

# Package ‘CSSQ’

September 18, 2024

**Title** Chip-seq Signal Quantifier Pipeline

**Version** 1.17.0

**Author** Ashwath Kumar [aut], Michael Y Hu [aut], Yajun Mei [aut], Yuhong Fan [aut]

**Maintainer** Fan Lab at Georgia Institute of Technology <yuhong.fan@biology.gatech.edu>

**Description** This package is designed to perform statistical analysis to identify statistically significant differentially bound regions between multiple groups of ChIP-seq dataset.

**License** Artistic-2.0

**Encoding** UTF-8

**biocViews** ChIPSeq, DifferentialPeakCalling, Sequencing, Normalization

**Depends** SummarizedExperiment, GenomicRanges, IRanges, S4Vectors, rtracklayer

**Imports** GenomicAlignments, GenomicFeatures, Rsamtools, ggplot2, grDevices, stats, utils

**Suggests** BiocStyle, knitr, rmarkdown, markdown

**VignetteBuilder** knitr

**LazyData** true

**RoxygenNote** 7.0.0

**git\_url** <https://git.bioconductor.org/packages/CSSQ>

**git\_branch** devel

**git\_last\_commit** f7f6b2d

**git\_last\_commit\_date** 2024-04-30

**Repository** Bioconductor 3.20

**Date/Publication** 2024-09-18

## Contents

ansTransform . . . . .	2
calculateFC . . . . .	3
calculatePvalue . . . . .	3
calculateTvalue . . . . .	4
DBAnalyze . . . . .	5
getBgSubVal . . . . .	5

getComparisons . . . . .	7
getNewLabels . . . . .	8
getRegionCounts . . . . .	8
kmeansNormalize . . . . .	9
loadCountData . . . . .	10
normalizeData . . . . .	11
plotDist . . . . .	11
preprocessData . . . . .	12

<b>Index</b>	<b>14</b>
--------------	-----------

---

ansTransform	<i>Perform quantification and normalization of count data</i>
--------------	---

---

## Description

This function quantifies each each region for a sample and performs background correction and normalization as instructed. Returns a vector of count information for the input regions.

## Usage

```
ansTransform(countData, noNeg = TRUE, plotDataToPDF = FALSE)
```

## Arguments

countData	A <a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">getRegionCounts</a> with count data.
noNeg	A Logical parameter indicating how to deal with negative values. When TRUE (default), all negative values will be moved to 0 before transforming. When FALSE, the signs will be maintained while the transformation will be applied to the absolute value. (default: TRUE)
plotDataToPDF	A logical parameter indicating whether to make plots of the data distribution to a separate PDF file for each sample. When TRUE, a histogram will be plotted for the data before and after transformation. When FALSE, no plots will be made. (default: FALSE)

## Value

A [RangedSummarizedExperiment-class](#) object containing the anscombe transformed count data as the assay.

## Examples

```
exRange <- GRanges(seqnames=c("chr1", "chr2", "chr3", "chr4"),
  ranges=IRanges(start=c(1000, 2000, 3000, 4000), end=c(1500, 2500, 3500, 4500)))
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
  package="CSSQ", mustWork = TRUE), sep="\t", header=TRUE)
exCount <- matrix(c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16), nrow=4, ncol=4)
exData <- SummarizedExperiment(assays = list(countData=exCount),
  rowRanges=exRange, colData=sampleInfo)
ansExData <- ansTransform(exData)
assays(ansExData)$ansCount
```

---

calculateFC	<i>Calculates Fold change values for the given label and comparison</i>
-------------	---

---

**Description**

This calculates the Fold change for the given comparison.

**Usage**

```
calculateFC(preprocessedData, label, comparison, numSamples)
```

**Arguments**

preprocessedData	A <a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">preprocessData</a> .
label	A vector containing the labels to use for the samples in preprocessedData.
comparison	A vector containing the comparison to be made. Names here need to correspond to the sample groups in the sample file (Eg. c("G1",G2") means the comparison G1/G2).
numSamples	Number of samples in the dataset.

**Value**

A vector that is the Fold change for the comparison and labels given.

