

# Package ‘groHMM’

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**Title** GRO-seq Analysis Pipeline

**Author** Charles G. Danko, Minh Chae, Andre Martins, W. Lee Kraus

**Maintainer** Anusha Nagari <anusha.nagari@utsouthwestern.edu>, Tulip Nandu <tulip.nandu@utsouthwestern.edu>, W. Lee Kraus <lee.kraus@utsouthwestern.edu>

**Depends** R (>= 3.0.2), MASS, parallel, S4Vectors (>= 0.17.25), IRanges (>= 2.13.12), GenomeInfoDb, GenomicRanges (>= 1.31.8), GenomicAlignments (>= 1.15.6), rtracklayer (>= 1.39.7)

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**Description** A pipeline for the analysis of GRO-seq data.

**URL** <https://github.com/Kraus-Lab/groHMM>

**BugReports** <https://github.com/Kraus-Lab/groHMM/issues>

**License** GPL-3

**biocViews** Sequencing, Software

**LazyLoad** yes

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groHMM-package	<i>groHMM: GRO-seq Analysis Pipeline</i>
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## Description

groHMM was developed for analysis of GRO-seq data, which provides a genome wide 'map' of the position and orientation of all transcriptionally active RNA polymerases. groHMM predicts the boundaries of transcriptional activity across the genome de novo using a two-state hidden Markov model (HMM). The model essentially divides the genome into 'transcribed' and 'non-transcribed' regions in a strand specific manner.

We also use HMMs to identify the leading edge of Pol II at genes activated by a stimulus in GRO-seq time course data. This approach allows the genome-wide interrogation of transcription rates in cells.

In addition to these advanced features, groHMM provides wrapper functions for counting raw reads, generating wiggle files for visualization, and creating metagene (averaging) plots. Although groHMM is tailored towards GRO-seq data, the same functions and analytical methodologies can, in principal, be applied to a wide variety of other short read data sets.

## Details

Package:	groHMM
Type:	Package
Version:	0.99.0
Date:	2014-04-02
License:	GPL (>=3)
LazyLoad:	yes
Depends:	R (>= 2.14.0), MASS, GenomicRanges, rtracklayer, parallel

**Author(s)**

Charles G. Danko, Minh Chae, Andre Martins

Maintainer: Minh Chae<minho.chae@gmail.com>

**References**

Luo, X., Chae, M., Krishnakumar, R., Danko, C., Kraus, L. Dynamic reorganization of the AC16 cardiomyocyte transcriptome in response to TNF $\alpha$  signaling revealed by integrated genomic analyses. BMC Genomics. 2014 Feb 24;15(1):155

Hah, N., Danko, C., Core, L., Waterfall, J., Siepel, A., Lis, J., Kraus, L. A Rapid, Extensive, and Transient Transcriptional Response to Estrogen Signaling in Breast Cancer Cells. Cell. 2011 May 13;145(4):622-34

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averagePlot	<i>Returns the average profile of tiling array probe intensity values or wiggle-like count data centered on a set of genomic positions (specified by 'Peaks').</i>
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**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

**Usage**

```
averagePlot(ProbeData, Peaks, size = 50, bins = seq(-1000, 1000, size))
```

**Arguments**

ProbeData	Data.frame representing chromosome, window center, and a value.
Peaks	Data.frame representing chromosome, and window center.
size	Numeric. The size of the moving window. Default: 50 bp.
bins	The bins of the meta gene – i.e. the number of moving windows to break it into. Default +/- 1kb from center.

**Value**

A vector representing the 'typical' signal centered on the peaks of interest.

**Author(s)**

Charles G. Danko and Minh Chae

breakTranscriptsOnGenes

*breakTranscriptsOnGenes* Breaks transcripts on genes

---

## Description

Breaks transcripts when they are overlapped with multiple well annotated genes.

