Package ‘GWASTools’

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Type Package

Title Tools for Genome Wide Association Studies

Description Classes for storing very large GWAS data sets and annotation, and functions for GWAS data cleaning and analysis.

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anomDetectLOH.R  anomSegStats.R  anomStatsPlot.R
anomIdentifyLowQuality.R  alleleFrequency.R  apartSnpSelection.R
hetByScanChrom.R  hetBySnpSex.R  missingGenotypeByScanChrom.R
missingGenotypeBySnpSex.R  meanIntensityByScanChrom.R
qualityScoreByScan.R  qualityScoreBySnp.R  batchChisqTest.R
batchFisherTest.R  duplicateDiscordanceAcrossDatasets.R
dupDosageCorAcrossDatasets.R  duplicateDiscordance.R
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assocCoxPH.R  exactHWE.R  mendelErr.R  qqPlot.R  manhattanPlot.R
snpCorrelationPlot.R  ibdAreasDraw.R  ibdAssignRelatedness.R
ibdPlot.R  findRelationsMeanVar.R  pedigreeCheck.R
pedigreeDeleteDuplicates.R  pedigreePairwiseRelatedness.R
pedigreeMaxUnrelated.R  simulateGenotypeMatrix.R
simulateIntensityMatrix.R  defunct.R

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R topics documented:
GWASTools-package ...........................................................  3
alleleFrequency ..............................................................  4
allequal .................................................................  5
anomDetectBAF ............................................................  6
anomDetectLOH ...........................................................  11
anomIdentifyLowQuality ..................................................  15
anomSegStats ...............................................................  18
apartSnpSelection ..........................................................  22
asSnpMatrix .................................................................  23
assocCoxPH .................................................................  25
assocRegression ............................................................  27
BAFfromClusterMeans .....................................................  30
BAFfromGenotypes ..........................................................  32
batchTest .................................................................  33
centromeres .................................................................  36
chromIntensityPlot .........................................................  37
convertNcdfGds ...........................................................  39
createDataFile .............................................................  40
duplicateDiscordance ......................................................  45
duplicateDiscordanceAcrossDatasets ....................................  47
duplicateDiscordanceProbability ........................................  52
exactHWE .................................................................  53
findBAFVariance ..........................................................  55
GdsGenotypeReader .........................................................  57
GdsIntensityReader .........................................................  60
GdsReader .................................................................  62
gdsSubset .................................................................  64
genoClusterPlot ............................................................  65
GenotypeData-class ........................................................  67
genotypeToCharacter ......................................................  71
getobj .................................................................  72
getVariable ...............................................................  73
GWASTools-package

Description

This package contains tools for facilitating cleaning (quality control and quality assurance) and analysis of GWAS data.
**Details**

GWASTools provides a set of classes for storing data and annotation from Genome Wide Association studies, and a set of functions for data cleaning and analysis that operate on those classes.

Genotype and intensity data are stored in external files (GDS or NetCDF), so it is possible to analyze data sets that are too large to be contained in memory. The GenotypeReader class and IntensityReader class unions provide a common interface for GDS and NetCDF files.

Two sets of classes for annotation are provided. SnpAnnotationDataFrame and ScanAnnotationDataFrame extend AnnotatedDataFrame and provide in-memory containers for SNP and scan annotation and metadata. SnpAnnotationSQLite and ScanAnnotationSQLite provide interfaces to SNP and scan annotation and metadata stored in SQLite databases.

The GenotypeData and IntensityData classes combine genotype or intensity data with SNP and scan annotation, ensuring that the data in the NetCDF files is consistent with annotation through unique SNP and scan IDs. A majority of the functions in the GWASTools package take GenotypeData and/or IntensityData objects as arguments.

**Author(s)**

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**References**


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**alleleFrequency**

*Allelic frequency*

**Description**

Calculates the frequency of the A allele over the specified scans.

**Usage**

```r
alleleFrequency(genoData, scan.exclude, verbose = TRUE)
```

**Arguments**

- `genoData` *GenotypeData* object.
- `scan.exclude` Integer vector with IDs of scans to exclude.
- `verbose` Logical value specifying whether to show progress information.
Details

Counts male heterozygotes on the X and Y chromosomes as missing values, and any genotype for females on the Y chromosome as missing values. A "sex" variable must be present in the scan annotation slot of genoData.

Samples with missing sex are included in the allele counts for "all" and "MAF" for autosomes, but not for sex chromosomes.

Value

A matrix with a row for each SNP. Columns "M" for males, "F" for females, and "all" for all scans give frequencies of the A allele. Sample size for males, females, and all is returned as "n.M", "n.F", and "n", respectively. "MAF" is the minor allele frequency over all scans.

Author(s)

Cathy Laurie, Stephanie Gogarten

See Also

GenotypeData

Examples

library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# need scan annotation with sex
data(illuminaScanADF)
genoData <- GenotypeData(gds, scanAnnot=illuminaScanADF)

afreq <- alleleFrequency(genoData, scan.exclude=(illuminaScanADF$race != "CEU"))
close(genoData)

allequal

Test if two objects have the same elements

Description

allequal tests if two objects have all the same elements, including whether they have NAs in the same place.

Usage

allequal(x, y)

Arguments

x first object to compare
y second object to compare
Details

Unlike `all(x == y)`, `allequal` will return `FALSE` if either object is `NULL`. Does not check class types, so `allequal` will return `TRUE` in some cases where `identical` will return `FALSE` (e.g. if two objects are identical when coerced to the same class). `allequal` always returns a logical value, so it can be used safely in `if` expressions.

Value

Returns `TRUE` if `x` and `y` exist and all elements are equal, `FALSE` if some elements are unequal. If there are `NA` values, returns `TRUE` if `is.na(x) == is.na(y)` and all other elements are equal. Returns `FALSE` if `is.na(x) != is.na(y)`. Returns `FALSE` if `x` or `y` (but not both) is `NULL`.

Author(s)

Stephanie Gogarten

See Also

`identical`, `all`, `all.equal`

Examples

```r
x <- c(1,2,NA,4); y <- c(1,2,NA,4);
allequal(x, y) ## TRUE
allequal(1, as.integer(1)) ## TRUE
allequal(1, "1") ## TRUE
```

anomDetectBAF

_BAF Method for Chromosome Anomaly Detection_

Description

`anomSegmentBAF` for each sample and chromosome, breaks the chromosome up into segments marked by change points of a metric based on B Allele Frequency (BAF) values.

`anomFilterBAF` selects segments which are likely to be anomalous.

`anomDetectBAF` is a wrapper to run `anomSegmentBAF` and `anomFilterBAF` in one step.

Usage

```r
anomSegmentBAF(intenData, genoData, scan.ids, chrom.ids, snp.ids, 
smooth = 50, min.width = 5, nperm = 10000, alpha = 0.001, 
verbose = TRUE)

anomFilterBAF(intenData, genoData, segments, snp.ids, centromere, 
low.qual.ids = NULL, num.mark.thresh = 15, long.num.mark.thresh = 200, 
sd.reg = 2, sd.long = 1, low.frac.used = 0.1, run.size = 10, 
inter.size = 2, low.frac.used.num.mark = 30, very.low.frac.used = 0.01, 
low.qual.frac.num.mark = 150, lrr.cut = -2, ct.thresh = 10, 
frac.thresh = 0.1, verbose=TRUE, 
small.thresh=2.5, dev.sim.thresh=0.1, centSpan.fac=1.25, centSpan.nmark=50)

anomDetectBAF(intenData, genoData, scan.ids, chrom.ids, snp.ids, 
centromere, low.qual.ids = NULL, ...)
```
Arguments

intenData  An `IntensityData` object containing the B Allele Frequency. The order of the rows of intenData and the snp annotation are expected to be by chromosome and then by position within chromosome. The scan annotation should contain sex, coded as "M" for male and "F" for female.

genoData  A `GenotypeData` object. The order of the rows of genoData and the snp annotation are expected to be by chromosome and then by position within chromosome.

scan.ids  vector of scan ids (sample numbers) to process

chrom.ids  vector of (unique) chromosomes to process. Should correspond to integer chromosome codes in intenData. Recommended to include all autosomes, and optionally X (males will be ignored) and the pseudoautosomal (XY) region.

snp.ids  vector of eligible snp ids. Usually exclude failed and intensity-only SNPs. Also recommended to exclude an HLA region on chromosome 6 and XTR region on X chromosome. See HLA and pseudoautosomal. If there are SNPs annotated in the centromere gap, exclude these as well (see centromeres).

smooth  number of markers for smoothing region. See smooth.CNA in the DNAcopy package.

min.width  minimum number of markers for a segment. See segment in the DNAcopy package.

nperm  number of permutations for deciding significance in segmentation. See segment in the DNAcopy package.

alpha  significance level. See segment in the DNAcopy package.

verbose  logical indicator whether to print information about the scan id currently being processed. anomSegmentBAF prints each scan id; anomFilterBAF prints a message after every 10 samples: "processing ith scan id out of n" where "ith" with be 10, 10, etc. and "n" is the total number of samples.

segments  data.frame of segments from anomSegmentBAF. Names must include "scanID", "chromosome", "num.mark", "left.index", "right.index", "seg.mean". Here "left.index" and "right.index" are row indices of intenData. Left and right refer to start and end of anomaly, respectively, in position order.

centromere  data.frame with centromere position information. Names must include "chrom", "left.base", "right.base". Valid values for "chrom" are 1:22, "X", "Y", "XY". Here "left.base" and "right.base" are base positions of start and end of centromere location in position order. Centromere data tables are provided in centromeres.

low.qual.ids  scan ids determined to be low quality for which some segments are filtered based on more stringent criteria. Default is NULL. Usual choice are scan ids for which median BAF across autosomes > 0.05. See sdByScanChromWindow and medianSdOverAutosomes.

num.mark.thresh  minimum number of SNP markers in a segment to be considered for anomaly

long.num.mark.thresh  min number of markers for "long" segment to be considered for anomaly for which significance threshold criterion is allowed to be less stringent

sd.reg  number of baseline standard deviations of segment mean from a baseline mean for "normal" needed to declare segment anomalous. This number is given by abs(mean of segment - baseline mean)/(baseline standard deviation)
sd.long: same meaning as sd.reg but applied to "long" segments

low.frac.used: if fraction of heterozygous or missing SNP markers compared with number of eligible SNP markers in segment is below this, more stringent criteria are applied to declare them anomalous.

run.size: min length of run of missing or heterozygous SNP markers for possible determination of homozygous deletions

inter.size: number of homozygotes allowed to "interrupt" run for possible determination of homozygous deletions

low.frac.used.num.mark: number of markers threshold for low.frac.used segments (which are not declared homozygous deletions)

very.low.frac.used: any segments with (num.mark)/(number of markers in interval) less than this are filtered out since they tend to be false positives

low.qual.frac.num.mark: minimum num.mark threshold for low quality scans (low.qual.ids) for segments that are also below low.frac.used threshold

lrr.cut: look for runs of LRR values below lrr.cut to adjust homozygous deletion endpoints

ct.thresh: minimum number of LRR values below lrr.cut needed in order to adjust

frac.thresh: investigate interval for homozygous deletion only if lrr.cut and ct.thresh thresholds met and (# LRR values below lrr.cut)/(# eligible SNPs in segment) > frac.thresh

small.thresh: sd.fac threshold use in making merge decisions involving small num.mark segments

dev.sim.thresh: relative error threshold for determining similarity in BAF deviations; used in merge decisions

centSpan.fac: thresholds increased by this factor when considering filtering/keeping together left and right halves of centromere spanning segments

centSpan.nmark: minimum number of markers under which centromere spanning segments are automatically filtered out

...: arguments to pass to anomFilterBAF

Details

anomSegmentBAF uses the function segment from the DNAcopy package to perform circular binary segmentation on a metric based on BAF values. The metric for a given sample/chromosome is \( \sqrt{\text{min}(\text{BAF},1-\text{BAF},\text{abs}(\text{BAF}-\text{median}(\text{BAF})))} \) where the median is across BAF values on the chromosome. Only BAF values for heterozygous or missing SNPs are used.

anomFilterBAF determines anomalous segments based on a combination of thresholds for number of SNP markers in the segment and on deviation from a "normal" baseline. (See num.mark.thresh, long.num.mark.thresh, sd.reg, and sd.long.) The "normal" baseline metric mean and standard deviation are found across all autosomes not segmented by anomSegmentBAF. This is why it is recommended to include all autosomes for the argument chrom.ids to ensure a more accurate baseline.

Some initial filtering is done, including possible merging of consecutive segments meeting sd.reg threshold along with other criteria (such as not spanning the centromere) and adjustment for accurate break points for possible homozygous deletions (see lrr.cut, ct.thresh, frac.thresh, run.size, and inter.size). Male samples for X chromosome are not processed.
More stringent criteria are applied to some segments (see \texttt{low.frac.used}, \texttt{low.frac.used.num.mark}, \texttt{very.low.frac.used}, \texttt{low.qual.ids}, and \texttt{low.qual.frac.num.mark}).

\texttt{anomDetectBAF} runs \texttt{anomSegmentBAF} with default values and then runs \texttt{anomFilterBAF}. Additional parameters for \texttt{anomFilterBAF} may be passed as arguments.

\textbf{Value}

\texttt{anomSegmentBAF} returns a \texttt{data.frame} with the following elements: Left and right refer to start and end of anomaly, respectively, in position order.

- \texttt{scanID}: integer id of scan
- \texttt{chromosome}: chromosome as integer code
- \texttt{left.index}: row index of \texttt{intenData} indicating left endpoint of segment
- \texttt{right.index}: row index of \texttt{intenData} indicating right endpoint of segment
- \texttt{num.mark}: number of heterozygous or missing SNPs in the segment
- \texttt{seg.mean}: mean of the BAF metric over the segment

\texttt{anomFilterBAF} and \texttt{anomDetectBAF} return a list with the following elements:

- \textbf{raw} \texttt{data.frame} of raw segmentation data, with same output as \texttt{anomSegmentBAF} as well as:
  - \texttt{left.base}: base position of left endpoint of segment
  - \texttt{right.base}: base position of right endpoint of segment
  - \texttt{sex}: sex of \texttt{scan.id} coded as "M" or "F"
  - \texttt{sd.fac}: measure of deviation from baseline equal to \texttt{abs(mean of segment - baseline mean)/(baseline standard deviation)}; used in determining anomalous segments

- \textbf{filtered} \texttt{data.frame} of the segments identified as anomalies, with the same columns as \texttt{raw} as well as:
  - \texttt{merge}: \texttt{TRUE} if segment was a result of merging. Consecutive segments from output of \texttt{anomSegmentBAF} that meet certain criteria are merged.
  - \texttt{homodel.adjust}: \texttt{TRUE} if original segment was adjusted to narrow in on a homozygous deletion
  - \texttt{frac.used}: fraction of (eligible) heterozygous or missing SNP markers compared with total number of eligible SNP markers in segment

- \textbf{base.info} \texttt{data frame} with columns:
  - \texttt{scanID}: integer id of scan
  - \texttt{base.mean}: mean of non-anomalous baseline. This is the mean of the BAF metric for heterozygous and missing SNPs over all unsegmented autosomes that were considered.
  - \texttt{base.sd}: standard deviation of non-anomalous baseline
  - \texttt{chr.ct}: number of unsegmented chromosomes used in determining the non-anomalous baseline

- \textbf{seg.info} \texttt{data frame} with columns:
  - \texttt{scanID}: integer id of scan
  - \texttt{chromosome}: chromosome as integer
  - \texttt{num.segs}: number of segments produced by \texttt{anomSegmentBAF}
Note

It is recommended to include all autosomes as input. This ensures a more accurate determination of baseline information.

Author(s)

Cecelia Laurie

References


See Also

segment and smooth.CNA in the package DNAcopy, also findBAFvvariance, anomDetectLOH

Examples

library(GWASdata)
data(illuminaScanADF, illuminaSnpADF)

blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
blData <- IntensityData(bl, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

# segment BAF
scan.ids <- illuminaScanADF$scanID[1:2]
chrom.ids <- unique(illuminaSnpADF$chromosome)
snp.ids <- illuminaSnpADF$snpID[illuminaSnpADF$missing.n1 < 1]
seg <- anomSegmentBAF(blData, genoData, scan.ids=scan.ids, chrom.ids=chrom.ids, snp.ids=snp.ids)

# filter segments to detect anomalies
data(centromeres.hg18)
filt <- anomFilterBAF(blData, genoData, segments=seg, snp.ids=snp.ids, centromere=centromeres.hg18)

# alternatively, run both steps at once
anom <- anomDetectBAF(blData, genoData, scan.ids=scan.ids, chrom.ids=chrom.ids, snp.ids=snp.ids, centromere=centromeres.hg18)

close(blData)
close(genoData)
**anomDetectLOH**  
*LOH Method for Chromosome Anomaly Detection*

**Description**

anomDetectLOH breaks a chromosome up into segments of homozygous runs of SNP markers determined by change points in Log R Ratio and selects segments which are likely to be anomalous.

**Usage**

```
anomDetectLOH(intenData, genoData, scan.ids, chrom.ids, snp.ids,  
known.anoms, smooth = 50, min.width = 5, nperm = 10000, alpha = 0.001,  
run.size = 50, inter.size = 4, homodel.min.num = 10, homodel.thresh = 10,  
small.num = 20, small.thresh = 2.25, medium.num = 50, medium.thresh = 2,  
long.num = 100, long.thresh = 1.5, small.na.thresh = 2.5,  
length.factor = 5, merge.fac = 0.85, min.lrr.num = 20, verbose = TRUE)
```

**Arguments**

- **intenData**: An *IntensityData* object containing the Log R Ratio. The order of the rows of intenData and the snp annotation are expected to be by chromosome and then by position within chromosome. The scan annotation should contain sex, coded as "M" for male and "F" for female.

- **genoData**: A *GenotypeData* object. The order of the rows of genoData and the snp annotation are expected to be by chromosome and then by position within chromosome.

- **scan.ids**: vector of scan ids (sample numbers) to process

- **chrom.ids**: vector of (unique) chromosomes to process. Should correspond to integer chromosome codes in intenData. Recommended for use with autosomes, X (males will be ignored), and the pseudoautosomal (XY) region.

- **snp.ids**: vector of eligible snp ids. Usually exclude failed and intensity-only snps. Also recommended to exclude an HLA region on chromosome 6 and XTR region on X chromosome. See HLA and pseudoautosomal. If there are SNPs annotated in the centromere gap, exclude these as well (see centromeres).

- **known.anoms**: data.frame of known anomalies (usually from anomDetectBAF); must have "scanID","chromosome","left.index","right.index". Here "left.index" and "right.index" are row indices of intenData. Left and right refer to start and end of anomaly, respectively, in position order.

- **smooth**: number of markers for smoothing region. See smooth.CNA in the DNAcopy package.

- **min.width**: minimum number of markers for segmenting. See segment in the DNAcopy package.

- **nperm**: number of permutations. See segment in the DNAcopy package.

- **alpha**: significance level. See segment in the DNAcopy package.

- **run.size**: number of markers to declare a 'homozygous' run (here 'homozygous' includes homozygous and missing)

- **inter.size**: number of consecutive heterozygous markers allowed to interrupt a 'homozygous' run
**anomDetectLOH**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>homodel.min.num</td>
<td>minimum number of markers to detect extreme difference in lrr (for homozygous deletion)</td>
</tr>
<tr>
<td>homodel.thresh</td>
<td>threshold for measure of deviation from non-anomalous needed to declare segment a homozygous deletion.</td>
</tr>
<tr>
<td>small.num</td>
<td>minimum number of SNP markers to declare segment as an anomaly (other than homozygous deletion)</td>
</tr>
<tr>
<td>small.thresh</td>
<td>threshold for measure of deviation from non-anomalous to declare segment anomalous if number of SNP markers is between small.num and medium.num.</td>
</tr>
<tr>
<td>medium.num</td>
<td>threshold for number of SNP markers to identify 'medium' size segment</td>
</tr>
<tr>
<td>medium.thresh</td>
<td>threshold for measure of deviation from non-anomalous needed to declare segment anomalous if number of SNP markers is between medium.num and long.num.</td>
</tr>
<tr>
<td>long.num</td>
<td>threshold for number of SNP markers to identify 'long' size segment</td>
</tr>
<tr>
<td>long.thresh</td>
<td>threshold for measure of deviation from non-anomalous when number of markers is bigger than long.num</td>
</tr>
<tr>
<td>small.na.thresh</td>
<td>threshold measure of deviation from non-anomalous when number of markers is between small.num and medium.num and 'local mad.fac' is NA. See Details section for definition of 'local mad.fac' .</td>
</tr>
<tr>
<td>length.factor</td>
<td>window around anomaly defined as length.factor*(no. of markers in segment) on either side of the given segment. Used in determining 'local mad.fac'. See Details section.</td>
</tr>
<tr>
<td>merge.fac</td>
<td>threshold for 'sd.fac'= number of baseline standard deviations of segment mean from baseline mean; consecutive segments with 'sd.fac' above threshold are merged.</td>
</tr>
<tr>
<td>min.lrr.num</td>
<td>if any 'non-anomalous' interval has fewer markers than min.lrr.num, interval is ignored in finding non-anomalous baseline unless it's the only piece left</td>
</tr>
<tr>
<td>verbose</td>
<td>logical indicator whether to print the scan id currently being processed</td>
</tr>
</tbody>
</table>

**Details**

Detection of anomalies with loss of heterozygosity accompanied by change in Log R Ratio. Male samples for X chromosome are not processed.

Circular binary segmentation (CBS) (using the R-package `DNAcopy`) is applied to LRR values and, in parallel, runs of homozygous or missing genotypes of a certain minimal size (run.size) (and allowing for some interruptions by no more than inter.size heterozygous SNPs) are identified. Intervals from known.anoms are excluded from the identification of runs. After some possible merging of consecutive CBS segments (based on satisfying a threshold merge.fac for deviation from non-anomalous baseline), the homozygous runs are intersected with the segments from CBS.

Determination of anomalous segments is based on a combination of number-of-marker thresholds and deviation from a non-anomalous baseline. Segments are declared anomalous if deviation from non-anomalous is above corresponding thresholds. (See small.num, small.thresh, medium.num, medium.thresh, long.num, long.thresh, and small.na.thresh.) Non-anomalous median and MAD are defined for each sample-chromosome combination. Intervals from known.anoms and the homozygous runs identified are excluded; remaining regions are the non-anomalous baseline.

Deviation from non-anomalous is measured by a combination of a chromosome-wide 'mad.fac' and a 'local mad.fac' (both the average and the minimum of these two measures are used). Here
'mad.fac’ is \((\text{segment median} - \text{non-anomalous median})/\text{non-anomalous MAD})\) and 'local mad.fac’ is the same definition except the non-anomalous median and MAD are computed over a window including the segment (see \texttt{length.factor}). Median and MAD are found for eligible LRR values.

**Value**

A list with the following elements:

- **raw**
  - raw homozygous run data, not including any regions present in \texttt{known.anoms}. A data.frame with the following columns: Left and right refer to start and end of anomaly, respectively, in position order.
    - \texttt{left.index}: row index of \texttt{intenData} indicating left endpoint of segment
    - \texttt{right.index}: row index of \texttt{intenData} indicating right endpoint of segment
    - \texttt{left.base}: base position of left endpoint of segment
    - \texttt{right.base}: base position of right endpoint of segment
    - \texttt{scanID}: integer id of scan
    - \texttt{chromosome}: chromosome as integer code

- **raw.adjusted**
  - data.frame of runs after merging and intersecting with CBS segments, with the following columns: Left and right refer to start and end of anomaly, respectively, in position order.
    - \texttt{scanID}: integer id of scan
    - \texttt{chromosome}: chromosome as integer code
    - \texttt{left.index}: row index of \texttt{intenData} indicating left endpoint of segment
    - \texttt{right.index}: row index of \texttt{intenData} indicating right endpoint of segment
    - \texttt{left.base}: base position of left endpoint of segment
    - \texttt{right.base}: base position of right endpoint of segment
    - \texttt{num.mark}: number of eligible SNP markers in segment
    - \texttt{seg.median}: median of eligible LRR values in segment
    - \texttt{seg.mean}: mean of eligible LRR values in segment
    - \texttt{mad.fac}: measure of deviation from non-anomalous baseline, equal to \(\text{abs(median of segment - baseline median)}/\text{baseline MAD})\); used in determining anomalous segments
    - \texttt{sd.fac}: measure of deviation from non-anomalous baseline, equal to \(\text{abs(mean of segment - baseline mean)}/\text{baseline standard deviation})\); used in determining whether to merge
    - \texttt{local}: measure of deviation from non-anomalous baseline used equal to \(\text{abs(median of segment - local baseline median)}/\text{local baseline MAD})\); local baseline consists of eligible LRR values in a window around segment; used in determining anomalous segments
    - \texttt{num.segs}: number of segments found by CBS for the given chromosome
    - \texttt{chrom.nonanom.mad}: MAD of eligible LRR values in non-anomalous regions across the chromosome
    - \texttt{chrom.nonanom.median}: median of eligible LRR values in non-anomalous regions across the chromosome
    - \texttt{chrom.nonanom.mean}: mean of eligible LRR values in non-anomalous regions across the chromosome
    - \texttt{chrom.nonanom.sd}: standard deviation of eligible LRR values in non-anomalous regions across the chromosome
    - \texttt{sex}: sex of the scan id coded as "M" or "F"
filtered data.frame of the segments identified as anomalies. Columns are the same as in raw.adjusted.

base.info data.frame with columns:
- chrom.nonanom.mad: MAD of eligible LRR values in non-anomalous regions across the chromosome
- chrom.nonanom.median: median of eligible LRR values in non-anomalous regions across the chromosome
- chrom.nonanom.mean: mean of eligible LRR values in non-anomalous regions across the chromosome
- chrom.nonanom.sd: standard deviation of eligible LRR values in non-anomalous regions across the chromosome
- sex: sex of the scan id coded as "M" or "F"
- num.runs: number of original homozygous runs found for given scan/chromosome
- num.segs: number of segments for given scan/chromosome produced by CBS
  - scanID: integer id of scan
  - chromosome: chromosome as integer code
  - sex: sex of the scan id coded as "M" or "F"

segments data.frame of the segmentation found by CBS with columns:
- scanID: integer id of scan
- chromosome: chromosome as integer code
- left.index: row index of intenData indicating left endpoint of segment
- right.index: row index of intenData indicating right endpoint of segment
- left.base: base position of left endpoint of segment
- right.base: base position of right endpoint of segment
- num.mark: number of eligible SNP markers in the segment
- seg.mean: mean of eligible LRR values in the segment
- sd.fac: measure of deviation from baseline equal to abs(mean of segment - baseline mean)/(baseline standard deviation) where the baseline is over non-anomalous regions

merge data.frame of scan id/chromosome pairs for which merging occurred.
- scanID: integer id of scan
- chromosome: chromosome as integer code

Author(s)
Cecelia Laurie

References
See references in segment in the package DNAcopy.

See Also
segment and smooth.CNA in the package DNAcopy, also findBAFvariance, anomDetectLOH
Examples

```r
library(GWASdata)
data(illuminaScanADF, illuminaSnpADF)
blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
blData <- IntensityData(bl, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

scan.ids <- illuminaScanADF$scanID[1:2]
chrom.ids <- unique(illuminaSnpADF$chromosome)
snp.ids <- illuminaSnpADF$snpID[illuminaSnpADF$missing.n1 < 1]

# example for known.anoms, would get this from anomDetectBAF
known.anoms <- data.frame("scanID"=scan.ids[1], "chromosome"=21,
                          "left.index"=100, "right.index"=200)

LOH.anom <- anomDetectLOH(blData, genoData, scan.ids=scan.ids,
                          chrom.ids=chrom.ids, snp.ids=snp.ids, known.anoms=known.anoms)

close(blData)
close(genoData)
```

---

anomIdentifyLowQuality

*Identify low quality samples*

Description

Identify low quality samples for which false positive rate for anomaly detection is likely to be high. Measures of noise (high variance) and high segmentation are used.

