A matrix of PCA scores. Each column corresponds to a principal component.

Author(s)

Weiliang Qiu <stwxq@channing.harvard.edu>, Brandon Guo <brandowonder@gmail.com>, Christopher Anderson <christopheranderson84@gmail.com>, Barbara Klanderman <BKLANDERMAN@partners.org>, Vincent Carey <stvjc@channing.harvard.edu>, Benjamin Raby <rebar@channing.harvard.edu>

Examples

```
    # generate simulated data set from conditional normal distribution
    set.seed(1234567)
    es.sim = genSimData.BayesNormal(nCpGs = 100,
      nCases = 20, nControls = 20,
      mu.n = -2, mu.c = 2,
      d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
      outlierFlag = FALSE,
      eps = 1.0e-3, applier = lapply)
    print(es.sim)

    pca.obj = getPCAFunc(es = es.sim,
                    labelVariable = "subjID",
                    hybName = "memSubj",
                    requireLog2 = FALSE,
                    corFlag = FALSE
)


pca3DPlot(pcaObj = pca.obj,
          plot.dim = c(1,2,3),
          labelVariable = "subjID",
          hybName = "memSubj",
          plotOutPutFlag = FALSE,
          cex.legend = 0.5,
          legendPosition = "topright")
```

`plotCurves` *Plot trajectories of probe profiles across arrays*

Description

Plot trajectories of probe profiles across arrays

Usage

```
plotCurves(
    dat,
    curveNames,
    fileName,
    plotOutPutFlag=FALSE,
```

```
    requireLog2 = FALSE,
    cex = 1,
    ylim = NULL,
    xlab = "",
    ylab = "intensity",
    lwd = 3,
    main = "Trajectory plot",
    mar = c(10, 4, 4, 2) + 0.1,
    las = 2,
    cex.axis=1,
    ...)
```

Arguments

dat	Numeric data matrix. Rows are probes; columns are arrays.
curveNames	Probe names.
fileName	file name of output figure.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
requireLog2	logical. requiredLog2=TRUE indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
ylim	Range of y axis.
xlab	Label of x axis.
ylab	Label of y axis.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
main	Main title of the plot.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.
las	'las' numeric in 0,1,2,3; the style of axis labels. 0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, or 3 - always vertical. see par.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.
...	Arguments to be passed to plot.

Value

no return value.

Author(s)

Weiliang Qiu <stwxq@channing.harvard.edu>, Brandon Guo <brandowonder@gmail.com>, Christopher Anderson <christopheranderson84@gmail.com>, Barbara Klanderman <BKLANDERMAN@partners.org>, Vincent Carey <stvjc@channing.harvard.edu>, Benjamin Raby <rebar@channing.harvard.edu>

Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)

# plot trajectories of the first 5 genes
plotCurves(
dat = exprs(es.sim)[1:5,],
curveNames = featureNames(es.sim)[1:5],
plotOutPutFlag=FALSE,
cex = 0.5,
requireLog2 = FALSE)
```

`plotQCCurves` *Plot trajectories of specific QC probes (e.g., biotin, cy3_hyb, housekeeping gene probes, low stringency probes, etc.) across arrays*

Description

Plot trajectories of specific QC probes (e.g., biotin, cy3_hyb, housekeeping gene probes, low stringency probes, etc.) across arrays

Usage