## Usage

```
breakTranscriptsOnGenes(tx, annox, strand = "+", geneSize = 5000,  
  threshold = 0.8, gap = 5, plot = FALSE)
```

## Arguments

tx	GRanges of transcripts.
annox	GRanges of non-overlapping annotations for reference.
strand	Takes "+" or "-" Default: "+"
geneSize	Numeric. Minimum gene size in annox to be used as reference. Default: 5000
threshold	Numeric. Ratio of overlapped region relative to a gene width. Transcripts only greater than this threshold are subjected to be broken. Default: 0.8
gap	Numeric. Gap (bp) between broken transcripts. Default: 5
plot	Logical. If set to TRUE, show each step in a plot. Default: FALSE

## Value

Returns GRanges object of broken transcripts.

## Author(s)

Minho Chae and Charles G. Danko

## Examples

```
tx <- GRanges("chr7", IRanges(1000, 30000), strand="+")  
annox <- GRanges("chr7", IRanges(start=c(1000, 20000),  
  width=c(10000,10000)), strand="+")  
bPlus <- breakTranscriptsOnGenes(tx, annox, strand="+")
```

---

combineTranscripts     *combineTranscripts* Combines transcripts.

---

### Description

Combines transcripts that are within the same gene annotation, combining smaller transcripts for genes with low regulation into a single transcript representing the gene.

### Usage

```
combineTranscripts(tx, annox, geneSize = 1000, threshold = 0.8,  
  plot = FALSE)
```

### Arguments

tx	GRanges of transcripts.
annox	GRanges of non-overlapping annotations for reference.
geneSize	Numeric. Minimum gene size in annotations to be used as reference. Default: 1000
threshold	Numeric. Ratio of overlapped region relative to transcript width. Transcripts only greater than this threshold are subjected to be combined. Default: 0.8
plot	Logical. If set to TRUE, show each step in a plot. Default: FALSE

### Value

Returns GRanges object of combined transcripts.

### Author(s)

Minho Chae and Charles G. Danko

### Examples

```
tx <- GRanges("chr7", IRanges(start=c(1000, 20000), width=c(10000,10000)),  
  strand="+")  
annox <- GRanges("chr7", IRanges(1000, 30000), strand="+")  
combined <- combineTranscripts(tx, annox)
```

---

countMappableReadsInInterval

*countMappableReadsInInterval* counts the number of mappable reads in a set of genomic features.

---

### Description

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

**Usage**

```
countMappableReadsInInterval(features, UnMap, debug = FALSE, ...)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates. The meta-plot will be centered on the start position.
UnMap	List object representing the position of un-mappable reads. Default: not used.
debug	If set to TRUE, provides additional print options. Default: FALSE
...	Extra argument passed to mclapply

**Value**

Returns a vector of counts, each representing the number of reads inside each genomic interval.

**Author(s)**

Charles G. Danko and Minh Chae

---

detectTranscripts	<i>detectTranscripts detects transcripts de novo using a two-state hidden Markov model (HMM).</i>
-------------------	---

---

**Description**

Read counts can be specified as either a GRanges object (reads), or using a fixed-step wiggle-format passed in a list (Fp and Fm). Either reads or BOTH Fp and Fm must be specified.

**Usage**

```
detectTranscripts(reads = NULL, Fp = NULL, Fm = NULL, LtProbA = -5,
  LtProbB = -200, UTS = 5, size = 50, threshold = 0.1, debug = TRUE,
  ...)
```

**Arguments**

reads	A GRanges object representing a set of mapped reads.
Fp	Wiggle-formatted read counts on "+" strand. Optionally, Fp and Fm represent list() filled with a vector of counts for each chromosome. Can detect transcripts starting from a fixed-step wiggle.
Fm	Wiggle-formatted read counts on "-" strand.
LtProbA	Log probability of t... . Default: -5. One of these is just an initialization, and the final value is set by EM. The other is a holdout parameter.
LtProbB	Log probability of t... . Default: -200.
UTS	Variance in read counts of the untranscribed sequence. Default: 5.
size	Log probability of t... . Default: -5.
threshold	Threshold change in total likelihood, below which EM exits.
debug	If set to TRUE, provides additional print options. Default: FALSE
...	Extra argument passed to mclapply

**Details**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors set the option 'mc.cores'.

Reference: Hah N, Danko CG, Core L, Waterfall JJ, Siepel A, Lis JT, Kraus WL. A rapid, extensive, and transient transcriptional response to estrogen signaling in breast cancer cells. Cell. 2011 May 13;145(4):622-34. doi: 10.1016/j.cell.2011.03.042.

**Value**

Returns a list of emisParams, trnasParams, viterbiStates, and transcripts. The transcript element is a GRanges object representing the predicted genomic coordinates of transcripts on both the + and - strand.

**Author(s)**

Charles G. Danko and Minh Chae

**Examples**