Usage

```r
anomIdentifyLowQuality(snp.annot, med.sd, seg.info, 
                    sd.thresh, sng.seg.thresh, auto.seg.thresh)
```

Arguments

- **snp.annot** `SnpAnnotationDataFrame` with column "eligible", where "eligible" is a logical vector indicating whether a SNP is eligible for consideration in anomaly detection (usually FALSE for HLA and XTR regions, failed SNPs, and intensity-only SNPs). See [HLA](https://www.example.com) and [pseudoautosomal](https://www.example.com).
- **med.sd** data.frame of median standard deviation of BAleleFrequency (BAF) or LogR-Ratio (LRR) values across autosomes for each scan, with columns "scanID" and "med.sd". Usually the result of `medianSdOverAutosomes`. Usually only eligible SNPs are used in these computations. In addition, for BAF, homozygous SNPS are excluded.
IdentifyLowQuality

seg.info
data.frame with segmentation information from anomDetectBAF or anomDetectLOH. Columns must include "scanID", "chromosome", and "num.segs". (For anomDetectBAF, segmentation information is found in $seg.info from output. For anomDetectLOH, segmentation information is found in $base.info from output.)

sd.thresh
Threshold for med. sd above which scan is identified as low quality. Suggested values are 0.1 for BAF and 0.25 for LOH.

sng.seg.thresh
Threshold for segmentation factor for a given chromosome, above which the chromosome is said to be highly segmented. See Details. Suggested values are 0.0008 for BAF and 0.0048 for LOH.

auto.seg.thresh
Threshold for segmentation factor across autosome, above which the scan is said to be highly segmented. See Details. Suggested values are 0.0001 for BAF and 0.0006 for LOH.

Details

Low quality samples are determined separately with regard to each of the two methods of segmentation, anomDetectBAF and anomDetectLOH. BAF anomalies (respectively LOH anomalies) found for samples identified as low quality for BAF (respectively LOH) tend to have a high false positive rate.

A scan is identified as low quality due to high variance (noise), i.e., if med. sd is above a certain threshold sd.thresh.

High segmentation is often an indication of artifactual patterns in the B Allele Frequency (BAF) or Log R Ratio values (LRR) that are not always captured by high variance. Here segmentation information is determined by anomDetectBAF or anomDetectLOH which use circular binary segmentation implemented by the R-package DNAcopy. The measure for high segmentation is a "segmentation factor" = (number of segments)/(number of eligible SNPS). A single chromosome segmentation factor uses information for one chromosome. A segmentation factor across autosomes uses the total number of segments and eligible SNPs across all autosomes. See med.sd, sd.thresh, sng.seg.thresh, and auto.seg.thresh.

Value

A data.frame with the following columns:

scanID
integer id for the scan
chrX.num.segs
number of segments for chromosome X
chrX.fac
segmentation factor for chromosome X
max.autosome
autosome with highest single segmentation factor
max.auto.fac
segmentation factor for chromosome = max.autosome
max.auto.num.segs
number of segments for chromosome = max.autosome
num.ch.segd
number of chromosomes segmented, i.e., for which change points were found
fac.all.auto
segmentation factor across all autosomes
med.sd
median standard deviation of BAF (or LRR values) across autosomes. See med.sd in Arguments section.
type
one of the following, indicating reason for identification as low quality:
  • auto.seg: segmentation factor fac.all.auto above auto.seg.thresh but med.sd acceptable
• sd: standard deviation factor med. sd above sd.thresh but fac.all.auto acceptable
• both. sd. seg: both high variance and high segmentation factors, fac.all.auto and med. sd, are above respective thresholds
• sng. seg: segmentation factor max.auto.fac is above sng. seg.thresh but other measures acceptable
• sng. seg.X: segmentation factor chrX.fac is above sng. seg.thresh but other measures acceptable

Author(s)

Cecelia Laurie

See Also

findBAFvariance, anomDetectBAF, anomDetectLOH

Examples

library(GWASdata)
data(illuminaScanADF, illuminaSnpADF)

blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
blData <- IntensityData(bl, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

# initial scan for low quality with median SD
baf.sd <- sdByScanChromWindow(blData, genoData)
med.baf.sd <- medianSdOverAutosomes(baf.sd)
low.qual.ids <- med.baf.sd$scanID[med.baf.sd$med.sd > 0.05]

# segment and filter BAF
scan.ids <- illuminaScanADF$scanID[1:2]
chrom.ids <- unique(illuminaSnpADF$chromosome)
snp.ids <- illuminaSnpADF$snpID[illuminaSnpADF$missing.n1 < 1]
data(centromeres.hg18)
anom <- anomDetectBAF(blData, genoData, scan.ids=scan.ids, chrom.ids=chrom.ids,
snp.ids=snp.ids, centromere=centromeres.hg18, low.qual.ids=low.qual.ids)

# further screen for low quality scans
snp.annot <- illuminaSnpADF
snp.annot$eligible <- snp.annot$missing.n1 < 1
low.qual <- anomIdentifyLowQuality(snp.annot, med.baf.sd, anom$seg.info,
sd.thresh=0.1, sng.seg.thresh=0.0008, auto.seg.thresh=0.0001)

close(blData)
close(genoData)
anomSegStats

Calculate LRR and BAF statistics for anomalous segments

Description

Calculate LRR and BAF statistics for anomalous segments and plot results

Usage

anomSegStats(intenData, genoData, snp.ids, anom, centromere, lrr.cut = -2, verbose = TRUE)
anomStatsPlot(intenData, genoData, anom.stats, snp.ineligible, plot.ineligible = FALSE, centromere = NULL, brackets = c("none", "bases", "markers"), brkpt.pct = 10, whole.chrom = FALSE, win = 5, win.calc = FALSE, win.fixed = 1, zoom = c("both", "left", "right"), main = NULL, info = NULL, ideogram = TRUE, ideo.zoom = FALSE, ideo.rect = TRUE, mult.anom = FALSE, cex = 0.5, cex.leg = 1.5, colors = c("default", "neon", "primary"), ...)

Arguments

intenData An IntensityData object containing BAlleleFreq and LogRRatio. The order of the rows of intenData and the snp annotation are expected to be by chromosome and then by position within chromosome.

genoData A GenotypeData object. The order of the rows of intenData and the snp annotation are expected to be by chromosome and then by position within chromosome.

snp.ids vector of eligible SNP ids. Usually exclude failed and intensity-only SNPS. Also recommended to exclude an HLA region on chromosome 6 and XTR region on X chromosome. See HLA and pseudoautosomal. If there are SNPs annotated in the centromere gap, exclude these as well (see centromeres).

anom data.frame of detected chromosome anomalies. Names must include "scanID", "chromosome", "left.index", "right.index", "sex", "method", "anom.id". Valid values for "method" are "BAF" or "LOH" referring to whether the anomaly was detected by BAF method (anomDetectBAF) or by LOH method (anomDetectLOH). Here "left.index" and "right.index" are row indices of intenData with left.index < right.index.

centromere data.frame with centromere position info. Names must include "chrom", "left.base", "right.base". Valid values for "chrom" are 1:22, "X", "Y", "XY". Here "left.base" and "right.base" are start and end base positions of the centromere location, respectively. Centromere data tables are provided in centromeres.

lrr.cut count the number of eligible LRR values less than lrr.cut

verbose whether to print the scan id currently being processed

anom.stats data.frame of chromosome anomalies with statistics, usually the output of anomSegStats. Names must include "anom.id", "scanID", "chromosome", "left.index", "right.index", "method", "nmark.all", "nmark elig", "left.base", "right.base", "nbase", "non.anom.baf.med", "non.anom.lrr.med", "anom.baf.dev.med", "anom.baf.dev.5", "anom.lrr.med", "nmark.baf", ...
"nmark.lrr". Left and right refer to start and end, respectively, of the anomaly, in position order.

snp.ineligible: vector of ineligible snp ids (e.g., intensity-only, failed snps, XTR and HLA regions). See HLA and pseudoautosomal.

plot.ineligible: whether or not to include ineligible points in the plot for LogRRatio.

brackets: type of brackets to plot around breakpoints - none, use base length, use number of markers (note that using markers give asymmetric brackets); could be used, along with brkpt.pct, to assess general accuracy of end points of the anomaly.

brkpt.pct: percent of anomaly length in bases (or number of markers) for width of brackets.

whole.chrom: logical to plot the whole chromosome or not (overrides win and zoom).

win: size of the window (a multiple of anomaly length) surrounding the anomaly to plot.

win.calc: logical to calculate window size from anomaly length; overrides win and gives window of fixed length given by win.fixed.

win.fixed: number of megabases for window size when win.calc=TRUE.

zoom: indicates whether plot includes the whole anomaly ("both") or zooms on just the left or right breakpoint; "both" is default.

main: Vector of titles for upper (LRR) plots. If NULL, titles will include anom.id, scanID, sex, chromosome, and detection method.

info: character vector of extra information to include in the main title of the upper (LRR) plot.

ideogram: logical for whether to plot a chromosome ideogram under the BAF and LRR plots.

ideo.zoom: logical for whether to zoom in on the ideogram to match the range of the BAF/LRR plots.

ideo.rect: logical for whether to draw a rectangle on the ideogram indicating the range of the BAF/LRR plots.

mult.anom: logical for whether to plot multiple anomalies from the same scan-chromosome pair on a single plot. If FALSE (default), each anomaly is shown on a separate plot.

cex: cex value for points on the plots.

cex.leg: cex value for the ideogram legend.

colors: Color scheme to use for genotypes. "default" is colorblind safe (colorbrewer Set2), "neon" is bright orange/green/fuschia, and "primary" is red/green/blue.

...: Other parameters to be passed directly to plot.

Details

anomSegStats computes various statistics of the input anomalies. Some of these are basic statistics for the characteristics of the anomaly and for measuring deviation of LRR or BAF from expected. Other statistics are used in downstream quality control analysis, including detecting terminal anomalies and investigating centromere-spanning anomalies.

anomStatsPlot produces separate png images of each anomaly in anom.stats. Each image consists of an upper plot of LogRRatio values and a lower plot of BAlleleFrequency values for a zoomed region around the anomaly or whole chromosome (depending up parameter choices). Each plot has vertical lines demarcating the anomaly and horizontal lines displaying certain statistics from anomSegStats. The upper plot title includes sample number and chromosome. Further plot annotation describes which anomaly statistics are represented.
anomSegStats produces a data.frame with the variables for anom plus the following columns: Left and right refer to position order with left < right.

- **nmark.all**: total number of SNP markers on the array from left.index to right.index inclusive
- **nmark.elig**: total number of eligible SNP markers on the array from left.index to right.index, inclusive. See snp.ids for definition of eligible SNP markers.
- **left.base**: base position corresponding to left.index
- **right.base**: base position corresponding to right.index
- **nbase**: number of bases from left.index to right.index, inclusive
- **non.anom.baf.med**: BAF median of non-anomalous segments on all autosomes for the associated sample, using eligible heterozygous or missing SNP markers
- **non.anom.lrr.med**: LRR median of non-anomalous segments on all autosomes for the associated sample, using eligible SNP markers
- **non.anom.lrr.mad**: MAD for LRR of non-anomalous segments on all autosomes for the associated sample, using eligible SNP markers
- **anom.baf.dev.med**: BAF median of deviations from non.anom.baf.med of points used to detect anomaly (eligible and heterozygous or missing)
- **anom.baf.dev.5**: median of BAF deviations from 0.5, using eligible heterozygous or missing SNP markers in anomaly
- **anom.baf.dev.mean**: mean of BAF deviations from non.anom.baf.med, using eligible heterozygous or missing SNP markers in anomaly
- **anom.baf.sd**: standard deviation of BAF deviations from non.anom.baf.med, using eligible heterozygous or missing SNP markers in anomaly
- **anom.baf.mad**: MAD of BAF deviations from non.anom.baf.med, using eligible heterozygous or missing SNP markers in anomaly
- **anom.lrr.med**: LRR median of eligible SNP markers within the anomaly
- **anom.lrr.sd**: standard deviation of LRR for eligible SNP markers within the anomaly
- **anom.lrr.mad**: MAD of LRR for eligible SNP markers within the anomaly
- **nmark.baf**: number of SNP markers within the anomaly eligible for BAF detection (eligible markers that are heterozygous or missing)
- **nmark.lrr**: number of SNP markers within the anomaly eligible for LOH detection (eligible markers)
- **cent.rel**: position relative to centromere - left, right, span
- **left.most**: T/F for whether the anomaly is the left-most anomaly for this sample-chromosome, i.e. no other anomalies with smaller start base position
- **right.most**: T/F whether the anomaly is the right-most anomaly for this sample-chromosome, i.e. no other anomalies with larger end base position
- **left.last.elig**: T/F for whether the anomaly contains the last eligible SNP marker going to the left (decreasing position)
anomSegStats

right.last.elig
T/F for whether the anomaly contains the last eligible SNP marker going to the right (increasing position)

left.term.lrr.med
median of LRR for all eligible SNP markers from left-most eligible marker to the left telomere (only calculated for the most distal anom)

right.term.lrr.med
median of LRR for all eligible markers from right-most eligible marker to the right telomere (only calculated for the most distal anom)

left.term.lrr.n
sample size for calculating left.term.lrr.med

right.term.lrr.n
sample size for calculating right.term.lrr.med

cent.span.left.elig.n
number of eligible markers on the left side of centromere-spanning anomalies

cent.span.right.elig.n
number of eligible markers on the right side of centromere-spanning anomalies

cent.span.left.bases
length of anomaly (in bases) covered by eligible markers on the left side of the centromere

cent.span.right.bases
length of anomaly (in bases) covered by eligible markers on the right side of the centromere

cent.span.left.index
index of eligible marker left-adjacent to centromere; recall that index refers to row indices of intenData

cent.span.right.index
index of elig marker right-adjacent to centromere

bafmetric.anom.mean
mean of BAF-metric values within anomaly, using eligible heterozygous or missing SNP markers BAF-metric values were used in the detection of anomalies. See anomalDetectBAF for definition of BAF-metric

bafmetric.non.anom.mean
mean of BAF-metric values within non-anomalous segments across all autosomes for the associated sample, using eligible heterozygous or missing SNP markers

bafmetric.non.anom.sd
standard deviation of BAF-metric values within non-anomalous segments across all autosomes for the associated sample, using eligible heterozygous or missing SNP markers

nmark.lrr.low
number of eligible markers within anomaly with LRR values less than lrr.cut

Note
The non-anomalous statistics are computed over all autosomes for the sample associated with an anomaly. Therefore the accuracy of these statistics relies on the input anomaly data.frame including all autosomal anomalies for a given sample.

Author(s)
Cathy Laurie
apartSnpSelection

Description

Randomly selects SNPs for which each pair is at least as far apart as the specified basepair distance.

Usage

```r
apartSnpSelection(chromosome, position, min.dist = 1e+05, 
                   init.sel = NULL, max.n.chromosomes = -1, 
                   verbose = TRUE)
```

See Also

anomDetectBAF, anomDetectLOH

Examples

```r
library(GWASdata)
data(illuminaScanADF, illuminaSnpADF)

blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
blData <- IntensityData(bl, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

scan.ids <- illuminaScanADF$scanID[1:2]
chrom.ids <- unique(illuminaSnpADF$chromosome)
snp.ids <- illuminaSnpADF$snpID[illuminaSnpADF$missing.n1 < 1]
snp.failed <- illuminaSnpADF$snpID[illuminaSnpADF$missing.n1 == 1]

# example results from anomDetectBAF
baf.anoms <- data.frame("scanID"=rep(scan.ids[1],2), "chromosome"=rep(21,2),
                      "left.index"=c(100,300), "right.index"=c(200,400), sex=rep("M",2),
                      method=rep("BAF",2), anom.id=1:2, stringsAsFactors=FALSE)

# example results from anomDetectLOH
loh.anoms <- data.frame("scanID"=scan.ids[2],"chromosome"=22,
                         "left.index"=400,"right.index"=500, sex="F", method="LOH",
                         anom.id=3, stringsAsFactors=FALSE)

anoms <- rbind(baf.anoms, loh.anoms)
data(centromeres.hg18)
stats <- anomSegStats(blData, genoData, snp.ids=snp.ids, anom=anoms,
                      centromere=centromeres.hg18)
anomStatsPlot(blData, genoData, anom.stats=stats,
              snp.ineligible=snp.failed, centromere=centromeres.hg18)

close(blData)
close(genoData)
```
**asSnpMatrix**

Arguments

- **chromosome**: An integer vector containing the chromosome for each SNP. Valid values are 1-26, any other value will be interpreted as missing and not selected.
- **position**: A numeric vector of the positions (in basepairs) of the SNPs.
- **min.dist**: A numeric value to specify minimum distance required (in basepairs).
- **init.sel**: A logical vector indicating the initial SNPs to be included.
- **max.n.chromosomes**: A numeric value specifying the maximum number of SNPs to return per chromosome. "-1" means no number limit.
- **verbose**: A logical value specifying whether to show progress information while running.

Details

apartSnpSelection selects SNPs randomly with the condition that they are at least as far apart as min.dist in basepairs. The starting set of SNPs can be specified with init.sel.

Value

A logical vector indicating which SNPs were selected.

Author(s)

Xiuwen Zheng

Examples

```r
library(GWASdata)
data(affy_snp_annot)
pool <- affy_snp_annot$chromosome < 23
r.snp <- apartSnpSelection(affy_snp_annot$chromosome, affy_snp_annot$position, min.dist=15000, init.sel=pool)
```

---

**asSnpMatrix**

Utilities for snpStats

Description

asSnpMatrix converts a GenotypeData object to a SnpMatrix-class object.

Usage

```r
asSnpMatrix(genoData, snpNames="snpID", scanNames="scanID", snp=c(1,-1), scan=c(1,-1))
```
Arguments

genoData       A GenotypeData object.
snpNames       The name of the SNP variable in genoData to use as the column (SNP) names in the SnpMatrix-class object.
scanNames      The name of the scan variable in genoData to use as the row (scan) names in the SnpMatrix-class object.
snp            An integer vector of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of '-1' for count indicates that all SNPs should be read.
scan           An integer vector of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of '-1' for count indicates that all scans should be read.

Details

The default is to extract all SNPs and scans from genoData, but for a large dataset this may exceed R’s memory limit. Alternatively, snp and scan may be used to specify (start, count) of SNPs and scans to extract from genoData.

In the SnpMatrix object, genotypes are stored as 0 = missing, 1 = "A/A", 2= "A/B" or "B/A", and 3 = "B/B". (In a GenotypeData object, 0 = "B/B", 1 = "A/B" or "B/A", and 2 = "A/A"). Columns are SNPs with names snpNames and rows are scans with names scanNames (the transpose of the GenotypeData object).

Value

A SnpMatrix-class object.

Author(s)

Stephanie Gogarten

See Also

SnpMatrix-class, GenotypeData

Examples

library(snpStats)
library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)
data(illuminaSnADF, illuminaScanADF)
genData <- GenotypeData(gds, snpAnnot=illuminaSnADF, scanAnnot=illuminaScanADF)
snpmat <- asSnpMatrix(genData, snpNames="rsID", scanNames="scanID")
snpmat
as(snpmat[1:5, 1:5], "character")
summary(snpmat)

# only chromosome 21
chr <- getChromosome(genoData)
c21 <- which(chr == 21)
snpmat <- asSnpMatrix(genData, snpNames="rsID", scanNames="scanID", np=s(c21[1], length(c21)))
assocCoxPH

snpmat
close(genoData)

---

**Description**

Fits Cox proportional hazards model

**Usage**

```r
assocCoxPH(genoData, event, time.to.event, gene.action = c("additive", "dominant", "recessive"), covar = NULL, ivar = NULL, strata = NULL, scan.exclude = NULL, effectAllele = c("minor", "alleleA"), snpStart = NULL, snpEnd = NULL, block.size = 5000, verbose = TRUE)
```

**Arguments**

- **genoData**: a `GenotypeData` object
- **event**: name of scan annotation variable in `genoData` for event to analyze (should be coded 0/1 or FALSE/TRUE)
- **time.to.event**: name of scan annotation variable in `genoData` for time to event
- **gene.action**: "additive" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 1, and homozygous major allele samples = 0. "dominant" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 2, and homozygous major allele samples = 0. "recessive" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 0, and homozygous major allele samples = 0. (If `effectAllele="alleleA"`, the coding reflects `alleleA` instead of the minor allele.)
- **covar**: a vector of the names of the covariates to adjust for (columns in the scan annotation of `genoData`)
- **ivar**: the name of the variable in `covar` to include as an interaction with genotype
- **strata**: a vector of names of variables to stratify on for a stratified analysis
- **scan.exclude**: a vector of scan IDs for scans to exclude
- **effectAllele**: whether the effects should be returned in terms of the minor allele for the tested sample (`effectAllele="minor"`) or the allele returned by `getAlleleA(genoData)` (`effectAllele="alleleA"`). If the minor allele is `alleleB` for a given SNP, the difference between these two options will be a sign change for the beta estimate.
assocCoxPH

snpStart: index of the first SNP to analyze, defaults to first SNP
snpEnd: index of the last SNP to analyze, defaults to last SNP
block.size: number of SNPs to read in at once
verbose: logical for whether to print status updates

Details

This function performs Cox proportional hazards regression of a survival object (using the Surv function) on SNP genotype and other covariates. It uses the coxph function from the R survival library.

It is recommended to filter results returned using \(2\times\text{MAF}\times(1-\text{MAF})\times\text{n.events} > 75\) where \(\text{MAF}\) = minor allele frequency and \(\text{n.events}\) = number of events. This filter was suggested by Ken Rice and Thomas Lumley, who found that without this requirement, at threshold levels of significance for genome-wide studies, Cox regression p-values based on standard asymptotic approximations can be notably anti-conservative.

Note: Y chromosome SNPs must be analyzed separately because they only use males.

Value

a data.frame with some or all of the following columns:

- **snpID**: the snpIDs
- **chr**: chromosome SNPs are on
- **n**: number of samples used to analyze each SNP
- **n.events**: number of events in complete cases for each SNP
- **effect.allele**: which allele (“A” or “B”) is the effect allele
- **EAF**: effect allele frequency
- **MAF**: minor allele frequency
- **filter**: TRUE if SNP passes the MAF filter \(2\times\text{MAF}\times(1-\text{MAF})\times\text{n.events} > 75\)
- **Est**: beta estimate for genotype
- **SE**: standard error of beta estimate for the genotype
- **z.Stat**: z statistic for association
- **z.pval**: p-value for association
- **GxE.Stat**: Likelihood ratio test statistic for the genotype*ivar interaction parameter
- **GxE.pval**: p-value for the likelihood ratio test statistic

Author(s)

Cathy Laurie, Matthew Conomos, Stephanie Gogarten

See Also

GenotypeData, coxph
assocRegression

Examples

library(GWASdata)
data(illuminaScanADF)
scanAnnot <- illuminaScanADF

# exclude duplicated subjects
scan.exclude <- scanAnnot$scanID[!duplicated(scanAnnot$scanID)]

# create some variables for the scans
scanAnnot$sex <- as.factor(scanAnnot$sex)
scanAnnot$age <- rnorm(nrow(scanAnnot), mean=40, sd=10)
scanAnnot$event <- rbinom(nrow(scanAnnot), 1, 0.4)
scanAnnot$ttoe <- rnorm(nrow(scanAnnot), mean=100, sd=10)

# create data object
gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(gdsfile)
genodata <- GenotypeData(gds, scanAnnot=scanAnnot)

res <- assocCoxPH(genodata,
       event="event", time.to.event="ttoe",
       covar=c("sex", "age"),
       scan.exclude=scan.exclude,
       snpStart=1, snpEnd=100)

close(genodata)

assocRegression

Association testing with regression

Description

Run association testing with regression

Usage

assocRegression(genodata,
       outcome,
       model.type = c("linear", "logistic", "poisson", "firth"),
       gene.action = c("additive", "dominant", "recessive"),
       covar = NULL,
       ivar = NULL,
       scan.exclude = NULL,
       CI = 0.95,
       robust = FALSE,
       LRtest = FALSE,
       PPLtest = TRUE,
       effectAllele = c("minor", "alleleA"),
       snpStart = NULL,
       snpEnd = NULL,
       block.size = 5000,
       verbose = TRUE)
Arguments

- genoData: a GenotypeData object
- outcome: the name of the phenotype of interest (a column in the scan annotation of genoData)
- model.type: the type of model to be run. "linear" uses lm, "logistic" uses glm with family=binomial(), "poisson" uses glm with family=poisson(), and "firth" uses logistf.
- gene.action: "additive" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 1, and homozygous major allele samples = 0. "dominant" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 2, and homozygous major allele samples = 0. "recessive" coding sets the marker variable for homozygous minor allele samples = 2, heterozygous samples = 0, and homozygous major allele samples = 0. (If effectAllele="alleleA", the coding reflects alleleA instead of the minor allele.)
- covar: a vector of the names of the covariates to adjust for (columns in the scan annotation of genoData)
- ivar: the name of the variable in covar to include as an interaction with genotype
- scan.exclude: a vector of scanIDs for scans to exclude
- CI: a value between 0 and 1 defining the confidence level for the confidence interval calculations
- robust: logical for whether to use sandwich-based robust standard errors for the "linear" or "logistic" method. The default value is FALSE, and uses model based standard errors. The standard error estimates are returned and also used for Wald Tests of significance.
- LRtest: logical for whether to perform Likelihood Ratio Tests in addition to Wald tests (which are always performed). Applies to linear, logistic, or poisson main effects only. NOTE: Performing the LR tests adds a noticeable amount of computation time.
- PPLtest: logical for whether to use the profile penalized likelihood to compute p values for the "firth" method (in addition to Wald tests, which are always performed).
- effectAllele: whether the effects should be returned in terms of the minor allele for the tested sample (effectAllele="minor") or the allele returned by getAlleleA(genoData) (effectAllele="alleleA"). If the minor allele is alleleB for a given SNP, the difference between these two options will be a sign change for the beta estimate.
- snpStart: index of the first SNP to analyze, defaults to first SNP
- snpEnd: index of the last SNP to analyze, defaults to last SNP
- block.size: number of SNPs to read in at once
- verbose: logical for whether to print status updates

Details

When using models without interaction terms, the association tests compare the model including the covariates and genotype value to the model including only the covariates (a test of genotype effect). When using a model with an interaction term, tests are performed for the interaction term separately as well as a joint test of all the genotype terms (main effects and interactions) to detect any genotype effect. All tests and p-values are always computed using Wald tests with p-values computed from Chi-Squared distributions. The option of using either sandwich based robust standard errors (which make no model assumptions) or using model based standard errors for the confidence intervals
and Wald tests is specified by the `robust` parameter. The option of also performing equivalent Likelihood Ratio tests is available and is specified by the `LRtest` parameter.

For logistic regression models, if the SNP is monomorphic in either cases or controls, then the slope parameter is not well-defined, and the result will be NA.

Note: Y chromosome SNPs must be analyzed separately because they only use males.