```
plotQCCurves(
    esQC,
    probes = c("biotin", "cy3_hyb", "housekeeping",
      "low_stringency_hyb", "signal", "p95p05"),
    labelVariable = "subjID",
    hybName = "Hybridization_Name",
    reporterGroupName = "Reporter_Group_Name",
    requireLog2 = TRUE,
    projectName = "test",
    plotOutPutFlag = FALSE,
    cex = 1,
    ylim = NULL,
    xlab = "",
    ylab = "intensity",
    lwd = 3,
    mar = c(10, 4, 4, 2) + 0.1,
    las = 2,
    cex.axis = 1,
    sortFlag = TRUE,
    varSort = c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
    timeFormat = c("%m/%d/%Y", NA, NA),
    ...)
```

Arguments

esQC	ExpressionSet object of QC probe profiles. fData(esQC) should contains the variable Reporter_Group_Name.
probes	A character vectors of QC probe names. By default, it includes the following probe names "biotin", "cy3_hyb", "housekeeping", "low_stringency_hyb", "signal", "p95p05". For "signal", trajectories of 5th, 25th, 50th, 75th, and 95th percentiles of the expression levels of all QC probes will be ploted. For "p95p05", the trajectory of the ratio of 95th percentile to 5th percentile of the expression levels of all QC probes will be ploted.
labelVariable	A character string. The name of a phenotype data variable use to label the arrays in the boxplots. By default, labelVariable = "subjID" which is equivalent to labelVariable = "Hybridization_Name".
hybName	character string. indicating the phenotype variable Hybridization_Name.
reporterGroupName	character string. indicating feature variable Reporter_Group_Name (QC probe's name).
requireLog2	logical. requiredLog2=TRUE indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
projectName	A character string. Name of the project. The plots will be saved as pdf format files, the names of which have the format projectName_probeName_traj_plot.pdf.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
ylim	Range of y axis.
xlab	Label of x axis.
ylab	Label of y axis.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.
las	'las' numeric in 0,1,2,3; the style of axis labels. 0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, or 3 - always vertical. see par.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.
sortFlag	logical. Indicates if arrays need to be sorted according to Batch_Run_Date, Chip_Barcode, and Chip_Address.
varSort	A vector of phenotype variable names to be used to sort the samples of es.
timeFormat	A vector of time format for the possible time variables in varSort. The length of timeFormat should be the same as that of varSort. For non-time variable, the corresponding time format should be set to be equal to NA.
...	Arguments to be passed to plot.

Value

no return value.

Author(s)

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
esQC.sim = genSimData.BayesNormal(nCpGs = 10,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)

print(esQC.sim)

fDat = fData(esQC.sim)
esQC.sim$Hybridization_Name = sampleNames(esQC.sim)
fDat$Reporter_Group_Name = c( rep("biotin", 5),
  rep("housekeeping", 5))
fData(esQC.sim)=fDat

# plot trajectories of the QC probes
plotQCCurves(
  esQC = esQC.sim,
  probes = c("biotin", "housekeeping"),
  labelVariable = "subjID",
  hybName = "Hybridization_Name",
  reporterGroupName = "Reporter_Group_Name",
  requireLog2 = FALSE,
  plotOutPutFlag = FALSE,
  sortFlag = FALSE)
```

`plotSamplep95p05` *Plot trajectories of the ratio of 95th percentile to 5th percentile of sample probe profiles across arrays*

Description

Plot trajectories of the ratio of 95th percentile to 5th percentile of sample probe profiles across arrays.

Usage

```
plotSamplep95p05(
    es,
    labelVariable = "subjID",
     hybName = "Hybridization_Name",
    requireLog2 = FALSE,
    projectName = "test",
    plotOutPutFlag = FALSE,
    cex = 1,
    ylim = NULL,
    xlab = "",
    ylab = "",
    lwd = 1.5,
    mar = c(10, 4, 4, 2) + 0.1,
    las = 2,
    cex.axis=1.5,
    title = "Trajectory of p95/p05",
    cex.legend = 1.5,
    cex.lab = 1.5,
    legendPosition = "topright",
    cut1 = 10,
    cut2 = 6,
    sortFlag = TRUE,
    varSort = c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
    timeFormat = c("%m/%d/%Y", NA, NA),
    verbose = FALSE,
    ...)
```

Arguments

es	ExpressionSet object of Sample probe profiles.
labelVariable	A character string. The name of a phenotype data variable use to label the arrays in the boxplots. By default, labelVariable = "subjID" which is equivalent to labelVariable = "Hybridization_Name".
hybName	character string. indicating the phenotype variable Hybridization_Name.
requireLog2	logical. requiredLog2=TRUE indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
projectName	A character string. Name of the project. The plots will be saved as pdf format files, the names of which have the format projectName_probeName_traj_plot.pdf.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
ylim	Range of y axis.
xlab	Label of x axis.
ylab	Label of y axis.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.

