Package 'crlmm'

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Type Package

Title Genotype Calling (CRLMM) and Copy Number Analysis tool for Affymetrix SNP 5.0 and 6.0 and Illumina arrays

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Description Faster implementation of CRLMM specific to SNP 5.0 and 6.0 arrays, as well as a copy number tool specific to 5.0, 6.0, and Illumina platforms.

License Artistic-2.0

Depends R (>= 2.14.0), oligoClasses (>= 1.21.12), preprocessCore (>= 1.17.7)

LinkingTo preprocessCore (>= 1.17.7)

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crlmm-package *Genotype Calling via CRLMM Algorithm*

Description

Faster implementation of CRLMM specific to SNP 5.0 and 6.0 arrays.

Details

Index:

```
crlmm-package          New implementation of the CRLMM Algorithm.
crlmm                  Genotype SNP 5.0 or 6.0 samples.
calls                  Accessor for genotype calls.
confs                  Accessor for confidences.
```

The 'crlmm' package reimplements the CRLMM algorithm present in the 'oligo' package. This implementation primes for efficient genotyping of samples on SNP 5.0 and SNP 6.0 Affymetrix arrays.

To use this package, the user must have additional data packages: 'genomewidesnp5Crlmm' - SNP 5.0 arrays 'genomewidesnp6Crlmm' - SNP 6.0 arrays

Author(s)

Rafael A Irizarry Maintainer: Benilton S Carvalho <carvalho@bclab.org>

References

Carvalho BS, Louis TA, Irizarry RA. Quantifying uncertainty in genotype calls. Bioinformatics. 2010 Jan 15;26(2):242-9. Epub 2009 Nov 11.

ABpanel *A panel function for plotting prediction regions and log-normalized intensities*

Description

A panel function for plotting prediction regions and log-normalized intensities

Usage

```
ABpanel(x, y, predictRegion, copyNumber = 0:4, fill, ..., subscripts)
```

Arguments

x	log-normalized intensities for the A or B allele
y	log-normalized intensities for the A or B allele
predictRegion	A list. See predictionRegion.
copyNumber	Integer vector. Indicates which prediction regions are drawn.
fill	Character or integer vector for coloring the points. Only valid for certain point symbols. See points.
...	Additional arguments to panel.xyplot and lpolygon.
subscripts	See xyplot in the **lattice** package.

Value

Not applicable

Note

ABpanel can be passed as the argument to panel in the xyplot method for CNSet objects. See the examples in xyplot.

Author(s)

R. Scharpf

See Also

xyplot, panel.xyplot lpolygon

AssayData-methods *Methods for class "AssayData" in crlmm*

Description

The batchStatistics slot in a CNSet object is an instance of the AssayData slot. In general, the accessors for AssayData are called indirectly by the corresponding method for the CNSet class and not called directly by the user.

Methods

Ns signature(object="AssayData"): Accessor for genotype frequencies

corr signature(object="AssayData"): Accessor for the correlation of the log-transformed normalized intensities within the diallelic genotype clusters

mads signature(x="AssayData"): Accessor for the median absolute deviation of the normalized intensities within the diallelic genotype clusters

medians signature(object="AssayData"): Accessor for the posterior mean of the normalized intensity within the diallelic genotype clusters.

tau2 signature(object="AssayData"): Accessor for the median absolute deviation of the log-transformed intensities within the diallelic genotype clusters

See Also

CNSet-class, Ns, tau2, corr, mads, medians

---

batchStatisticAccessors

Accessors for batch-specific summary statistics.

Description

The summary statistics stored here are used by the tools for copy number estimation.

Usage

```
corr(object, ...)
tau2(object, ...)
mads(object,...)
medians(object,...)
Ns(object,...)
```

Arguments

object	An object of class CNSet.
...	Ignored

Value

An array with dimension R x A x G x C, or R x G x C.

R: number of markers A: number of alleles (2) G: number of biallelic genotypes (3) C: number of batches

Ns returns an array of genotype frequencies stratified by batch. Dimension R x G x C.

corr returns an array of within-genotype correlations (log2-scale) stratified by batch. Dimension R x G x C.

medians returns an array of the within-genotype medians (intensity-scale) stratified by batch and allele. Dimension R x A x G x C.

mads returns an array of the within-genotype median absolute deviations (intensity-scale) stratified by batch and allele. Dimension is the same as for medians.

tau2 returns an array of the squared within-genotype median absolute deviation on the log-scale. Only the mads for AA and BB genotypes are stored. Dimension is R x A x G x C, where G is AA or BB. Note that the mad for allele A/B for subjects with genotype BB/AA is a robust estimate of the background variance, whereas the the mad for allele A/B for subjects with genotype AA/BB is a robust estimate of the variance for copy number greater than 0 (we assume that on the log-scale the variance is rougly constant for CA, CB > 0).

See Also

batchStatistics

Examples

```
data(cnSetExample)
Ns(cnSetExample)[1:5, , ]
corr(cnSetExample)[1:5, , ]
meds <- medians(cnSetExample)
mads(cnSetExample)[1:5, , ,]
tau2(cnSetExample)[1:5, , ,]
```

---

calculateRBaf *Calculate log R ratios and B allele frequencies.*

Description

Calculate log R ratios and B allele frequencies from a CNSet object

Usage

```
calculateRBaf(object, batch.name, chrom)
```

Arguments

object	A CNSet object.
batch.name	A character string indicating the batch. If missing, log R ratios and B allele frequencies are calculated for all batches in the object.
chrom	Integer indicating which chromosome to process. If missing, B allele frequencies and log R ratios are calculated for all autosomal chromosomes and chromosome X that are included in object.

Details

batch.name must be a value in batch(object). Currently, one must specify a single batch.name. If a character vector for batch.name is supplied, only the first is evaluated.

TODO: A description of how these values are calculated.

Value

A named list.

baf: Each element in the baf list is a matrix of B allele frequencies (one matrix for each chromosome).

lrr: Each element in the lrr list is a matrix of log R ratios (one matrix for each chromosome).

The log R ratios were scaled by a factor of 100 and stored as an integer. B allele frequencies were scaled by a factor of 1000 and stored as an integer.

Author(s)

Lynn Mireless

References

Peiffer et al., High-resolution genomic profiling of chromosomal aberrations using Infinium whole-genome genotyping (2006), Genome Research

Examples

```
data(cnSetExample)
baf.lrr <- suppressWarnings(calculateRBaf(cnSetExample, "SHELF"))
hist(baf.lrr[["baf"]][[1]]/1000, breaks=100)
hist(baf.lrr[["lrr"]][[1]]/100, breaks=100)
## Not run:
 library(ff)
 baf.lrr <- suppressWarnings(calculateRBaf(cnSetExample, "SHELF"))
 class(baf.lrr[["baf"]][[1]]) ## ff_matrix
 class(baf.lrr[["lrr"]][[1]]) ## ff_matrix

## End(Not run)
```

---

cnrmaAffy *quantile normalize nonpolymorphic markers*

Description

Quantile normalize nonpolymorphic markers to hapmap reference distribution

Usage

```
cnrmaAffy(cnSet, seed = 1, verbose = TRUE)
```

Arguments

cnSet	Object of class CNSet
seed	Random number seed
verbose	Logical.

Value

Returns logical. Normalized intensities are written to the alleleA ff_matrix stored in the CNSet assayData.

Author(s)

R. Scharpf

See Also

snprmaAffy

CNSet-methods *crlmm methods for class "CNSet"*

Description

CNSet is a container defined in the oligoClasses package for storing normalized intensities for genotyping platforms, genotype calls, and parameters estimated for copy number. Accessors for data that an object of this class contains are largely defined in the package oligoClasses. CNSet methods that involve more complex calculations that are specific to the crlmm package, such as computing allele-specific copy number, are included in crlmm and described here.

Methods

`as(from, "oligoSnpSet")`: Method for coercing object `from` (class `CNSet`) to an object of class `oligoSnpSet`.