**Value**

A data.frame with some or all of the following columns:

- **snpID** the snpIDs
- **chr** chromosome SNPs are on
- **effect.allele** which allele ("A" or "B") is the effect allele
- **EAF** effect allele frequency
- **MAF** minor allele frequency
- **n** number of samples used to analyze each SNP
- **n0** number of controls (outcome=0) used to analyze each SNP
- **n1** number of cases (outcome=1) used to analyze each SNP
- **Est** beta estimate for genotype
- **SE** standard error of beta estimate for the genotype
- **LL** Lower limit of confidence interval for Est
- **UL** Upper limit of confidence interval for Est
- **Wald.Stat** chi-squared test statistic for association
- **Wald.pval** p-value for association
- **LR.Stat** likelihood ratio test statistic for association
- **LR.pval** p-value for association
- **PPL.Stat** profile penalized likelihood test statistic for association
- **PPL.pval** p-value for association
- **GxE.Est** beta estimate for the genotype*ivar interaction parameter (NA if this parameter is a factor with >2 levels)
- **GxE.SE** standard error of beta estimate for the genotype*ivar interaction parameter
- **GxE.Stat** Wald test statistic for the genotype*ivar interaction parameter
- **GxE.pval** Wald test p-value for the genotype*ivar interaction parameter
- **Joint.Stat** Wald test statistic for jointly testing all genotype parameters
- **Joint.pval** Wald test p-value for jointly testing all genotype parameters

**Author(s)**

Tushar Bhangale, Matthew Conomos, Stephanie Gogarten

**See Also**

`GenotypeData, lm, glm, logistf, vcovHC, lrtest`
Examples

library(GWASdata)
data(illuminaScanADF)
scanAnnot <- illuminaScanADF

# exclude duplicated subjects
scan.exclude <- scanAnnot$scanID[scanAnnot$duplicated]

# create some variables for the scans
scanAnnot$sex <- as.factor(scanAnnot$sex)
scanAnnot$age <- rnorm(nrow(scanAnnot), mean=40, sd=10)
scanAnnot$case.cntl.status <- rbinom(nrow(scanAnnot), 1, 0.4)
scanAnnot$blood.pressure[scanAnnot$case.cntl.status==1] <- rnorm(sum(scanAnnot$case.cntl.status==1), mean=100, sd=10)
scanAnnot$blood.pressure[scanAnnot$case.cntl.status==0] <- rnorm(sum(scanAnnot$case.cntl.status==0), mean=90)

# create data object

# BAFFromClusterMeans

BAFfromClusterMeans

B Allele Frequency & Log R Ratio Calculation

Description

This function calculates the B allele frequency and the log R ratio values from the mean R and theta values for each cluster.

Usage

BAFfromClusterMeans(intenData, filename, file.type = c("gds", "ncdf"),
clusterMeanVars = c("tAA","tAB","tBB","rAA","rAB","rBB"),
precision="single", compress="ZIP_RA",
verbose = TRUE)
BAFfromClusterMeans

Arguments

intenData  
IntensityData object holding the X and Y intensity data from which the B allele frequency and log R ratio are calculated.

filename  
The name of the genotype GDS or netCDF file to create

file.type  
The type of file to create ("gds" or "ncdf")

clusterMeanVars  
Character vector indicating the names of the cluster mean columns in the SNP annotation of intenData. Must be in order (tAA,tAB,tBB,rAA,rAB,rBB).

precision  
A character value indicating whether floating point numbers should be stored as "double" or "single" precision.

compress  
The compression level for variables in a GDS file (see add.gdsn for options).

verbose  
Logical value specifying whether to show progress information.

Details

This function calculates the B allele frequency and the log R ratio values from the mean R and theta values for each cluster and writes them to a GDS or NetCDF file.

Author(s)

Stephanie Gogarten, Caitlin McHugh

References


See Also

IntensityData, BAFfromClusterMeans

Examples

# create IntensityData object from GDS
library(GWASdata)
xyfile <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
xy <- GdsIntensityReader(xyfile)
data(illuminaSnpADF)
xyData <- IntensityData(xy, snpAnnot=illuminaSnpADF)

# calculate BAF and LRR and store in GDS file
blfile <- tempfile()
BAFfromClusterMeans(xyData, blfile, file.type="gds", verbose=FALSE)

# read output
bl <- GdsIntensityReader(blfile)
baf <- getBAlleleFreq(bl)
lrr <- getLogRRatio(bl)

close(xy)
close(bl)
file.remove(blfile)
B Allele Frequency & Log R Ratio Calculation

Description

This function calculates the B allele frequency and the log R ratio values for samples by either plate or by study.

Usage

```r
BAFfromGenotypes(intenData, genoData, 
    filename, file.type = c("gds", "ncdf"), 
    min.n.genotypes = 2, 
    call.method = c("by.plate", "by.study"), 
    plate.name = "plate", 
    block.size = 5000, 
    precision="single", compress="ZIP_RA", 
    verbose = TRUE)
```

Arguments

- `intenData`: `IntensityData` object holding the X and Y intensity data from which the B allele frequency and log R ratio are calculated.
- `genoData`: `GenotypeData` object.
- `filename`: The name of the genotype GDS or netCDF file to create.
- `file.type`: The type of file to create ("gds" or "ncdf").
- `min.n.genotypes`: The minimum number of samples for each genotype at any SNP in order to have non-missing B allele frequency and log R ratio. Setting this parameter to 2 or a similar value is recommended.
- `call.method`: If `call.method` is 'by.plate', the B allele frequency and log R ratio are calculated for samples delineated by plates. This is the default method. If `call.method` is 'by.study', the calculation uses all samples at once. If a study does not have plate specifications, 'by.study' is the call.method that must be used.
- `plate.name`: Character string specifying the name of the plate variable in `intenData` or `genoData`. By default, the plate.name is simply 'plate' but oftentimes there are variations, such as 'plateID' or 'plate.num'.
- `block.size`: An integer specifying the number of SNPs to be loaded at one time. The recommended value is around 1000, but should vary depending on computing power.
- `precision`: A character value indicating whether floating point numbers should be stored as "double" or "single" precision.
- `compress`: The compression level for variables in a GDS file (see `add.gdsn` for options).
- `verbose`: Logical value specifying whether to show progress information.

Details

Because this function can take a considerable amount of time and space, sufficient attention should be given to the value used for `block.size`. 
Author(s)
Caitlin McHugh

References

See Also
IntensityData, GenotypeData, chromIntensityPlot, BAFfromClusterMeans

Examples
## Not run:
# create IntensityData and GenotypeData objects from netCDF
library(GWASdata)
data(affySnpADF)
data(affyScanADF)
nsamp <- nrow(affyScanADF)

xyfile <- system.file("extdata", "affy_qxy.nc", package="GWASdata")
xyNC <- NcdfIntensityReader(xyfile)
xyData <- IntensityData(xyNC, snpAnnot=affySnpADF, scanAnnot=affyScanADF)

genofile <- system.file("extdata", "affy_geno.nc", package="GWASdata")
genoNC <- NcdfGenotypeReader(genofile)
genoData <- GenotypeData(genoNC, snpAnnot=affySnpADF, scanAnnot=affyScanADF)

# calculate BAF and LRR
blfile <- tempfile()
BAFfromGenotypes(xyData, genoData, blfile, file.type="ncdf", min.n.genotypes=2,
call.method="by.plate", plate.name="plate")
blNC <- NcdfIntensityReader(blfile)
baf <- getBAAlleleFreq(blNC)
lrr <- getLogRRatio(blNC)

close(xyData)
close(genoData)
close(blNC)
file.remove(blfile)

## End(Not run)
Usage

batchChisqTest(genoData, batchVar, snp.include = NULL,
chrom.include = 1:22, sex.include = c("M", "F"),
scan.exclude = NULL, return.by.snp = FALSE,
correct = TRUE, verbose = TRUE)

batchFisherTest(genoData, batchVar, snp.include = NULL,
chrom.include = 1:22, sex.include = c("M", "F"),
scan.exclude = NULL, return.by.snp = FALSE,
conf.int = FALSE, verbose = TRUE)

Arguments

genoData GenotypeData object
batchVar A character string indicating which annotation variable should be used as the batch.
snp.include A vector containing the IDs of SNPs to include.
chrom.include Integer vector with codes for chromosomes to include. Ignored if snp.include is not NULL. Default is 1:22 (autosomes). Use 23, 24, 25, 26, 27 for X, XY, Y, M, Unmapped respectively
sex.include Character vector with sex to include. Default is c("M", "F"). If sex chromosomes are present in chrom.include, only one sex is allowed.
scan.exclude A vector containing the IDs of scans to be excluded.
return.by.snp Logical value to indicate whether snp-by-batch matrices should be returned.
conf.int Logical value to indicate if a confidence interval should be computed.
correct Logical value to specify whether to apply the Yates continuity correction.
verbose Logical value specifying whether to show progress information.

Details

Because of potential batch effects due to sample processing and genotype calling, batches are an important experimental design factor.

batchChisqTest calculates the Chi square values from 2-by-2 table for each SNP, comparing each batch with the other batches.

batchFisherTest calculates Fisher’s Exact Test from 2-by-2 table for each SNP, comparing each batch with the other batches.

For each SNP and each batch, batch effect is evaluated by a 2-by-2 table: # of A alleles, and # of B alleles in the batch, versus # of A alleles, and # of B alleles in the other batches. Monomorphic SNPs are set to NA for all batches.

The default behavior is to combine allele frequencies from males and females and return results for autosomes only. If results for sex chromosomes (X or Y) are desired, use chrom.include with values 23 and/or 25 and sex.include="M" or "F".

If there are only two batches, the calculation is only performed once and the values for each batch will be identical.
batchChisqTest returns a list with the following elements:

- **mean.chisq**: a vector of mean chi-squared values for each batch.
- **lambda**: a vector of genomic inflation factor computed as \(\text{median}(\text{chisq}) / 0.456\) for each batch.
- **chisq**: a matrix of chi-squared values with SNPs as rows and batches as columns. Only returned if \(\text{return.by.snp}=\text{TRUE}\).

batchFisherTest returns a list with the following elements:

- **mean.or**: a vector of mean odds-ratio values for each batch. \(\text{mean.or}\) is computed as \(1/\text{mean}(\text{pmin(or, 1/or)})\) since the odds ratio is >1 when the batch has a higher allele frequency than the other batches and <1 for the reverse.
- **lambda**: a vector of genomic inflation factor computed as \(\text{median}(-2\log(pval) / 1.39\) for each batch.

Each of the following is a matrix with SNPs as rows and batches as columns, and is only returned if \(\text{return.by.snp}=\text{TRUE}\):

- **pval**: P value
- **oddsratio**: Odds ratio
- **confint.low**: Low value of the confidence interval for the odds ratio. Only returned if \(\text{conf.int}=\text{TRUE}\).
- **confint.high**: High value of the confidence interval for the odds ratio. Only returned if \(\text{conf.int}=\text{TRUE}\).

batchChisqTest and batchFisherTest both also return the following if \(\text{return.by.snp}=\text{TRUE}\):

- **allele.counts**: matrix with total number of A and B alleles over all batches.
- **min.exp.freq**: matrix of minimum expected allele frequency with SNPs as rows and batches as columns.

Author(s)

Xiuwen Zheng, Stephanie Gogarten

See Also

- GenotypeData, chisq.test, fisher.test

Examples

```
library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)
data(illuminaScanADF)
genoData <- GenotypeData(gds, scanAnnot=illuminaScanADF)

# autosomes only, sexes combined (default)
res.chisq <- batchChisqTest(genoData, batchVar="plate")
res.chisq$mean.chisq
res.chisq$lambda

# X chromosome for females
res.chisq <- batchChisqTest(genoData, batchVar="status",
```

head(res.chisq$chisq)

# Fisher exact test of "status" on X chromosome for females
res.fisher <- batchFisherTest(genoData, batchVar="status",
   chrom.include=23, sex.include="F", return.by.snp=TRUE)
qqPlot(res.fisher$pval)
close(genoData)

centromeres

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centromere base positions from the GRCh36/hg18, GRCh37/hg19 and GRCh38/hg38 genome builds.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>data(centromeres.hg18)</td>
</tr>
<tr>
<td>data(centromeres.hg19)</td>
</tr>
<tr>
<td>data(centromeres.hg38)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>A data frame with the following columns.</td>
</tr>
<tr>
<td>chrom</td>
</tr>
<tr>
<td>left.base</td>
</tr>
<tr>
<td>right.base</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>The UCSC genome browser lists two regions for the Y chromosome centromere in build hg18. We removed the positions (12208578, 12308578) from the centromere table to avoid problems with duplicate entries in the code.</td>
</tr>
</tbody>
</table>

<table>
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<th>Source</th>
</tr>
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<tr>
<td>hg18 and hg19: UCSC genome browser (<a href="http://genome.ucsc.edu">http://genome.ucsc.edu</a>)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>data(centromeres.hg18)</td>
</tr>
<tr>
<td>data(centromeres.hg19)</td>
</tr>
<tr>
<td>data(centromeres.hg38)</td>
</tr>
</tbody>
</table>
chromIntensityPlot

Plot B Allele Frequency and/or Log R Ratio, R or Theta values for samples by probe position on a chromosome

Description

This function creates plots for one or more of the 'B AlleleFreq', 'Log R Ratio', 'R' or 'Theta' values for given sample by chromosome combinations.

Usage

```r
chromIntensityPlot(intenData, scan.ids, chrom.ids,
    type = c("BAF/LRR", "BAF", "LRR", "R", "Theta", "R/Theta"),
    main = NULL, info = NULL, abln = NULL,
    horizln = c(1/2, 1/3, 2/3),
    colorGenotypes = FALSE, genoData = NULL,
    colorBatch = FALSE, batch.column = NULL,
    snp.exclude = NULL,
    ideogram=TRUE, ideo.zoom=TRUE, ideo.rect=FALSE,
    cex=0.5, cex.leg=1.5,
    colors = c("default", "neon", "primary"), ...)
```

Arguments

- `intenData` \texttt{IntensityData} object, must contain at least one of 'BAlleleFreq', 'LogRRatio', 'X', 'Y'.
- `scan.ids` A vector containing the scan IDs to plot.
- `chrom.ids` A vector containing the chromosomes to plot for each scanID (should have same length as `scan.ids`).
- `type` The type of plot to be created. 'BAF/LRR' creates both 'B Allele Freq' and 'Log R Ratio' plots. 'R/Theta' creates both 'R' and 'Theta' plots.
- `main` Vector of plot titles. If NULL then the title will include scanID, sex, and chromosome.
- `info` A character vector containing extra information to include in the main title.
- `abln` A vector of values that is of length 2*length(`scan.ids`). Each pair of entries specifies where vertical lines will be drawn in each plot. This is especially useful when drawing the start & end breakpoints for anomalies, for example. Use -1 as one pair value for plots that warrant only one line. By default, no lines will be drawn.
- `horizln` A vector containing the y-axis values at which a horizontal line will be drawn in B Allele Frequency plots.
- `colorGenotypes` A logical value specifying whether to color-code the points by called genotype. if TRUE, genoData must be given also.
- `genoData` \texttt{GenotypeData} object, required if colorGenotypes = TRUE.
- `colorBatch` A logical value specifying whether to color-code the points by sample batch (e.g. plate). If TRUE, batch.column must also be specified.
- `batch.column` A character string indicating which annotation variable in intenData should be used as the batch.
snp.exclude  An integer vector giving the IDs of SNPs to exclude from the plot.

ideogram  logical for whether to plot a chromosome ideogram under the BAF and LRR plots.

ideo.zoom  logical for whether to zoom in on the ideogram to match the range of the BAF/LRR plots.

ideo.rect  logical for whether to draw a rectangle on the ideogram indicating the range of the BAF/LRR plots.

cex  cex value for points on the plots.

cex.leg  cex value for the ideogram legend.

colors  Color scheme to use for genotypes. "default" is colorblind safe (colorbrewer Set2), "neon" is bright orange/green/fuschia, and "primary" is red/green/blue.

...  Other parameters to be passed directly to plot.

Details

For all plots, a vertical line is drawn every one eigth of the chromosome. For the Log R Ratio plot, the y-axis has been given the range of (-2,2).

Author(s)

Caitlin McHugh, Cathy Laurie

See Also

IntensityData, GenotypeData, BAFfromGenotypes

Examples

library(GWASdata)
data(illuminaScanADF)

blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
tenData <- IntensityData(bl, scanAnnot=illuminaScanADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
genot <- GdsGenotypeReader(genofile)
genotData <- GenotypeData(genot, scanAnnot=illuminaScanADF)

scanID <- getScanID(illuminaScanADF, index=1)
chromIntensityPlot(intenData=intenData, scan.ids=scanID,
  chrom.ids=22, type="BAF/LRR", info="interesting sample",
  colorGenotypes=TRUE, genoData=genotData)

close(genoData)
close(intenData)
**convertNcdfGds**  
*Convert between NetCDF and GDS format*

**Description**

`convertNcdfGds` converts a NetCDF file to GDS format.  
`convertGdsNcdf` converts a GDS file to NetCDF format.  
`checkNcdfGds` checks whether a genotype NetCDF file and a GDS file contain identical data.

**Usage**

```r
convertNcdfGds(ncdf.filename, gds.filename, snp.annot = NULL,  
                 precision = "single", compress = "ZIP_RA", verbose = TRUE)
```

```r
convertGdsNcdf(gds.filename, ncdf.filename,  
                 precision = "single", verbose = TRUE)
```

```r
checkNcdfGds(ncdf.filename, gds.filename, verbose = TRUE)
```

**Arguments**

- `ncdf.filename`: name of the NetCDF file
- `gds.filename`: name of the GDS file
- `snp.annot`: a `SnpAnnotationDataFrame` with SNP annotation. The column named "snpName" will be written to "snp.rs.id" in the GDS file.
- `precision`: A character value indicating whether floating point numbers should be stored as "double" or "single" precision.
- `compress`: The compression level for variables in a GDS file (see `add.gdsn` for options.
- `verbose`: whether to show progress information

**Details**

`convertNcdfGds` assumes any variables other than "sampleID", "chromosome", and "position" have dimensions SNP x sample.

If `snp.annot` has columns "rsID", "alleleA", "alleleB", these will be stored in the GDS file as "snp.rs.id" and "snp.allele" (the latter has the format "A/B").

Chromosome codes from `snp.annot` (for autosomes, X, Y, etc.) will be stored in the GDS file.

`convertGdsNcdf` assumes any variables not starting with "snp" or "sample" have dimensions SNP x sample.

**Value**

`checkNcdfGds` returns `TRUE` if the NetCDF and GDS files contain identical data. If the files differ, it will print a diagnostic message and return `FALSE`.

**Author(s)**

Xiuwen Zheng, Stephanie Gogarten
createDataFile

Write genotypic calls and/or associated metrics to a GDS or netCDF file.

Description

Genotypic calls and/or associated quantitative variables (e.g. quality score, intensities) are read from text files and written to a GDS or netCDF file.

Usage

createDataFile(path=".", filename, file.type=c("gds", "ncdf"),
variables="genotype", snp.annotation, scan.annotation,
sep.type, skip.num, col.total, col.nums, scan.name.in.file,
allele.coding=c("AB", "nucleotide"),
precision="single", compress="ZIP_RA:8M", compress.geno="ZIP_RA", compress.annot="ZIP_RA",
array.name=NULL, genome.build=NULL,
diagnostics.filename="createDataFile.diagnostics.RData",
verbose=TRUE)

createAffyIntensityFile(path=".", filename, file.type=c("gds", "ncdf"),
snp.annotation, scan.annotation,
precision="single", compress="ZIP_RA:8M", compress.annot="ZIP_RA",
array.name=NULL, genome.build=NULL,
diagnostics.filename="createAffyIntensityFile.diagnostics.RData",
verbose=TRUE)

checkGenotypeFile(path=".", filename, file.type=c("gds", "ncdf"),
snp.annotation, scan.annotation,
sep.type, skip.num, col.total, col.nums, scan.name.in.file,
check.scan.index, n.scans.loaded,
allele.coding=c("AB", "nucleotide"),

See Also

gdsfmt, ncdf4

Examples

library(GWASdata)
ncfile <- system.file("extdata", "illumina_geno.nc", package="GWASdata")
data(illuminaSnpADF)

gdsfile <- tempfile()
convertNcdfGds(ncfile, gdsfile, snp.annot=illuminaSnpADF)
checkNcdfGds(ncfile, gdsfile)

ncfile2 <- tempfile()
convertGdsNcdf(gdsfile, ncfile2)

file.remove(gdsfile, ncfile2)
createDataFile

diagnostics.filename="checkGenotypeFile.diagnostics.RData",
verbose=TRUE)

checkIntensityFile(path=".", filename, file.type=c("gds", "ncdf"),
snp.annotation, scan.annotation,
sep.type, skip.num, col.total, col.nums, scan.name.in.file,
check.scan.index, n.scans.loaded, affy.inten=FALSE,
diagnostics.filename="checkIntensityFile.diagnostics.RData",
verbose=TRUE)

Arguments

path Path to the raw text files.
filename The name of the genotype GDS or netCDF file to create
file.type The type of file to create ("gds" or "ncdf")
variables A character vector containing the names of the variables to create (must be one
or more of c("genotype", "quality", "X", "Y", "rawX", "rawY", "R", "Theta", "BAlleleFreq")
snp.annotation Snp annotation dataframe with columns "snpID", "chromosome", "position" and
"snpName". snpID should be a unique integer vector, sorted with respect to
chromosome and position. snpName should match the snp identifiers inside the
raw genotypic data files If file.type="gds", optional columns "alleleA", and
"alleleB" will be written if present.
scan.annotation Scan annotation dataframe with columns "scanID" (unique id of genotyping
instance), "scanName", (sample name inside the raw data file) and "file" (corre-
sponding raw data file name).
sep.type Field separator in the raw text files.
skip.num Number of rows to skip, which should be all rows preceding the genotypic or
quantitative data (including the header).
col.total Total number of columns in the raw text files.
col.nums An integer vector indicating which columns of the raw text file contain variables
for input. names(col.nums) must be a subset of c("snp", "sample", "geno",
"a1", "a2", "quality", "X", "Y", "rawX", "rawY", "R", "Theta", "BAlleleFreq",
"LogRRatio"). The element "snp" is the column of SNP ids, "sample" is sam-
ple ids, "geno" is diploid genotype (in AB format), "a1" and "a2" are alleles 1
and 2 (in AB format). "quality" is quality score, "X" and "Y" are normalized in-
tensities, "rawX" and "rawY" are raw intensities, "R" is the sum of normalized
intensities, "Theta" is angular polar coordinate, "BAlleleFreq" is the B allele
frequency, and "LogRRatio" is the Log R Ratio.
scan.name.in.file An indicator for the presence of sample name within the file. A value of 1
indicates a column with repeated values of the sample name (Illumina format),
-1 indicates sample name embedded in a column heading (Affymetrix format) and
0 indicates no sample name inside the raw data file.
allele.coding Whether the genotypes in the file are coded as "AB" (recognized characters are
A,B) or "nucleotide" (recognized characters are A,C,G,T). If allele.coding="nucelotide",
the columns "alleleA" and "alleleB" must be present in snp.annotation to map
the genotypes to integer format (number of A alleles).
createDataFile

check.scan.index
   An integer vector containing the indices of the sample dimension of the GDS or netCDF file to check.

n.scans.loaded
   Number of scans loaded in the GDS or netCDF file.

affy.inten
   Logical value indicating whether intensity files are in Affymetrix format (two lines per SNP).

precision
   A character value indicating whether floating point numbers should be stored as "double" or "single" precision.

compress
   The compression level for floating-point variables in a GDS file (see add.gdsn for options).

compress.geno
   The compression level for genotypes in a GDS file (see add.gdsn for options).

compress.annot
   The compression level for annotation variables in a GDS file (see add.gdsn for options).

array.name
   Name of the array, to be stored as an attribute in the netCDF file.

genome.build
   Genome build used in determining chromosome and position, to be stored as an attribute in the netCDF file.

diagnostics.filename
   Name of the output file to save diagnostics.

verbose
   Logical value specifying whether to show progress information.

Details

These functions read genotypic and associated data from raw text files. The files to be read and processed are specified in the sample annotation. createDataFile expects one file per sample, with each file having one row of data per SNP probe. The col.nums argument allows the user to select and identify specific fields for writing to the GDS or netCDF file. Illumina text files and Affymetrix ".CHP" files can be used here (but not Affymetrix "ALLELE_SUMMARY" files).

A SNP annotation data.frame is a pre-requisite for this function. It has the same number of rows (one per SNP) as the raw text file and a column of SNP names matching those within the raw text file. It also has a column of integer SNP ids to be used as a unique key for each SNP in the GDS or netCDF file.

A sample annotation data.frame is also a pre-requisite. It has one row per sample with columns corresponding to sample name (as it occurs within the raw text file), name of the raw text file for that sample and a unique sample id (to be written as the "sampleID" variable in the GDS or netCDF file). If file.type="ncdf", the unique id must be an integer.

The genotype calls in the raw text file may be either one column of diploid calls or two columns of allele calls. The function takes calls in "AB" or "nucleotide" format and converts them to a numeric code indicating the number of "A" alleles in the genotype (i.e. AA=2, AB=1, BB=0 and missing=-1). If the genotype calls are nucleotides (A,C,G,T), the columns "alleleA" and "alleleB" in snp.annotation are used to map to AB format.

While each raw text file is being read, the functions check for errors and irregularities and records the results in a list of vectors. If any problem is detected, that raw text file is skipped.

createAffyIntensityFile create an intensity data file from Affymetrix "ALLELE_SUMMARY" files. The "ALLELE_SUMMARY" files have two rows per SNP, one for X (A allele) and one for Y (B allele). These are reformatted to one row per SNP and ordered according to the SNP integer id. The correspondence between SNP names in the "ALLELE_SUMMARY" file and the SNP integer ids is made using the SNP annotation data.frame.

checkGenotypeFile and checkIntensityFile check the contents of GDS or netCDF files against raw text files.
Value

The GDS or netCDF file specified in argument filename is populated with genotype calls and/or associated quantitative variables. A list of diagnostics with the following components is returned. Each vector has one element per raw text file processed.

- **read.file** A vector indicating whether (1) or not (0) each file was read successfully.
- **row.num** A vector of the number of rows read from each file. These should all be the same and equal to the number of rows in the SNP annotation data.frame.
- **samples** A list of vectors containing the unique sample names in the sample column of each raw text file. Each vector should have just one element.
- **sample.match** A vector indicating whether (1) or not (0) the sample name inside the raw text file matches that in the sample annotation data.frame.
- **missg** A list of vectors containing the unique character string(s) for missing genotypes (i.e. not AA, AB or BB) for each raw text file.
- **snp.chk** A vector indicating whether (1) or not (0) the raw text file has the expected set of SNP names (i.e. matching those in the SNP annotation data.frame).
- **chk** A vector indicating whether (1) or not (0) all previous checks were successful and the data were written to the netCDF file.

checkGenotypeFile returns the following additional list items.

- **snp.order** A vector indicating whether (1) or not (0) the snp ids are in the same order in each file.
- **geno.chk** A vector indicating whether (1) or not (0) the genotypes in the netCDF match the text file.

checkIntensityFile returns the following additional list items.