las	'las' numeric in 0,1,2,3; the style of axis labels. 0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, or 3 - always vertical. see par.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.
title	Figure title.
cex.legend	Font size of legend text.
cex.lab	The magnification to be used for x and y labels relative to the current setting of cex.
legendPosition	Position of legend. Possible values are "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right" and "center".
cut1	second horiztonal line setting the cutoff for the ratio p95/p05. A ratio above this line indicates the corresponding array is good.
cut2	second horiztonal line setting the cutoff for the ratio p95/p05. A ratio below this line indicates the corresponding array is bad.
sortFlag	logical. Indicates if arrays need to be sorted according to Batch_Run_Date, Chip_Barcode, and Chip_Address.
varSort	A vector of phenotype variable names to be used to sort the samples of es.
timeFormat	A vector of time format for the possible time variables in varSort. The length of timeFormat should be the same as that of varSort. For non-time variable, the corresponding time format should be set to be equal to NA. The details of the time format for time variable can be found in the R function strptime.
verbose	logical. Determine if intermediate output need to be suppressed. By default verbose=FALSE, intermediate output will not be printed.
...	Arguments to be passed to plot.

Details

The trajectory of the ratio of 95 to 5

Value

A list of 2 elements. The first element is the 2 x n matrix, where n is the number of arrays. The first row of the matrix is the 5-th percentile and the second row of the matrix is the 95-th percentile.

The second element is the ratio of the 95-th percentile to the 5-th percentile.

Author(s)

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
```

```
    mu.n = -2, mu.c = 2,
    d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
    outlierFlag = FALSE,
    eps = 1.0e-3, applier = lapply)
  print(es.sim)

es.sim$Batch_Run_Date = 1:ncol(es.sim)
es.sim$Chip_Barcode = 1:ncol(es.sim)
es.sim$Chip_Address = 1:ncol(es.sim)


plotSamplep95p05(
 es = es.sim,
 labelVariable = "subjID",
 hybName = "memSubj",
 requireLog2 = FALSE,
 projectName = "test",
 plotOutPutFlag = FALSE,
 title = "Trajectory of p95/p05",
 cex.legend = 0.5,
 legendPosition = "topright",
 sortFlag = TRUE,
 varSort = c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
 timeFormat = c("%m/%d/%Y", NA, NA),
 verbose = FALSE)
```

---

quantilePlot *Plot trajectories of quantiles across arrays*

Description

Plot trajectories of quantiles across arrays.

Usage

```
quantilePlot(
    dat,
    fileName,
    probs = c(0, 0.05, 0.25, 0.5, 0.75, 0.95, 1),
    plotOutPutFlag = FALSE,
    requireLog2 = FALSE,
    sortFlag = TRUE,
    cex = 1,
    ylim = NULL,
    xlab = "",
    ylab = "intensity",
    lwd = 3,
    main = "Trajectory plot of quantiles",
    mar = c(15, 4, 4, 2) + 0.1,
    las = 2,
    cex.axis = 1)
```

Arguments

dat	Expression data. Rows are gene probes; columns are arrays.
fileName	File name of output figure.
probs	quantiles (any real values between the interval $[0, 1]$).
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
requireLog2	logical. requiredLog2=TRUE indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
sortFlag	logical. sortFlag=TRUE indicates arrays will be sorted by the ascending order of MAD (median absolute deviation)
cex	numerical value giving the amount by which plotting text and symbols should be magnified relative to the default. see par.
ylim	Range of y axis.
xlab	Label of x axis.
ylab	Label of y axis.
lwd	The line width, a _positive_ number, defaulting to '1'. see par.
main	Charater string. main title of the plot.
mar	A numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. The default is 'c(5, 4, 4, 2) + 0.1'. see par.
las	'las' numeric in 0,1,2,3; the style of axis labels. 0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, or 3 - always vertical. see par.
cex.axis	The magnification to be used for axis annotation relative to the current setting of cex. see par.

Value

The quantile matrix with row quantiles and column array.

Author(s)

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)
```

```
png(file="qplot.png")

  quantilePlot(
    dat = exprs(es.sim),
    probs = c(0, 0.05, 0.25, 0.5, 0.75, 0.95, 1),
    plotOutPutFlag = FALSE,
    requireLog2 = FALSE,
    sortFlag = TRUE)

dev.off()
```

R2PlotFunc *Draw heatmap of square of correlations among arrays*

Description

Draw heatmap of square of correlations among arrays.