CA `signature(object="CNSet")`: calculates raw copy number for allele A

CB `signature(object="CNSet")`: calculates raw copy number for allele B

lines `signature(x="CNSet")`: plot ellipses (95th percentile) for prediction regions

totalCopynumber `signature(object="CNSet")`: calculates total raw copy number

rawCopynumber `signature(object="CNSet")`: same as totalCopynumber

nuA `signature(object="CNSet")`: estimate of mean background (intensity-scale) for allele A

nuB `signature(object="CNSet")`: estimate of mean background (intensity-scale) for allele A

phiA `signature(object="CNSet")`: estimate of slope coefficient (intensity-scale) for allele A

phiB `signature(object="CNSet")`: estimate of slope coefficient (intensity-scale) for allele B

Ns `signature(object="CNSet")`: genotype frequencies

corr `signature(object="CNSet")`: correlation of log-transformed normalized intensities within the genotype clusters

mads `signature(x="CNSet")`: ...

medians `signature(object="CNSet")`: ...

tau2 `signature(object="CNSet")`: ...

`OligoSetList(object)`: constructs an object of class `OligoSetList` from `object` having class `CNSet`.

`BafLrrSetList(object)`: constructs an object of class `BafLrrSetList` from `object` having class `CNSet`.

See Also

CNSet-class, CA, CB, totalCopynumber, rawCopynumber

cnSetExample *Object of class 'CNSet'*

Description

The data for the first 16 polymorphic markers in the HapMap analysis.

Usage

```
data(cnSetExample)
data(cnSetExample2)
```

Format

The data illustrates the `CNSet-class`, with `assayData` containing the quantile-normalized intensities for the A and B alleles, genotype calls and confidence scores.

Details

This object was created from the copynumber vignette in inst/scripts. A subset of markers was selected to keep the package size small.

Examples

```
data(cnSetExample)
data(cnSetExample2)
```

constructAffyCNSet *Construct an object of class CNSet from Affymetrix cel files*

Description

Construct a container for normalized intensities for Affymetrix cel files, referred to as a `CNSet`

Usage

```
constructAffyCNSet(filenames, sns, cdfName, batch, verbose = TRUE, genome)
```

Arguments

`filenames`	Vector of cel file names.
`sns`	Sample identifiers. Defaults to `basename(filenames)`.
`cdfName`	Character string indicating annotation package (e.g., "genomewidesnp6Crlmm")
`batch`	Vector of same length as filenames indicating batch.
`verbose`	Logical.
`genome`	Character string indicating UCSC genome build (hg18 or hg19 supported)

Value

An object of class CNSet

Author(s)

R. Scharpf

---

constructInf *Instantiate an object of class CNSet for the Infinium platforms.*

Description

Instantiates an object of class CNSet for the Infinium platforms. Elements of assayData and batchStatistics will be ff objects. See details.

Usage

```
constructInf(sampleSheet = NULL, arrayNames = NULL, path = ".",
    arrayInfoColNames = list(barcode="SentrixBarcode_A",position="SentrixPosition_A"), highDensity =
    fileExt = list(green = "Grn.idat", red = "Red.idat"), XY, cdfName, anno, genome, verbose = FALSE, ba
```

Arguments

sampleSheet	data.frame containing Illumina sample sheet information (for required columns, refer to BeadStudio Genotyping guide - Appendix A).
arrayNames	character vector containing names of arrays to be read in. If NULL, all arrays that can be found in the specified working directory will be read in.
path	character string specifying the location of files to be read by the function
arrayInfoColNames	(used when sampleSheet is specified) list containing elements 'barcode' which indicates column names in the sampleSheet which contains the arrayNumber/barcode number and 'position' which indicates the strip number. In older style sample sheets, this information is combined (usually in a column named 'SentrixPosition') and this should be specified as list(barcode=NULL, position="SentrixPosition"
highDensity	logical (used when sampleSheet is specified). If TRUE, array extensions '_A', '_B' in sampleSheet are replaced with 'R01C01', 'R01C02' etc.
sep	character string specifying separator used in .idat file names.
fileExt	list containing elements 'Green' and 'Red' which specify the .idat file extension for the Cy3 and Cy5 channels.
XY	an NChannelSet containing X and Y intensities.
cdfName	annotation package (see also validCdfNames) or 'nopackage' when an anno data.frame and genome supplied
anno	data.frame containing SNP annotation information from manifest and additional columns 'isSnp', 'position', 'chromosome' and 'featureNames'. For use when cdfName='nopackage'

genome	character string specifying which genome is used in annotation
verbose	'logical.' Whether to print descriptive messages during processing.
batch	batch variable. See details.
saveDate	'logical'. Should the dates from each .idat be saved with sample information?

Details

This function initializes a container for storing the normalized intensities for the A and B alleles at polymorphic loci and the normalized intensities for the 'A' allele at nonpolymorphic loci. CRLMM genotype calls and confidence scores are also stored in the assayData. This function does not do any preprocessing or genotyping – it only creates an object of the appropriate size. The initialized values will all be 'NA'.

The ff package provides infrastructure for accessing and writing data to disk instead of keeping data in memory. Each element of the `assayData` and `batchStatistics` slot are ff objects. ff objects in the R workspace contain pointers to several files with the '.ff' extension on disk. The location of where the data is stored on disk can be specified by use of the `ldPath` function. Users should not move or rename this directory. If only output files are stored in `ldPath`, one can either remove the entire directory prior to rerunning the analysis or all of the '.ff' files. Otherwise, one would accumulate a large number of '.ff' files on disk that are no longer in use.

We have adopted the `ff` package in order to reduce crlmm's memory footprint. The memory usage can be fine-tuned by the utilities `ocSamples` and `ocProbesets` provided in the `oligoClasses` package. In most instances, the user-level interface will be no different than accessing data from ordinary matrices in R. However, the differences in the underlying representation can become more noticeable for very large datasets in which the I/O for accessing data from the disk can be substantial.

Value

A `CNSet` object

Author(s)

R. Scharpf

See Also

`ldPath`, `ocSamples`, `ocProbesets`, `CNSet-class`, `preprocessInf`, `genotypeInf`

Examples

```
## See the Illumina vignettes in inst/scripts of the
## source package for an example
```

copynumberAccessors *Accessors for allele-specific or total copy number*

Description

These methods can be applied after an object of class CNSet has been generated by the crlmmCopynumber function.

Usage

```
CA(object, ...)
CB(object, ...)
nuA(object)
nuB(object)
phiA(object)
phiB(object)
totalCopynumber(object,...)
rawCopynumber(object,...)
```

Arguments

object	An object of class CNSet.
...	An additional argument named 'i' can be passed to subset the markers and an argument 'j' can be passed to subset the samples. Other arguments are ignored.

Details

At polymorphic markers, nuA and nuB provide the intercept coefficient (the estimated background intensity) for the A and B alleles, respectively. phiA and phiB provide the slope coefficients for the A and B alleles, respectively.

At nonpolymorphic markers, nuB and phiB are 'NA'.

These functions can be used to tranlate the normalized intensities to the copy number scale. Plotting the copy number estimates as a function of physical position can be used to guide downstream algorithms that smooth, as well as to assess possible mosaicism.

Value

nu[A/B] and phi[A/B] return matrices of the intercept and slope coefficients, respectively.

CA and CB return matrices of allele-specific copy number.

totalCopynumber (or rawCopynumber) returns a matrix of CA+CB.

Note

Subsetting the CNSet object before extracting copy number can be very inefficient when the data set is very large, particularly if using ff objects. The [method will subset all of the assay data elements and all of the elements in the LinearModelParameter slot.

See Also

crlmmCopynumber, CNSet-class

Examples

```
## Not run:
data(cnSetExample)
all(isCurrent(cnSetExample)) ## is the cnSet object current?

## ------------------------------------------------
## calculating allele-specific copy number
## ------------------------------------------------
## copy number for allele A, first 5 markers, first 2 samples
(ca <- CA(cnSetExample, i=1:5, j=1:2))
## copy number for allele B, first 5 markers, first 2 samples
(cb <- CB(cnSetExample, i=1:5, j=1:2))
## total copy number for first 5 markers, first 2 samples
(cn1 <- ca+cb)

## total copy number at first 5 nonpolymorphic loci
index <- which(!isSnp(cnSetExample))[1:5]
cn2 <- CA(cnSetExample, i=index, j=1:2)
## note, cb is NA at nonpolymorphic loci
(cb <- CB(cnSetExample, i=index, j=1:2))
## note, ca+cb will give NAs at nonpolymorphic loci
CA(cnSetExample, i=index, j=1:2) + cb
## A shortcut for total copy number
cn3 <- totalCopynumber(cnSetExample, i=1:5, j=1:2)
all.equal(cn3, cn1)
cn4 <- totalCopynumber(cnSetExample, i=index, j=1:2)
all.equal(cn4, cn2)

## markers 1-5, all samples
cn5 <- totalCopynumber(cnSetExample, i=1:5)
## all markers, samples 1-5
cn6 <- totalCopynumber(cnSetExample, j=1:2)

## End(Not run)
```

---

crlmm *Genotype oligonucleotide arrays with CRLMM*

Description

This is a faster and more efficient implementation of the CRLMM algorithm, especially designed for Affymetrix SNP 5 and 6 arrays (to be soon extended to other platforms).