```
S0mR1 <- as(readGAlignments(system.file("extdata", "S0mR1.bam",
package="groHMM")), "GRanges")
## Not run:
# hmmResult <- detectTranscripts(S0mR1, LtProbB=-200, UTS=5, threshold=1)
# txHMM <- hmmResult$transcripts
```

---

evaluateHMMInAnnotations

*evaluateHMM Evaluates HMM calling.*

---

**Description**

Evaluates HMM calling of transcripts compared to known annotations.

**Usage**

```
evaluateHMMInAnnotations(tx, annox)
```

**Arguments**

tx	GRanges of transcripts predicted by HMM.
annox	GRanges of non-overlapping annotations.

**Value**

a list of error information; merged annotations, dissociated annotation, total, and rate.

**Author(s)**

Minho Chae

**Examples**

```
tx <- GRanges("chr7", IRanges(start=seq(100, 1000, by=200),
width=seq(100, 1000, by=100)), strand="+")
annox <- GRanges("chr7", IRanges(start=seq(110, 1100, by=150),
width=seq(100, 1000, by=150)), strand="+")
error <- evaluateHMMInAnnotations(tx, annox)
```

---

expressedGenes	<i>Function identifies expressed features using the methods introduced in Core, Waterfall, Lis; Science, Dec. 2008.</i>
----------------	---

---

**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors use the argument 'mc.cores'.

**Usage**

```
expressedGenes(features, reads, Lambda = NULL, UnMap = NULL,
  debug = FALSE, ...)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates. The meta-plot will be centered on the start position. There can be optional "ID" column for gene ids.
reads	A GRanges object representing a set of mapped reads.
Lambda	Measurement of assay noise. Default: 0.04 reads/ kb in a library of 10,751,533 mapped reads. (background computed in Core, Waterfall, Lis. (2008) Science.).
UnMap	List object representing the position of un-mappable reads. Default: not used.
debug	If set to true, returns the number of positions. Default: FALSE.
...	Extra argument passed to mclapply

**Value**

Returns a data.frame representing the expression p.values for features of interest.

**Author(s)**

Charles G. Danko



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getCores	<i>Returns the number of cores.</i>
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**Description**

Returns the number of cores.

**Usage**

```
getCores(cores)
```

**Arguments**

cores            the number of cores, it is 1 in windows platform.

**Examples**

```
cores <- getCores(2L)
```

---

getTxDensity	<i>getTxDensity Calculates transcript density.</i>
--------------	--

---

**Description**

Calculates transcript density for transcripts which overlaps with annotations. For 'run genes together' or 'broken up a single annotation' errors, best overlapped transcripts or annotations are used.

**Usage**

```
getTxDensity(tx, annox, plot = TRUE, scale = 1000L, nSampling = 0L,
             samplingRatio = 0.1, ...)
```

**Arguments**

tx	GRanges of transcripts.
annox	GRanges of non-overlapping annotations.
plot	Logical. If TRUE, plot transcript density. Default: TRUE
scale	Numeric. Scaled size of a gene for transcript density calculation. Default: 1000L
nSampling	Numeric. Number of subsampling. Default: 0L
samplingRatio	Numeric. Ratio of sampling for annotations. Default: 0.1
...	Extra argument passed to mclapply.

**Details**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors set the option 'mc.cores'.

**Value**

Returns a list of FTD, TTD, PostTTS, and AUC.