- **qs.chk** A vector indicating whether (1) or not (0) the quality scores in the netCDF match the text file.
- **read.file.inten** A vector indicating whether (1) or not (0) each intensity file was read successfully (if intensity files are separate).
- **sample.match.inten** A vector indicating whether (1) or not (0) the sample name inside the raw text file matches that in the sample annotation data.frame (if intensity files are separate).
- **rows.equal** A vector indicating whether (1) or not (0) the number of rows read from each file are the same and equal to the number of rows in the SNP annotation data.frame (if intensity files are separate).
- **snp.chk.inten** A vector indicating whether (1) or not (0) the raw text file has the expected set of SNP names (i.e. matching those in the SNP annotation data.frame) (if intensity files are separate).
- **inten.chk** A vector for each intensity variable indicating whether (1) or not (0) the intensities in the netCDF match the text file.

Author(s)

Stephanie Gogarten, Cathy Laurie
createDataFile

See Also
gdsfmt, ncdf4

Examples

library(GWASdata)

#############
# Illumina - genotype file
#############
gdsfile <- tempfile()
path <- system.file("extdata", "illumina_raw_data", package="GWASdata")
data(illumina_snp_annot, illumina_scan_annot)
snpAnnot <- illumina_snp_annot[,c("snpID", "rsID", "chromosome", "position", "alleleA", "alleleB")]
names(snpAnnot)[2] <- "snpName"
# subset of samples for testing
scanAnnot <- illumina_scan_annot[1:3, c("scanID", "genoRunID", "file")]
names(scanAnnot)[2] <- "scanName"
col.nums <- as.integer(c(1,2,12,13))
names(col.nums) <- c("snp", "sample", "a1", "a2")
diagfile <- tempfile()
res <- createDataFile(path, gdsfile, file.type="gds", variables="genotype",
snpAnnot, scanAnnot, sep.type="\", skip.num=11, col.total=21, col.nums=col.nums,
scan.name.in.file=1, diagnostics.filename=diagfile)

file.remove(diagfile)
file.remove(gdsfile)

#############
# Affymetrix - genotype file
#############
gdsfile <- tempfile()
path <- system.file("extdata", "affy_raw_data", package="GWASdata")
data(affy_snp_annot, affy_scan_annot)
snpAnnot <- affy_snp_annot[,c("snpID", "probeID", "chromosome", "position")]
names(snpAnnot)[2] <- "snpName"
# subset of samples for testing
scanAnnot <- affy_scan_annot[1:3, c("scanID", "genoRunID", "chpFile")]
names(scanAnnot)[2:3] <- c("scanName", "file")
col.nums <- as.integer(c(2,3)); names(col.nums) <- c("snp", "geno")
diagfile <- tempfile()
res <- createDataFile(path, gdsfile, file.type="gds", variables="genotype",
snpAnnot, scanAnnot, sep.type="\t", skip.num=1, col.total=6, col.nums=col.nums,
scan.name.in.file=-1, diagnostics.filename=diagfile)

file.remove(diagfile)

# check
diagfile <- tempfile()
res <- checkGenotypeFile(path, gdsfile, file.type="gds", snpAnnot, scanAnnot,
sep.type="\t", skip.num=1, col.total=6, col.nums=col.nums,
scan.name.in.file=-1, check.scan.index=1:3, n.scans.loaded=3,
duplicateDiscordance

### duplicateDiscordance - Duplicate discordance

**Description**

A function to compute pair-wise genotype discordances between multiple genotyping instances of the same subject.

**Usage**

```r
duplicateDiscordance(genoData, subjName.col, one.pair.per.subj=TRUE, corr.by.snp=FALSE, minor.allele.only=FALSE, allele.freq=NULL, scan.exclude=NULL, snp.exclude=NULL, snp.block.size=5000, verbose=TRUE)
```

**Arguments**

- `genoData`: GenotypeData object
- `subjName.col`: A character string indicating the name of the annotation variable that will be identical for duplicate scans.
one.pair.per.subj
A logical indicating whether a single pair of scans should be randomly selected for each subject with more than 2 scans.

corr.by.snp
A logical indicating whether correlation by SNP should be computed (may significantly increase run time).

minor.allele.only
A logical indicating whether discordance should be calculated only between pairs of scans in which at least one scan has a genotype with the minor allele (i.e., exclude major allele homozygotes).

allele.freq
A numeric vector with the frequency of the A allele for each SNP in genoData. Required if minor.allele.only=TRUE.

scan.exclude
An integer vector containing the ids of scans to be excluded.

snp.exclude
An integer vector containing the ids of SNPs to be excluded.

snp.block.size
Integer block size for SNPs if corr.by.snp=TRUE.

verbose
Logical value specifying whether to show progress information.

Details
duplicateDiscordance calculates discordance metrics both by scan and by SNP. If one.pair.per.subj=TRUE (the default), each subject with more than two duplicate genotyping instances will have two scans randomly selected for computing discordance. If one.pair.per.subj=FALSE, discordances will be calculated pair-wise for all possible pairs for each subject.

Value
A list with the following components:

discordance.by.snp
data frame with 5 columns: 1. snpID, 2. discordant (number of discordant pairs), 3. npair (number of pairs examined), 4. n.disc.subj (number of subjects with at least one discordance), 5. discord.rate (discordance rate i.e. discordant/npair)

discordance.by.subject
a list of matrices (one for each subject) with the pair-wise discordance between the different genotyping instances of the subject

correlation.by.subject
a list of matrices (one for each subject) with the pair-wise correlation between the different genotyping instances of the subject

If corr.by.snp=TRUE, discordance.by.snp will also have a column "correlation" with the correlation between duplicate subjects. For this calculation, the first two samples per subject are selected.

Author(s)
Tushar Bhangale, Cathy Laurie, Stephanie Gogarten, Sarah Nelson

See Also
GenotypeData, duplicateDiscordanceAcrossDatasets, duplicateDiscordanceProbability, alleleFrequency
**Examples**

```r
library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)
data(illuminaScanADF)

disc <- duplicateDiscordance(genoData, subjName.col="subjectID")

# minor allele discordance
afreq <- alleleFrequency(genoData)
minor.disc <- duplicateDiscordance(genoData, subjName.col="subjectID",
  minor.allele.only=TRUE, allele.freq=afreq[,"all"])

close(genoData)
```

**duplicateDiscordanceAcrossDatasets**

*Functions to check discordance and allelic dosage correlation across datasets*

**Description**

These functions compare genotypes in pairs of duplicate scans of the same sample across multiple datasets. 'duplicateDiscordanceAcrossDatasets' finds the number of discordant genotypes both by scan and by SNP. 'dupDosageCorAcrossDatasets' calculates correlations between allelic dosages both by scan and by SNP, allowing for comparison between imputed datasets or between imputed and observed - i.e., where one or more of the datasets contains continuous dosage \([0,2]\) rather than discrete allele counts \(\{0,1,2\}\).

**Usage**

```r
duplicateDiscordanceAcrossDatasets(genoData1, genoData2,
  match.snps.on=c("position", "alleles"),
  subjName.cols, snpName.cols=NULL,
  one.pair.per.subj=TRUE, minor.allele.only=FALSE,
  missing.fail=c(FALSE, FALSE),
  scan.exclude1=NULL, scan.exclude2=NULL,
  snp.exclude1=NULL, snp.exclude2=NULL,
  snp.include=NULL,
  verbose=TRUE)

minorAlleleDetectionAccuracy(genoData1, genoData2,
  match.snps.on=c("position", "alleles"),
  subjName.cols, snpName.cols=NULL,
  missing.fail=TRUE,
  scan.exclude1=NULL, scan.exclude2=NULL,
  snp.exclude1=NULL, snp.exclude2=NULL,
  snp.include=NULL,
  verbose=TRUE)

dupDosageCorAcrossDatasets(genoData1, genoData2,
  match.snps.on=c("position", "alleles"),
  subjName.cols, snpName.cols=NULL,
  missing.fail=TRUE,
  scan.exclude1=NULL, scan.exclude2=NULL,
  snp.exclude1=NULL, snp.exclude2=NULL,
  snp.include=NULL,
  verbose=TRUE)
```
duplicateDiscordanceAcrossDatasets

match.snps.on=c("position", "alleles"),
subjName.cols="subjectID", snpName.cols=NULL,
scan.exclude1=NULL, scan.exclude2=NULL,
snp.exclude1=NULL, snp.exclude2=NULL,
snp.include=NULL,
snp.block.size=5000, scan.block.size=100,
verbose=TRUE)

Arguments

**genoData1**  
*GenotypeData* object containing the first dataset.

**genoData2**  
*GenotypeData* object containing the second dataset.

**match.snps.on**  
One or more of ("position", "alleles", "name") indicating how to match SNPs.  
"position" will match SNPs on chromosome and position, "alleles" will also require the same alleles (but A/B designations need not be the same), and "name" will match on the columns give in `snpName.cols`.

**subjName.cols**  
2-element character vector indicating the names of the annotation variables that will be identical for duplicate scans in the two datasets. (Alternatively, one character value that will be recycled).

**snpName.cols**  
2-element character vector indicating the names of the annotation variables that will be identical for the same SNPs in the two datasets. (Alternatively, one character value that will be recycled).

**one.pair.per.subj**  
A logical indicating whether a single pair of scans should be randomly selected for each subject with more than 2 scans.

**minor.allele.only**  
A logical indicating whether discordance should be calculated only between pairs of scans in which at least one scan has a genotype with the minor allele (i.e., exclude major allele homozygotes).

**missing.fail**  
For `duplicateDiscordanceAcrossDatasets`, a 2-element logical vector indicating whether missing values in datasets 1 and 2, respectively, will be considered failures (discordances with called genotypes in the other dataset). For `minorAlleleDetectionAccuracy`, a single logical indicating whether missing values in dataset 2 will be considered false negatives (`missing.fail=TRUE`) or ignored (`missing.fail=FALSE`).

**scan.exclude1**  
An integer vector containing the ids of scans to be excluded from the first dataset.

**scan.exclude2**  
An integer vector containing the ids of scans to be excluded from the second dataset.

**snp.exclude1**  
An integer vector containing the ids of SNPs to be excluded from the first dataset.

**snp.exclude2**  
An integer vector containing the ids of SNPs to be excluded from the second dataset.

**snp.include**  
List of SNPs to include in the comparison. Should match the contents of the columns referred to by `snpName.cols`. Only valid if `match.snps.on` includes "name".

**snp.block.size**  
Block size for SNPs

**scan.block.size**  
Block size for scans

**verbose**  
Logical value specifying whether to show progress information.
**Details**

duplicateDiscordanceAcrossDatasets calculates discordance metrics both by scan and by SNP. If `one.pair.per.subj=TRUE` (the default), each subject with more than two duplicate genotyping instances will have one scan from each dataset randomly selected for computing discordance. If `one.pair.per.subj=FALSE`, discordances will be calculated pair-wise for all possible cross-dataset pairs for each subject.

dupDosageCorAcrossDatasets calculates dosage correlation (Pearson correlation coefficient) both by scan and by SNP. Note it only allows for one pair of duplicate scans per sample. For this function only, genoData1 and genoData2 must have been created with GdsGenotypeReader objects.

By default, overlapping variants are identified based on position and alleles. Alleles are determined via `getAlleleA` and `getAlleleB` accessors, so users should ensure these variables are referring to the same strand orientation in both datasets (e.g., both plus strand alleles). It is not necessary for the A/B ordering to be consistent across datasets. For example, two variants at the same position with alleleA=“C” and alleleB=“T” in genoData1 and alleleA=“T” and alleleB=“C” in genoData2 will still be identified as overlapping.

If `minor.allele.only=TRUE`, the allele frequency will be calculated in genoData1, using only samples common to both datasets.

If `snp.include=NULL` (the default), discordances will be found for all SNPs common to both datasets.

genoData1 and genoData2 should each have "alleleA" and "alleleB" defined in their SNP annotation. If allele coding cannot be found, the two datasets are assumed to have identical coding. Note that `dupDosageCorAcrossDatasets` can NOT detect where strand-ambiguous (A/T or C/G) SNPs are annotated on different strands, although the r2 in these instances would be unaffected: r may be negative but r2 will be positive.

minorAlleleDetectionAccuracy summarizes the accuracy of minor allele detection in genoData2 with respect to genoData1 (the "gold standard"). TP=number of true positives, TN=number of true negatives, FP=number of false positives, and FN=number of false negatives. Accuracy is represented by four metrics:

- sensitivity for each SNP as TP/(TP+FN)
- specificity for each SNP as TN/(TN+FP)
- positive predictive value for each SNP as TP/(TP+FP)
- negative predictive value for each SNP as TN/(TN+FN).

TP, TN, FP, and FN are calculated as follows:

<table>
<thead>
<tr>
<th></th>
<th>genoData1</th>
<th>genoData2</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>2TP</td>
<td>1TP + 1FN</td>
</tr>
<tr>
<td>Mm</td>
<td>1TP + 1FP</td>
<td>1TN + 1TP</td>
</tr>
<tr>
<td>MM</td>
<td>1FN + 1TN</td>
<td>2TN</td>
</tr>
<tr>
<td>-</td>
<td>2FN</td>
<td>1FN</td>
</tr>
</tbody>
</table>

"M" is the major allele and "m" is the minor allele (as calculated in genoData1). "-" is a missing call in genoData2. Missing calls in genoData1 are ignored. If `missing.fail=FALSE`, missing calls in genoData2 (the last row of the table) are also ignored.
**Value**

SNP annotation columns returned by all functions are:

- `chromosome`  : chromosome
- `position`    : base pair position
- `snpID1`      : snpID from genoData1
- `snpID2`      : snpID from genoData2

If matching on "alleles":

- `alleles`    : alleles sorted alphabetically
- `alleleA1`   : allele A from genoData1
- `alleleB1`   : allele B from genoData2
- `alleleA2`   : allele A from genoData2
- `alleleB2`   : allele B from genoData2

If matching on "name":

- `name`       : the common SNP name given in snpName.cols

`duplicateDiscordanceAcrossDatasets` returns a list with two data frames: The data.frame "discordance.by.snp" contains the SNP annotation columns listed above as well as:

- `discordant` : number of discordant pairs
- `npair`      : number of pairs examined
- `n.disc.subj` : number of subjects with at least one discordance
- `discord.rate` : discordance rate i.e. discordant/npair

The data.frame "discordance.by.subject" contains a list of matrices (one for each subject) with the pair-wise discordance between the different genotyping instances of the subject.

`minorAlleleDetectionAccuracy` returns a data.frame with the SNP annotation columns listed above as well as:

- `npair`      : number of sample pairs compared (non-missing in genoData1)
- `sensitivity` : sensitivity
- `specificity` : specificity
- `positivePredictiveValue` : Positive predictive value
- `negativePredictiveValue` : Negative predictive value

`dupDosageCorAcrossDatasets` returns a list with two data frames:

The data.frame "snps" contains the by-SNP correlation (r) values with the SNP annotation columns listed above as well as:

- `nsamp.dosageR` : number of samples in r calculation (i.e., non missing data in both genoData1 and genoData2)
- `dosageR`      : dosage correlation

The data.frame "samps" contains the by-sample r values with the following columns:
**duplicateDiscordanceAcrossDatasets**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subjectID</td>
<td>subject-level identifier for duplicate sample pair</td>
</tr>
<tr>
<td>scanID1</td>
<td>scanID from genoData1</td>
</tr>
<tr>
<td>scanID2</td>
<td>scanID from genoData2</td>
</tr>
<tr>
<td>nsnp.dosageR</td>
<td>number of SNPs in r calculation (i.e., non missing data in both genoData1 and genoData2)</td>
</tr>
<tr>
<td>dosageR</td>
<td>dosage correlation</td>
</tr>
</tbody>
</table>

If no duplicate scans or no common SNPs are found, these functions issue a warning message and return NULL.

**Author(s)**

Stephanie Gogarten, Jess Shen, Sarah Nelson

**See Also**

GenotypeData, duplicateDiscordance, duplicateDiscordanceProbability

**Examples**

```r
# first set
snp1 <- data.frame(snpID=1:10, chromosome=1L, position=101:110, 
   rsID=paste("rs", 101:110, sep=""), 
   alleleA="A", alleleB="G", stringsAsFactors=FALSE)
scan1 <- data.frame(scanID=1:3, subjectID=c("A","B","C"), sex="F", stringsAsFactors=FALSE)
mgr <- MatrixGenotypeReader(genotype=matrix(c(0,1,2), ncol=3, nrow=10), snpID=snp1$snpID, 
   chromosome=snp1$chromosome, position=snp1$position, scanID=1:3)
genoData1 <- GenotypeData(mgr, snpAnnot=SnpAnnotationDataFrame(snp1), 
   scanAnnot=ScanAnnotationDataFrame(scan1))

# second set
snp2 <- data.frame(snpID=1:5, chromosome=1L, 
   position=as.integer(c(101,103,105,107,107)), 
   rsID=c("rs101", "rs103", "rs105", "rs107", "rsXXX"), 
   alleleA= c("A","C","G","A","A"), 
   alleleB=c("G","T","A","G","G"), 
   stringsAsFactors=FALSE)
scan2 <- data.frame(scanID=1:3, subjectID=c("A","C","C"), sex="F", stringsAsFactors=FALSE)
mgr <- MatrixGenotypeReader(genotype=matrix(c(1,2,0), ncol=3, nrow=5), snpID=snp2$snpID, 
   chromosome=snp2$chromosome, position=snp2$position, scanID=1:3)
genoData2 <- GenotypeData(mgr, snpAnnot=SnpAnnotationDataFrame(snp2), 
   scanAnnot=ScanAnnotationDataFrame(scan2))

duplicateDiscordanceAcrossDatasets(genoData1, genoData2, match.snps.on="position", subjName.cols="subjectID")
duplicateDiscordanceAcrossDatasets(genoData1, genoData2, match.snps.on=c("position", "alleles"), subjName.cols="subjectID")
duplicateDiscordanceAcrossDatasets(genoData1, genoData2, match.snps.on=c("position", "alleles", "name"), subjName.cols="subjectID", 
   snpName.cols="rsID")
```
duplicateDiscordanceProbability

**Probability of duplicate discordance**

Description

duplicateDiscordanceProbability calculates the probability of observing discordant genotypes for duplicate samples.

Usage

duplicateDiscordanceProbability(npair,
  error.rate = c(1e-5, 1e-4, 1e-3, 1e-2),
  max.disc = 7)

Arguments

- **npair**: The number of pairs of duplicate samples.
- **error.rate**: A numeric vector of error rates (i.e., the rate at which a genotype will be called incorrectly).
- **max.disc**: The maximum number of discordances for which to compute the probability.

Details

Since there are three possible genotypes, one call is correct and the other two are erroneous, so theoretically there are two error rates, a and b. The probability that duplicate genotyping instances of the same subject will give a discordant genotype is \(2(1 - a - b)(a + b) + ab\). When a and b are very small, this is approximately \(2(a + b)\) or twice the total error rate. This function assumes that a == b, and the argument error.rate is the total error rate a + b.

Any negative values for the probability (due to precision problems for very small numbers) are set to 0.

Value

This function returns a matrix of probabilities, where the column names are error rates and the row names are expected number of discordant genotypes (>0 through > max.disc).

Author(s)

Cathy Laurie
**exactHWE**

**Hardy-Weinberg Equilibrium testing**

**Description**

This function performs exact Hardy-Weinberg Equilibrium testing (using Fisher’s Test) over a selection of SNPs. It also counts genotype, calculates allele frequencies, and calculates inbreeding coefficients.

**Usage**

```r
exactHWE(genoData, scan.exclude = NULL, geno.counts = TRUE, snpStart = NULL, snpEnd = NULL, block.size = 5000, verbose = TRUE, permute = FALSE)
```

**Arguments**

- `genoData`: a `GenotypeData` object
- `scan.exclude`: a vector of scanIDs for scans to exclude
- `geno.counts`: if `TRUE` (default), genotype counts are returned in the output data.frame.
- `snpStart`: index of the first SNP to analyze, defaults to first SNP
- `snpEnd`: index of the last SNP to analyze, defaults to last SNP
- `block.size`: number of SNPs to read in at once
- `verbose`: logical for whether to print status updates
- `permute`: logical indicator for whether to permute alleles before calculations

**Examples**

```r
disc <- duplicateDiscordanceProbability(npair=10, error.rate=c(1e-6, 1e-4))
#probability of observing >0 discordant genotypes given an error rate 1e-6
disc[1,1]
#probability of observing >1 discordant genotypes given an error rate 1e-4
disc[2,2]
```
Details

HWE calculations are performed with the `HWExact` function in the `GWASExactHW` package.

For the X chromosome, only female samples will be used in all calculations (since males are excluded from HWE testing on this chromosome). The X chromosome may not be included in a block with SNPs from other chromosomes. If the SNP selection includes the X chromosome, the scan annotation of genoData should include a "sex" column.

Y and M and chromosome SNPs are not permitted in the SNP selection, since the HWE test is not valid for these SNPs.

If `permute=TRUE`, alleles will be randomly shuffled before the HWE calculations. Running permutation can yield the expected distribution of p-values and corresponding confidence intervals.

Value

A data frame with the following columns:

- `snpID`: the snp IDs
- `chr`: chromosome SNPs are on

If `geno.counts=TRUE`:

- `nAA`: number of AA genotypes in samples
- `nAB`: number of AB genotypes in samples
- `nBB`: number of BB genotypes in samples
- `MAF`: minor allele frequency
- `minor.allele`: which allele ("A" or "B") is the minor allele
- `f`: the inbreeding coefficient
- `pval`: exact Hardy-Weinberg Equilibrium (using Fisher’s Test) p-value. `pval` will be NA for monomorphic SNPs (MAF=0).

Author(s)

Ian Painter, Matthew P. Conomos, Stephanie Gogarten, Adrienne Stilp

See Also

`HWExact`

Examples

```r
library(GWASdata)
data(illuminaScanADF)

# run only on YRI subjects
scan.exclude <- illuminaScanADF$scanID[illuminaScanADF$race != "YRI"]

# create data object
gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(gdsfile)
genodata <- GenotypeData(gds, scanAnnot=illuminaScanADF)
chr <- getChromosome(genodata)

# autosomal SNPs
```
auto <- range(which(is.element(chr, 1:22)))
hwe <- exactHWE(genoData, scan.exclude=scan.exclude, 
snpStart=auto[1], snpEnd=auto[2])

# permutation
perm <- exactHWE(genoData, scan.exclude=scan.exclude, 
snpStart=auto[1], snpEnd=auto[2], 
permute=TRUE)

# X chromosome SNPs must be run separately since they only use females
Xchr <- range(which(chr == 23))
hweX <- exactHWE(genoData, scan.exclude=scan.exclude, 
snpStart=Xchr[1], snpEnd=Xchr[2])
close(genoData)

---

**findBAFvariance**  
*Find chromosomal areas with high BAlleleFreq (or LogRRatio) standard deviation*

**Description**

`sdByScanChromWindow` uses a sliding window algorithm to calculate the standard deviation of the BAlleleFreq (or LogRRatio) values for a user specified number of bins across each chromosome of each scan.

`medianSdOverAutosomes` calculates the median of the BAlleleFreq (or LogRRatio) standard deviation over all autosomes for each scan.

`meanSdByChromWindow` calculates the mean and standard deviation of the BAlleleFreq standard deviation in each window in each chromosome over all scans.

`findBAFvariance` flags chromosomal areas with high BAlleleFreq standard deviation using previously calculated means and standard deviations over scans, typically results from `sdByScanChromWindow`.

**Usage**

```r
sdByScanChromWindow(intenData, genoData=NULL, var="BAlleleFreq", nbins=NULL, 
snp.exclude=NULL, return.mean=FALSE, incl.miss=TRUE, incl.het=TRUE, incl.hom=FALSE)
```

```r
medianSdOverAutosomes(sd.by.scan.chrom.window)
```

```r
meanSdByChromWindow(sd.by.scan.chrom.window, sex)
```

```r
findBAFvariance(sd.by.chrom.window, sd.by.scan.chrom.window, 
sex, sd.threshold)
```

**Arguments**

- `intenData`  
  A `IntensityData` object. The order of SNPs is expected to be by chromosome and then by position within chromosome.

- `genoData`  
  A `GenotypeData` object. May be omitted if `incl.miss`, `incl.het`, and `incl.hom` are all `TRUE`, as there is no need to distinguish between genotype calls in that case.
**findBAFvariance**

- **var**
  The variable for which to calculate standard deviations, typically "BAlleleFreq" (the default) or "LogRRatio."

- **nbins**
  A vector with integers corresponding to the number of bins for each chromosome. The values must all be even integers.

- **snp.exclude**
  An integer vector containing the snpIDs of SNPs to be excluded.

- **return.mean**
  A logical. If TRUE, return mean as well as standard deviation.

- **incl.miss**
  A logical. If TRUE, include SNPs with missing genotype calls.

- **incl.het**
  A logical. If TRUE, include SNPs called as heterozygotes.

- **incl.hom**
  A logical. If TRUE, include SNPs called as homozygotes. This is typically FALSE (the default) for BAlleleFreq calculations.

- **sd.by.scan.chrom.window**
  A list of matrices of standard deviation for each chromosome, with dimensions of number of scans x number of windows. This is typically the output of `sdByScanChromWindow`.

- **sd.by.chrom.window**
  A list of matrices of the standard deviations, as generated by `meanSdByChromWindow`.

- **sex**
  A character vector of sex ("M"/"F") for the scans.

- **sd.threshold**
  A value specifying the threshold for the number of standard deviations above the mean at which to flag.

**Details**

- `sdByScanChromWindow` calculates the standard deviation of BAlleleFreq (or LogRRatio) values across chromosomes 1-22 and chromosome X for a specified number of 'bins' in each chromosome as passed to the function in the 'nbins' argument. The standard deviation is calculated using windows of width equal to 2 bins, and moves along the chromosome by an offset of 1 bin (or half a window). Thus, there will be a total of nbins-1 windows per chromosome. If nbins=NULL (the default), there will be 2 bins (one window) for each chromosome.

- `medianSdOverAutosomes` calculates the median over autosomes of BAlleleFreq (or LogRRatio) standard deviations calculated for sliding windows within each chromosome of each scan. The standard deviations should be a list with one element for each chromosome, and each element consisting of a matrix with scans as rows.

- `meanSdByChromWindow` calculates the mean and standard deviation over scans of BAlleleFreq standard deviations calculated for sliding windows within each chromosome of each scan. The BAlleleFreq standard deviations should be a list with one element for each chromosome, and each element consisting of a matrix containing the BAlleleFreq standard deviation for the i'th scan in the j'th bin. This is typically created using the `sdByScanChromWindow` function. For the X chromosome the calculations are separated out by sex.

- `findBAFvariance` determines which chromosomes of which scans have regions which are at least a given number of SDs from the mean, using BAlleleFreq means and standard deviations calculated from sliding windows over each chromosome by scan.

**Value**

- `sdByScanChromWindow` returns a list of matrices containing standard deviations. There is a matrix for each chromosome, with each matrix having dimensions of number of scans x number of windows. If return.mean=TRUE, two lists to matrices are returned, one with standard deviations and one with means.
medianSdOverAutosomes returns a data frame with columns "scanID" and "med.sd" containing the median standard deviations over all autosomes for each scan.

meanSdByChromWindow returns a list of matrices, one for each chromosome. Each matrix contains two columns called "Mean" and "SD", containing the mean and SD of the BAlleleFreq standard deviations over scans for each bin. For the X chromosome the matrix has four columns "Female Mean", "Male Mean", "Female SD" and "Male SD".

findBAFvariance returns a matrix with columns "scanID", "chromosome", "bin", and "sex" containing those scan by chromosome combinations with BAlleleFreq standard deviations greater than those specified by sd.threshold.