**See Also**

[DBAnalyze](#) which calls this function

---

calculatePvalue	<i>Calculates P-value for the regions</i>
-----------------	---

---

**Description**

This calculates the adjusted P-values for the regions using column permutation and Benjamini Hochberg correction methods.

**Usage**

```
calculatePvalue(trueTstat, compare_tstats)
```

**Arguments**

trueTstat	The T-statistics value calculated using <a href="#">calculateTvalue</a> for the intended comparison.
compare_tstats	The T-statistics value calculated using <a href="#">calculateTvalue</a> for all other comparisons possible.

**Value**

A vector that is the adjusted P-value for the intended comparison.

**See Also**

[DBAnalyze](#) which calls this function

---

calculateTvalue	<i>Calculates modified T-statistics values for the given label and comparison</i>
-----------------	---

---

**Description**

This calculates the modified T-statistics for the given comparison.

**Usage**

```
calculateTvalue(preprocessedData, label, comparison, numSamples)
```

**Arguments**

preprocessedData	A <a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">preprocessData</a> .
label	A vector containing the labels to use for the samples in preprocessedData.
comparison	A vector containing the comparison to be made. Names here need to correspond to the sample groups in the sample file (Eg. c("G1",G2") means the comparison G1/G2).
numSamples	Number of samples in the dataset.

**Value**

A vector that is the modified T-statistics for the comparison and labels given.

**See Also**

[DBAnalyze](#) which calls this function

---

DBAnalyze

*Performs differential binding analysis*

---

### Description

This is a wrapper function that performs the different parts of differential binding analysis. Returns a [GRanges-class](#) with a calculated P-value and Fold change for each region.

### Usage

```
DBAnalyze(preprocessedData, comparison)
```

### Arguments

preprocessedData

A [RangedSummarizedExperiment-class](#) object from [preprocessData](#).

comparison

A vector containing the comparison to be made. Names here need to correspond to the sample groups in the sample file (Eg. c("G1", "G2") means the comparison G1/G2).

### Value

A [GRanges-class](#) object containing the regions along with their P-values and Fold change for the comparison.

### Examples

```
exRange <- GRanges(seqnames=c("chr1", "chr2", "chr3", "chr4"),
  ranges=IRanges(start=c(1000, 2000, 3000, 4000), end=c(1500, 2500, 3500, 4500)))
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
  package="CSSQ", mustWork = TRUE), sep="\t", header=TRUE)
exCount <- matrix(c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16), nrow=4, ncol=4)
exData <- SummarizedExperiment(assays = list(ansCount=exCount),
  rowRanges=exRange, colData=sampleInfo)
normExData <- normalizeData(exData, numClusters=2)
res <- DBAnalyze(normExData, comparison=c("HSMM", "HESC"))
res
```

---

getBgSubVal

*Perform quantification and normalization of count data*

---

### Description

This function quantifies each each region for a sample and performs background correction and normalization as instructed. Returns a vector of count information for the input regions.

**Usage**

```

getBgSubVal(
  analysisInfo,
  sampleIndex,
  normalizeReadDepth = TRUE,
  normalizeLength = FALSE,
  backgroundSubtract = TRUE,
  countMode = "Union",
  ignore.strand = TRUE,
  inter.feature = FALSE
)

```

**Arguments**

**analysisInfo** A [RangedSummarizedExperiment-class](#) object with regions and sample information from within [getRegionCounts](#).

**sampleIndex** Index of the sample to process.

**normalizeReadDepth** Logical indicating if count data should be normalized for library sequencing depth. When TRUE (default), counts will be normalized for sequencing depth for each library. When FALSE, no such normalization will be performed and raw counts will be used. (default: TRUE)

**normalizeLength** Logical indicating if count data should be normalized to the length of the regions. When TRUE, count data will be normalized for the length of the region being analyzed. When FALSE (default), no such normalization will be performed. (default: FALSE)

**backgroundSubtract** Logical indicating if background correction should be performed. When TRUE (default), background subtraction will be performed after length and depth normalization if applicable. When FALSE, no background subtraction will be performed. (default: TRUE)

**countMode** Count method passed on to `summarizeOverlaps` from `GenomicAlignments` package. ("Union", "IntersectionNotEmpty", "IntersectionStrict" or "user supplied function"). (default: "Union")

**ignore.strand** A logical indicating if strand should be considered when matching. (default: TRUE) Passed on to `summarizeOverlaps` from `GenomicAlignments` package.