**Author(s)**

Minho Chae

**Examples**

```
tx <- GRanges("chr7", IRanges(start=seq(1000,4000, by=1000),
width=seq(1000, 1300, by=100)), strand=rep("+", 4))
annox <- GRanges("chr7", IRanges(start=seq(1100,4100, by=1000),
width=seq(900, 1200, by=100)), strand=rep("+", 4))
## Not run:
# density <- getTxDensity(tx, annox)
```

---

limitToXkb	<i>limitToXkb truncates a set of genomic intervals at a constant, maximum size.</i>
------------	---

---

**Description**

limitToXkb truncates a set of genomic intervals at a constant, maximum size.

**Usage**

```
limitToXkb(features, offset = 1000, size = 13000)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates. The meta-plot will be centered on the start position.
offset	Starts the interval from this position relative to the start of each genomic features.
size	Specifies the size of the window.

**Value**

Returns GRanges object with new genomic coordinates.

**Author(s)**

Minho Chae and Charles G. Danko

**Examples**

```
tx <- GRanges("chr7", IRanges(1000, 30000), strand="+")
newTX <- limitToXkb(tx)
```

---

`makeConsensusAnnotations`*makeConsensusAnnotations Makes a consensus annotation*

---

## Description

Makes a non-overlapping consensus annotation. Gene annotations are often overlapping due to #' multiple isoforms for a gene. In consensus annotation, isoforms are first reduced so that only redundant intervals are used to represent a genomic interval for a gene, i.e., a gene id. Remaining unresolved annotations are further reduced by truncating 3' end of annotations.

## Usage

```
makeConsensusAnnotations(ar, minGap = 1L, minWidth = 1000L, ...)
```

## Arguments

<code>ar</code>	GRanges of annotations to be collapsed.
<code>minGap</code>	Minimum gap between overlapped annotations after truncated. Default: 1L
<code>minWidth</code>	Minimum width of consensus annotations. Default: 1000L
<code>...</code>	Extra argument passed to <code>mclapply</code> .

## Details

Supports parallel processing using `mclapply` in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

## Value

Returns GRanges object of annotations.

## Author(s)

Minho Chae

## Examples

```
## Not run:  
# library(TxDb.Hsapiens.UCSC.hg19.knownGene)  
# txdb <- TxDb.Hsapiens.UCSC.hg19.knownGene  
# tx <- transcripts(txdb, columns=c("gene_id", "tx_id", "tx_name"),  
#                       filter=list(tx_chrom="chr7"))  
# tx <- tx[grepl("random", as.character(seqnames(tx)), invert=TRUE),]  
# ca <- makeConsensusAnnotations(tx)
```

---

metaGene	<i>Returns a histogram of the number of reads in each section of a moving window centered on a certain feature.</i>
----------	---

---

### Description

Supports parallel processing using `mclapply` in the 'parallel' package. To change the number of processors, set the option 'mc.cores'.

### Usage

```
metaGene(features, reads = NULL, plusCVG = NULL, minusCVG = NULL,
         size = 100L, up = 10000L, down = NULL, ...)
```

### Arguments

features	A GRanges object representing a set of genomic coordinates. The meta-plot will be centered on the transcription start site (TSS)
reads	A GRanges object representing a set of mapped reads. Instead of 'reads', 'plusCVG' and 'minusCVG' can be used Default: NULL
plusCVG	An IntegerRangesList object for reads with '+' strand.
minusCVG	An IntegerRangesList object for reads with '-' strand.
size	The size of the moving window.
up	Distance upstream of each features to align and histogram. Default: 10 kb.
down	Distance downstream of each features to align and histogram. If NULL, same as up. Default: NULL.
...	Extra argument passed to <code>mclapply</code>

### Value

Returns a integer-Rle representing the 'typical' signal centered on a point of interest.

### Author(s)

Charles G. Danko and Minh Chae

### Examples

```
features <- GRanges("chr7", IRanges(1000, 1000), strand="+")
reads <- GRanges("chr7", IRanges(start=c(1000:1004, 1100),
  width=rep(1, 6)), strand="+")
mg <- metaGene(features, reads, size=4, up=10)
```

---

metaGeneMatrix	<i>Returns a matrix, with rows representing read counts across a specified gene, or other features of interest.</i>
----------------	---

---

**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

**Usage**