Usage

```
crlmm(filenames, row.names=TRUE, col.names=TRUE,
      probs=c(1/3, 1/3, 1/3), DF=6, SNRMin=5,
      gender=NULL, save.it=FALSE, load.it=FALSE,
      intensityFile, mixtureSampleSize=10^5,
      eps=0.1, verbose=TRUE, cdfName, sns, recallMin=10,
      recallRegMin=1000, returnParams=FALSE, badSNP=0.7)
crlmm2(filenames, row.names=TRUE, col.names=TRUE,
      probs=c(1/3, 1/3, 1/3), DF=6, SNRMin=5,
      gender=NULL, save.it=FALSE, load.it=FALSE,
      intensityFile, mixtureSampleSize=10^5,
      eps=0.1, verbose=TRUE, cdfName, sns, recallMin=10,
      recallRegMin=1000, returnParams=FALSE, badSNP=0.7)
```

Arguments

filenames	'character' vector with CEL files to be genotyped.
row.names	'logical'. Use rownames - SNP names?
col.names	'logical'. Use colnames - Sample names?
probs	'numeric' vector with priors for AA, AB and BB.
DF	'integer' with number of degrees of freedom to use with t-distribution.
SNRMin	'numeric' scalar defining the minimum SNR used to filter out samples.
gender	'integer' vector, with same length as 'filenames', defining sex. (1 - male; 2 - female)
save.it	'logical'. Save preprocessed data?
load.it	'logical'. Load preprocessed data to speed up analysis?
intensityFile	'character' with filename to be saved/loaded - preprocessed data.
mixtureSampleSize	Number of SNP's to be used with the mixture model.
eps	Minimum change for mixture model.
verbose	'logical'.
cdfName	'character' defining the CDF name to use ('GenomeWideSnp5', 'GenomeWideSnp6')
sns	'character' vector with sample names to be used.
recallMin	Minimum number of samples for recalibration.
recallRegMin	Minimum number of SNP's for regression.
returnParams	'logical'. Return recalibrated parameters.
badSNP	'numeric'. Threshold to flag as bad SNP (affects batchQC)

Details

'crlmm2' allows one to genotype very large datasets (via ff package) and also permits the use of clusters or multiple cores (via snow package) to speed up genotyping.

As noted above, the call probabilities are stored using an integer representation to reduce file size using the transformation 'round(-1000*log2(1-p))', where p is the probability. The function `i2P` can be used to convert the integers back to the scale of probabilities.

Value

A SnpSet object.

calls	Genotype calls (1 - AA, 2 - AB, 3 - BB)
confs	Confidence scores 'round(-1000*log2(1-p))'
SNPQC	SNP Quality Scores
batchQC	Batch Quality Score
params	Recalibrated parameters

References

Carvalho B, Bengtsson H, Speed TP, Irizarry RA. Exploration, normalization, and genotype calls of high-density oligonucleotide SNP array data. Biostatistics. 2007 Apr;8(2):485-99. Epub 2006 Dec 22. PMID: 17189563.

Carvalho BS, Louis TA, Irizarry RA. Quantifying uncertainty in genotype calls. Bioinformatics. 2010 Jan 15;26(2):242-9.

See Also

i2p, snpCall, snpCallProbability

Examples

```
## this can be slow
library(oligoClasses)
if (require(genomewidesnp6Crlmm) & require(hapmapsnp6)){
  path <- system.file("celFiles", package="hapmapsnp6")

  ## the filenames with full path...
  ## very useful when genotyping samples not in the working directory
  cels <- list.celfiles(path, full.names=TRUE)
  (crlmmOutput <- crlmm(cels))
  ## If gender is known, one should check that the assigned gender is
  ## correct, or pass the integer coding of gender as an argument to the
  ## crlmm function as done below
}

## Not run:
## HPC Example
library(ff)
library(snow)
library(crlmm)
## genotype 50K SNPs at a time
ocProbesets(50000)
## setup cluster - 8 cores on the machine
library(doSNOW)
cl <- makeCluster(8, "SOCK")
registerDoSNOW(cl)
##setCluster(8, "SOCK")
```

```
path <- system.file("celFiles", package="hapmapsnp6")
cels <- list.celfiles(path, full.names=TRUE)
crlmmOutput <- crlmm2(cels)

## End(Not run)
```

---

crlmmCopynumber *Locus- and allele-specific estimation of copy number*

Description

Locus- and allele-specific estimation of copy number.

Usage

```
crlmmCopynumber(object, MIN.SAMPLES=10, SNRMin = 5, MIN.OBS = 1,
         DF.PRIOR = 50, bias.adj = FALSE,
                prior.prob = rep(1/4, 4), seed = 1, verbose = TRUE,
                GT.CONF.THR = 0.80, MIN.NU = 2^3, MIN.PHI = 2^3,
                THR.NU.PHI = TRUE, type=c("SNP", "NP", "X.SNP", "X.NP"),
                fit.linearModel=TRUE)
```

Arguments

object	object of class CNSet.
MIN.SAMPLES	'Integer'. The minimum number of samples in a batch. Bathes with fewer than MIN.SAMPLES are skipped. Therefore, samples in batches with fewer than MIN.SAMPLES have NA's for the allele-specific copy number and NA's for the linear model parameters.
SNRMin	Samples with low signal to noise ratios are excluded.
MIN.OBS	For a SNP with with fewer than MIN.OBS of a genotype in a given batch, the within-genotype median is imputed. The imputation is based on a regression using SNPs for which all three biallelic genotypes are observed. For example, assume at at a given SNP genotypes AA and AB were observed and BB is an unobserved genotype. For SNPs in which all 3 genotypes were observed, we fit the model E(mean_BB) = beta0 + beta1*mean_AA + beta2*mean_AB, obtaining estimates; of beta0, beta1, and beta2. The imputed mean at the SNP with unobserved BB is then beta0hat + beta1hat * mean_AA of beta2hat * mean_AB.
DF.PRIOR	The 2 x 2 covariance matrix of the background and signal variances is estimated from the data at each locus. This matrix is then smoothed towards a common matrix estimated from all of the loci. DF.PRIOR controls the amount of smoothing towards the common matrix, with higher values corresponding to greater smoothing. Currently, DF.PRIOR is not estimated from the data. Future versions may estimate DF.PRIOR empirically.

`bias.adj` `bias.adj` is currently ignored (as well as the prior.prob argument). We plan to add this feature back to the crlmm package in the near future. This feature, when `TRUE`, updated initial estimates from the linear model after excluding samples with a low posterior probability of normal copy number. Excluding samples that have a low posterior probability can be helpful at loci in which a substantial fraction of the samples have a copy number alteration. For additional information, see Scharpf et al., 2010.

`prior.prob` This argument is currently ignored. A numerical vector providing prior probabilities for copy number states corresponding to homozygous deletion, hemizygous deletion, normal copy number, and amplification, respectively.

`seed` Seed for random number generation.

`verbose` Logical.

`GT.CONF.THR` Confidence threshold for genotype calls (0, 1). Calls with confidence scores below this theshold are not used to estimate the within-genotype medians. See Carvalho et al., 2007 for information regarding confidence scores of biallelic genotypes.

`MIN.NU` numeric. Minimum value for background intensity. Ignored if `THR.NU.PHI` is `FALSE`.

`MIN.PHI` numeric. Minimum value for slope. Ignored if `THR.NU.PHI` is `FALSE`.

`THR.NU.PHI` If `THR.NU.PHI` is `FALSE`, `MIN.NU` and `MIN.PHI` are ignored. When TRUE, background (nu) and slope (phi) coefficients below MIN.NU and MIN.PHI are set to MIN.NU and MIN.PHI, respectively.