**inter.feature** A logical indicating if the 'r countMode' should be aware of overlapping features. When TRUE, reads mapping to multiple features are dropped (i.e., not counted). When FALSE (default), these reads are retained and a count is assigned to each feature they map to. Passed on to `summarizeOverlaps` from `GenomicAlignments` package. (default: FALSE)

**Value**

A vector containing the counts for all the regions.

**See Also**

[getRegionCounts](#) which calls this function

**Examples**

```

regionBed <- read.table(system.file("extdata", "chr19_regions.bed",
package="CSSQ",mustWork = TRUE))
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
package="CSSQ",mustWork = TRUE),sep="\t",header=TRUE)
sampleInfo[,3] <- sapply(sampleInfo[,3],
function(x) system.file("extdata", x, package="CSSQ"))
sampleInfo[,5] <- sapply(sampleInfo[,5],
function(x) system.file("extdata", x, package="CSSQ"))
regionRange <- GRanges(seqnames=regionBed$V1,
ranges=IRanges(start=regionBed$V2,end=regionBed$V3))
analysisInfo <- SummarizedExperiment(rowRanges=regionRange,
colData=sampleInfo)
NormbgSubCounts <- data.frame(sapply(c(1:nrow(colData(analysisInfo))),
function(x) getBgSubVal(analysisInfo,sampleIndex = x,backgroundSubtract=TRUE,
normalizeReadDepth=TRUE,normalizeLength=FALSE,countMode="Union",
ignore.strand=TRUE,inter.feature=FALSE)))
NormbgSubCounts

```

---

getComparisons

*Identify possible combinations*


---

**Description**

This function creates a data frame of all possible combinations of sample labels. This information is utilized by [calculatePvalue](#) to calculate the P-value using column permutation method.

**Usage**

```
getComparisons(trueLabel, comparison, numSamples)
```

**Arguments**

trueLabel	The true labels for the samples.
comparison	A vector containing the comparison to be made. Names here need to correspond to the sample groups in the sample file (Eg. c("G1",G2") means the comparison G1/G2).
numSamples	Number of samples in the dataset.

**Value**

A data frame with possible combinations of samples other the true intended comparison.

**See Also**

[DBAnalyze](#) which calls this function and [getNewLabels](#) which this function calls

---

getNewLabels	<i>Labels the samples according to the combinations from <a href="#">getComparisons</a></i>
--------------	---

---

### Description

This function labels the samples according the combinations generated by [getComparisons](#).

### Usage

```
getNewLabels(trueLabel, comparison, numSamples, combns, index)
```

### Arguments

trueLabel	The true labels for the samples.
comparison	A vector containing the comparison to be made. Names here need to correspond to the sample groups in the sample file (Eg. c("G1",G2") means the comparison G1/G2).
numSamples	Number of samples in the dataset.
combns	Possible combinations of sample index generated in <a href="#">getComparisons</a> .
index	index of the combination to use for labeling.

### Value

A vector with labels.

### See Also

[getComparisons](#) which calls this function

---

getRegionCounts	<i>Quantify region level count data</i>
-----------------	---

---

### Description

The input is the set of regions and the sample information. It will calculate the number of reads falling in each region for each sample. Returns a [RangedSummarizedExperiment-class](#) object with regions, sample informationa and counts for all samples.

### Usage

```
getRegionCounts(
  regionBed,
  sampleInfo,
  sampleDir = ".",
  backgroundSubtract = TRUE,
  ...
)
```



**Arguments**

regionBed	A bed file containing the list of regions that are being analyzed.
sampleInfo	Object from <a href="#">preprocessData</a> containing sample information.
sampleDir	Location of the input sample files in ‘sampleInfo‘ file. (default: ".")
backgroundSubtract	Logical indicating if background correction should be performed. (default: TRUE)
...	Additional arguments passed on to <a href="#">getBgSubVal</a> .

**Value**

[RangedSummarizedExperiment-class](#) containing the regions, sample information and counts for all samples.

**See Also**

[getBgSubVal](#) which this function calls.