```
metaGeneMatrix(features, reads, size = 50, up = 1000, down = up,
  debug = FALSE, ...)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates.
reads	A GRanges object representing a set of mapped reads.
size	The size of the moving window.
up	Distance upstream of each f to align and histogram Default: 1 kb.
down	Distance downstream of each f to align and histogram Default: same as up.
debug	If set to TRUE, provides additional print options. Default: FALSE
...	Extra argument passed to mclapply

**Value**

Returns a vector representing the 'typical' signal across genes of different length.

**Author(s)**

Charles G. Danko and Minh Chae

---

metaGene_nL	<i>Returns a histogram of the number of reads in each section of a moving window of #' variable size across genes.</i>
-------------	--

---

**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

**Usage**

```
metaGene_nL(features, reads, n_windows = 1000, debug = FALSE, ...)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates.
reads	A GRanges object representing a set of mapped reads.
n_windows	The number of windows to break genes into.
debug	If set to TRUE, provides additional print options. Default: FALSE
...	Extra argument passed to mclapply

**Value**

Returns a vector representing the 'typical' signal across genes of different length.

**Author(s)**

Charles G. Danko and Minh Chae

---

pausingIndex	<i>Returns the pausing index for different genes. TODO: DESCRIBE THE PAUSING INDEX.</i>
--------------	---

---

**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, use the argument 'mc.cores'.

**Usage**

```
pausingIndex(features, reads, size = 50, up = 1000, down = 1000,
             UnMAQ = NULL, debug = FALSE, ...)
```

**Arguments**

features	A GRanges object representing a set of genomic coordinates.
reads	A GRanges object representing a set of mapped reads.
size	The size of the moving window.
up	Distance upstream of each f to align and histogram.
down	Distance downstream of each f to align and histogram (NULL).
UnMAQ	Data structure representing the coordinates of all un-mappable regions in the genome.
debug	If set to TRUE, provides additional print options. Default: FALSE
...	Extra argument passed to mclapply

**Value**

Returns a data.frame of the pausing indices for the input genes.

Returns the pausing index for different genes.

**Author(s)**

Charles G. Danko and Minh Chae.

**Examples**

```

features <- GRanges("chr7", IRanges(2394474,2420377), strand="+")
reads <- as(readGAlignments(system.file("extdata", "S0mR1.bam",
package="groHMM")), "GRanges")

## Not run:
# pi <- pausingIndex(features, reads)

```

---

polymeraseWave	<i>Given GRO-seq data, identifies the location of the polymerase 'wave' in up- or down- regulated genes.</i>
----------------	--

---

**Description**

The model is a three state hidden Markov model (HMM). States represent: (1) the 5' end of genes upstream of the transcription start site, (2) upregulated sequence, and (3) the 3' end of the gene through the polyadenylation site.

**Usage**