Author(s)
Caitlin McHugh, Cathy Laurie

See Also
IntensityData, GenotypeData, BAFfromClusterMeans, BAFfromGenotypes

Examples

```r
library(GWASdata)
data(illuminaScanADF)
blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
bl <- GdsIntensityReader(blfile)
blData <- IntensityData(bl, scanAnnot=illuminaScanADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF)

nbins <- rep(8, 3) # need bins for chromosomes 21,22,23
baf.sd <- sdByScanChromWindow(blData, genoData, nbins=nbins)

close(blData)
close(genoData)
med.res <- medianSdOverAutosomes(baf.sd)

sex <- illuminaScanADF$sex
sd.res <- meanSdByChromWindow(baf.sd, sex)

var.res <- findBAFvariance(sd.res, baf.sd, sex, sd.threshold=2)
```

GdsGenotypeReader

Class GdsGenotypeReader

Description

The GdsGenotypeReader class is an extension of the GdsReader class specific to reading genotype data stored in GDS files. GDS files with both snp x scan and scan x snp dimensions are supported.
**GdsGenotypeReader**

**Extends**

*GdsReader*

**Constructor**

GdsGenotypeReader(filename, genotypeDim):

filename must be the path to a GDS file or a gds object. The GDS file must contain the following variables:

- 'snp.id': a unique integer vector of snp ids
- 'snp.chromosome': integer chromosome codes
- 'snp.position': integer position values
- 'sample.id': a unique integer vector of scan ids
- 'genotype': a matrix of bytes with dimensions ('snp','sample'). The byte values must be the number of A alleles: 2=AA, 1=AB, 0=BB.

The optional variable "snp.allele" stores the A and B alleles in a character vector with format "A/B".

Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.

The constructor automatically detects whether the GDS file is in snp x scan or scan x snp order using the dimensions of snp.id and sample.id. In the case of GDS files with equal SNP and scan dimensions, genotypeDim is a required input to the function and can take values "snp,scan" or "scan,snp".

The GdsGenotypeReader constructor creates and returns a GdsGenotypeReader instance pointing to this file.

**Accessors**

In the code snippets below, object is a GdsGenotypeReader object. See *GdsReader* for additional methods.

- **nsnp(object)**: The number of SNPs in the GDS file.
- **nscan(object)**: The number of scans in the GDS file.
- **getSnpID(object, index)**: A unique integer vector of snp IDs. The optional index is a logical or integer vector specifying elements to extract.
- **getChromosome(object, index, char=FALSE)**: A vector of chromosomes. The optional index is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.
- **getPosition(object, index)**: An integer vector of base pair positions. The optional index is a logical or integer vector specifying elements to extract.
- **getAlleleA(object, index)**: A character vector of A alleles. The optional index is a logical or integer vector specifying elements to extract.
- **getAlleleB(object, index)**: A character vector of B alleles. The optional index is a logical or integer vector specifying elements to extract.
- **getScanID(object, index)**: A unique integer vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract.
getGenotype(object, snp=c(1,-1), scan=c(1,-1), drop=TRUE, use.names=FALSE, order=c("file", "selection"), transpose=FALSE, ...):
Extracts genotype values (number of A alleles). snp and scan indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of `-1` for count indicates that the entire dimension should be read. If drop=TRUE, the result is coerced to the lowest possible dimension. If use.names=TRUE, names of the resulting vector or matrix are set to the SNP and scan IDs. Missing values are represented as NA. If order="file", genotypes are returned in the order they are stored in the file. If order="selection", the order of SNPs and scans will match the index selection provided in snp and scan respectively. Genotypes are returned in SNP x scan order if transpose=FALSE, otherwise they are returned in scan x SNP order.

getGenotypeSelection(object, snp=NULL, scan=NULL, snpID=NULL, scanID=NULL, drop=TRUE, use.names=TRUE, transpose=FALSE, ...):
Extracts genotype values (number of A alleles). snp and scan may be integer or logical vectors indicating which elements to return along the snp and scan dimensions. snpID and scanID allow section by values of snpID and scanID. Unlike getGenotype, the values requested need not be in contiguous blocks. Other arguments are identical to getGenotype.

getVariable(object, varname, index, drop=TRUE, ...):
Extracts the contents of the variable varname. The optional index is a logical or integer vector (if varname is 1D) or list (if varname is 2D or higher) specifying elements to extract. If drop=TRUE, the result is coerced to the lowest possible dimension. Missing values are represented as NA. If the variable is not found, returns NULL.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
GdsReader, GenotypeData

Examples

```r
file <- system.file("extdata", "illumina_genot.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# dimensions
nsnp(gds)
nscan(gds)

# get snpID and chromosome
snpID <- getSnpID(gds)
chrom <- getChromosome(gds)

# get positions only for chromosome 22
pos22 <- getPosition(gds, index=(chrom == 22))

# get all snps for first scan
geno <- getGenotype(gds, snp=c(1,-1), scan=c(1,1))
length(geno)
```
# starting at snp 100, get 10 snps for the first 5 scans
getGenotype(gds, snp=1:100, scan=1:5)

# get snps 1-10, 25-30 for scans 3,5,7
snp.index <- c(1:10, 25:30)
scan.index <- c(3,5,7)
getGenotypeSelection(gds, snp=snp.index, scan=scan.index)

# illustrate drop argument
getGenotypeSelection(gds, snp=5, scan=1:10, drop=TRUE, use.names=FALSE)
getGenotypeSelection(gds, snp=5, scan=1:10, drop=FALSE, use.names=FALSE)

# illustrate order="file" vs order="selection"
snp.index <- c(9,3,5)
scan.index <- c(3,2,1)
getGenotypeSelection(gds, snp=snp.index, scan=scan.index, order="file")
getGenotypeSelection(gds, snp=snp.index, scan=scan.index, order="selection")

close(gds)

---

### GdsIntensityReader

**Class GdsIntensityReader**

**Description**

The GdsIntensityReader class is an extension of the GdsReader class specific to reading intensity data stored in GDS files.

**Extends**

- GdsReader

**Constructor**

GdsIntensityReader(filename):

- filename must be the path to a GDS file. The GDS file must contain the following variables:
  - 'snp': a coordinate variable with a unique integer vector of snp ids
  - 'chromosome': integer chromosome values of dimension 'snp'
  - 'position': integer position values of dimension 'snp'
  - 'sampleID': a unique integer vector of scan ids with dimension 'sample'

Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.

The GDS file should also contain at least one of the following variables with dimensions ('snp','sample'):

- 'quality': quality score
- 'X': X intensity
- 'Y': Y intensity
- 'BAlleleFreq': B allele frequency
- 'LogRRatio': Log R Ratio

The GdsIntensityReader constructor creates and returns a GdsIntensityReader instance pointing to this file.
Accessors

In the code snippets below, `object` is a GdsIntensityReader object. `snp` and `scan` indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of `-1` for count indicates that the entire dimension should be read. If `snp` and/or `scan` is omitted, the entire variable is read.

See GdsReader for additional methods.

- `nsnp(object)`: The number of SNPs in the GDS file.
- `nscan(object)`: The number of scans in the GDS file.
- `getSnpID(object, index)`: A unique integer vector of snp IDs. The optional `index` is a logical or integer vector specifying elements to extract.
- `getChromosome(object, index, char=FALSE)`: A vector of chromosomes. The optional `index` is a logical or integer vector specifying elements to extract. If `char=FALSE` (default), returns an integer vector. If `char=TRUE`, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.
- `getPosition(object, index)`: An integer vector of base pair positions. The optional `index` is a logical or integer vector specifying elements to extract.
- `getScanID(object, index)`: A unique integer vector of scan IDs. The optional `index` is a logical or integer vector specifying elements to extract.
- `getQuality(object, snp, scan, drop=TRUE)`: Extracts quality scores. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA.
- `hasQuality(object)`: Returns `TRUE` if the GDS file contains a variable 'quality'.
- `getX(object, snp, scan, drop=TRUE)`: Extracts X intensity. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA.
- `hasX(object)`: Returns `TRUE` if the GDS file contains a variable 'X'.
- `getY(object, snp, scan, drop=TRUE)`: Extracts Y intensity. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA.
- `hasY(object)`: Returns `TRUE` if the GDS file contains a variable 'Y'.
- `getBAlleleFreq(object, snp, scan, drop=TRUE)`: Extracts B allele frequency. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA.
- `hasBAlleleFreq(object)`: Returns `TRUE` if the GDS file contains a variable 'BAlleleFreq'.
- `getLogRRatio(object, snp, scan, drop=TRUE)`: Extracts Log R Ratio. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA.
- `hasLogRRatio(object)`: Returns `TRUE` if the GDS file contains a variable 'LogRRatio'.
- `getVariable(object, varname, snp, scan, drop=TRUE)`: Returns the contents of the variable `varname`. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of `drop`. Missing values are represented as NA. If the variable is not found in the GDS file, returns NULL.
- `autosomeCode(object)`: Returns the integer codes for the autosomes.
XchromCode(object): Returns the integer code for the X chromosome.
XYchromCode(object): Returns the integer code for the pseudoautosomal region.
YchromCode(object): Returns the integer code for the Y chromosome.
MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
GdsReader, GdsGenotypeReader, GenotypeData, IntensityData

Examples
```r
file <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
gds <- GdsIntensityReader(file)

# dimensions
nsnp(gds)
nscan(gds)

# get snpID and chromosome
snpID <- getSnpID(gds)
chrom <- getChromosome(gds)

# get positions only for chromosome 22
pos22 <- getPosition(gds, index=(chrom == 22))

# get all snps for first scan
x <- getX(gds, snp=c(1,-1), scan=c(1,1))

# starting at snp 100, get 10 snps for the first 5 scans
x <- getX(gds, snp=c(100,10), scan=c(1,5))

close(gds)
```

GdsReader

Class GdsReader

Description
The GdsReader class provides an interface for reading GDS files.

Constructor

GdsReader(filename, ...):
filename must be the path to a GDS file or an already opened gds object.
The GdsReader constructor creates and returns a GdsReader instance pointing to this file.
Accessors

In the code snippets below, object is a GdsReader object.

getVariable(object, varname, start, count, sel=NULL, drop=TRUE): Returns the contents of the variable varname.

• start is a vector of integers indicating where to start reading values. The length of this vector must equal the number of dimensions the variable has. If not specified, reading starts at the beginning of the file (1,1,...).

• count is a vector of integers indicating the count of values to read along each dimension. The length of this vector must equal the number of dimensions the variable has. If not specified and the variable does NOT have an unlimited dimension, the entire variable is read. As a special case, the value "-1" indicates that all entries along that dimension should be read.

• sel may be specified instead of start and count. It is a list of m logical vectors, where m is the number of dimensions of varname and each logical vector should have the same size as the corresponding dimension in varname.

• drop is a logical for whether the result will be coerced to the lowest possible dimension. The result is a vector, matrix, or array, depending on the number of dimensions in the returned values and the value of drop. Missing values (specified by a "missing.value" attribute, see put.attr.gdsn) are represented as NA. If the variable is not found in the GDS file, returns NULL.

getVariableNames(object): Returns names of variables in the GDS file.
getDimension(object, varname): Returns dimension for GDS variable varname.
getNodeDescription(object, varname): Returns description for GDS variable varname.
getAttribute(object, attname, varname): Returns the attribute attname associated with the variable varname.
hasVariable(object, varname): Returns TRUE if varname is a variable in the GDS file.

Standard Generic Methods

In the code snippets below, object is a GdsReader object.

open(object): Opens a connection to a GDS file.
close(object): Closes the connection to a GDS file.
show(object): Summarizes the contents of a GDS file.

Author(s)
Stephanie Gogarten

See Also
gdsfmt

Examples

library(SNPRelate)
gds <- GdsReader(snp2gdsExampleFileName())
getVariableNames(gds)
hasVariable(gds, "genotype")
geno <- getVariable(gds, "genotype", start=c(1,1), count=c(10,10))

close(gds)

---

**Description**

`gdsSubset` takes a subset of data (snps and samples) from a GDS file and write it to a new GDS file. `gdsSubsetCheck` checks that a GDS file is the desired subset of another GDS file.

**Usage**

```r
gdsSubset(parent.gds, sub.gds,
          sample.include=NULL, snp.include=NULL,
          sub.storage=NULL,
          compress="ZIP_RA",
          block.size=5000,
          verbose=TRUE)

gdsSubsetCheck(parent.gds, sub.gds,
                sample.include=NULL, snp.include=NULL,
                sub.storage=NULL,
                verbose=TRUE)
```

**Arguments**

- `parent.gds`: Name of the parent GDS file
- `sub.gds`: Name of the subset GDS file
- `sample.include`: Vector of sampleIDs to include in sub.gds
- `snp.include`: Vector of snpIDs to include in sub.gds
- `sub.storage`: Storage type for the subset file; defaults to original storage type
- `compress`: The compression level for variables in a GDS file (see `add.gdsn` for options.
- `block.size`: For GDS files stored with scan,snp dimensions, the number of SNPs to read from the parent file at a time. Ignored for snp,scan dimensions.
- `verbose`: Logical value specifying whether to show progress information.

**Details**

`gdsSubset` can select a subset of snps for all samples by setting `snp.include`, a subset of samples for all snps by setting `sample.include`, or a subset of snps and samples with both arguments. The GDS nodes "snp.id", "snp.position", "snp.chromosome", and "sample.id" are copied, as well as any 2-dimensional nodes. Other nodes are not copied. The attributes of the 2-dimensional nodes are also copied to the subset file. If `sub.storage` is specified, the subset gds file will have a different storage mode for any 2-dimensional array. In the special case where the 2-dimensional node has an attribute named "missing.value" and the `sub.storage` type is "bit2", the `missing.value` attribute for the subset node is automatically set to 3. At this point, no checking is done to ensure that the
values will be properly stored with a different storage type, but `gdsSubsetCheck` will return an error if the values do not match. If the nodes in the GDS file are stored with scan.snp dimensions, then `block.size` allows you to loop over a block of SNPs at a time. If the nodes are stored with snp.scan dimensions, then the function simply loops over samples, one at a time.

`gdsSubsetCheck` checks that a subset GDS file has the expected SNPs and samples of the parent file. It also checks that attributes were similarly copied, except for the above-mentioned special case of `missing.value` for `sub.storage="bit2"`.

**Author(s)**

Adrienne Stilp

**See Also**

`gdsfmt`, `createDataFile`

**Examples**

```r
gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(gdsfile)
sample.sel <- getScanID(gds, index=1:10)
snp.sel <- getSnpID(gds, index=1:100)
close(gds)

subfile <- tempfile()
gdsSubset(gdsfile, subfile, sample.include=sample.sel, snp.include=snp.sel)
gdsSubsetCheck(gdsfile, subfile, sample.include=sample.sel, snp.include=snp.sel)

file.remove(subfile)
```

**genoClusterPlot**

**SNP cluster plots**

**Description**

Generates either X,Y or R,Theta cluster plots for specified SNP’s.

**Usage**

```r
genoClusterPlot(intenData, genoData, plot.type = c("RTheta", "XY"),
    snpID, main.txt = NULL, by.sex = FALSE,
    scan.sel = NULL, scan.hilite = NULL,
    start.axis.at.0 = FALSE,
    colors = c("default", "neon", "primary"),
    verbose = TRUE, ...)
```

```r
genoClusterPlotByBatch(intenData, genoData, plot.type = c("RTheta", "XY"),
    snpID, batchVar, main.txt = NULL, scan.sel = NULL,
    colors = c("default", "neon", "primary"),
    verbose = TRUE, ...)
```
Arguments

intenData \hspace{5mm} \textbf{IntensityData} \ object containing 'X' and 'Y' values.

genoData \hspace{5mm} \textbf{GenotypeData} \ object

plot.type \hspace{5mm} The type of plots to generate. Possible values are "RTheta" (default) or "XY".

snpID \hspace{5mm} A numerical vector containing the SNP number for each plot.

batchVar \hspace{5mm} A character string indicating which annotation variable should be used as the batch.

main.txt \hspace{5mm} A character vector containing the title to give to each plot.

by.sex \hspace{5mm} Logical value specifying whether to indicate sex on the plot. If TRUE, sex must be present in intenData or genoData.

scan.sel \hspace{5mm} integer vector of scans to include in the plot. If NULL, all scans will be included.

scan.hilite \hspace{5mm} integer vector of scans to highlight in the plot with different colors. If NULL, all scans will be plotted with the same colors.

start.axis.at.0 \hspace{5mm} Logical for whether the min value of each axis should be 0.

colors \hspace{5mm} Color scheme to use for genotypes. "default" is colorblind safe (colorbrewer Set2), "neon" is bright orange/green/fuschia, and "primary" is red/green/blue.

verbose \hspace{5mm} Logical value specifying whether to show progress.

... \hspace{5mm} Other parameters to be passed directly to \texttt{plot}.

Details

Either 'RTheta' (default) or 'XY' plots can be generated. R and Theta values are computed from X and Y using the formulas 
\[ r = x+y \]  
and 
\[ \theta = \text{atan}(y/x)*(2/\pi) \].

If by.sex==TRUE, females are indicated with circles and males with crosses.

Author(s)

Caitlin McHugh

See Also

\texttt{IntensityData, GenotypeData}

Examples

# create data object
library(GWASdata)
data(illuminaScanADF, illuminaSnpADF)

xyfile <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
xy <- GdsIntensityReader(xyfile)
xyData <- IntensityData(xy, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

# select first 9 snps
snpID <- illuminaSnpADF$snpID[1:9]
rsID <- illuminaSnpADF$rsID[1:9]

par(mfrow=c(3,3))  # plot 3x3
genoClusterPlot(xyData, genoData, snpID=snpID, main.txt=rsID)

# select samples
scan.sel <- illuminaScanADF$scanID[illuminaScanADF$race == "CEU"]
genoClusterPlot(xyData, genoData, snpID=snpID, main.txt=rsID,
    scan.sel=scan.sel, by.sex=TRUE)
genoClusterPlot(xyData, genoData, snpID=snpID, main.txt=rsID,
    scan.hilite=scan.sel)
close(xyData)
close(genoData)

## affy data - cluster plots by plate
data(affyScanADF, affySnpADF)

xyfile <- system.file("extdata", "affy_qxy.nc", package="GWASdata")
xy <- NcdfIntensityReader(xyfile)
xyData <- IntensityData(xy, scanAnnot=affyScanADF, snpAnnot=affySnpADF)
genofile <- system.file("extdata", "affy_genoc.nc", package="GWASdata")
geno <- NcdfGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=affyScanADF, snpAnnot=affySnpADF)

# select first 9 snps
snpID <- affySnpADF$snpID[1:9]
rsID <- affySnpADF$rsID[1:9]
genoClusterPlotByBatch(xyData, genoData, snpID=snpID, main.txt=rsID,
    batchVar="plate")
close(xyData)
close(genoData)

---

**GenotypeData-class**

**Class GenotypeData**

**Description**

The GenotypeData class is a container for storing genotype data from a genome-wide association study together with the metadata associated with the subjects and SNPs involved in the study.

**Details**

The GenotypeData class consists of three slots: data, snp annotation, and scan annotation. There may be multiple scans associated with a subject (e.g. duplicate scans for quality control), hence the use of "scan" as one dimension of the data. Snp and scan annotation are optional, but if included in the GenotypeData object, their unique integer ids (snpID and scanID) are checked against the ids stored in the data slot to ensure consistency.
**Constructor**

GenotypeData(data, snpAnnot=NULL, scanAnnot=NULL):

- **data** must be an NcfGenotypeReader, GdsGenotypeReader, or MatrixGenotypeReader object.
- **snpAnnot**, if not NULL, must be a SnpAnnotationDataFrame or SnpAnnotationSQLite object.
- **scanAnnot**, if not NULL, must be a ScanAnnotationDataFrame or ScanAnnotationSQLite object.

The GenotypeData constructor creates and returns a GenotypeData instance, ensuring that data, snpAnnot, and scanAnnot are internally consistent.

**Accessors**

In the code snippets below, `object` is a GenotypeData object.

- `nsnp(object)`: The number of SNPs in the data.
- `nscan(object)`: The number of scans in the data.
- `getSnpID(object, index)`: A unique integer vector of snp IDs. The optional `index` is a logical or integer vector specifying elements to extract.
- `getChromosome(object, index, char=FALSE)`: A vector of chromosomes. The optional `index` is a logical or integer vector specifying elements to extract. If `char=FALSE` (default), returns an integer vector. If `char=TRUE`, returns a character vector with elements in (1:22,X,XY,Y,M,U).
- `getPosition(object, index)`: An integer vector of base pair positions. The optional `index` is a logical or integer vector specifying elements to extract.
- `getAlleleA(object, index)`: A character vector of A alleles. The optional `index` is a logical or integer vector specifying elements to extract.
- `getAlleleB(object, index)`: A character vector of B alleles. The optional `index` is a logical or integer vector specifying elements to extract.
- `getScanID(object, index)`: A unique integer vector of scan IDs. The optional `index` is a logical or integer vector specifying elements to extract.
- `getSex(object, index)`: A character vector of sex, with values ‘M’ or ‘F’. The optional `index` is a logical or integer vector specifying elements to extract.
- `hasSex(object)`: Returns `TRUE` if the column ‘sex’ is present in `object`.

- `getGenotype(object, snp=c(1,-1), scan=c(1,-1), char=FALSE, sort=TRUE, drop=TRUE, use.names=FALSE, ...)`: Extracts genotype values (number of A alleles). `snp` and `scan` indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of `-1` for count indicates that the entire dimension should be read. If `drop=TRUE`, the result is coerced to the lowest possible dimension. If `use.names=TRUE`, names of the resulting vector or matrix are set to the SNP and scan IDs. Missing values are represented as `NA`. If `char=TRUE`, genotypes are returned as characters of the form "A/B". If `sort=TRUE`, alleles are lexicographically sorted ("G/T" instead of "T/G").

- `getGenotypeSelection(object, snp=NULL, scan=NULL, snpID=NULL, scanID=NULL, char=FALSE, sort=TRUE, drop=TRUE, use.names=TRUE, ...)`: May be used only if the data slot contains a GdsGenotypeReader or MatrixGenotypeReader object. Extracts genotype values (number of A alleles). `snp` and `scan` may be integer or logical vectors indicating which elements to return along the snp and scan dimensions. `snpID` and `scanID` allow section by values of snpID and scanID. Unlike `getGenotype`, the values requested need not be in contiguous blocks. Other arguments are identical to `getGenotype`.
getSnpVariable(object, varname, index): Returns the snp annotation variable varname. The optional index is a logical or integer vector specifying elements to extract.

getSnpVariableNames(object): Returns a character vector with the names of the columns in the snp annotation.

hasSnpVariable(object, varname): Returns TRUE if the variable varname is present in the snp annotation.

getScanVariable(object, varname, index): Returns the scan annotation variable varname. The optional index is a logical or integer vector specifying elements to extract.

getScanVariableNames(object): Returns a character vector with the names of the columns in the scan annotation.

hasScanVariable(object, varname): Returns TRUE if the variable varname is present in the scan annotation.

getVariable(object, varname, drop=TRUE, ...): Extracts the contents of the variable varname from the data. If drop=TRUE, the result is coerced to the lowest possible dimension. Missing values are represented as NA. If the variable is not found, returns NULL.

hasVariable(object, varname): Returns TRUE if the data contains varname, FALSE if not.

getSnpAnnotation(object): Returns the snp annotation.

hasSnpAnnotation(object): Returns TRUE if the snp annotation slot is not NULL.

getScanAnnotation(object): Returns the scan annotation.

hasScanAnnotation(object): Returns TRUE if the scan annotation slot is not NULL.

open(object): Opens a connection to the data.

close(object): Closes the data connection.

autosomeCode(object): Returns the integer codes for the autosomes.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
SnpAnnotationDataFrame, SnpAnnotationSQLite, ScanAnnotationDataFrame, ScanAnnotationSQLite, GdsGenotypeReader, NcdfGenotypeReader, MatrixGenotypeReader, IntensityData

Examples
library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# object without annotation
genoData <- GenotypeData(gds)

# object with annotation
data(illuminaSnpADF)
data(illuminaScanADF)
# need to rebuild old SNP annotation object to get allele methods
snpAnnot <- SnpAnnotationDataFrame(pData(illuminaSnpADF))
genoData <- GenotypeData(gds, snpAnnot=snpAnnot, scanAnnot=illuminaScanADF)

# dimensions
nsnp(genoData)
nscan(genoData)

# get snpID and chromosome
snpID <- getSnpID(genoData)
chrom <- getChromosome(genoData)

# get positions only for chromosome 22
pos22 <- getPosition(genoData, index=(chrom == 22))

# get other annotations
if (hasSex(genoData)) sex <- getSex(genoData)
plate <- getScanVariable(genoData, "plate")
rsID <- getSnpVariable(genoData, "rsID")

# get all snps for first scan
geno <- getGenotype(genoData, snp=c(1,-1), scan=c(1,1))

# starting at snp 100, get 10 snps for the first 5 scans
-geno <- getGenotype(genoData, snp=c(100,10), scan=c(1,5))
geno

# return genotypes as "A/B" rather than number of A alleles
-geno <- getGenotype(genoData, snp=c(100,10), scan=c(1,5), char=TRUE)
geno
close(genoData)

#--------------------------------------
# An example using a non-human organism
#--------------------------------------
# Chicken has 38 autosomes, Z, and W. Male is ZZ, female is ZW.
# Define sex chromosomes as X=Z and Y=W.
gdsfile <- tempfile()
simulateGenotypeMatrix(n.snps=10, n.chromosomes=40, n.samples=5,
filename=gdsfile, file.type="gds")
gds <- GdsGenotypeReader(gdsfile, autosomeCode=1:38L,
XchromCode=39L, YchromCode=40L,
XYchromCode=41L, MchromCode=42L)
table(getChromosome(gds))
table(getChromosome(gds, char=TRUE))

# SNP annotation
snpdf <- data.frame(snpID=getSnpID(gds),
chromosome=getChromosome(gds),
position=getPosition(gds))
snpAnnot <- SnpAnnotationDataFrame(snpdf, autosomeCode=1:38L,
XchromCode=39L, YchromCode=40L,
XYchromCode=41L, MchromCode=42L)
varMetadata(snpAnnot) [,"labelDescription"] <-
c("unique integer ID","chromosome coded as 1:38=autosomes, 39=Z, 40=W","base position")

# reverse sex coding to get proper counting of sex chromosome SNPs
scandf <- data.frame(scanID=1:5, sex=c("M","M","F","F","F"), stringsAsFactors=FALSE)
scanAnnot <- ScanAnnotationDataFrame(scandf)
varMetadata(scanAnnot)[,"labelDescription"] <-
c("unique integer ID","sex coded as M=female and F=male")

genodata <- GenotypeData(gds, snpAnnot=snpAnnot, scanAnnot=scanAnnot)
afreq <- alleleFrequency(genoData)
# frequency of Z chromosome in females ("M") and males ("F")
afreq[snpAnnot$chromosome == 39, c("M","F")]
# frequency of W chromosome in females ("M") and males ("F")
afreq[snpAnnot$chromosome == 40, c("M","F")]

close(genoData)
unlink(gdsfile)

---

**genotypeToCharacter**  
*Convert number of A alleles to character genotypes*

**Description**

Converts a vector or matrix of genotypes encoded as number of A alleles to character strings of the form "A/B".

**Usage**

```r
genotypeToCharacter(geno, alleleA=NULL, alleleB=NULL, sort=TRUE)
```

**Arguments**

- **geno**: Vector or matrix of genotype values, encoded as number of A alleles. If a matrix, dimensions should be (snp, sample).
- **alleleA**: Character vector with allele A.
- **alleleB**: Character vector with allele B.
- **sort**: Logical for whether to sort alleles lexicographically ("G/T" instead of "T/G").