Usage

```
R2PlotFunc(
    es,
    hybName = "Hybridization_Name",
    arrayType = c("all", "replicates", "GC"),
    GCid = c("128115", "Hela", "Brain"),
    probs = seq(0, 1, 0.25),
    col = gplots::greenred(75),
    labelVariable = "subjID",
    outFileName = "test_R2_raw.pdf",
    title = "Raw Data R^2 Plot",
    requireLog2 = FALSE,
    plotOutPutFlag = FALSE,
    las = 2,
    keysize = 1,
    margins = c(10, 10),
    sortFlag = TRUE,
    varSort=c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
    timeFormat=c("%m/%d/%Y", NA, NA),
    ...)
```

Arguments

es	ExpressionSet object of QC probe profiles.
hybName	character string. indicating the phenotype variable Hybridization_Name.
arrayType	A character string indicating if the correlations are calculated based on all arrays, arrays with replicates, or genetic control arrays.
GCid	A vector of character string. symbols for genetic control samples. The symbols can be more than one.
probs	A vector of probabilities specify the quantiles of correlations to be output.

col	colors used for the image. see the function heatmap.2 in R package gplots.
labelVariable	A character string indicating how to label the arrays.
outFileName	A character string. The name of output file.
title	Title of the plot.
requireLog2	logical. requiredLog2=TRUE indicates probe expression levels will be log2 transformed. Otherwise, no transformation will be performed.
plotOutPutFlag	logical. plotOutPutFlag=TRUE indicates the plots will be output to pdf format files. Otherwise, the plots will not be output to external files.
las	'las' numeric in 0,1,2,3; the style of axis labels. 0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, or 3 - always vertical. see par.
keysize	numeric value indicating the size of the key. see the function heatmap.2 in R package gplots.
margins	numeric vector of length 2 containing the margins. see the function heatmap.2 in R package gplots.
sortFlag	logical. Indicates if arrays need to be sorted according to Batch_Run_Date, Chip_Barcode, and Chip_Address.
varSort	A vector of phenotype variable names to be used to sort the samples of es.
timeFormat	A vector of time format for the possible time variables in varSort. The length of timeFormat should be the same as that of varSort. For non-time variable, the corresponding time format should be set to be equal to NA. The details of the time format for time variable can be found in the R function strptime.
...	Arguments to be passed to heatmap.2.

Value

A list with 3 elments. The first element R2Mat is the matrix of squared correlation. The second element R2vec is the vector of the upper triangle of the matrix of squared correlation (diagnoal elements are excluded). The third element R2vec.within.req is the vector of within-replicate R^2, that is, any element in R2vec.within.req is the squared correlation coefficient between two arrays/replicates for a subject.

Author(s)

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)
```

```
es.sim$Batch_Run_Date = 1:ncol(es.sim)
es.sim$Chip_Barcode = 1:ncol(es.sim)
es.sim$Chip_Address = 1:ncol(es.sim)

# draw heatmap for the first 5 subjects
png(file="r2plot.png")
R2PlotFunc(
  es = es.sim[, 1:5],
  hybName = "memSubj",
  arrayType = c("all", "replicates", "GC"),
  GCid = c("128115", "Hela", "Brain"),
  probs = seq(0, 1, 0.25),
  col = gplots::greenred(75),
  labelVariable = "subjID",
  outFileName = "test_R2_raw.pdf",
  title = "Raw Data R^2 Plot",
  requireLog2 = FALSE,
  plotOutPutFlag = FALSE,
  las = 2,
  keysize = 1,
  margins = c(10, 10),
  sortFlag = TRUE,
  varSort=c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
  timeFormat=c("%m/%d/%Y", NA, NA))
dev.off()
```

`scatterPlots` *Draw scatter plots for top results in whole-genome-wide analysis*

Description

Draw scatter plots for top results in whole-genome-wide analysis to test for the association of probes to a continuous-type phenotype variable.

Usage