```

polymeraseWave(reads1, reads2, genes, approxDist, size = 50,
  upstreamDist = 10000, TSmooth = NA, NonMap = NULL, prefix = NULL,
  emissionDistAssumption = "gamma", finterWindowSize = 10000,
  limitPCRDups = FALSE, returnVal = "simple", debug = TRUE)

```

**Arguments**

reads1	Mapped reads in time point 1.
reads2	Mapped reads in time point 2.
genes	A set of genes in which to search for the wave.
approxDist	The approximate position of the wave. Suggest using 2000 [bp/ min] * time [min], for mammalian data.
size	The size of the moving window. Suggest using 50 for direct ligation data, and 200 for circular ligation data. Default: 50.
upstreamDist	The amount of upstream sequence to include Default: 10 kb.
TSmooth	Optionally, outlying windows are set a maximum value over the inter-quantile interval, specified by TSmooth. Reasonable value: 20; Default: NA (for no smoothing). Users are encouraged to use this parameter ONLY in combination with the normal distribution assumptions.
NonMap	Optionally, un-mappable positions are treated as missing data. NonMap passes in the list() structure for un-mappable regions.
prefix	Optionally, writes out png images of each gene examined for a wave. 'Prefix' denotes the file prefix for image names written to disk. Users are encouraged to create a new directory and write in a full path.
emissionDistAssumption	Takes values "norm", "normExp", and "gamma". Specifies the functional form of the 'emission' distribution for states I and II (i.e. 5' of the gene, and inside of the wave). In our experience, "gamma" works best for highly-variable 'spikey' data, and "norm" works for smooth data. As a general rule of thumb, "gamma" is used for libraries made using the direct ligation method, and "norm" for circular ligation data. Default: "gamma".

finterWindowSize	Method returns 'quality' information for each gene to which a wave was fit. Included in these metrics are several that define a moving window. The moving window size is specified by filterWindowSize. Default: 10 kb.
limitPCRDups	If true, counts only 1 read at each position with $\geq 1$ read. NOT recommended to set this to TRUE. Defulat: FALSE.
returnVal	Takes value "simple" (default) or "alldata". "simple" returns a data.frame with Pol II wave end positions. "alldata" returns all of the avaiiable data from each gene, including the full posterior distribution of the model after EM.
debug	If TRUE, prints error messages.

### Details

The model computes differences in read counts between the two conditions. Differences are assumed fit a functional form which can be specified by the user (using the emissionDistAssumption argument). Currently supported functional forms include a normal distribution (good for GRO-seq data prepared using the circular ligation protocol), a gamma distribution (good for 'spikey' ligation based GRO-seq data), and a long-tailed normal+exponential distribution was implemented, but never deployed.

Initial parameter estimates are based on initial assumptions of transcription rates taken from the literature. Subsequently all parameters are fit using Baum-Welch expetation maximization.

Reference: Danko CG, Hah N, Luo X, Martins AL, Core L, Lis JT, Siepel A, Kraus WL. Signaling Pathways Differentially Affect RNA Polymerase II Initiation, Pausing, and Elongation Rate in Cells. Mol Cell. 2013 Mar 19. doi:pii: S1097-2765(13)00171-8. 10.1016/j.molcel.2013.02.015.

Arguments:

### Value

Returns either a data.frame with Pol II wave end positions, or a List() structure with additional data, as specified by returnVal.

### Author(s)

Charles G. Danko

### Examples

```
genes <- GRanges("chr7", IRanges(2394474,2420377), strand="+",
  SYMBOL="CYP2W1", ID="54905")
reads1 <- as(readGAlignments(system.file("extdata", "S0mR1.bam",
  package="groHMM")), "GRanges")
reads2 <- as(readGAlignments(system.file("extdata", "S40mR1.bam",
  package="groHMM")), "GRanges")

approxDist <- 2000*10
# Not run:
# pw <- polymeraseWave(reads1, reads2, genes, approxDist)
```



---

readBed	<i>readBed Returns a GenomicRanges object constructed from the specified bed file.</i>
---------	--

---

### Description

Bed file format is assumed to be either four column: seqnames, start, end, strand columns; or six column: seqnames, start, end, name, score, and strand. Three column format is also possible when there is no strand information.

### Usage

```
readBed(file, ...)
```

### Arguments

file	Path to the input file.
...	Extra argument passed to read.table

### Details

Any additional arguments available to read.table can be specified.

### Value

Returns GRanges object representing mapped reads.

### Author(s)

Minho Chae and Charles G. Danko.

---

RgammaMLE	<i>RgammaMLE fits a gamma distribution to a specified data vector using maximum likelihood.</i>
-----------	---

---

### Description

RgammaMLE fits a gamma distribution to a specified data vector using maximum likelihood.

### Usage

```
RgammaMLE(X)
```

### Arguments

X	A vector of observations, assumed to be real numbers in the inveraval [0,+Inf).
---	---

### Value

Returns a list of parameters for the best-fit gamma distribution (shape and scale).

**Author(s)**

Charles G. Danko

---

Rnorm	<i>Rnorm fits a normal distribution to a specified data vector using maximum likelihood.</i>
-------	--

---

**Description**

Rnorm fits a normal distribution to a specified data vector using maximum likelihood.

**Usage**