**Details**

If geno is a vector, alleleA and alleleB should have the same length as geno or length 1 (in the latter case the values are recycled).
If geno is a matrix, length of alleleA and alleleB should be equal to the number of rows of geno.
If alleleA or alleleB is NULL, returned genotypes will have values "A/A", "A/B", or "B/B".

**Value**

Character vector or matrix of the same dimensions as geno.
getobj

Author(s)
Stephanie Gogarten

See Also
GenotypeData

Examples

geno <- matrix(c(0,1,2,0,1,2,1,NA), nrow=4)
alleleA <- c("A","T","C","T")
alleleB <- c("C","G","G","A")
genotypeToCharacter(geno, alleleA, alleleB)

geno <- matrix(c(0,1,2,0,1,2,1,NA), nrow=4)
alleleA <- c("A","T","C","T")
alleleB <- c("C","G","G","A")
genotypeToCharacter(geno, alleleA, alleleB)

getobj Rdata

Description
Returns an R object stored in an Rdata file

Usage
getobj(Rdata)

Arguments
Rdata path to an Rdata file containing a single R object to load

Details
Loads an R object and stores it under a new name without creating a duplicate copy. If multiple objects are stored in the same file, only the first one will be returned

Value
The R object stored in Rdata.

Author(s)
Stephanie Gogarten

See Also
saveas

Examples

x <- 1:10
file <- tempfile()
save(x, file=file)
y <- getobj(file)
unlink(file)
getVariable

Accessors for variables in GenotypeData and IntensityData classes and their component classes

Description

These generic functions provide access to variables associated with GWAS data cleaning.

Usage

getScanAnnotation(object, ...)
getScanVariable(object, varname, ...)
getScanVariableNames(object, ...)
getScanID(object, ...)
getSex(object, ...)
getSnpAnnotation(object, ...)
getSnpVariable(object, varname, ...)
getSnpVariableNames(object, ...)
getSnpID(object, ...)
getChromosome(object, ...)
gGetPosition(object, ...)
getAlleleA(object, ...)
getAlleleB(object, ...)

getVariable(object, varname, ...)
getVariableNames(object, ...)
getGenotype(object, ...)
getGenotypeSelection(object, ...)
getQuality(object, ...)
getX(object, ...)
g getY(object, ...)
g getBAlleleFreq(object, ...)
g getLogRRatio(object, ...)
g getDimension(object, varname, ...)
g getAttribute(object, attname, varname, ...)
g getNodeDescription(object, varname, ...)

g getAnnotation(object, ...)
g getMetadata(object, ...)
g getQuery(object, statement, ...)

hasScanAnnotation(object)
hasScanVariable(object, varname)
hasSex(object)
hasSnpAnnotation(object)
hasSnpVariable(object, varname)
hasVariable(object, varname)
hasQuality(object)
hasX(object)
hasY(object)
hasBAlleleFreq(object)
hasLogRRatio(object)
nSNP(object)
nSCAN(object)
autosomeCode(object)
XchromCode(object)
XYchromCode(object)
YchromCode(object)
MchromCode(object)

writeAnnotation(object, value, ...)
writeMetadata(object, value, ...)

Arguments

object Object, possibly derived from or containing NcdfReader-class, GdsReader-class, ScanAnnotationDataFrame-class, SnpAnnotationDataFrame-class, ScanAnnotationSQLite-class, or SnpAnnotationSQLite-class.

varname Name of the variable (single character string, or a character vector for multiple variables).

attname Name of an attribute.

statement SQL statement to query ScanAnnotationSQLite-class or SnpAnnotationSQLite-class objects.

value data.frame with annotation or metadata to write to ScanAnnotationSQLite-class or SnpAnnotationSQLite-class objects.

... Additional arguments.

Value

get methods return vectors or matrices of the requested variables (with the exception of getQuery, which returns a data frame).

has methods return TRUE if the requested variable is present in object.

nsnp and nscan return the number of SNPs and scans in the object, respectively.


Author(s)

Stephanie Gogarten

See Also

ScanAnnotationDataFrame-class, SnpAnnotationDataFrame-class, ScanAnnotationSQLite-class, SnpAnnotationSQLite-class, NcdfReader-class, NcdfGenotypeReader-class, NcdfIntensityReader-class, GdsReader-class, GdsGenotypeReader-class, GdsIntensityReader-class, GenotypeData-class, IntensityData-class
Description

These functions are defunct and no longer available.

Details

The following functions are defunct; use the replacement indicated below:

- `pedigreeClean`: `pedigreeCheck`
- `pedigreeFindDuplicates`: `pedigreeCheck`
- `ncdfCreate`: `createDataFile`
- `ncdfAddData`: `createDataFile`
- `ncdfAddIntensity`: `createAffyIntensityFile`
- `ncdfCheckGenotype`: `checkGenotypeFile`
- `ncdfCheckIntensity`: `checkIntensityFile`
- `ncdfSetMissingGenotypes`: `setMissingGenotypes`
- `gdsSetMissingGenotypes`: `setMissingGenotypes`
- `ncdfImputedDosage`: `imputedDosageFile`
- `gdsImputedDosage`: `imputedDosageFile`
- `gdsCheckImputedDosage`: `checkImputedDosageFile`
- `assocTestRegression`: `assocRegression`
- `assocTestCPH`: `assocCoxPH`
- `assocTestFisherExact`: `batchFisherTest`
- `gwasExactHW`: `exactHWE`
- `ncdfSubset`: `gdsSubset`
- `ncdfSubsetCheck`: `gdsSubsetCheck`
- `plinkToNcdf`: `snpgdsBED2GDS`
- `convertVcfGds`: `snpgdsVCF2GDS`

hetByScanChrom

Heterozygosity rates by scan and chromosome

Description

This function calculates the fraction of heterozygous genotypes for each chromosome for a set of scans.

Usage

hetByScanChrom(genoData, snp.exclude = NULL, verbose = TRUE)
hetBySnpSex

Arguments

genoData \hspace{1cm} \texttt{GenotypeData} object. Chromosomes are expected to be in contiguous blocks.
snp.exclude An integer vector containing the id’s of SNPs to be excluded.
verbose Logical value specifying whether to show progress information.

Details

This function calculates the percent of heterozygous and missing genotypes in each chromosome of each scan given in genoData.

Value

The result is a matrix containing the heterozygosity rates with scans as rows and chromosomes as columns, including a column "A" for all autosomes.

Author(s)

Cathy Laurie

See Also

\texttt{GenotypeData}, \texttt{hetBySnpSex}

Examples

\begin{verbatim}
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)
genoData <- GenotypeData(gds)
het <- hetByScanChrom(genoData)
close(genoData)
\end{verbatim}

\begin{verbatim}
hetBySnpSex
\end{verbatim}

Heterozygosity by SNP and sex

Description

This function calculates the percent of heterozygous genotypes for males and females for each SNP.

Usage

\begin{verbatim}
hetBySnpSex(genoData, scan.exclude = NULL,
            verbose = TRUE)
\end{verbatim}

Arguments

genoData \hspace{1cm} \texttt{GenotypeData} object
scan.exclude An integer vector containing the id’s of scans to be excluded.
verbose Logical value specifying whether to show progress information.
Details

This function calculates the percent of heterozygous genotypes for males and females for each SNP given in genoData. A "sex" variable must be present in the scan annotation slot of genoData.

Value

The result is a matrix containing the heterozygosity rates with snps as rows and 2 columns ("M" for males and "F" for females).

Author(s)

Cathy Laurie

See Also

GenotypeData, hetByScanChrom

Examples

library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# need scan annotation with sex
data(illuminaScanADF)
genoData <- GenotypeData(gds, scanAnnot=illuminaScanADF)

het <- hetBySnpSex(genoData)
close(genoData)

HLA

<table>
<thead>
<tr>
<th>HLA region base positions</th>
</tr>
</thead>
</table>

Description

HLA region base positions from the GRCh36/hg18, GRCh37/hg19 and GRCh38/hg38 genome builds.

Usage

HLA.hg18
HLA.hg19
HLA.hg38

Format

A data.frame with the following columns.

chrom  chromosome
start.base  starting base position of region
end.base  ending base position of region
ibdPlot

Plot theoretical and observed identity by descent values and assign relationships

Description

ibdPlot produces an IBD plot showing observed identity by descent values color coded by expected relationship. Theoretical boundaries for full-sibling, second-degree, and third-degree relatives are plotted in orange. ibdAreasDraw overlays relationship areas for IBD analysis on the plot. ibdAssignRelatedness identifies observed relatives. ibdAssignRelatednessKing identifies observed relatives using the kinship coefficients and IBS0 estimates from the KING model. kingIBS0FSCI returns a confidence interval for expected IBS0 for full siblings.

Usage

ibdPlot(k0, k1, alpha=0.05, relation=NULL, color=NULL, rel.lwd=2, rel.draw=c("FS", "Deg2", "Deg3"), ...)
ibdAreasDraw(alpha=0.05, m=0.04, po.w=0.1, po.h=0.1, dup.w=0.1, dup.h=0.1, un.w=0.25, un.h=0.25, rel.lwd=2, xcol=c("cyan","red","blue","lightgreen","magenta","black"))
ibdAssignRelatedness(k0, k1, alpha=0.05, m=0.04, po.w=0.1, po.h=0.1, dup.w=0.1, dup.h=0.1, un.w=0.25, un.h=0.25)
ibdAssignRelatednessKing(ibs0, kc, cut.kc.dup=1/(2^(3/2)), cut.kc.fs=1/(2^(5/2)), cut.kc.deg2=1/(2^(7/2)), cut.kc.deg3=1/(2^(9/2)), cut.ibs0.err=0.003)
kingsIBS0FSCI(freq, alpha=0.01)

Arguments

k0 A vector of k0 values.
k1 A vector of k1 values.
kc A vector of kinship coefficient values (KING model).

Source

UCSC genome browser (http://genome.ucsc.edu).

References

**ibdPlot**

`ibdPlot` produces an IBD plot showing observed identity by descent values color coded by expected relationship, typically as deduced from pedigree data. Points are plotted according to their corresponding value in the `color` vector, and the `relation` vector is used to make the plot legend. In addition to the relationships listed above, any relationships output from `pedigreePairwiseRelatedness` will be recognized.

Theoretical boundary for full-sibs is indicated by ellipse and boundaries for second and third degree intervals are indicated in orange. For full-sibs, 100(1-alpha)% prediction ellipse is based on assuming bivariate normal distribution with known mean and covariance matrix. For second degree (half siblings, avuncular, grandparent-grandchild) and third degree (first cousins), 100(1-alpha)% prediction intervals for k1 are based on assuming normal distribution with known mean and variance, computed as in Hill and Weir (2011).

`ibdAreasDraw` overlays relationship areas on the plot to help with analyzing observed relationships. `ibdAssignRelatedness` identifies relatives based on their (k0, k1) coordinates. `ibdAssignRelatednessKing` identifies relatives based on their (ibs0, kc) coordinates (KING model).

---

**Description**

- **ibs0**: A vector of IBS0 values (KING model).
- **alpha**: Significance level - finds 100(1-alpha)% prediction intervals for second and third degree relatives and 100(1-alpha)% prediction ellipse for full siblings.
- **relation**: A vector of relationships. Recognized values are "PO"=parent/offspring, "FS"=full siblings, "Av"=avuncular, "GpGc"=grandparent-grandchild, "Deg2"=any second-degree, "FC"=first cousins, "HAv"=half-avuncular, "Deg3"=any third degree, "U"=unrelated, and "Q"=unknown.
- **color**: A vector of colors for (k0,k1) points.
- **rel.lwd**: Line width for theoretical full-sib, Deg2, and Deg3 boundaries.
- **rel.draw**: Which theoretical boundaries to plot: one or more of "FS" (full-sib), "Deg2" (second-degree), "Deg3" (third-degree). If NULL, no boundaries are drawn.
- **m**: width of rectangle along diagonal line
- **po.w**: width of parent-offspring rectangle
- **po.h**: height of parent-offspring rectangle
- **dup.w**: width of duplicate rectangle
- **dup.h**: height of duplicate rectangle
- **un.w**: width of unrelated rectangle
- **un.h**: height of unrelated rectangle
- **xcol**: colors for parent-offspring, full-sib, Deg2, Deg3, dup & unrelated areas
- **cut.kc.dup**: Kinship coefficient threshold for dividing duplicates and first degree relatives.
- **cut.kc.fs**: Kinship coefficient threshold for dividing full siblings and second degree relatives.
- **cut.kc.deg2**: Kinship coefficient threshold for dividing second and third degree relatives.
- **cut.kc.deg3**: Kinship coefficient threshold for dividing third degree relatives and unrelated.
- **cut.ibs0.err**: IBS0 threshold for dividing parent-offspring pairs from other relatives. Should be 0, but is usually slightly higher due to genotyping errors.
- **freq**: vector of allele frequencies at the variants used in the KING analysis

---

**Details**

Theoretical boundary for full-sibs is indicated by ellipse and boundaries for second and third degree intervals are indicated in orange. For full-sibs, 100(1-alpha)% prediction ellipse is based on assuming bivariate normal distribution with known mean and covariance matrix. For second degree (half siblings, avuncular, grandparent-grandchild) and third degree (first cousins), 100(1-alpha)% prediction intervals for k1 are based on assuming normal distribution with known mean and variance, computed as in Hill and Weir (2011).
kingIBS0FSCI uses allele frequencies to find the confidence interval for expected IBS0 for full siblings. We condition on the three possible IBD states: IBD0, IBD1, or IBD2; but $P(AA, aa|IBD1) = P(AA, aa|IBD2) = 0$.

$$P(\text{IBS0}|FS) = P(AA, aa|FS) + P(\text{aa}, AA|FS) = P(AA, aa|IBD0)P(\text{IBD0}) + P(\text{aa}, AA|IBD0)P(\text{IBD0}) = p^2.$$ Knowing a pair’s value of $k_0$ and the allele frequencies at each variant, we can get an estimate of $P(\text{IBS0}|FS)$ by averaging across all the markers used in the analysis. Siblings have $k_0 = 0.25$ on average.

**Value**

`ibdAssignRelatedness` and `ibdAssignRelatednessKing` return a vector of relationships with values "Dup"=duplicate, "PO"=parent-offspring, "FS"=full sibling, "Deg2"=second degree, "Deg3"=third degree, "U"=unrelated, and "Q"=unknown.

kingIBS0FSCI returns a vector with 3 values: the point estimate, the lower bound of the CI, the upper bound of the CI

**Author(s)**

Cathy Laurie, Cecelia Laurie, Adrienne Stilp, Matthew Conomos

**References**


**See Also**

`relationsMeanVar`, `pedigreePairwiseRelatedness`

**Examples**

```r
k0 <- c(0, 0, 0.25, 0.5, 0.75, 1)
k1 <- c(0, 1, 0.5, 0.5, 0.25, 0)
exp.rel <- c("Dup", "PO", "FS", "HS", "FC", "U")
ibdPlot(k0, k1, relation=exp.rel)
ibdAreasDraw()
ob.rel <- ibdAssignRelatedness(k0, k1)

kc <- c(0.5, 0.25, 0.25, 0.125, 0.063, 0)
ibs0 <- c(0, 0, 0.25, 0.5, 0.75, 1)
ob.rel.king <- ibdAssignRelatednessKing(ibs0, kc)

library(SNPRelate)
library(GWASdata)
gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- snpgdsOpen(gdsfile)
ibd <- snpgdsIBDKING(gds)
ibd <- snpgdsIBDSelection(ibd, kinship.cutoff=1/32)
snpgdsclose(gds)
```
imputedDosageFile

Create and check a GDS or NetCDF file with imputed dosages

Description

These functions create or check a GDS or NetCDF file and corresponding annotation for imputed dosages from IMPUTE2, BEAGLE, or MaCH.

Usage

imputedDosageFile(input.files, filename, chromosome, 
input.type=c("IMPUTE2", "BEAGLE", "MaCH"), 
input.dosage=FALSE, 
output.type = c("dosage", "genotype"), 
file.type=c("gds", "ncdf"), 
snp.annot.filename="dosage.snp.RData", 
scan.annot.filename="dosage.scan.RData", 
compress="LZMA_RA:1M", 
compress.annot="LZMA_RA", 
genotypeDim="scan,snp", 
scan.df=NULL, 
snp.exclude=NULL, 
snp.id.start=1, 
block.size=5000, 
prob.threshold=0.9, verbose=TRUE)

checkImputedDosageFile(genoData, snpAnnot, scanAnnot, 
input.files, chromosome, 
input.type=c("IMPUTE2", "BEAGLE", "MaCH"), 
input.dosage=FALSE, 
output.type=c("dosage", "genotype"), 
snp.exclude=NULL, snp.id.start=1, 
tolerance=1e-4, na.logfile=NULL, 
block.size=5000, 
prob.threshold=0.9, 
verbose=TRUE)
Arguments

input.files  A character vector of input files. The first file should always be genotypes (either probabilities or dosages). Files for each input type should be as follows:
  • IMPUTE2: 1) .gens, 2) .samples
  • BEAGLE: 1) .grobs or .dose, 2) .markers
  • MaCH: 1) .mlprob or .mldose, 2) .mlinfo, 3) file with columns named "SNP" and "position" giving base pair position of all SNPs

filename  Character string with name of output GDS or NetCDF file.

chromosome  Chromosome corresponding to the SNPs in the genotype file. Character codes will be mapped to integer values as follows: "X"->23, "XY"->24, "Y"-> 25, "M","MT"->26.

input.type  Format of input files. Accepted file types are "IMPUTE2", "BEAGLE", and "MaCH".

input.dosage  Logical for whether the genotype file (input.files[1]) contains dosages. If FALSE (default), the genotype file is assumed to contain genotype probabilities.

file.type  The type of file to create ("gds" or "ncdf")

snp.annot.filename  Output .RData file for storing a SnpAnnotationDataFrame.

scan.annot.filename  Output .RData file for storing a ScanAnnotationDataFrame.

compress  The compression level for dosage variables in a GDS file (see add.gdsn for options.

compress.annot  The compression level for annotation variables in a GDS file (see add.gdsn for options.

genotypeDim  character string specifying genotype dimensions of output file. Either "snp,scan" or "scan,snp". "scan,snp" is usually much faster to create for GDS files, but "snp,scan" is required for NetCDF files.

scan.df  data frame specifying which samples to include in the output GDS files, with optional scanIDs already assigned. See details.

snp.exclude  vector of integers specifying which SNPs to exclude from the GDS file.

snp.id.start  Starting index for snpID.

block.size  Number of lines to read at once.

verbose  Logical for whether to print progress messages.

genoData  A GenotypeData object from a GDS file created with imputedDosageFile.

snpAnnot  The SnpAnnotationDataFrame created by imputedDosageFile

scanAnnot  The ScanAnnotationDataFrame created by imputedDosageFile

tolerance  tolerance for checking differences against input files

na.logfile  filename for recording snpID and scanID of missing dosages

output.type  output to record in gds file (either "dosage" or "genotype")

prob.threshold  if output.type="genotype", SNP/sample combinations with a maximum probabilityless than prob.threshold will be set to missing
Details

Input files can contain either imputed dosages or genotype probabilities, specified by the `input.dosage` flag. In either case, the GDS/NetCDF file will store dosage of the A allele in the "genotype" variable. All SNPs are assumed to be on the same chromosome, which is indicated by the `chromosome` argument.

If the input file contains genotype probabilities for all three genotypes, the dosage is set to missing if the genotype probability strings (before numerical conversion) are equal (e.g., (0,0,0), (0.33, 0.33, 0.33), or (-1, -1, -1)). The dosage is also normalized by the sum of all three genotype probabilities.

The `scan.df` argument allows the user to specify what samples should be included in the GDS files and an optional sampleID-scanID mapping. `scan.df` is a data frame with required column `sampleID`. The function attempts to match the given sampleID in the `scan.df` data frame with a unique sampleID in the input files. The format of sampleID is different for different input types:

- **IMPUTE2**: "ID_1 ID_2" as given in the sample file, where IDs are separated by a space
- **BEAGLE**: Column header names corresponding to that sample in .dose or .gprobs file
- **MaCH**: The first column of the .mlprob or .mlprobs file

The `snp.names` argument allows the user to specify the which SNPs should be included in the GDS files. However, `snp.names` must be in the same order as SNPs occur in the imputation files; this option therefore only allows selection of SNPs, not reordering of SNPs. The ordering is checked and an error is thrown if the SNP names are not in order, but due to the design of imputation files, this may not occur until well into the GDS file population. The user can specify the starting `snp.id.start`, and included SNPs are numbered sequentially starting with `snp.id.start`. For IMPUTE2 data, `snp.names` must correspond to the second column of the .gprobs file.

Minimal SNP and scan annotation are created from the input files and stored in RData format in `snp.annot.filename` and `scan.annot.filename`.

If requested with `na.logfile`, `checkImputedDosageFile` will output a file with scanIDs and SNP IDs of missing genotype calls.

Either dosage or genotypes can be output using `output.type`. If dosage is requested, the dosages will be $2*AAprob + ABprob$. If genotype is requested, the value will be set to the genotype with the maximum probability, unless all probabilities are less than `prob.threshold`. In that case, the genotype will be set to missing. SNPs with max probabilities that are the same for two genotypes (i.e., AA=0.5, AB=0.5, BB=0) will also be set to missing.

Currently supported input file types are IMPUTE2, BEAGLE, and MaCH.

Author(s)

Adrienne Stilp, Stephanie Gogarten

References

- **IMPUTE2**: [http://mathgen.stats.ox.ac.uk/impute/impute_v2.html](http://mathgen.stats.ox.ac.uk/impute/impute_v2.html)
- **BEAGLE**: [http://faculty.washington.edu/browning/beagle/beagle.html](http://faculty.washington.edu/browning/beagle/beagle.html)
- **MaCH**: [http://www.sph.umich.edu/csg/abecasis/MACH/tour/imputation.html](http://www.sph.umich.edu/csg/abecasis/MACH/tour/imputation.html)

See Also

- `createDataFile`, `GdsGenotypeReader`, `NcdfGenotypeReader`, `GenotypeData`, `assocRegression`
Examples

gdsfile <- tempfile()
snppfile <- tempfile()
scanfile <- tempfile()
logfile <- tempfile()

# IMPUTE2
probfile <- system.file("extdata", "imputation", "IMPUTE2", "example.chr22.study.gens", package="GWASdata")
sampfile <- system.file("extdata", "imputation", "IMPUTE2", "example.study.samples", package="GWASdata")
imputedDosageFile(input.files=c(probfile, sampfile), filename=gdsfile, chromosome=22,
input.type="IMPUTE2", input.dosage=FALSE,
snp.annot.filename=snppfile, scan.annot.filename=scanfile)

gds <- GdsGenotypeReader(gdsfile)
scanAnnot <- getobj(scanfile)
snpAnnot <- getobj(snppfile)
genData <- GenotypeData(gds, scanAnnot=scanAnnot, snpAnnot=snpAnnot)

checkImputedDosageFile(genData, snpAnnot, scanAnnot,
input.files=c(probfile, sampfile), chromosome=22,
input.type="IMPUTE2", input.dosage=FALSE, na.logfile=logfile)

gen <- getGenotype(genData)
getAlleleA(genData)
getAlleleB(genData)

log <- read.table(logfile)
head(log)

# association test with imputed dosages
scanAnnot$status <- sample(0:1, nrow(scanAnnot), replace=TRUE)
genData <- GenotypeData(gds, scanAnnot=scanAnnot, snpAnnot=snpAnnot)
assoc <- assocRegression(genData, outcome="status", model.type="logistic")
head(assoc)
close(assoc)

# BEAGLE - genotype probabilities
probfile <- system.file("extdata", "imputation", "BEAGLE", "example.hapmap.unphased.bgl.gprobs", package="GWASdata")
markfile <- system.file("extdata", "imputation", "BEAGLE", "hapmap.markers", package="GWASdata")
imputedDosageFile(input.files=c(probfile, markfile), filename=gdsfile, chromosome=22,
input.type="BEAGLE", input.dosage=FALSE, file.type="gds",
snp.annot.filename=snppfile, scan.annot.filename=scanfile)

# BEAGLE - dosage
dosefile <- system.file("extdata", "imputation", "BEAGLE", "example.hapmap.unphased.bgl.dose", package="GWASdata")
imputedDosageFile(input.files=c(dosefile, markfile), filename=gdsfile, chromosome=22,
input.type="BEAGLE", input.dosage=TRUE, file.type="gds",
snp.annot.filename=snppfile, scan.annot.filename=scanfile)
```r
# MaCH - genotype probabilities
probfile <- system.file("extdata", "imputation", "MaCH", "mach1.out.mlprob", 
package="GWASdata")
markfile <- system.file("extdata", "imputation", "MaCH", "mach1.out.mlinfo", 
package="GWASdata")
posfile <- system.file("extdata", "imputation", "MaCH", "mach1.snp.position", 
package="GWASdata")
imputedDosageFile(input.files=c(probfile, markfile, posfile), filename=gdsfile, chromosome=22, 
input.type="MaCH", input.dosage=FALSE, file.type="gds", 
snp.annot.filename=snpfile, scan.annot.filename=scanfile)

# MaCH - dosage
dosefile <- system.file("extdata", "imputation", "MaCH", "mach1.out.mldose", 
package="GWASdata")
imputedDosageFile(input.files=c(dosefile, markfile, posfile), filename=gdsfile, chromosome=22, 
input.type="MaCH", input.dosage=TRUE, file.type="gds", 
snp.annot.filename=snpfile, scan.annot.filename=scanfile)

unlink(c(gdsfile, snpfile, scanfile))
```

---

**IntensityData-class**

**Class IntensityData**

**Description**

The IntensityData class is a container for storing intensity data from a genome-wide association study together with the metadata associated with the subjects and SNPs involved in the study.

**Details**

The IntensityData class consists of three slots: data, snp annotation, and scan annotation. There may be multiple scans associated with a subject (e.g. duplicate scans for quality control), hence the use of "scan" as one dimension of the data. Snp and scan annotation are optional, but if included in the IntensityData object, their unique integer ids (snpID and scanID) are checked against the ids stored in the data file to ensure consistency.

**Constructor**

```r
IntensityData(data, snpAnnot=NULL, scanAnnot=NULL):
  data must be a GdsIntensityReader or NcdfIntensityReader object.
  snpAnnot, if not NULL, must be a SnpAnnotationDataFrame or SnpAnnotationSQLite object.
  scanAnnot, if not NULL, must be a ScanAnnotationDataFrame or ScanAnnotationSQLite object.
```

The IntensityData constructor creates and returns a IntensityData instance, ensuring that data, snpAnnot, and scanAnnot are internally consistent.