`type` Character string vector that must be one or more of "SNP", "NP", "X.SNP", or "X.NP". Type refers to a set of markers. See details below

`fit.linearModel`
Logical. If TRUE, a linear model is fit to estimate the parameters for computing the absolute copy number. If FALSE, we compute the batch-specific, within-genotype median and MAD at polymorphic loci and the median and MAD at nonpolymorphic loci.

Details

We suggest a minimum of 10 samples per batch for using `crlmmCopynumber`. 50 or more samples per batch is preferred and will improve the estimates.

The functions `crlmmCopynumberLD` and `crlmmCopynumber2` have been deprecated.

The argument `type` can be used to specify a subset of markers for which the copy number estimation algorithm is run. One or more of the following possible entries are valid: 'SNP', 'NP', 'X.SNP', and 'X.NP'.

'SNP' referers to autosomal SNPs.

'NP' refers to autosomal nonpolymorphic markers.

'X.SNP' refers to SNPs on chromosome X.

'X.NP' refers to autosomes on chromosome X.

However, users must run 'SNP' prior to running 'NP' and 'X.NP', or specify `type = c('SNP', 'X.NP')`.

Value

The value returned by the crlmmCopynumber function depends on whether the data is stored in RAM or whether the data is stored on disk using the R package ff for reading / writing. If uncertain, the first line of the show method defined for CNSet objects prints whether the assayData elements are derived from the ff package in the first line. Specifically,

- if the elements of the batchStaticts slot in the CNSet object have the class "ff_matrix" or "ffdf", then the crlmmCopynumber function updates the data stored on disk and returns the value TRUE.

- if the elements of the batchStatistics slot in the CNSet object have the class 'matrix', then the crlmmCopynumber function returns an object of class CNSet with the elements of batchStatistics updated.

Author(s)

R. Scharpf

References

Carvalho B, Bengtsson H, Speed TP, Irizarry RA. Exploration, normalization, and genotype calls of high-density oligonucleotide SNP array data. Biostatistics. 2007 Apr;8(2):485-99. Epub 2006 Dec 22. PMID: 17189563.

Carvalho BS, Louis TA, Irizarry RA. Quantifying uncertainty in genotype calls. Bioinformatics. 2010 Jan 15;26(2):242-9.

Scharpf RB, Ruczinski I, Carvalho B, Doan B, Chakravarti A, and Irizarry RA, Biostatistics. Biostatistics, Epub July 2010.

---

genotype *Preprocessing and genotyping of Affymetrix arrays.*

Description

Preprocessing and genotyping of Affymetrix arrays.

Usage

```
genotype(filenames, cdfName, batch, mixtureSampleSize = 10^5, eps =0.1,
         verbose = TRUE, seed = 1, sns, probs = rep(1/3, 3),
         DF = 6, SNRMin = 5, recallMin = 10, recallRegMin = 1000,
       gender = NULL, returnParams = TRUE, badSNP = 0.7,  genome=c("hg19", "hg18"))
```

Arguments

filenames	complete path to CEL files
cdfName	annotation package (see also validCdfNames)
batch	vector of class character denoting the batch for each sample in filenames. The batch vector must be the same length as the number of samples. See details.

mixtureSampleSize	Sample size to be use when fitting the mixture model.
eps	Stop criteria.
verbose	Logical. Whether to print descriptive messages during processing.
seed	Seed to be used when sampling. Useful for reproducibility
sns	The sample identifiers. If missing, the default sample names are basename(filenames)
probs	'numeric' vector with priors for AA, AB and BB.
DF	'integer' with number of degrees of freedom to use with t-distribution.
SNRMin	'numeric' scalar defining the minimum SNR used to filter out samples.
recallMin	Minimum number of samples for recalibration.
recallRegMin	Minimum number of SNP's for regression.
gender	integer vector (male = 1, female =2) or missing, with same length as filenames. If missing, the gender is predicted.
returnParams	'logical'. Return recalibrated parameters from crlmm.
badSNP	'numeric'. Threshold to flag as bad SNP (affects batchQC)
genome	character string indicating the UCSC genome build for the SNP annotation

Details

For large datasets it is important to utilize the large data support by installing and loading the ff package before calling the genotype function. In previous versions of the crlmm package, we useed different functions for genotyping depending on whether the ff package is loaded, namely genotype and genotype2. The genotype function now handles both instances.

genotype is essentially a wrapper of the crlmm function for genotyping. Differences include (1) that the copy number probes (if present) are also quantile-normalized and (2) the class of object returned by this function, CNSet, is needed for subsequent copy number estimation. Note that the batch variable that must be passed to this function has no effect on the normalization or genotyping steps. Rather, batch is required in order to initialize a CNSet container with the appropriate dimensions and is used directly when estimating copy number.

Value

A SnpSuperSet instance.

Note

For large datasets, load the 'ff' package prior to genotyping – this will greatly reduce the RAM required for big jobs. See ldPath and ocSamples.

Author(s)

R. Scharpf

References

Carvalho B, Bengtsson H, Speed TP, Irizarry RA. Exploration, normalization, and genotype calls of high-density oligonucleotide SNP array data. Biostatistics. 2007 Apr;8(2):485-99. Epub 2006 Dec 22. PMID: 17189563.

Carvalho BS, Louis TA, Irizarry RA. Quantifying uncertainty in genotype calls. Bioinformatics. 2010 Jan 15;26(2):242-9.

See Also

snprma, crlmm, ocSamples, ldOpts, batch, crlmmCopynumber

Examples

```
if (require(ff) & require(genomewidesnp6Crlmm) & require(hapmapsnp6)){
  ldPath(tempdir())
  path <- system.file("celFiles", package="hapmapsnp6")
  ## the filenames with full path...
  ## very useful when genotyping samples not in the working directory
  cels <- list.celfiles(path, full.names=TRUE)
  ## Note: one would need at least 10 CEL files for copy number estimation
  ## To use less RAM, specify a smaller argument to ocProbesets
  ocProbesets(50e3)
  batch <- rep("A", length(cels))
  (cnSet <- genotype(cels, cdfName="genomewidesnp6", batch=batch))

##Segment faults that occur with the above step can often be traced to a
##corrupt cel file. To check if any of the files are corrupt, try
##reading the files in one at a time:

## Not run:
require(affyio)
validCEL(cels)

## End(Not run)

  ## when gender is not specified (as in the above example), crlmm tries
  ## to predict the gender from SNPs on chromosome X
  cnSet$gender

  ## If gender is known, one should check that the assigned gender is
  ## correct. Alternatively, one can pass gender as an argument to the
  ## genotype function.
  gender <- c("female", "female", "male")
  gender[gender == "female"] <- 2
  gender[gender == "male"] <- 1
  dim(cnSet)
  table(isSnp(cnSet))
}
```

genotype.Illumina *Preprocessing and genotyping of Illumina Infinium II arrays.*

Description

Preprocessing and genotyping of Illumina Infinium II arrays.

Usage

```
genotype.Illumina(sampleSheet=NULL, arrayNames=NULL, ids=NULL, path=".",
    arrayInfoColNames=list(barcode="SentrixBarcode_A", position="SentrixPosition_A"),
    highDensity=FALSE, sep="_", fileExt=list(green="Grn.idat", red="Red.idat"), XY=NULL, anno, genome
    call.method="crlmm", trueCalls=NULL, cdfName, copynumber=TRUE, batch=NULL, saveDate=FALSE, stripN
    useTarget=TRUE, quantile.method="between", nopackage.norm="quantile", mixtureSampleSize=10^5, fit
    eps=0.1, verbose = TRUE, seed = 1, sns, probs = rep(1/3, 3), DF = 6, SNRMin = 5,
    recallMin = 10, recallRegMin = 1000, gender = NULL, returnParams = TRUE, badSNP = 0.7)

crlmmIllumina(sampleSheet=NULL, arrayNames=NULL, ids=NULL, path=".",
    arrayInfoColNames=list(barcode="SentrixBarcode_A", position="SentrixPosition_A"),
    highDensity=FALSE, sep="_", fileExt=list(green="Grn.idat", red="Red.idat"), XY=NULL, anno, genome
    call.method="crlmm", trueCalls=NULL, cdfName, copynumber=TRUE, batch=NULL, saveDate=FALSE, stripN
    useTarget=TRUE, quantile.method="between", nopackage.norm="quantile", mixtureSampleSize=10^5, fit
    eps=0.1, verbose = TRUE, seed = 1, sns, probs = rep(1/3, 3), DF = 6, SNRMin = 5,
    recallMin = 10, recallRegMin = 1000, gender = NULL, returnParams = TRUE, badSNP = 0.7)
```