**Examples**

```
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
package="CSSQ", mustWork = TRUE), sep="\t", header=TRUE)
countData <- getRegionCounts(system.file("extdata", "chr19_regions.bed",
package="CSSQ"), sampleInfo,
sampleDir = system.file("extdata", package="CSSQ"))
countData
head(assays(countData)$countData)
colData(countData)
rowRanges(countData)
```

---

kmeansNormalize	<i>Perform k-means clustering, normalize anscombe data and calculate cluster variances for a sample.</i>
-----------------	--

---

**Description**

This function performs normalization on the anscombe transformed data by clustering them using k-means algorithm and utilizing the information from clusters. It returns an `DataFrame` object normalized counts, cluster information and the variance of that cluster for that sample.

**Usage**

```
kmeansNormalize(ansDataVec, numClusters = 4)
```

**Arguments**

ansDataVec	Anscombe transformed count data for a sample.
numClusters	A number indicating the number of clusters to use for k-means clustering. (default: 4)

**Value**

DataFrame containing the normalized counts, cluster information and the variance of the cluster in the sample.

**See Also**

[normalizeData](#) which iterates over this function.

**Examples**

```
exCount <- c(1,2,3,4,5,6,7,8,9,10)
kmeansEx <- kmeansNormalize(exCount,numClusters=2)
kmeansEx
```

---

<code>loadCountData</code>	<i>Load count data from input file.</i>
----------------------------	---

---

**Description**

It converts input count file and a bed file regions into a [RangedSummarizedExperiment-class](#) object.

**Usage**

```
loadCountData(countFile, regionBed, sampleInfo)
```

**Arguments**

<code>countFile</code>	A path to file containing the count data for the dataset. This should be a tab separated file sample names as header.
<code>regionBed</code>	A bed file containing the list of regions that are being analyzed.
<code>sampleInfo</code>	Object from <a href="#">preprocessData</a> containing sample information.

**Value**

[RangedSummarizedExperiment-class](#) object containing the region information, sample information and the count data.

**Examples**

```
countData <- loadCountData(system.file("extdata", "sample_count_data.txt",
package="CSSQ",mustWork = TRUE),system.file("extdata", "chr19_regions.bed",
package="CSSQ"),
read.table(system.file("extdata", "sample_info.txt", package="CSSQ",
mustWork = TRUE),
sep="\t",header=TRUE))
countData
```

---

normalizeData	<i>Normalize anscombe transformed data</i>
---------------	--

---

### Description

This function iterates over [kmeansNormalize](#) to perform normalization for all samples in the dataset. It returns an [RangedSummarizedExperiment-class](#) object normalized counts, cluster information and the variance of that cluster for that sample.

### Usage

```
normalizeData(ansData, numClusters = 4)
```

### Arguments

ansData	<a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">ansTransform</a> .
numClusters	A number indicating the number of clusters to use for k-means clustering. (default: 4)

### Value

[RangedSummarizedExperiment-class](#) containing the normalized counts, cluster information and the variance of the cluster in the sample.

### See Also

[kmeansNormalize](#) which this function calls.

### Examples

```
exRange <- GRanges(seqnames=c("chr1","chr2","chr3","chr4"),
  ranges=IRanges(start=c(1000,2000,3000,4000),end=c(1500,2500,3500,4500)))
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
  package="CSSQ",mustWork = TRUE),sep="\t",header=TRUE)
exCount <- matrix(c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16),nrow=4,ncol=4)
exData <- SummarizedExperiment(assays = list(ansCount=exCount),
  rowRanges=exRange,colData=sampleInfo)
normExData <- normalizeData(exData,numClusters=2)
assays(normExData)$normCount
```

---

plotDist	<i>Plot data distribution histograms</i>
----------	--

---

### Description

This function is to plot data distribution histogram before and after anscombe transformation.

### Usage

```
plotDist(countData, ansCount, sampleName, plotDataToPDF = FALSE)
```

**Arguments**

countData	A <a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">getRegionCounts</a> with count data.
ansCount	A <a href="#">RangedSummarizedExperiment-class</a> object from <a href="#">ansTransform</a> with anscombe transformed data.
sampleName	Name of the sample being plotted.
plotDataToPDF	A logical parameter indicating whether to make plots of the data distribution to a separate PDF file for each sample. When TRUE, a histogram will be plotted for the data before and after transformation. When FALSE, no plots will be made. (default: FALSE)

**Value**

A list of the histogram of the count data before and after anscombe transformation if `plotDataToPDF == FALSE`. None if `plotDataToPDF == TRUE`.