**Accessors**

In the code snippets below, object is an IntensityData object. snp and scan indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of '-1' for count indicates that the entire dimension should be read. If snp and/or is scan omitted, the entire variable is read.
nsnp(object): The number of SNPs in the data.
nscan(object): The number of scans in the data.

getSnpID(object, index): A unique integer vector of snp IDs. The optional index is a logical
or integer vector specifying elements to extract.

getChromosome(object, index, char=FALSE): A vector of chromosomes. The optional index
is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an
integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U).

getPosition(object, index): An integer vector of base pair positions. The optional index is
a logical or integer vector specifying elements to extract.

getScanID(object, index): A unique integer vector of scan IDs. The optional index is a
logical or integer vector specifying elements to extract.

getSex(object, index): A character vector of sex, with values 'M' or 'F'. The optional index
is a logical or integer vector specifying elements to extract.

hasSex(object): Returns TRUE if the column 'sex' is present in object.

getQuality(object, snp, scan): Extracts quality scores. The result is a vector or matrix,
depending on the number of dimensions in the returned values. Missing values are represented
as NA.

getX(object, snp, scan): Extracts X intensity values. The result is a vector or matrix, de-
dpending on the number of dimensions in the returned values. Missing values are represented
as NA.

getY(object, snp, scan): Extracts Y intensity values. The result is a vector or matrix, de-
dpending on the number of dimensions in the returned values. Missing values are represented
as NA.

getBAlleleFreq(object, snp, scan): Extracts B allele frequency values. The result is a vector
or matrix, depending on the number of dimensions in the returned values. Missing values are
represented as NA.

getLogRRatio(object, snp, scan): Extracts Log R Ratio values. The result is a vector or
matrix, depending on the number of dimensions in the returned values. Missing values are
represented as NA.

getSnpVariable(object, varname, index): Returns the snp annotation variable varname.
The optional index is a logical or integer vector specifying elements to extract.

getSnpVariableNames(object): Returns a character vector with the names of the columns in
the snp annotation.

hasSnpVariable(object, varname): Returns TRUE if the variable varname is present in the snp
annotation.

getScanVariable(object, varname, index): Returns the scan annotation variable varname.
The optional index is a logical or integer vector specifying elements to extract.

getScanVariableNames(object): Returns a character vector with the names of the columns in
the scan annotation.

hasScanVariable(object, varname): Returns TRUE if the variable varname is present in the
scan annotation.

getVariable(object, varname, snp, scan): Extracts the contents of the variable varname
from the data. The result is a vector or matrix, depending on the number of dimensions in
the returned values. Missing values are represented as NA. If the variable is not found, returns
NULL.

hasVariable(object, varname): Returns TRUE if the data contains contains varname, FALSE if
not.
hasSnpAnnotation(object): Returns TRUE if the snp annotation slot is not NULL.
hasScanAnnotation(object): Returns TRUE if the scan annotation slot is not NULL.
open(object): Opens a connection to the data.
close(object): Closes the data connection.
autosomeCode(object): Returns the integer codes for the autosomes.
XchromCode(object): Returns the integer code for the X chromosome.
XYchromCode(object): Returns the integer code for the pseudoautosomal region.
YchromCode(object): Returns the integer code for the Y chromosome.
MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
SnpAnnotationDataFrame, SnpAnnotationSQLite, ScanAnnotationDataFrame, ScanAnnotationSQLite,
ScanAnnotationDataFrame, GdsIntensityReader, NcdfIntensityReader, GenotypeData

Examples

library(GWASdata)
file <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
gds <- GdsIntensityReader(file)

# object without annotation
intenData <- IntensityData(gds)

# object with annotation
data(illuminaSnpADF, illuminaScanADF)
intenData <- IntensityData(gds, snpAnnot=illuminaSnpADF, scanAnnot=illuminaScanADF)

# dimensions
nsnp(intenData)
nscan(intenData)

# get snpID and chromosome
snpID <- getSnpID(intenData)
chrom <- getChromosome(intenData)

# get positions only for chromosome 22
pos22 <- getPosition(intenData, index=(chrom == 22))

# get other annotations
if (hasSex(intenData)) sex <- getSex(intenData)
plate <- getScanVariable(intenData, "plate")
rsID <- getSnpVariable(intenData, "rsID")

# get all snps for first scan
x <- getX(intenData, snp=c(1,-1), scan=c(1,1))

# starting at snp 100, get 10 snps for the first 5 scans
x <- getX(intenData, snp=c(100,10), scan=c(1,5))
close(intenData)

intensityOutliersPlot  *Plot mean intensity and highlight outliers*

**Description**

`intensityOutliersPlot` is a function to plot mean intensity for chromosome i vs mean of intensities for autosomes (excluding i) and highlight outliers

**Usage**

```
intensityOutliersPlot(mean.intensities, sex, outliers,
                      sep = FALSE, label, ...)
```

**Arguments**

- `mean.intensities`: scan x chromosome matrix of mean intensities
- `sex`: vector with values of "M" or "F" corresponding to scans in the rows of `mean.intensities`
- `outliers`: list of outliers, each member corresponds to a chromosome (member "X" is itself a list of female and male outliers)
- `sep`: plot outliers within a chromosome separately (TRUE) or together (FALSE)
- `label`: list of plot labels (to be positioned below X axis) corresponding to list of outliers
- `...`: additional arguments to `plot`

**Details**

Outliers must be determined in advance and stored as a list, with one element per chromosome. The X chromosome must be a list of two elements, "M" and "F". Each element should contain a vector of ids corresponding to the row names of `mean.intensities`.

If `sep=TRUE`, `labels` must also be specified. `labels` should be a list that corresponds exactly to the elements of `outliers`.

**Author(s)**

Cathy Laurie

**See Also**

`meanIntensityByScanChrom`
Examples

# calculate mean intensity
library(GWASdata)
file <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
gds <- GdsIntensityReader(file)
data(illuminaScanADF)
intenData <- IntensityData(gds, scanAnnot=illuminaScanADF)
meanInten <- meanIntensityByScanChrom(intenData)
intenMatrix <- meanInten$mean.intensity

# find outliers
outliers <- list()
sex <- illuminaScanADF$sex
id <- illuminaScanADF$scanID
allequal(id, rownames(intenMatrix))
for (i in colnames(intenMatrix)) {
  if (i != "X") {
    imean <- intenMatrix[,i]
    imin <- id[imean == min(imean)]
    imax <- id[imean == max(imean)]
    outliers[[i]] <- c(imin, imax)
  } else {
    idf <- id[sex == "F"]
    fmean <- intenMatrix[sex == "F", i]
    fmin <- idf[fmean == min(fmean)]
    fmax <- idf[fmean == max(fmean)]
    outliers[[i]][["F"]]<- c(fmin, fmax)
    idm <- id[sex == "M"]
    mmean <- intenMatrix[sex == "M", i]
    mmin <- idm[mmean == min(mmean)]
    mmax <- idm[mmean == max(mmean)]
    outliers[[i]][["M"]]<- c(mmin, mmax)
  }
}
par(mfrow=c(2,4))
intensityOutliersPlot(intenMatrix, sex, outliers)
close(intenData)


manhattanPlot

Manhattan plot for genome wide association tests

Description

Generates a manhattan plot of the results of a genome wide association test.

Usage

manhattanPlot(p, chromosome,
              ylim = NULL, trunc.lines = TRUE,
              signif = 5e-8, thinThreshold=NULL, pointsPerBin=10000, col=NULL, ...)


Argument

- `p`: A vector of p-values.
- `chromosome`: A vector containing the chromosome for each SNP.
- `ylim`: The limits of the y axis. If NULL, the y axis is \((0, \log_{10}(\text{length}(p)) + 4)\).
- `trunc.lines`: Logical value indicating whether to show truncation lines.
- `signif`: Genome-wide significance level for plotting horizontal line. If `signif=NULL`, no line will be drawn.
- `thinThreshold`: if not NULL, -log10(pval) threshold for thinning points.
- `pointsPerBin`: number of points to plot in each bin if `thinThreshold` is given. Ignored otherwise.
- `col`: vector containing colors of points; defaults to coloring by chromosome using the colorbrewer Dark2 palette with 8 colors
- `...`: Other parameters to be passed directly to `plot`.

Details

Plots -log10(p) versus chromosome. Point size is scaled so that smaller p values have larger points. `p` must have the same length as `chromosome` and is assumed to be in order of position on each chromosome. Values within each chromosome are evenly spaced along the X axis.

Plot limits are determined as follows: if `ylim` is provided, any points with -log10(p) > `ylim[2]` are plotted as triangles at the maximum y value of the plot. A line will be drawn to indicate truncation (if `trunc.lines == TRUE`, the default). If `ylim == NULL`, the maximum y value is defined as \(\log_{10}(\text{length}(p)) + 4\).

If requested with `thinThreshold`, points with -log10(pval) < `thinThreshold` are thinned before plotting. All points with -log10(pval) >= `thinThreshold` are displayed. P-values with -log10(pval) < `thinThreshold` are sampled such that `pointsPerBin` points are randomly selected from 10 bins with uniform spacing in -log10(pval) space.

Author(s)

Cathy Laurie, Adrienne Stilp

See Also

`snpCorrelationPlot`

Examples

```r
n <- 1000
pvals <- sample(-log10((1:n)/n), n, replace=TRUE)
chromosome <- c(rep(1,400), rep(2,350), rep("X",200), rep("Y",50))
manhattanPlot(pvals, chromosome, signif=1e-7)
manhattanPlot(pvals, chromosome, thinThreshold=2)
```
MatrixGenotypeReader

Description

The MatrixGenotypeReader class stores a matrix of genotypes as well as SNP and scan IDs, chromosome, and position.

Constructor

MatrixGenotypeReader(genotype=genotype, snpID=snpID, chromosome=chromosome, position=position, scanID=scanID)

- genotype must be a matrix with dimensions ('snp','scan') containing the number of A alleles: 2=AA, 1=AB, 0=BB.
- snp must be a unique integer vector of SNP ids.
- chromosome must be an integer vector of chromosomes. Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.
- position must be an integer vector of base positions
- scanID must be a unique integer vector of scan ids.

The MatrixGenotypeReader constructor creates and returns a MatrixGenotypeReader instance.

Accessors

In the code snippets below, object is a MatrixGenotypeReader object.

- nsnp(object): The number of SNPs.
- nscan(object): The number of scans.
- getSnpID(object, index): A unique integer vector of snp IDs. The optional index is a logical or integer vector specifying elements to extract.
- getChromosome(object, index, char=FALSE): A vector of chromosomes. The optional index is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.
- getPosition(object, index): An integer vector of base pair positions. The optional index is a logical or integer vector specifying elements to extract.
- getScanID(object, index): A unique integer vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract.
- getGenotype(object, snp=c(1,-1), scan=c(1,-1), drop=TRUE, use.names=FALSE): Extracts genotype values (number of A alleles). snp and scan indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of '-1' for count indicates that the entire dimension should be read. If drop=TRUE, the result is coerced to the lowest possible dimension. If use.names=TRUE, names of the resulting vector or matrix are set to the SNP and scan IDs. Missing values are represented as NA.
getGenotypeSelection(object, snp=NULL, scan=NULL, snpID=NULL, scanID=NULL, drop=TRUE, use.names=TRUE)
Extracts genotype values (number of A alleles). snp and scan may be integer or logical vectors indicating which elements to return along the snp and scan dimensions. snpID and scanID allow section by values of snpID and scanID. Unlike getGenotype, the values requested need not be in contiguous blocks. Other arguments are identical to getGenotype.

autosomeCode(object): Returns the integer codes for the autosomes.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
NcdfGenotypeReader, GenotypeData

Examples

snpID <- 1:100
chrom <- rep(1:20, each=5)
pos <- 1001:1100
scanID <- 1:20
geno <- matrix(sample(c(0,1,2,NA), 2000, replace=TRUE), nrow=100, ncol=20)
mgr <- MatrixGenotypeReader(genotype=geno, snpID=snpID, chromosome=chrom, position=pos, scanID=scanID)

# dimensions
nsnp(mgr)
nscan(mgr)

# get snpID and chromosome
snpID <- getSnpID(mgr)
chrom <- getChromosome(mgr)

# get positions only for chromosome 10
pos10 <- getPosition(mgr, index=(chrom == 10))

# get all snps for first scan
geno <- getGenotype(mgr, snp=c(1,-1), scan=c(1,1))

# starting at snp 50, get 10 snps for the first 5 scans
geno <- getGenotype(mgr, snp=c(50,10), scan=c(1,5))
meanIntensityByScanChrom

Describe Means & Standard Deviations of Intensities

Description

Function to calculate the mean and standard deviation of the intensity for each chromosome for each scan.

Usage

meanIntensityByScanChrom(intenData, vars = c("X", "Y"),
                          snp.exclude = NULL, verbose = TRUE)

Arguments

- intenData: `IntensityData` object. Chromosomes are expected to be in contiguous blocks.
- vars: Character vector with the names of one or two intensity variables.
- snp.exclude: An integer vector containing SNPs to be excluded.
- verbose: Logical value specifying whether to show progress information.

Details

The names of two intensity variables in `intenData` may be supplied. If two variables are given, the mean of their sum is computed as well. The default is to compute the mean and standard deviation for X and Y intensity.

Value

A list with two components for each variable in `vars`: `mean.var` and `sd.var`. If two variables are given, the first two elements of the list will be mean and sd for the sum of the intensity variables:

- mean.intensity: A matrix with one row per scan and one column per chromosome containing the means of the summed intensity values for each scan and chromosome.
- sd.intensity: A matrix with one row per scan and one column per chromosome containing the standard deviations of the summed intensity values for each scan and chromosome.
- mean.var: A matrix with one row per scan and one column per chromosome containing the means of the intensity values for each scan and chromosome.
- sd.var: A matrix with one row per scan and one column per chromosome containing the standard deviations of the intensity values for each scan and chromosome.

Author(s)

Cathy Laurie

See Also

`IntensityData`, `mean`, `sd`
Examples

```r
file <- system.file("extdata","illumina_qxy.gds", package="GWASdata")
gds <- GdsIntensityReader(file)
intenData <- IntensityData(gds)

meanInten <- meanIntensityByScanChrom(intenData)
close(intenData)
```

---

mendelErr

**Mendelian Error Checking**

Description

Mendelian and mtDNA inheritance tests.

Usage

```r
mendelErr(genoData, mendel.list, snp.exclude=NULL,
          error.by.snp=TRUE, error.by.snp.trio=FALSE,
          verbose=TRUE)
```

Arguments

- `genoData` *GenotypeData* object, must have scan variable "sex"
- `mendel.list` A *mendelList* object, to specify trios.
- `snp.exclude` An integer vector with snpIDs of SNPs to exclude. If NULL (default), all SNPs are used.
- `error.by.snp` Whether or not to output Mendelian errors per SNP. This will only return the total number of trios checked and the total number of errors for each SNP. The default value is `TRUE`.
- `error.by.snp.trio` Whether or not to output Mendelian errors per SNP for each trio. This will return the total number of trios checked and the total number of errors for each SNP as well as indicators of which SNPs have an error for each trio. The default value is `FALSE`. **NOTE:** `error.by.snp` must be set to `TRUE` as well in order to use this option. **NOTE:** Using this option causes the output to be very large that may be slow to load into R.
- `verbose` If `TRUE` (default), will print status updates while the function runs.

Details

genoData must contain the scan annotation variable "sex". Chromosome index: 1..22 autosomes, 23 X, 24 XY, 25 Y, 26 mtDNA, 27 missing.

If a trio has one parent missing, Mendelian errors are still calculated for the available pair. In other words, "trio" here also includes duos.
mendelErr

Value

mendelErr returns an object of class "mendelClass". The object contains two data frames: "trios" and "all.trios", and a list: "snp" (if error.by.snp is specified to be TRUE). If there are no duplicate samples in the dataset, "trios" will be the same as "all.trios". Otherwise, "all.trios" contains the results of all combinations of duplicate samples, and "trios" only stores the average values of unique trios. i.e: "trios" averages duplicate samples for each unique subject trio. "trios" and "all.trios" contain the following components:

fam.id  Specifying the family ID from the mendel.list object used as input.
child.id  Specifying the offspring ID from the mendel.list object used as input.
child.scanID  Specifying the offspring scanID from the mendel.list object used as input. (only in "all.trios")
father.scanID  Specifying the father scanID from the mendel.list object used as input. (only in "all.trios")
mother.scanID  Specifying the mother scanID from the mendel.list object used as input. (only in "all.trios")
Men.err.cnt  The number of SNPs with Mendelian errors in this trio.
Men.cnt  The total number of SNPs checked for Mendelian errors in this trio. It excludes those cases where the SNP is missing in the offspring and those cases where it is missing in both parents. Hence, Mendelian error rate = Men.err.cnt / Men.cnt.
mtDNA.err  The number of SNPs with mtDNA inheritance errors in this trio.
mtDNA.cnt  The total number of SNPs checked for mtDNA inheritance errors in this trio. It excludes those cases where the SNP is missing in the offspring and in the mother. Hence, mtDNA error rate = mtDNA.err / mtDNA.cnt.
chr1, ..., chr25  The number of Mendelian errors in each chromosome for this trio.

"snp" is a list that contains the following components:

check.cnt  A vector of integers, indicating the number of trios valid for checking on each SNP.
error.cnt  A vector of integers, indicating the number of trios with errors on each SNP.
familyid.childid  A vector of indicators (0/1) for whether or not any of the duplicate trios for the unique trio, "familyid.childid", have a Mendelian error on each SNP. (Only if error.by.snp.trio is specified to be TRUE).

Author(s)

Xiuwen Zheng, Matthew P. Conomos

See Also

mendelList
Examples

library(GWASdata)
data(illuminaScanADF)
scanAnnot <- illuminaScanADF

# generate trio list
men.list <- mendelList(scanAnnot$family, scanAnnot$subjectID,
    scanAnnot$father, scanAnnot$mother, scanAnnot$sex,
    scanAnnot$scanID)

# create genoData object
gdsfile <- system.file(“extdata”, “illumina_geno.gds”, package=“GWASdata”)
gds <- GdsGenotypeReader(gdsfile)
genoData <- GenotypeData(gds, scanAnnot=scanAnnot)

# Run!
R <- mendelErr(genoData, men.list, error.by.snp.trio = TRUE)

names(R)
# [1] “trios” “all.trios” “snp”

names(R$trios)
# [1] “fam.id” “child.id” “Men.err.cnt” “Men.cnt” “mtDNA.err”
# [6] “chr1” “chr2” “chr3” “chr4”
# [11] “chr5” “chr6” “chr7” “chr8” “chr9”
# [16] “chr10” “chr11” “chr12” “chr13” “chr14”
# [21] “chr15” “chr16” “chr17” “chr18” “chr19”
# [26] “chr20” “chr21” “chr22” “chrX” “chrXY”
# [31] “chrY”

# Mendelian error rate = Men.err.cnt / Men.cnt

data.frame(fam.id = R$trios$fam.id, child.id = R$trios$child.id,
    Mendel.err.rate = R$trios$Men.err.cnt / R$trios$Men.cnt)

names(R$snp)
summary(R$snp$check.cnt)

# summary Mendelian error for first family
summary(R$snp[[1]])

close(genoData)

mendelList

Mendelian Error Checking

Description

mendelList creates a "mendelList" object (a list of trios). mendelListAsDataFrame converts a "mendelList" object to a data frame.

Usage

mendelList(familyid, offspring, father, mother, sex, scanID)
mendelListAsDataFrame(mendel.list)
Arguments

familyid  A vector of family identifiers.
offspring  A vector of offspring subject identifiers.
father  A vector of father identifiers.
mother  A vector of mother identifiers.
sex  A vector to specify whether each subject is male "M" or female "F".
scanID  A vector of scanIDs indicating unique genotyping instances for the offspring vector. In the case of duplicate samples, the same offspring identifier may correspond to multiple scanID values.

mendel.list  An object of class "mendelList".

Details

The lengths of familyid, offspring, father, mother, sex, and scanID must all be identical. These vectors should include all genotyped samples, i.e., samples present in the father and mother vectors should also appear in the offspring vector if there are genotypes for these samples, and their unique scan IDs should be given in the scanID vector.

Identifiers may be character strings or integers, but not factors.

The "mendelList" object is required as input for the mendelErr function.

Value

mendelList returns a "mendelList" object. A "mendelList" object is a list of lists. The first level list is all the families. The second level list is offspring within families who have one or both parents genotyped. Within the second level are data.frame(s) with columns "offspring", "father", and "mother" which each contain the scanID for each member of the trio (a missing parent is denoted by -1). When replicates of the same offspring ID occur (duplicate scans for the same subject), this data.frame has multiple rows representing all combinations of scanIDs for that trio.

mendelListAsDataFrame returns a data.frame with variables "offspring", "father", and "mother" which each contain the scanID for each member of the trio (a missing parent is denoted by -1). This takes every data.frame from the "mendelList" object and puts them all into one large data frame. This can be easier to work with for certain analyses.

Author(s)

Xiuwen Zheng, Matthew P. Conomos

See Also

mendelErr

Examples

# data frame of sample information. No factors!
dat <- data.frame(family=c(1,1,1,2,2,2), offspring=c("a","a","b","c","d","e","f"),
father=c("b","b",0,0,"e",0,0), mother=c("c","c",0,0,"f",0,0),
sex=c("M","M","M","F","F","F"), scanID=1:7,
stringsAsFactors=FALSE)
dat

men.list <- mendelList(dat$family, dat$offspring, dat$father, dat$mother,
missingGenotypeByScanChrom

Missing Counts per Scan per Chromosome

Description

This function tabulates missing genotype calls for each scan for each chromosome.

Usage

missingGenotypeByScanChrom(genoData, snp.exclude = NULL, verbose = TRUE)

Arguments

genoData GenotypeData object. Chromosomes are expected to be in contiguous blocks.
snp.exclude A vector of IDs corresponding to the SNPs that should be excluded from the overall missing count.
verbose Logical value specifying whether to show progress information.

Details

This function calculates the percent of missing genotypes in each chromosome of each scan given in genoData. A "sex" variable must be present in the scan annotation slot of genoData.

Value

This function returns a list with three components: "missing.counts," "snps.per.chr", and "missing.fraction."

missing.counts A matrix with rows corresponding to the scans and columns indicating unique chromosomes containing the number of missing SNP’s for each scan and chromosome.
snps.per.chr A vector containing the number of non-excluded SNPs for each chromosome.
missing.fraction A vector containing the fraction of missing counts for each scan over all chromosomes, excluding the Y chromosome for females.
missingGenotypeBySnpSex

Author(s)
Cathy Laurie

See Also
GenotypeData, missingGenotypeBySnpSex

Examples

library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# need scan annotation with sex
data(illuminaScanADF)
genodata <- GenotypeData(gds, scanAnnot=illuminaScanADF)
missingRate <- missingGenotypeByScanChrom(genodata)
close(genodata)

missingGenotypeBySnpSex

Missing Counts per SNP by Sex

Description
For all SNPs for each sex tabulates missing SNP counts, allele counts and heterozygous counts.

Usage

missingGenotypeBySnpSex(genoData, scan.exclude = NULL,
verbose = TRUE)

Arguments

genoData \hspace{1cm} GenotypeData object.
scan.exclude \hspace{1cm} A vector containing the scan numbers of scans that are to be excluded from the total scan list.
verbose \hspace{1cm} Logical value specifying whether to show progress information.

Details
This function calculates the fraction of missing genotypes for males and females for each SNP given in genoData. A "sex" variable must be present in the scan annotation slot of genoData.
Value

This function returns a list with three components: "missing.counts," "scans.per.sex," and "missing.fraction."

missing.counts A matrix with one row per SNP and one column per sex containing the number of missing SNP counts for males and females, respectively.
scans.per.sex A vector containing the number of males and females respectively.
missing.fraction A vector containing the fraction of missing counts for each SNP, with females excluded for the Y chromosome.

Author(s)
Cathy Laurie, Stephanie Gogarten

See Also
GenotypeData, missingGenotypeByScanChrom

Examples

library(GWASdata)
file <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(file)

# need scan annotation with sex
data(illuminaScanADF)
genoData <- GenotypeData(gds, scanAnnot=illuminaScanADF)

missingRate <- missingGenotypeBySnpSex(genoData)
close(genoData)

NcdfGenotypeReader

Class NcdfGenotypeReader

Description

The NcdfGenotypeReader class is an extension of the NcdfReader class specific to reading genotype data stored in NetCDF files.

Extends
NcdfReader

Constructor

NcdfGenotypeReader(filename):

filename must be the path to a NetCDF file. The NetCDF file must contain the following variables:

• 'snp': a coordinate variable with a unique integer vector of snp ids
• 'chromosome': integer chromosome codes of dimension 'snp'
NcdfGenotypeReader

- 'position': integer position values of dimension 'snp'
- 'sampleID': a unique integer vector of scan ids with dimension 'sample'
- 'genotype': a matrix of bytes with dimensions ('snp', 'sample'). The byte values must be the number of A alleles: 2=AA, 1=AB, 0=BB.

Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.

The NcdfGenotypeReader constructor creates and returns a NcdfGenotypeReader instance pointing to this file.

Accessors

In the code snippets below, object is a NcdfGenotypeReader object.

See NcdfReader for additional methods.

nsnp(object): The number of SNPs in the NetCDF file.

nscan(object): The number of scans in the NetCDF file.

getSnpID(object, index): A unique integer vector of snp IDs. The optional index is a logical or integer vector specifying elements to extract.

getChromosome(object, index, char=FALSE): A vector of chromosomes. The optional index is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.

getPosition(object, index): An integer vector of base pair positions. The optional index is a logical or integer vector specifying elements to extract.

getScanID(object, index): A unique integer vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract.

getGenotype(object, snp=c(1,-1), scan=c(1,-1), drop=TRUE, use.names=FALSE, ...): Extracts genotype values (number of A alleles). snp and scan indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of '-1' for count indicates that the entire dimension should be read. If drop=TRUE, the result is coerced to the lowest possible dimension. If use.names=TRUE and the result is a matrix, dimnames are set to the SNP and scan IDs. Missing values are represented as NA.

getVariable(object, varname, ...): Extracts the contents of the variable varname. If the variable is not found in the NetCDF file, returns NULL.

autosomeCode(object): Returns the integer codes for the autosomes.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)

Stephanie Gogarten
NcdfIntensityReader

See Also
NcdfReader, NcdfIntensityReader, GenotypeData, IntensityData

Examples
file <- system.file("extdata", "illumina_geno.nc", package="GWASdata")
nc <- NcdfGenotypeReader(file)

# dimensions
nsnp(nc)
nscan(nc)

# get snpID and chromosome
snpID <- getSnPID(nc)
chrom <- getChromosome(nc)

# get positions only for chromosome 22
pos22 <- getPosition(nc, index=(chrom == 22))

# get all snps for first scan
geno <- getGenotype(nc, snp=c(1,-1), scan=c(1,1))

# starting at snp 100, get 10 snps for the first 5 scans
ngen <- getGenotype(nc, snp=c(100,10), scan=c(1,5))

close(nc)

NcdfIntensityReader

Class NcdfIntensityReader

Description
The NcdfIntensityReader class is an extension of the NcdfReader class specific to reading intensity data stored in NetCDF files.

Extends
NcdfReader

Constructor
NcdfIntensityReader(filename):  
filename must be the path to a NetCDF file. The NetCDF file must contain the following variables:
  • 'snp': a coordinate variable with a unique integer vector of snp ids
  • 'chromosome': integer chromosome values of dimension 'snp'
  • 'position': integer position values of dimension 'snp'
  • 'sampleID': a unique integer vector of scan ids with dimension 'sample'

Default values for chromosome codes are 1-22=autosomal, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.
The NetCDF file should also contain at least one of the following variables with dimensions ('snp', 'sample'):
NcdfIntensityReader

- 'quality': quality score
- 'X': X intensity
- 'Y': Y intensity
- 'BAlleleFreq': B allele frequency
- 'LogRRatio': Log R Ratio

The NcdfIntensityReader constructor creates and returns a NcdfIntensityReader instance pointing to this file.