Arguments

sampleSheet	data.frame containing Illumina sample sheet information (for required columns, refer to BeadStudio Genotyping guide - Appendix A).
arrayNames	character vector containing names of arrays to be read in. If NULL, all arrays that can be found in the specified working directory will be read in.
ids	vector containing ids of probes to be read in. If NULL all probes found on the first array are read in.
path	character string specifying the location of files to be read by the function
arrayInfoColNames	(used when sampleSheet is specified) list containing elements 'barcode' which indicates column names in the sampleSheet which contains the arrayNumber/barcode number and 'position' which indicates the strip number. In older style sample sheets, this information is combined (usually in a column named 'SentrixPosition') and this should be specified as list(barcode=NULL, position="SentrixPosition"
highDensity	logical (used when sampleSheet is specified). If TRUE, array extensions '_A', '_B' in sampleSheet are replaced with 'R01C01', 'R01C02' etc.
sep	character string specifying separator used in .idat file names.

fileExt	list containing elements 'Green' and 'Red' which specify the .idat file extension for the Cy3 and Cy5 channels.
XY	NChannelSet containing X and Y intensities.
anno	data.frame containing SNP annotation information from manifest and additional columns 'isSnp', 'position', 'chromosome' and 'featureNames'. For use when cdfName='nopackage'
genome	character string specifying which genome is used in annotation
call.method	character string specifying the genotype calling algorithm to use ('crlmm' or 'krlmm').
trueCalls	matrix specifying known Genotype calls(can contain some NAs) for a subset of samples and features (1 - AA, 2 - AB, 3 - BB).
cdfName	annotation package (see also validCdfNames) or 'nopackage' when combined with 'krlmm', an anno data.frame and genome.
copynumber	'logical.' Whether to store copy number intensities with SNP output.
batch	character vector indicating the batch variable. Must be the same length as the number of samples. See details.
saveDate	'logical'. Should the dates from each .idat be saved with sample information?
stripNorm	'logical'. Should the data be strip-level normalized?
useTarget	'logical' (only used when stripNorm=TRUE). Should the reference HapMap intensities be used in strip-level normalization?
quantile.method	character string specifying the quantile normalization method to use ('within' or 'between' channels).
nopackage.norm	character string specifying normalization to be used when cdfName='nopackage'. Options are 'none', 'quantile' (within channel, between array) and 'loess'.
mixtureSampleSize	Sample size to be use when fitting the mixture model.
fitMixture	'logical.' Whether to fit per-array mixture model.
eps	Stop criteria.
verbose	'logical.' Whether to print descriptive messages during processing.
seed	Seed to be used when sampling. Useful for reproducibility
sns	The sample identifiers. If missing, the default sample names are basename(filenames)
probs	'numeric' vector with priors for AA, AB and BB.
DF	'integer' with number of degrees of freedom to use with t-distribution.
SNRMin	'numeric' scalar defining the minimum SNR used to filter out samples.
recallMin	Minimum number of samples for recalibration.
recallRegMin	Minimum number of SNP's for regression.
gender	integer vector (male = 1, female = 2) or missing, with same length as filenames. If missing, the gender is predicted.
returnParams	'logical'. Return recalibrated parameters from crlmm.
badSNP	'numeric'. Threshold to flag as bad SNP (affects batchQC)

Details

genotype.Illumina (or equivalently crlmmIllumina) is a wrapper of the crlmm function for genotyping. Differences include (1) that the copy number probes (if present) are also quantile-normalized and (2) the class of object returned by this function, CNSet, is needed for subsequent copy number estimation. Note that the batch variable (a character string) has no effect on the normalization or genotyping steps. Rather, batch is required in order to initialize a CNSet container with the appropriate dimensions.

The new 'krlmm' option is available for certain chip types. Optional argument trueCalls matrix contains known Genotype calls (1 - AA, 2 - AB, 3 - BB) for a subset of samples and features. This will used to compute KRLMM coefficients by calling vglm function from VGAM package.

The 'krlmm' method makes use of functions provided in parallel package to speed up the process. It by default initialises up to 8 clusters. This is configurable by setting up an option named "krlmm.cores", e.g. options("krlmm.cores" = 16).

In general, a chip specific annotation package is required to use the genotype.Illumina function. If this is not available (newer chip types or custom chips often don't have a chip-specific package available on Bioconductor), consider using cdfName='nopackage' and specifying anno and genome, which runs 'krlmm' on the samples available. Here anno is a data.frame read in from the relevant chip-specific manifest, which must have additional columns 'isSnp' which is a logical that indicates whether a probe is polymorphic or not, 'position', 'chromosome' and 'featureNames' that give the location on the chromosome and SNP name.

Value

A SnpSuperSet instance.

Author(s)

Matt Ritchie, Cynthia Liu, Zhiyin Dai

References

Ritchie ME, Carvalho BS, Hetrick KN, Tavar\'e S, Irizarry RA. R/Bioconductor software for Illumina's Infinium whole-genome genotyping BeadChips. Bioinformatics. 2009 Oct 1;25(19):2621-3.

Liu R, Dai Z, Yeager M, Irizarry RA1, Ritchie ME. KRLMM: an adaptive genotype calling method for common and low frequency variants. BMC Bioinformatics. 2014 May 23;15:158.

Carvalho B, Bengtsson H, Speed TP, Irizarry RA. Exploration, normalization, and genotype calls of high-density oligonucleotide SNP array data. Biostatistics. 2007 Apr;8(2):485-99. Epub 2006 Dec 22. PMID: 17189563.

Carvalho BS, Louis TA, Irizarry RA. Quantifying uncertainty in genotype calls. Bioinformatics. 2010 Jan 15;26(2):242-9.

See Also

ocSamples, ldOpts

Examples

```
## Not run:
 # example for 'crlmm' option
 library(ff)
 library(crlmm)
 ## to enable paralellization, set to TRUE
 if(FALSE){
  library(snow)
  library(doSNOW)
  ## with 10 workers
  cl <- makeCluster(10, type="SOCK")
  registerDoSNOW(cl)
 }
 ## path to idat files
 datadir <- "/thumper/ctsa/snpmicroarray/illumina/IDATS/370k"
 ## read in your samplesheet
 samplesheet = read.csv(file.path(datadir, "HumanHap370Duo_Sample_Map.csv"), header=TRUE, as.is=TRUE)
 samplesheet <- samplesheet[-c(28:46,61:75,78:79), ]
 arrayNames <- file.path(datadir, unique(samplesheet[, "SentrixPosition"]))
 arrayInfo <- list(barcode=NULL, position="SentrixPosition")
 cnSet <- genotype.Illumina(sampleSheet=samplesheet,
       arrayNames=arrayNames,
       arrayInfoColNames=arrayInfo,
       cdfName="human370v1c",
       batch=rep("1", nrow(samplesheet)))


## End(Not run)
## Not run:
 # example for 'krlmm' option
 library(crlmm)
 library(ff)
 # line below is an optional step for krlmm to initialise 16 workers
 # options("krlmm.cores" = 16)
 # read in raw X and Y intensities output by GenomeStudio's GenCall genotyping module
 XY = readGenCallOutput(c("HumanOmni2-5_4v1_FinalReport_83TUSCAN.csv","HumanOmni2-5_4v1_FinalReport_88CHB-JPT.c
    cdfName="humanomni25quadv1b",
    verbose=TRUE)
 krlmmResult = genotype.Illumina(XY=XY,
           cdfName=ThiscdfName,
     call.method="krlmm",
     verbose=TRUE)

 # example for 'krlmm' option with known genotype call for some SNPs and samples
 library(VGAM)
 hapmapCalls = load("hapmapCalls.rda")
 # hapmapCalls should have rownames and colnames corresponding to XY featureNames and sampleNames
 krlmmResult = genotype.Illumina(XY=XY,
     cdfName=ThiscdfName,
     call.method="krlmm",
     trueCalls=hapmapCalls,
     verbose=TRUE)
```

```
## End(Not run)
```

---

genotypeAffy *Genotype Affymetrix CEL files*

Description

Assign diallelic genotypes at polymorphic markers

Usage

```
genotypeAffy(cnSet, SNRMin = 5, recallMin = 10, recallRegMin = 1000, gender = NULL, badSNP = 0.7, returnP
```

Arguments

cnSet	An object of class CNSet
SNRMin	See crlmm
recallMin	See crlmm
recallRegMin	See crlmm
gender	See crlmm
badSNP	See crlmm
returnParams	See crlmm
verbose	Logical.