```
Rnorm(X)
```

**Arguments**

X                    A vector of observations, assumed to be real numbers in the inveraval (-Inf,+Inf).

**Value**

Returns a list of parameters for the best-fit normal distribution (mean and variance).

**Author(s)**

Charles G. Danko

---

Rnorm.exp	<i>Rnorm.exp fits a normal+exponential distribution to a specified data vector using maximum likelihood.</i>
-----------	--

---

**Description**

Distribtion function devined by:  $\alpha * \text{Normal}(\text{mean}, \text{variance}) + (1 - \alpha) * \text{Exponential}(\text{lambda})$ .

**Usage**

```
Rnorm.exp(xi, wi = rep(1, NROW(xi)), guess = c(0.5, 0, 1, 1),
  tol = sqrt(.Machine$double.eps), maxit = 10000)
```

**Arguments**

xi                    A vector of observations, assumed to be real numbers in the inveraval (-Inf,+Inf).

wi                    A vector of weights. Default: vector of repeating 1; indicating all observations are weighted equally. (Are these normalized internally?! Or do they have to be [0,1]?)

guess                Initial guess for paremeters. Default: c(0.5, 0, 1, 1).

tol                    Convergence tolerance. Default: sqrt(.Machine\$double.eps).

maxit                Maximum number of iterations. Default: 10,000.

**Details**

Fits nicely with data types that look normal overall, but have a long tail starting for positive values.

**Value**

Returns a list of parameters for the best-fit normal distribution (alpha, mean, variance, and lambda).

**Author(s)**

Charles G. Danko

---

runMetaGene	<i>Runs metagene analysis for sense and antisense direction.</i>
-------------	--

---

**Description**

Supports parallel processing using mclapply in the 'parallel' package. To change the number of processors, set the option 'mc.cores'.

**Usage**

```
runMetaGene(features, reads, anchorType = "TSS", size = 100L,
  normCounts = 1L, up = 1000L, down = NULL, sampling = FALSE,
  nSampling = 1000L, samplingRatio = 0.1, ...)
```

**Arguments**

features	GRanges A GRanges object representing a set of genomic coordinates, i.e., set of genes.
reads	GRanges of reads.
anchorType	Either 'TSS' or 'TTS'. Metagene will be centered on the transcription start site(TSS) or transcription termination site(TTS). Default: TSS.
size	Numeric. The size of the moving window. Default: 100L
normCounts	Numeric. Normalization vector such as average reads. Default: 1L
up	Numeric. Distance upstream of each feature to align and histogram. Default: 1 kb
down	Numeric. Distance downstream of each feature to align and histogram. If NULL, down is same as up. Default: NULL
sampling	Logical. If TRUE, subsampling of Metagene is used. Default: FALSE
nSampling	Numeric. Number of subsampling. Default: 1000L
samplingRatio	Numeric. Ratio of sampling for features. Default: 0.1
...	Extra argument passed to mclapply.

**Value**

A list of integer-Rle for sense and antisense.

**Author(s)**

Minho Chae

**Examples**

```
features <- GRanges("chr7", IRanges(start=1000:1001, width=rep(1,2)),
  strand=c("+", "-"))
reads <- GRanges("chr7", IRanges(start=c(1000:1003, 1100:1101),
  width=rep(1, 6)), strand=rep(c("+", "-"), 3))
## Not run:
# mg <- runMetaGene(features, reads, size=4, up=10)
```

---

tlsDeming

*A 'total least squares' implementation using demming regression.*

---

**Description**

A 'total least squares' implementation using demming regression.

**Usage**

```
tlsDeming(x, y, d = 1)
```

**Arguments**

x                    X values.  
y                    Y values.  
d                    Ratio of variances. Default: 1, for orthogonal regression.

**Value**

Parameters for the linear model.

**Author(s)**

Charles G. Danko

---

tlsLoess

*A 'total least squares'-like hack for LOESS. Works by rotating points 45 degrees, fitting LOESS, and rotating back.*

---

**Description**

A 'total least squares'-like hack for LOESS. Works by rotating points 45 degrees, fitting LOESS, and rotating back.

**Usage**