**Examples**

```
exRange <- GRanges(seqnames=c("chr1", "chr2", "chr3", "chr4"),
  ranges=IRanges(start=c(1000, 2000, 3000, 4000), end=c(1500, 2500, 3500, 4500)))
sampleInfo <- read.table(system.file("extdata", "sample_info.txt",
  package="CSSQ", mustWork = TRUE), sep="\t", header=TRUE)
exCount <- matrix(c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16), nrow=4, ncol=4)
exData <- SummarizedExperiment(assays = list(countData=exCount),
  rowRanges=exRange, colData=sampleInfo)
ansExData <- ansTransform(exData)
plotEx <- plotDist(exData, ansExData, "HESC_R1")
plotEx[[1]]
```

---

```
preprocessData
```

---

*Wrapper function to preprocess the data*

---

**Description**

This is a wrapper function that calls the functions to preprocess the data. It results in a [RangedSummarizedExperiment-class](#) object normalized counts and meta data that can be used by [DBAnalyze](#).

**Usage**

```
preprocessData(
  inputRegions,
  sampleInfoFile,
  sampleDir = ".",
  inputCountData,
  numClusters = 4,
  noNeg = TRUE,
  plotDataToPDF = FALSE,
  ...
)
```

**Arguments**

<code>inputRegions</code>	A bed file the regions to analyze.
<code>sampleInfoFile</code>	A tab separated file all sample information. The following are the columns that are present in the file. * Sample Name : Names for the samples. * Group : The group the sample belongs. * IP : The name of the sample bam file. * IP_aligned_reads : The number of aligned reads in the sample. This is used in depth normalization process. * IN : The name of the sample's control bam file. * IN_aligned_reads : The number of aligned reads in the control file. This is used in depth normalization process.
<code>sampleDir</code>	Location of the input sample files in 'sampleInfoFile' file. (default: ".") Name,Group/Label,IP bam location,IP number of reads,IN bam location, IN number of reads).
<code>inputCountData</code>	The path to the file count data. This parameter is used when directly loading count data from a file. This should be a tab separated file sample names as header.
<code>numClusters</code>	A numerical parameter indicating the number of clusters to use in the normalization step. Passed on to <a href="#">normalizeData</a> . (default: 4)
<code>noNeg</code>	A logical parameter indicating how to deal negative values. It is passed to <a href="#">ansTransform</a> . (default: TRUE)
<code>plotDataToPDF</code>	A logical parameter indicating whether to make plots of the data distribution to a separate PDF file for each sample. It is passed on to passed to <a href="#">ansTransform</a> . (default: FALSE)
<code>...</code>	Additional arguments passed on to <a href="#">getRegionCounts</a> .

**Value**

[RangedSummarizedExperiment-class](#) containing the normalized counts, cluster information, the variance of the cluster in the sample and metadata.

**See Also**

[getRegionCounts](#), [ansTransform](#) and [normalizeData](#) which this function calls

**Examples**

```
processedData <- preprocessData(system.file("extdata", "chr19_regions.bed",
package="CSSQ"),system.file("extdata", "sample_info.txt", package="CSSQ"),
sampleDir = system.file("extdata", package="CSSQ"),
numClusters=4,noNeg=TRUE,plotDataToPDF=FALSE)
processedData
```

# Index

## \* **internal**

calculateFC, 3

ansTransform, 2, 11–13

calculateFC, 3

calculatePvalue, 3, 7

calculateTvalue, 3, 4

DBAnalyze, 3, 4, 5, 7, 12

getBgSubVal, 5, 9

getComparisons, 7, 8

getNewLabels, 7, 8

getRegionCounts, 2, 6, 8, 12, 13

kmeansNormalize, 9, 11

loadCountData, 10

normalizeData, 10, 11, 13

plotDist, 11

preprocessData, 3–5, 9, 10, 12