Details

Wrapper for crlmm genotyping.

Value

Returns logical. SNP genotypes and confidence scores are written to ff_matrix objects.

Author(s)

R.Scharpf

See Also

crlmm, calls, confs

genotypeInf *Genotyping of Illumina Infinium II arrays.*

Description

Genotyping of Illumina Infinium II arrays. This function provides CRLMM/KRLMM genotypes and confidence scores for the the polymorphic markers and is a required step prior to copy number estimation.

Usage

```
genotypeInf(cnSet, mixtureParams, probs = rep(1/3, 3), SNRMin = 5,
          recallMin = 10, recallRegMin = 1000, verbose = TRUE, returnParams = TRUE,
          badSNP = 0.7, gender = NULL, DF = 6, cdfName, nopackage.norm="quantile",
              call.method="crlmm", trueCalls = NULL)
```

Arguments

cnSet	An object of class CNSet
mixtureParams	data.frame containing mixture model parameters needed for genotyping. The mixture model parameters are estimated from the preprocessInf function.
probs	'numeric' vector with priors for AA, AB and BB.
SNRMin	'numeric' scalar defining the minimum SNR used to filter out samples.
recallMin	Minimum number of samples for recalibration.
recallRegMin	Minimum number of SNP's for regression.
verbose	'logical.' Whether to print descriptive messages during processing.
returnParams	'logical'. Return recalibrated parameters from crlmm.
badSNP	'numeric'. Threshold to flag as bad SNP (affects batchQC)
gender	integer vector (male = 1, female =2) or missing, with same length as filenames. If missing, the gender is predicted.
DF	'integer' with number of degrees of freedom to use with t-distribution.
cdfName	character string indicating which annotation package to load.
nopackage.norm	character string specifying normalization to be used when cdfName='nopackage'. Options are 'none', 'quantile' (within channel, between array) and 'quantileloess'.
call.method	character string specifying the genotype calling algorithm to use ('crlmm' or 'krlmm').
trueCalls	matrix specifying known Genotype calls for a subset of samples and features(1 - AA, 2 - AB, 3 - BB).

Details

The genotype calls and confidence scores are written to file using `ff` protocols for I/O. For the most part, the calls and confidence scores can be accessed as though the data is in memory through the methods `snpCall` and `snpCallProbability`, respectively.

The genotype calls are stored using an integer representation: 1 - AA, 2 - AB, 3 - BB. Similarly, the call probabilities are stored using an integer representation to reduce file size using the transformation 'round(-1000*log2(1-p))', where p is the probability. The function `i2P` can be used to convert the integers back to the scale of probabilities.

An optional `trueCalls` argument can be provided to KRLMM method which contains known genotype calls(can contain some NAs) for some samples and SNPs. This will used to compute KRLMM parameters by calling `vglm` function from `VGAM` package.

The KRLMM method makes use of functions provided in `parallel` package to speed up the process. It by default initialises up to 8 clusters. This is configurable by setting up an option named "krlmm.cores", e.g. options("krlmm.cores" = 16).

Value

Logical. If the genotyping is completed, the value 'TRUE' is returned. Note that `assayData` elements 'call' and 'callProbability' are updated on disk. Therefore, the genotypes and confidence scores can be retrieved using accessors for the `CNSet` class.

Author(s)

R. Scharpf

See Also

`crlmm`, `snpCall`, `snpCallProbability`, `annotationPackages`

Examples

```
## See the 'illumina_copynumber' vignette in inst/scripts of
## the source package
```

---

genotypes *The possible genotypes for an integer copy number.*

Description

The possible genotypes for an integer copy number (0-4).

Usage

```
genotypes(copyNumber, is.snp=TRUE)
```

Arguments

copyNumber	Integer (0-4 allowed).
is.snp	Logical. If TRUE, possible genotypes for a polymorphic SNP is returned. If FALSE, only monomorphic genotypes returned.

Value

Character vector.

Author(s)

R. Scharpf

Examples

```
for(i in 0:4) print(genotypes(i))
for(i in 0:4) print(genotypes(i, FALSE))
```

ListClassConstructors *Methods for Function* BafLrrSetList *in Package* **crlmm** ~~

Description

Constructors for BafLrrSetList and OligoSetList objects.

Usage

```
BafLrrSetList(object, ...)
OligoSetList(object, ...)
```

Arguments

object	A CNSet object.
...	Additional arguments batch.name and chrom can be used to specify specific batches or chromosomes in the CNSet object.

Details

Constructs a BafLrrSetList object or a OligoSetList object from an object of class CNSet.

Value

A BafLrrSetList or OligoSetList

See Also

BeadStudioSetList

Examples

```
data(cnSetExample)
oligoList <- OligoSetList(cnSetExample)
## only contains 1 chromosome, so list only has one element
dims(oligoList)
brList <- BafLrrSetList(cnSetExample)
dims(brList)
```

---

plotSNPs *Make M vs S plot for SNPs or samples.*

Description

These functions plot the M-values (log-ratios) versus S-values (average intensities) for given SNP/(s) or sample/(s) or beanplots for M-values from different samples.

Usage

```
plotSNPs(cnSet, row=1, offset=0, xlim=c(9,16), ylim=c(-5,5), verbose=FALSE)
plotSamples(cnSet, col=1, offset=0, xlim=c(9,16), ylim=c(-5,5), verbose=FALSE, sample=100000, seed=1,
```

Arguments

cnSet	An object of class CNSet
row	scalar/vector of SNP indexes to plot
col	scalar/vector of sample indexes to plot
offset	numeric, offset to add to intensities in cnSet before log2-transforming to make log-ratios or average log-intensities
xlim	the x limits of the plot
ylim	the y limits of the plot
verbose	'logical.' Whether to print descriptive messages during processing
sample	integer indicating the number of SNPs to sample for the plot
seed	integer seed for the random number generator to sample the SNPs
type	character vector specifying the type of sample plot (either 'smoothScatter' or 'beanplot')

Details

The plotSNPs and plotSamples functions plot the M and S values derived from the cnSet object.

Value

One or more M vs S plot for plotSNPs for a given SNP(/s) or either a smoothed scatter plot of M vs S or a beanplot of the M-values for a selected sample(/s) for plotSamples.

Author(s)

Matt Ritchie and Cynthia Liu

See Also

genotype.Illumina

Examples

```
## Not run:
   crlmmResult <- genotype.Illumina(sampleSheet=samples[1:10,], path=path,
                                    arrayInfoColNames=list(barcode=NULL,
                                    position="SentrixPosition"),
                                    saveDate=TRUE, cdfName="human370v1c")
   par(mfrow=c(2,2))
   plotSamples(crlmmResult, col=1:4)
   plotSNPs(crlmmResult, row=1:4)

## End(Not run)
```

---

posteriorProbability *Calculate the posterior probability for integer copy numbers.*

Description

Calculate the posterior probability for integer copy numbers using the bivariate normal prediction regions.

Usage

```
posteriorProbability(object, predictRegion, copyNumber = 0:4, w)
```

Arguments

object	A CNSet object.
predictRegion	A list containing the bivariate normal prediction region for each of the possible genotypes.
copyNumber	Integer vector.
w	numeric vector of prior probabilities for each of the copy number states. Must be the same length as copyNumber and sum to 1.

Details

This is currently under development.

Value

An array (features x samples x copy number)

Note

This is under development. Use at your own risk.

Author(s)

R. Scharpf

See Also

predictionRegion, genotypes

Examples

```
data(cnSetExample)
pr <- predictionRegion(cnSetExample, copyNumber=0:4)
pp <- posteriorProbability(cnSetExample, predictRegion=pr)
dim(pp)

## multiple batches
data(cnSetExample2)
pr <- predictionRegion(cnSetExample2, copyNumber=0:4)
pp <- posteriorProbability(cnSetExample2, predictRegion=pr)
```

---

predictionRegion *Prediction regions for integer copy number*

Description

Bivariate normal prediction regions for integer copy number. Copy numbers 0-4 allowed.