```
scatterPlots(
  resFrame,
  es,
  col.resFrame = c("probeIDs", "stats", "pval", "p.adj"),
  var.pheno = "bmi",
  outcomeFlag = FALSE,
  fitLineFlag = TRUE,
  var.probe = "TargetID",
  var.gene = "Symbol",
  var.chr = "Chr",
  nTop = 20,
  myylab = "expression level",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "scatterPlots.ps")
```

Arguments

resFrame	A data frame stores testing results, which must contain columns that indicate probe id, test statistic, p-value and optionally adjusted p-value.
es	An ExpressionSet object that used to run the whole genome-wide tests.
col.resFrame	A vector of characters indicating column names of resFrame corresponding to probe id, test statistic, p-value and optionally adjusted p-value.
var.pheno	character. the name of continuous-type phenotype variable that is used to test the association of this variable to probes.
outcomeFlag	logic. indicating if var.pheno is the outcome variable in regression analysis.
fitLineFlag	logic. indicating if a fitted line $y = a+bx$ should be plotted. If outcomeFlag=TRUE, then y is var.pheno and x is the top probe. If outcomeFlag=FALSE, then y is the top probe and x is var.pheno.
var.probe	character. the name of feature variable indicating probe id.
var.gene	character. the name of feature variable indicating gene symbol.
var.chr	character. the name of feature variable indicating chromosome number.
nTop	integer. indicating how many top tests will be used to draw the scatter plot.
myylab	character. indicating y-axis label.
datExtrFunc	name of the function to extract genomic data. For an ExpressionSet object, you should set datExtrFunc=exprs; for a MethyLumiSet object, you should set datExtrFunc=betas.
fileFlag	logic. indicating if plot should be saved to an external figure file.
fileFormat	character. indicating the figure file type. Possible values are "ps", "pdf", or "jpeg". All other values will produce "png" file.
fileName	character. indicating figure file name (file extension should be specified). For example, you set fileFormat="pdf", then you can set fileName="test.pdf", but not fileName="test".

Value

Value 0 will be returned if no error occurs.

Author(s)

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Examples

```
# generate simulated data set from conditional normal distribution
set.seed(1234567)
es.sim = genSimData.BayesNormal(nCpGs = 100,
  nCases = 20, nControls = 20,
  mu.n = -2, mu.c = 2,
  d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
  outlierFlag = FALSE,
  eps = 1.0e-3, applier = lapply)
print(es.sim)
```

```
# generate phenotype age
es.sim$age = rnorm(ncol(es.sim), mean=50, sd=5)

res.limma = lmFitWrapper(
  es = es.sim,
  formula = ~age,
  pos.var.interest = 1,
  pvalAdjMethod = "fdr",
  alpha = 0.05,
  probeID.var = "probe",
  gene.var = "gene",
  chr.var = "chr",
  verbose = TRUE)

scatterPlots(
  resFrame=res.limma$frame,
  es=es.sim,
  col.resFrame = c("probeIDs", "stats", "pval"),
  var.pheno = "age",
  outcomeFlag = FALSE,
  fitLineFlag = TRUE,
  var.probe = "probe",
  var.gene = "gene",
  var.chr = "chr",
  nTop = 20,
  myylab = "expression level",
  datExtrFunc = exprs,
  fileFlag = FALSE,
  fileFormat = "ps",
  fileName = "scatterPlots.ps")
```

`sortExpressionSet` *Sort the order of samples for an ExpressionSet object*

Description

Sort the order of samples for an ExpressionSet object.

Usage

```
sortExpressionSet(
    es,
    varSort = c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
    timeFormat = c("%m/%d/%Y", NA, NA)
)
```

Arguments

`es`	An ExpressionSet.
`varSort`	A vector of phenotype variable names to be used to sort the samples of `es`.
`timeFormat`	A vector of time format for the possible time variables in `varSort`. The length of `timeFormat` should be the same as that of `varSort`. For non-time variable, the corresponding time format should be set to be equal to `NA`. Please refer to function `strptime` of the `base` package.

Value

An ExpressionSet object with samples sorted based on the variables indicated in `varSort`.

Author(s)

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Examples

```
  # generate simulated data set from conditional normal distribution
  set.seed(1234567)
  es.sim = genSimData.BayesNormal(nCpGs = 100,
    nCases = 20, nControls = 20,
    mu.n = -2, mu.c = 2,
    d0 = 20, s02 = 0.64, s02.c = 1.5, testPara = "var",
    outlierFlag = FALSE,
    eps = 1.0e-3, applier = lapply)
  print(es.sim)

es.sim$Batch_Run_Date = 1:ncol(es.sim)
es.sim$Chip_Barcode = 1:ncol(es.sim)
es.sim$Chip_Address = 1:ncol(es.sim)


es.sim2 = sortExpressionSet(
  es = es.sim,
  varSort = c("Batch_Run_Date", "Chip_Barcode", "Chip_Address"),
  timeFormat = c("%m/%d/%Y", NA, NA)
)
```

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