```
tlsLoess(x, y, theta = -pi/4, span = 1)
```

**Arguments**

x	X values.
y	Y values.
theta	Amount to rotate, sets the ratio of variences that are assumed by the hack. Default: -pi/4 radians (45 degrees) for orthogonal regression.
span	The LOESS span parameter. Default: 1

**Value**

List of input values and LOESS predictions.

**Author(s)**

Charles G. Danko

---

tlsSvd	<i>A 'total least squares' implementation using singular value demposition.</i>
--------	---

---

**Description**

A 'total least squares' implementation using singular value demposition.

**Usage**

```
tlsSvd(x, y)
```

**Arguments**

x	X values.
y	Y values.

**Value**

Parameters for the linear model  $Y \sim a * X + e$ .

**Author(s)**

Charles G. Danko

---

windowAnalysis	<i>windowAnalysis Returns a vector of integers representing the counts of reads in a moving window.</i>
----------------	---

---

### Description

Supports parallel processing using `mclapply` in the 'parallel' package. To change the number of processors, set the option 'mc.cores'.

### Usage

```
windowAnalysis(reads, strand = "*", windowSize = stepSize,
  stepSize = windowSize, chrom = NULL, limitPCRDups = FALSE, ...)
```

### Arguments

reads	GenomicRanges object representing the position of reads mapping in the genome.
strand	Takes values of "+", "-", or "*". "*" denotes collapsing reads on both strands. Default: "*".
windowSize	Size of the moving window. Either windowSize or stepSize must be specified.
stepSize	The number of bp moved with each step.
chrom	Chromosome for which to return data. Default: returns all available data.
limitPCRDups	Counts only one read mapping to each start site. NOTE: If set to TRUE, assumes that all reads are the same length (don't use for paired-end data). Default: FALSE.
...	Extra argument passed to <code>mclapply</code>

### Value

Returns a list object, each element of which represents a chromosome.

### Author(s)

Charles G. Danko and Minh Chae

### Examples

```
S0mR1 <- as(readGAlignments(system.file("extdata", "S0mR1.bam",
  package="groHMM")), "GRanges")
## Not run:
# Fp <- windowAnalysis(S0mR1, strand="+", windowSize=50)
```

---

writeWiggle	<i>writeWiggle writes a wiggle track or BigWig file suitable for uploading to the UCSC genome browser.</i>
-------------	--

---

### Description

writeWiggle writes a wiggle track or BigWig file suitable for uploading to the UCSC genome browser.

### Usage

```
writeWiggle(reads, file, strand = "*", fileType = "wig", size = 50,
  normCounts = NULL, reverse = FALSE, seqinfo = NULL,
  track.type.line = FALSE, ...)
```

### Arguments

reads	GenomicRanges object representing the position of reads mapping in the genome.
file	Specifies the filename for output.
strand	Takes values of "+", "-", or "*". Computes Writes a wiggle on the specified strand. "*" denotes collapsing reads on both strands. Default: "*".
fileType	Takes values of "wig" or "BigWig". Default: "wig".
size	Size of the moving window.
normCounts	A normalization factor correcting for library size or other effects. For example, total mappable read counts might be a reasonable value. Default: 1 (i.e. no normalization).
reverse	If set to TRUE, multiplies values by -1. Used for reversing GRO-seq data on the negative (-) strand. Default: FALSE
seqinfo	Seqinfo object for reads. Default: NULL.
track.type.line	If set to TRUE, prints a header identifying the file as a wiggle. Necessary to upload a custom track to the UCSC genome browser. Default: TRUE
...	Extra argument passed to mclapply.

### Author(s)

Minho Chae and Charles G. Danko

### Examples

```
S0mR1 <- as(readGAlignments(system.file("extdata", "S0mR1.bam",
  package="groHMM")), "GRanges")
## Not run:
# writeWiggle(reads=S0mR1, file="S0mR1_Plus.wig", fileType="wig",
# strand="+", reverse=FALSE)
```

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