Usage

```
predictionRegion(object, copyNumber)
```

Arguments

object	A CNSet object.
copyNumber	Integer vector. 0-4 allowed.

Details

We fit a linear regression for each allele to the diallic genotype cluster medians. Denoting the background and slope by nu and phi, respectively, the mean for the bivariate normal prediction region is given by

mu_A = nu_A + CA * phi_A

and

mu_B nu_B + CB * phi_B

The variance and correlation of the normalized intensities is estimated from the diallelic genotype clusters AA, AB, and BB on the log-scale. For copy number not equal to two, we assume that the variance is approximately the same for copy number not equal to 2.

Value

A list named by the genotype. 'NULL' refers to copy number zero, 'A' is a hemizygous deletion, etc. Each element is a list of the means (mu) and covariance (cov) for each marker stored as an array. For 'mu', the dimensions of the array are marker x allele (A or B) x batch. For 'cov', the dimensions of the array are marker x 3 (varA, cor, and varB) x batch.

Author(s)

R. Scharpf

References

Scharpf et al., 2011, Biostatistics.

See Also

posteriorProbability, genotypes

Examples

```
data(cnSetExample)
pr <- predictionRegion(cnSetExample, copyNumber=0:4)
names(pr)
## bivariate normal prediction region for NULL genotype (homozygous deletion)
str(pr[["NULL"]])
```

PredictionRegion-class

Class "PredictionRegion"

Description

A container for bivariate normal prediction regions for SNP data and univarite prediction regions for nonpolymorphic markers.

Objects from the Class

Objects from the class are created from the predictionRegion function.

Slots

.Data: Object of class "list" ~~

Extends

Class "list", from data part. Class "vector", by class "list", distance 2. Class "AssayData", by class "list", distance 2. Class "list_or_ffdf", by class "list", distance 2. Class vectorORfactor, by class "list", distance 3.

Methods

[signature(x = "PredictionRegion"): ... Prediction regions can be subset by markers.

Author(s)

R. Scharpf

See Also

predictionRegion

Examples

```
showClass("PredictionRegion")
```

---

preprocessInf *Preprocessing of Illumina Infinium II arrays.*

Description

This function normalizes the intensities for the 'A' and 'B' alleles for a CNSet object and estimates mixture parameters used for subsequent genotyping. See details for how the normalized intensities are written to file. This step is required for subsequent genotyping and copy number estimation.

Usage

```
preprocessInf(cnSet, sampleSheet=NULL, arrayNames = NULL, ids = NULL,
path = ".", arrayInfoColNames = list(barcode = "SentrixBarcode_A",
position = "SentrixPosition_A"), highDensity = TRUE, sep = "_", fileExt
= list(green = "Grn.idat", red = "Red.idat"), XY, anno, saveDate = TRUE, stripNorm
= TRUE, useTarget = TRUE, mixtureSampleSize = 10^5, fitMixture = TRUE,
quantile.method="between", eps = 0.1, verbose = TRUE, seed = 1, cdfName)
```

Arguments

cnSet	object of class CNSet
sampleSheet	data.frame containing Illumina sample sheet information (for required columns, refer to BeadStudio Genotyping guide - Appendix A).
arrayNames	character vector containing names of arrays to be read in. If NULL, all arrays that can be found in the specified working directory will be read in.

ids	vector containing ids of probes to be read in. If NULL all probes found on the first array are read in.
path	character string specifying the location of files to be read by the function
arrayInfoColNames	(used when sampleSheet is specified) list containing elements 'barcode' which indicates column names in the sampleSheet which contains the arrayNumber/barcode number and 'position' which indicates the strip number. In older style sample sheets, this information is combined (usually in a column named 'SentrixPosition') and this should be specified as list(barcode=NULL, position="SentrixPosition")
highDensity	logical (used when sampleSheet is specified). If TRUE, array extensions '_A', '_B' in sampleSheet are replaced with 'R01C01', 'R01C02' etc.
sep	character string specifying separator used in .idat file names.
fileExt	list containing elements 'Green' and 'Red' which specify the .idat file extension for the Cy3 and Cy5 channels.
XY	an NChannelSet object containing X and Y intensities.
anno	data.frame containing SNP annotation information from manifest and additional columns 'isSnp', 'position', 'chromosome' and 'featureNames'. For use when cdfName='nopackage'
saveDate	'logical'. Should the dates from each .idat be saved with sample information?
stripNorm	'logical'. Should the data be strip-level normalized?
useTarget	'logical' (only used when stripNorm=TRUE). Should the reference HapMap intensities be used in strip-level normalization?
mixtureSampleSize	Sample size to be use when fitting the mixture model.
fitMixture	'logical.' Whether to fit per-array mixture model.
quantile.method	character string specifying the quantile normalization method to use ('within' or 'between' channels).
eps	Stop criteria.
verbose	'logical.' Whether to print descriptive messages during processing.
seed	Seed to be used when sampling. Useful for reproducibility
cdfName	character string indicating which annotation package to load.

Details

The normalized intensities are written to disk using package ff protocols for writing/reading to disk. Note that the object CNSet containing the ff objects in the assayData slot will be updated after applying this function.

Value

A ff_matrix object containing parameters for fitting the mixture model. Note that while the CNSet object is not returned by this function, the object will be updated as the normalized intensities are written to disk. In particular, after applying this function the normalized intensities in the alleleA and alleleB elements of assayData are now available.

Author(s)

R. Scharpf

See Also

CNSet-class, A, B, constructInf, genotypeInf, annotationPackages

Examples

```
## See the 'illumina_copynumber' vignette in inst/scripts of
## the source package
```

---

readGenCallOutput *Read X and Y intensities from GenCall output*

Description

This function reads the raw X and Y intensities output by GenomeStudio's GenCall genotyping module in preparation for genotyping with crlmm.

Usage

```
readGenCallOutput(filenames, path=".", cdfName, colnames=list("SampleID"="Sample ID", "SNPID"="SNP Na
            type=list("SampleID"="character", "SNPID"="character", "XRaw"="integer", "YRaw"="integer
```

Arguments

filenames	'character' string, or a vector of character string specifying the name of the file(s) to read in
path	'character' string specifying the location of file to be read by the function
cdfName	'character' defining the chip annotation (manifest) to use ('human370v1c', human550v3b', 'human650v3a', 'human1mv1c', 'human370quadv3c', 'human610quadv1b', 'human660quadv1a', 'human1mduov3b', 'humanomni1quadv1b', 'humanomniexpress12v1b', 'humancytosnp12v2p1h')
colnames	list containing elements 'SampleID', 'SNPID', 'XRaw' and 'YRaw', which specify the column names from in 'file' that pertain to these variables. The default should suffice in most situations.
type	list containing data types for the columns to be read in. The default should be fine in most situations.
verbose	'logical'. Should processing information be displayed as data is read in?

Details

This function returns an NChannelSet containing raw intensity data (X and Y) from GenCall final report file. It assumes the GenCall output is formatted to have samples listed one below the other, and that the columns 'X Raw' and 'Y Raw' are available in the file. The function crlmmillumina() can be run on the output of the readGenCallOutput function.

Value

NChannelSet containing X and Y bead intensities.

Author(s)

Cynthia Liu, Matt Ritchie, Zhiyin Dai

References

Ritchie ME, Carvalho BS, Hetrick KN, Tavar\'e S, Irizarry RA. R/Bioconductor software for Illumina's Infinium whole-genome genotyping BeadChips. Bioinformatics. 2009 Oct 1;25(19):2621-3.

Examples

```
#XY = readGenCallOutput(file="Hap650Yv3_Final_Report.txt", cdfName="human650v3a")
#crlmmOut = crlmmIllumina(XY=XY)
```

---

readIdatFiles *Reads Idat Files from Infinium II Illumina BeadChips*

Description

Reads intensity information for each bead type from .idat files of Infinium II genotyping BeadChips

Usage

```
readIdatFiles(sampleSheet=NULL, arrayNames=NULL, ids=NULL, path="",
              arrayInfoColNames=list(barcode="SentrixBarcode_A",
                                     position="SentrixPosition_A"),
              highDensity=FALSE, sep="_",
              fileExt=list(green="Grn.idat", red="Red.idat"),
              saveDate=FALSE, verbose=FALSE)
```

Arguments

sampleSheet	data.frame containing Illumina sample sheet information (for required columns, refer to BeadStudio Genotyping guide - Appendix A).
arrayNames	character vector containing names of arrays to be read in. If NULL, all arrays that can be found in the specified working directory will be read in.
ids	vector containing ids of probes to be read in. If NULL all probes found on the first array are read in.
path	character string specifying the location of files to be read by the function
arrayInfoColNames	(used when sampleSheet is specified) list containing elements 'barcode' which indicates column names in the sampleSheet which contains the arrayNumber/barcode number and 'position' which indicates the strip number. In older style sample sheets, this information is combined (usually in a column named 'SentrixPosition') and this should be specified as list(barcode=NULL, position="SentrixPosition"

highDensity	logical (used when sampleSheet is specified). If TRUE, array extensions '_A', '_B' in sampleSheet are replaced with 'R01C01', 'R01C02' etc.
sep	character string specifying separator used in .idat file names.
fileExt	list containing elements 'Green' and 'Red' which specify the .idat file extension for the Cy3 and Cy5 channels.
saveDate	logical. Should the dates from each .idat be saved with sample information?
verbose	logical. Should processing information be displayed as data is read in?

Details

The summarised Cy3 (G) and Cy5 (R) intensities (on the orginal scale) are read in from the .idat files.

Where available, a sampleSheet data.frame, in the same format as used by BeadStudio (columns 'Sample_ID', 'SentrixBarcode_A' and 'SentrixPosition_A' are required) which keeps track of sample information can be specified.

Thanks to Keith Baggerly who provided the code to read in the binary .idat files.

Value

NChannelSet with intensity data (R, G), and indicator for SNPs with 0 beads (zero) for each bead type.

Author(s)

Matt Ritchie

References

Ritchie ME, Carvalho BS, Hetrick KN, Tavar\'e S, Irizarry RA. R/Bioconductor software for Illumina's Infinium whole-genome genotyping BeadChips. Bioinformatics. 2009 Oct 1;25(19):2621-3.

Examples

```
#RG = readIdatFiles()
```

---

snprma *Preprocessing tool for SNP arrays.*

Description

SNPRMA will preprocess SNP chips. The preprocessing consists of quantile normalization to a known target distribution and summarization to the SNP-Allele level.

Usage

```
snprma(filenames, mixtureSampleSize = 10^5, fitMixture = FALSE, eps = 0.1, verbose = TRUE, seed = 1, cdfN
snprma2(filenames, mixtureSampleSize = 10^5, fitMixture = FALSE, eps = 0.1, verbose = TRUE, seed = 1, cdf
```

Arguments

filenames	'character' vector with file names.
mixtureSampleSize	Sample size to be use when fitting the mixture model.
fitMixture	'logical'. Fit the mixture model?
eps	Stop criteria.
verbose	'logical'.
seed	Seed to be used when sampling.
cdfName	cdfName: 'GenomeWideSnp_5', 'GenomeWideSnp_6'
sns	Sample names.

Details

'snprma2' allows one to genotype very large datasets (via ff package) and also permits the use of clusters or multiple cores (via snow package) to speed up preprocessing.

Value

A	Summarized intensities for Allele A
B	Summarized intensities for Allele B
sns	Sample names
gns	SNP names
SNR	Signal-to-noise ratio
SKW	Skewness
mixtureParams	Parameters from mixture model
cdfName	Name of the CDF

Examples

```
if (require(genomewidesnp6Crlmm) & require(hapmapsnp6) & require(oligoClasses)){
  path <- system.file("celFiles", package="hapmapsnp6")

  ## the filenames with full path...
  ## very useful when genotyping samples not in the working directory
  cels <- list.celfiles(path, full.names=TRUE)
  snprmaOutput <- snprma(cels)
  snprmaOutput[["A"]][1:10,]
  snprmaOutput[["B"]][1:10,]
}
## Not run:
## HPC Example
```

```
library(ff)
library(snow)
library(crlmm)
## genotype 50K SNPs at a time
ocProbesets(50000)
## setup cluster - 8 cores on the machine
setCluster(8, "SOCK")

path <- system.file("celFiles", package="hapmapsnp6")
cels <- list.celfiles(path, full.names=TRUE)
snprmaOutput <- snprma2(cels)


## End(Not run)
```

---

snprmaAffy *Quantile normalize intensities for SNPs*

Description

Quantile normalize intensities for SNPs to a HapMap target reference distribution

Usage

```
snprmaAffy(cnSet, mixtureSampleSize = 10^5, eps = 0.1, seed = 1, verbose = TRUE)
```

Arguments

cnSet	Object of class CNSet
mixtureSampleSize	Sample size to be use when fitting the mixture model.
eps	Stop criteria.
seed	Seed to be used when sampling.
verbose	Logical.

Value

Returns nothing. Normalized intensities are written to files.

Author(s)

R.Scharpf

See Also

snprma

validCdfNames *Supported annotation packages for crlmm genotyping*

Description

Supported annotation packages for crlmm genotyping

Usage

```
validCdfNames()
```

Details

List of available annotation packages

Value

character vector

Author(s)

R.Scharpf

Examples

```
validCdfNames()
```

validCEL *Reads cel files and return an error if a file is not read*

Description

Reads cel files and return an error if a file is not read

Usage

```
validCEL(celfiles)
celDates(celfiles)
```

Arguments

celfiles	vector of cel file names to read

Value

Returns a message that cel files were successfully read, or an error if there were problems reading the cel files.

Author(s)

R. Scharpf

See Also

read.celfile.header, *POSIXt*, `read.celfile`

Examples

```
library(oligoClasses)
if(require(hapmapsnp6)){
  path <- system.file("celFiles", package="hapmapsnp6")
  cels <- list.celfiles(path, full.names=TRUE)
  validCEL(cels)
  celDates(cels)
}
```

---

xyplot *Plot prediction regions and normalized intensities.*

Description

Plot prediction regions for integer copy number and normalized intensities.

Usage

```
xyplot(x, data, ...)
```

Arguments

`x`	A `formula`.
`data`	A `CNSet` object.
`...`	Additional arguments passed to `xyplot` function in lattice.

Value

A `trellis` object.

Author(s)

R. Scharpf

See Also

`xyplot`, `ABpanel`

Examples

```
library(oligoClasses)
data(cnSetExample2)
table(batch(cnSetExample2))
sample.index <- which(batch(cnSetExample2) == "CUPID")
## A single SNP
pr <- predictionRegion(cnSetExample2[1:4, sample.index], copyNumber=0:4)
gt <- calls(cnSetExample2[1:4, sample.index])
lim <- c(6,13)
xyplot(B~A|snpid, data=cnSetExample2[1:4, sample.index],
       predictRegion=pr,
       panel=ABpanel,
       pch=21,
       fill=c("red", "blue", "green3")[gt],
       xlim=lim, ylim=lim)

## multiple SNPs, prediction regions for 3 batches
## Not run:
 tab <- table(batch(cnSetExample2))
 bns <- names(tab)[tab > 50]
 sample.index <- which(batch(cnSetExample2)
 pr <- predictionRegion(cnSetExample2[1:10, sample.index], copyNumber=0:4)
 gt <- as.integer(calls(cnSetExample2[1:10, sample.index]))
 xyplot(B~A|snpid, data=cnSetExample2[1:10, sample.index],
        predictRegion=pr,
        panel=ABpanel,
        pch=21,
        fill=c("red", "blue", "green3")[gt],
        xlim=c(6,12), ylim=c(6,12))

 ## nonpolymorphic markers
 data(cnSetExample2)
 tab <- table(batch(cnSetExample2))
 bns <- names(tab)[tab > 50]
 sample.index <- which(batch(cnSetExample2)
 np.index <- which(!isSnp(cnSetExample2))[1:10]
 taus <- tau2(cnSetExample)[np.index, , , ]
 pr <- predictionRegion(cnSetExample2[np.index, sample.index],
          copyNumber=0:4)
 pp <- posteriorProbability(cnSetExample2[np.index, sample.index],
       predictRegion=pr,
       copyNumber=0:4)

## End(Not run)
```

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