Accessors

In the code snippets below, object is a NcdfIntensityReader object, snp and scan indicate which elements to return along the snp and scan dimensions. They must be integer vectors of the form (start, count), where start is the index of the first data element to read and count is the number of elements to read. A value of `-1` for count indicates that the entire dimension should be read. If snp and/or is scan omitted, the entire variable is read. If drop=TRUE the result is coerced to the lowest possible dimension.

See NcdfReader for additional methods.

nsnp(object): The number of SNPs in the NetCDF file.
nscan(object): The number of scans in the NetCDF file.

getSnpID(object, index): A unique integer vector of snp IDs. The optional index is a logical or integer vector specifying elements to extract.

getChromosome(object, index, char=FALSE): A vector of chromosomes. The optional index is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.

getPosition(object, index): An integer vector of base pair positions. The optional index is a logical or integer vector specifying elements to extract.

getScanID(object, index): A unique integer vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract.

getQuality(object, snp, scan, drop=TRUE): Extracts quality scores. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA.

hasQuality(object): Returns TRUE if the GDS file contains a variable 'quality'.

getX(object, snp, scan, drop=TRUE): Extracts X intensity. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA.

hasX(object): Returns TRUE if the GDS file contains a variable 'X'.

getY(object, snp, scan, drop=TRUE): Extracts Y intensity. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA.

hasY(object): Returns TRUE if the GDS file contains a variable 'Y'.

getBAlleleFreq(object, snp, scan, drop=TRUE): Extracts B allele frequency. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA.

hasBAlleleFreq(object): Returns TRUE if the GDS file contains a variable 'BAlleleFreq'.

**getLogRRatio***(object, snp, scan, drop=TRUE): Extracts Log R Ratio. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA.

**hasLogRRatio***(object): Returns *TRUE* if the GDS file contains a variable 'LogRRatio'.

**getVariable***(object, varname, snp, scan, drop=TRUE): Returns the contents of the variable varname. The result is a vector or matrix, depending on the number of dimensions in the returned values and the value of drop. Missing values are represented as NA. If the variable is not found in the NetCDF file, returns NULL.

**autosomeCode***(object): Returns the integer codes for the autosomes.

**XchromCode***(object): Returns the integer code for the X chromosome.

**XYchromCode***(object): Returns the integer code for the pseudoautosomal region.

**YchromCode***(object): Returns the integer code for the Y chromosome.

**MchromCode***(object): Returns the integer code for mitochondrial SNPs.

**Author(s)**

Stephanie Gogarten

**See Also**

* NcdfReader, NcdfGenotypeReader, GenotypeData, IntensityData

**Examples**

```
file <- system.file("extdata", "illumina_qxy.nc", package="GWASdata")
nc <- NcdfIntensityReader(file)

# dimensions
nsnp(nc)
nscan(nc)

# get snpID and chromosome
snpID <- getSnpID(nc)
chrom <- getChromosome(nc)

# get positions only for chromosome 22
pos22 <- getPosition(nc, index=(chrom == 22))

# get all snps for first scan
x <- getX(nc, snp=c(1,-1), scan=c(1,1))

# starting at snp 100, get 10 snps for the first 5 scans
x <- getX(nc, snp=c(100,10), scan=c(1,5))

close(nc)
```
**Description**

The NcdfReader class is a wrapper for the ncdf4 library that provides an interface for reading NetCDF files.

**Constructor**

NcdfReader(filename):
   filename must be the path to a NetCDF file.
   The NcdfReader constructor creates and returns a NcdfReader instance pointing to this file.

**Accessors**

In the code snippets below, object is a NcdfReader object.

getVariable(object, varname, start, count, drop=TRUE): Returns the contents of the variable varname.
   • start is a vector of integers indicating where to start reading values. The length of this vector must equal the number of dimensions the variable has. If not specified, reading starts at the beginning of the file (1,1,...).
   • count is a vector of integers indicating the count of values to read along each dimension. The length of this vector must equal the number of dimensions the variable has. If not specified and the variable does NOT have an unlimited dimension, the entire variable is read. As a special case, the value “-1” indicates that all entries along that dimension should be read.
   • drop is a logical for whether the result will be coerced to the lowest possible dimension.
   The result is a vector, matrix, or array, depending on the number of dimensions in the returned values and the value of drop. Missing values (specified by a "missing_value" attribute, see ncvar_change_missval) are represented as NA. If the variable is not found in the NetCDF file, returns NULL.

getVariableNames(object): Returns names of variables in the NetCDF file.

getDimension(object, varname): Returns dimension for NetCDF variable varname.

getDimensionNames(object, varname): Returns names of dimensions in the NetCDF file. If varname is provided, returns dimension names for NetCDF variable varname.

getAttribute(object, attname, varname): Returns the attribute attname associated with the variable varname. If varname is not specified, attname is assumed to be a global attribute.

hasCoordVariable(object, varname): Returns TRUE if varname is a coordinate variable (a variable with the same name as a dimension).

hasVariable(object, varname): Returns TRUE if varname is a variable in the NetCDF file (including coordinate variables).

**Standard Generic Methods**

In the code snippets below, object is a NcdfReader object.

open(object): Opens a connection to a NetCDF file.

close(object): Closes the connection to a NetCDF file.

show(object): Summarizes the contents of a NetCDF file.
Author(s)
Stephanie Gogarten

See Also
ncdf4, NcdfGenotypeReader, NcdfIntensityReader

Examples
file <- system.file("extdata", "affy_geno.nc", package="GWASdata")
c <- NcdfReader(file)

getDimensionNames(nc)
getVariableNames(nc)

hasVariable(nc, "genotype")
geno <- getVariable(nc, "genotype", start=c(1,1), count=c(10,10))
close(nc)

pasteSorted <- Paste two vectors sorted pairwise

Description
Read a configuration file

Usage
pasteSorted(a, b, sep="/")

Arguments
a     vector 1
b     vector 2
sep    a character string to separate the terms.

Value
A character vector of the concatenated values, sorted pairwise.

Author(s)
Stephanie Gogarten

See Also
paste

Examples
a <- c("A","C","G","T")
b <- c("C","A","T","G")
pasteSorted(a,b)
**Description**

Base positions for the LCT (2q21), HLA (including MHC), and inversion (8p23, 17q21.31) regions from the GRCh36/hg18, GRCh37/hg19 and GRCh38/hg38 genome genome builds.

**Usage**

- pcaSnpFilters.hg18
- pcaSnpFilters.hg19
- pcaSnpFilters.hg38

**Format**

A data.frame with the following columns.

- chrom  chromosome
- start.base  starting base position of region
- end.base  ending base position of region
- comment  description of the region

**Details**

These regions result in high SNP-PC correlation if they are included in Principal Component Analysis (PCA). The pcaSnpFilters datasets can be used to filter SNPs prior to running PCA to avoid correlations.

**Source**

UCSC genome browser ([http://genome.ucsc.edu](http://genome.ucsc.edu)).

**References**


**See Also**

- snpCorrelationPlot, SNPRelate

**Examples**

```r
data(pcaSnpFilters.hg18)
data(pcaSnpFilters.hg19)
data(pcaSnpFilters.hg38)
```
pedigreeCheck

Testing for internal consistency of pedigrees

Description
Find inconsistencies within pedigrees.

Usage
pedigreeCheck(pedigree)

Arguments
pedigree
A dataframe containing the pedigree information for the samples to be examined
with columns labeled "family", "individ", "mother", "father" and "sex" containing
the identifiers of the family, individual, individual's mother, individual's fa-
thor and individual's sex (coded as "M" or "F"). Identifiers can be integer, nu-
meric or character but identifiers for mother and father for founders are assumed
to be 0.

Details
The function pedigreeCheck finds any of a number of possible errors and inconsistencies within
pedigree data. If no problems are encountered, the output is NULL. If problems are encountered,
output contains information for the errors encountered (a sub-list of the output values described
below) and the following message is printed: "All row numbers refer to rows in the full pedigree (not
just within a family). Correct current problems and rerun pedigreeCheck. There may be additional
problems not investigated because of the current problems."

Value
The output for pedigreeCheck is NULL or a sub-list of the following:

family.missing.rows
A vector of integers containing the row positions of entries in the full pedigree
where family id's are missing (NA) or blank

individ.missing_or_0.rows
A vector of integers containing the row positions of entries in the full pedigree
where individual id's are missing (NA), blank, or 0

father.missing.rows
A vector of integers containing the row positions of entries in the full pedigree
where father id's are missing (NA) or blank

mother.missing.rows
A vector of integers containing the row positions of entries in the full pedigree
where mother id's are missing (NA) or blank

sexcode.error.rows
A vector of integers containing the row positions of entries in the full pedigree
where the 'sex' variable is mis-coded
both.mother.father

A data.frame with the variables ‘family’, ‘parentID’, ‘mother.row’, and ‘father.row’ where ‘family’ = family identifier, ‘parentID’ = identifier of parent that appears as both mother and father, ‘father.row’ = row positions(s) in full pedigree in which parent appears as father, and ‘mother.row’ = row position(s) in full pedigree in which parent appears as mother (if multiple rows, row numbers are concatenated with separator = ‘;’)

parent.no.individ.entry

A data.frame with the variables ‘row.num’, ‘family’, ‘no.individ.entry’, and ‘parentID’, where ‘row.num’ = row position of entry in the full pedigree where mother and/or father IDs are not included in the pedigree, ‘family’ = family identifier, ‘no.individ.entry’ has values ‘father’, ‘mother’ or ‘both’ indicating which parent is not in the pedigree, and ‘parentID’ = the identifier(s) for individuals not in the pedigree (if more than one, identifiers are concatenated with separator = ‘;’)

unknown.parent.rows

A data.frame with variables ‘row.num’ = row position in full pedigree where one parent is known and one parent is unknown and ‘family’ = family identifier.

duplicates

A data.frame with variables ‘family’ = family identifier, ‘individ’ = individual identifier, ‘copies’ = number of copies of individual and ‘match’ = T/F depending upon whether all copies have identical pedigree information

one.person.fams

A data.frame identifying singletons (one person families) with variables ‘family’ = family identifier and ‘founder’ = T/F depending up whether the singleton is a founder or not

mismatch.sex

A data.frame with variables ‘family’ = family identifier and ‘individ’ = individual identifier for individuals that occur as mothers but sex is “M” or occur as fathers but sex is “F”

impossible.related.rows

A list where each entry in the list contains a set of row positions in the full pedigree which together indicate impossible relationships: where either a child is mother of self or an individual is both child and mother of the same person. Names of list entries are associated family identifiers.

subfamilies.ident

A data.frame with variables ‘family’ = family identifier, “subfamily” = subfamily identifier within family, and ‘individ’ = individual identifier of members of identified sub-family.

If no inconsistencies are found, the output is NULL.

Note

All row numbers in output refer to row positions in the full pedigree (not just within family). User should correct current problems and rerun pedigreeCheck. There may be additional problems not investigated because of the current problems.

Author(s)

Cecelia Laurie

See Also

pedigreeDeleteDuplicates, pedigreePairwiseRelatedness
Examples

```r
# basic errors
family <- c("a", "a", "a", "b", "b", "c","")
individ <- c("A", "B", "C", "A", "B","")
mother <- c("B", "C", 0, 0, NA, 0)
father <- c("C", "D", 0, 0, "", 0, "D")
sex <- c("F", "M", "F", "F", "M", "F")
samp <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
pedigreeCheck(samp)
# there are other problems not investigated since
# the above are basic problems to be cleared up first

##/quotesingle.Var
duplicates
##/quotesingle.Var
both.mother.father
##/quotesingle.Var
parent.no.individ.entry

# other problems not investigated since already had both.mother.father inconsistency

family <- c("b", "b", "b", "b", "c", rep("d", 5))
mother <- c("B", 0, 0, "D", 0, 0, 0, 1, 2, 1)
father <- c("C", 0, 0, "C", 0, 0, 0, 2, 1, 2)
samp <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
pedigreeCheck(samp)
# there are other problems (such as mismatch.sex) but not investigated
# directly because already had both.mother.father inconsistency

#/quotesingle.Var
parent.no.individ.entry
##/quotesingle.Var
one.person.fams
##/quotesingle.Var
unknown.parent.rows

# mismatch.sex
# impossible.related.rows

family <- c(1, 1, 2, 2, 3, 4, 4, 4, 5, 5, 5, 6, 6, 6)
individ <- c(1, 2, 3, 1, 2, 3, 1, 2, 1, 2, 3, 4, 1, 2, 3)
mother <- c(2, 0, 1, 2, 1, 0, 1, 2, 0, 2, 1, 0)
father <- c(3, 0, 3, 0, 3, 0, 3, 3, 0, 3, 3, 0)
samp <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
pedigreeCheck(samp)
# mismatch.sex and impossible.related.rows are only investigated
# for families where there are no other inconsistencies

##/quotesingle.Var
subfamilies.ident

family <- rep(1, 12)
individ <- 1:12
mother <- c(0, 0, 2, 2, 0, 0, 5, 0, 7, 0, 0, 10)
father <- c(0, 0, 1, 1, 0, 0, 6, 0, 8, 0, 0, 11)
samp <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
pedigreeCheck(samp)
# 'subfamilies.ident' is only investigated for families
# where there are no other inconsistencies
```

pedigreeDeleteDuplicates

Remove duplicates from a pedigree

Description

pedigreeDeleteDuplicates removes duplicates from a pedigree.
Usage

pedigreeDeleteDuplicates(pedigree, duplicates)

Arguments

pedigree  A dataframe containing the pedigree information for the samples to be examined with columns labeled "family", "individ", "mother", "father" and "sex" containing the identifiers of the family, individual, individual’s mother, individual’s father and individual’s sex (coded as "M" or "F").

duplicates  dataframe with columns "family" (family id) and "individ" (individual id).

Details

The output of pedigreeCheck can be provided to pedigreeDeleteDuplicates in order to generate a new pedigree with duplicates removed.

Value

The output of pedigreeDeleteDuplicates is a pedigree identical to pedigree, but with duplicates removed.

Author(s)

Cecelia Laurie

See Also

pedigreeCheck, pedigreePairwiseRelatedness

Examples

family <- c(1,1,1,2,2,2)
individ <- c(1,2,3,4,5,6)
mother <- c(0,0,1,0,0,0)
father <- c(0,0,2,0,0,0)
sex <- c("F","M","F","F","F","M")
pedigree <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
duplicates <- pedigreeCheck(pedigree)$duplicates
pedigree.no.dups <- pedigreeDeleteDuplicates(pedigree, duplicates)

pedigreeMaxUnrelated  Find a maximal set of unrelated individuals in a subset of a pedigree.

Description

Given a full pedigree (with no duplicates and no one-person families), this function finds a maximal set of unrelated individuals in a specified subset of the pedigree. This is done family by family. The full pedigree is checked for inconsistencies and an error message is given if inconsistencies are found (see pedigreeCheck). Maximal sets are not unique; there is an option for the user to identify preference(s) in the choice of individuals.
pedigreeMaxUnrelated

Usage

pedigreeMaxUnrelated(pedigree, pref = NULL)

Arguments

pedigree
A dataframe containing the full pedigree with columns 'family', 'individ', 'mother', 'father', 'sex', and 'selset'. The variables 'family', 'individ', 'mother', 'father' contain the identifiers for family, individual, individual’s mother and individual’s father. Identifiers can be integer, numeric or character but identifiers for mother and father for founders are assumed to be 0. The variable 'sex' contains the individual’s sex (coded as "M" or "F"). The variable 'selset' is coded as 1 = if individual is in the subset of interest and 0 otherwise. The dataframe can contain an optional variable indicating preferences for choosing individuals. See the item pref below.

pref
pref = the name of the (optional) preference column in samp. Preferences can be layered. This variable must have integer or numeric values greater than or equal to 1 where a lower value indicates higher preference. If pref is missing, the default is to prefer choosing founders.

Details

Commonly used for selecting a maximal unrelated set of genotyped individuals from a pedigree ('selset' = 1 if individual is genotyped and 0 otherwise).

An example of the use of a layered preference variable: if one wanted to prefer cases over controls and then prefer founders, the preference variable would = 1 for cases, 2 = founder, 3 = otherwise.

Value

A dataframe with variables 'family' = family identifier and 'Individ' = individual identifier of individuals in the maximal unrelated set.

Note

Since pedigreeMaxUnrelated does not accept one-person families included in the input pedigree, to get a complete maximal set of unrelated individuals from a specified subset of the pedigree, the user will need to append to the output from the function the one-person family (singleton) individuals from the specified subset.

Author(s)

Cecelia Laurie

See Also

pedigreeCheck, pedigreePairwiseRelatedness

Examples

## Example set 1
family <- rep("A",8)
individ <- c("a", "b", "c", "d", "e", "f", "g", "h")
mother <- c(0, "a", "b", 0, "f", 0, 0, "f")
father <- c(0, "d", "e", 0, "g", 0, 0, "g")
sex <- c(rep("F",3),"M","M","F","M","F")
pedigree <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)

## preference default (i.e. choose founders if possible)
pedigree$selset <- 1 # all selected
pedigreeMaxUnrelated(pedigree) # chose the founders

# family Individ
#1 A a
#2 A d
#3 A f
#4 A g

sel <- is.element(pedigree$individ,c("a","f","g"))
pedigree$selset[sel] <- 0 # only one founder 'd' in desired subset

# default preference of founders
pedigreeMaxUnrelated(pedigree)
# family Individ
#1 A d #founder
#2 A e

## preference choice
pedigree$pref <- 2
sel2 <- is.element(pedigree$individ, c("c","h")) # preferred choices
pedigree$pref[sel2] <- 1
pedigreeMaxUnrelated(pedigree,pref="pref")
# family Individ
#1 A h
#2 A b

## add preference layer of secondary choice of founders
pedigree$pref <- 3
sel2 <- pedigree$mother==0 & pedigree$father==0
sel1 <- is.element(pedigree$individ, c("c","h"))
pedigree$pref[sel2] <- 2
pedigree$pref[sel1] <- 1
pedigreeMaxUnrelated(pedigree,pref="pref")
# family Individ
#1 A h #top pref
#2 A d #founder

# Note that the other top preference 'c' is related to everyone so not chosen

## Example Set 2
family <- c(1,1,1,1,2,2,2,2,2,2)
individ <- c(2,1,3,4,2,3,4,5,6,7)
mother <- c(3,3,0,0,0,0,0,0,0,0)
father <- c(4,4,0,0,0,0,0,0,0,0)
sex <- c("F","M","F","M","F","M","M","M","M")
pedigree <- data.frame(family, individ, mother, father, sex, stringsAsFactors=FALSE)
pedigree$selset <- 1
pedigree$selset[is.element(pedigree$individ, c("A5",4))] <- 0
pedigree$pref <- 2
pedigree$pref[is.element(pedigree$individ,c("A8","A7"))] <- 1
pedigreeMaxUnrelated(pedigree,pref="pref")
# family Individ
#1 1 2
#2 2 A6
pedigreePairwiseRelatedness

Assign relatedness from pedigree data

Description

This function assigns relationships from pedigree data. Output includes the theoretical pairwise kinship coefficients.

Usage

pedigreePairwiseRelatedness(pedigree)

Arguments

pedigree A dataframe containing the pedigree information for the samples to be examined with columns labeled "family", "individ", "mother", "father" and "sex" containing the identifiers for family, individual, individual’s mother, individual’s father and individual’s sex (coded as "M" or "F") . Identifiers can be integer, numeric or character but identifiers for mother and father for founders are assumed to be 0. Error messages are returned for pedigree inconsistencies. See pedigreeCheck

Details

Assigns relationships between individuals in a pedigree, including "U" = unrelated, "PO" = parent/offspring, "FS" = full siblings, "HS" = half siblings, "Av" = avuncular, "FC" = first cousins, "GpGc" = grandparent-grandchild, "HAv" = half-avuncular, "HFC" = half-first-cousin, "GGp" = great-grandparent-great-grandchild, "GAv" = grand-avuncular, "HSFC" = half-sib-first-cousin, "DFC" = double first cousin, among others. Relatedness is not calculated for inbred families but kinship coefficients are.

Value

A list with the following components:

inbred.fam A vector of id’s of families with inbreeding (relationships are not assigned).
inbred.KC  A dataframe for inbred families with columns "Individ1", "Individ2", "kinship" and "family" containing the id’s of the pair of individuals, kinship coefficient and family id.

relativeprs  A dataframe with columns "Individ1", "Individ2", "relation", "kinship" and "family" containing the id’s of the pair of individuals, the relationship between the individuals if closely related (possible values are "U" = unrelated, "PO" = parent/offspring, "FS" = full siblings, "HS" = half siblings, "Av" = avuncular, "GpGc" = grandparent-grandchild, and "FC" = first cousins, among others), kinship coefficient and family id.

Author(s)
Cecelia Laurie

See Also
pedigreeCheck, pedigreeMaxUnrelated

Examples
family <- c(1,1,1,2,2,2,2,2)
individ <- c(1,2,3,4,5,6,7,8)
mother <- c(0,1,0,0,0,1,0,0)
father <- c(0,0,0,2,0,0,0,0)
sex <- c("F","M","F","M","F","F","F","F")
pedigree <- data.frame(family, individ, mother, father, sex)
familyPairwiseRelatedness(pedigree)

# inbred family
family <- rep(2,7)
individ <- paste("I",c(1,2,3,4,5,6,7),sep="")
mother <- c(0,0,0,"I1","I1","I3","I5")
father <- c(0,0,0,"I2","I2","I4","I4")
sex <- c("F","M","F","M","F","F","F")
samp2 <- data.frame(family, individ, mother, father, sex)
familyPairwiseRelatedness(samp2)

plinkUtils
Utilities to create and check PLINK files

Description
plinkWrite creates ped and map format files (used by PLINK) from a GenotypeData object. plinkCheck checks whether a set of ped and map files has identical data to a GenotypeData object.

Usage
plinkWrite(genoData, pedFile="testPlink", family.col="Family", individual.col="scanID", father.col="father", mother.col="mother", phenotype.col=NULL, rs.col="rsID", mapdist.col=NULL, scan.exclude=NULL, scan.chromosome.filter=NULL, blockSize=100, verbose=TRUE)
plinkCheck(genoData, pedFile, logFile="plinkCheck.txt", family.col="family",
individual.col="scanID", father.col="father", mother.col="mother",
phenotype.col=NULL,
rs.col="rsID", map.alt=NULL, check.parents=TRUE, check.sex=TRUE,
scan.exclude=NULL, scan.chromosome.filter=NULL, verbose=TRUE)

Arguments

- genoData: A GenotypeData object with scan and SNP annotation.
- pedFile: prefix for PLINK files (pedFile.ped, pedFile.map)
- logFile: Name of the output file to log the results of plinkCheck
- family.col: name of the column in the scan annotation that contains family ID of the sample
- individual.col: name of the column in the scan annotation that contains individual ID of the sample
- father.col: name of the column in the scan annotation that contains father ID of the sample
- mother.col: name of the column in the scan annotation that contains mother ID of the sample
- phenotype.col: name of the column in the scan annotation that contains phenotype variable (e.g. case control status) of the sample
- rs.col: name of the column in the SNP annotation that contains rs ID (or some other ID) for the SNP
- mapdist.col: name of the column in the SNP annotation that contains genetic distance in Morgans for the SNP
- map.alt: data frame with alternate SNP mapping for genoData to PLINK. If not NULL, this annotation will be used to compare SNP information to the PLINK file, rather than the default conversion from the SNP annotation embedded in genoData. Columns should include "snpID", "rsID", "chromosome", "position".
- check.parents: logical for whether to check the father and mother columns
- check.sex: logical for whether to check the sex column
- scan.exclude: vector of scan IDs to exclude from PLINK file
- scan.chromosome.filter: a logical matrix that can be used to zero out (set to missing) some chromosomes, some scans, or some specific scan-chromosome pairs. Entries should be TRUE if that scan-chromosome pair should have data in the PLINK file, FALSE if not. The number of rows must be equal to the number of scans in genoData. The column labels must be in the set ("1"::"22", "X", "XY", "Y", "M", "U").
- blockSize: Number of samples to read from genoData at a time
- verbose: logical for whether to show progress information.

Details

If "alleleA" and "alleleB" columns are not found in the SNP annotation of genoData, genotypes are written as "A A", "A B", "B B" (or "0 0" for missing data).

If phenotype.col=NULL, plinkWrite will use ".9" for writing phenotype data and plinkCheck will omit checking this column.

If mapdist.col=NULL, plinkWrite will use "0" for writing this column in the map file and plinkCheck will omit checking this column.
plinkCheck first reads the map file and checks for SNP mismatches (chromosome, rsID, and/or position). Any mismatches are written to logFile. plinkCheck then reads the ped file line by line, recording all mismatches in logFile. SNPs and sample order is not required to be the same as in genoData. In the case of genotype mismatches, for each sample the log file output gives the position of the first mismatched SNP in the PLINK file, as well as the genotypes of the first six mismatched SNPs (which may not be consecutive).

These utilities convert between chromosome coding in GenotypeData, which by default is 24=XY, 25=Y, and PLINK chromosome coding, which is 24=Y, 25=XY.

Larger blockSize will improve speed but will require more RAM.

Value

plinkCheck returns TRUE if the PLINK files contain identical data to genoData, and FALSE if a mismatch is encountered.

Author(s)

Stephanie Gogarten, Tushar Bhangale

References

Please see http://pngu.mgh.harvard.edu/~purcell/plink/data.shtml#ped for more information on the ped and map files.

See Also

snpgdsBED2GDS

Examples

library(GWASdata)
ncfile <- system.file("extdata", "illumina_geno.nc", package="GWASdata")
data(illuminaSnpADF, illuminaScanADF)
genodata <- GenotypeData(NcdfGenotypeReader(ncfile),
  scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)

pedfile <- tempfile()
plinkWrite(genoData, pedfile)
logfile <- tempfile()
plinkCheck(genoData, pedfile, logfile)

# exclude samples
plinkWrite(genoData, pedfile, scan.exclude=c(281, 283),
  blockSize=10)
plinkCheck(genoData, pedfile, logfile)
readlines(logfile)
#samples not found in Ped:
#281
#283

close(genoData)
unlink(c(logfile, paste(pedfile, ".*", sep=".")))
pseudoautoIntensityPlot

Plot B Allele Frequency and Log R Ratio for the X and Y chromosomes, overlaying XY SNPs

Description

This function plots X, Y and pseudoautosomal SNPs on BAF/LRR plots.

Usage

pseudoautoIntensityPlot(intenData, scan.ids, main=NULL, plotY=FALSE, hg.build=c("hg18", "hg19"), snp.exclude = NULL, cex=0.5, ...)

Arguments

scan.ids A vector containing the sample indices of the plots.
intenData IntensityData object, must contain 'BAlleleFreq' and 'LogRRatio'
main A character vector containing the titles to be used for each plot. If NULL then the title will be the sample number and the chromosome.
plotY If plotY is TRUE, the Y chromosome will be plotted in addition to X.
hg.build Human genome build number
snp.exclude An integer vector giving the IDs of SNPs to exclude from the plot.
cex cex value for points on the plots
... Other parameters to be passed directly to plot.

Details

The pseudoautosomal regions are highlighted on the plots (PAR1 and PAR2 in gray, XTR in yellow), and the X, Y, and XY SNPs are plotted in different colors. The base positions for these regions depend on genome build (hg.build). Currently hg18 and hg19 are supported.

By default the output is a 2-panel plot with LRR and BAF for the X chromosome. If plotY is TRUE, the output is a 4-panel plot with the Y chromosome plotted as well.

Author(s)

Caitlin McHugh

References


See Also

pseudoautosomal, IntensityData, GenotypeData, BAFfromGenotypes
Examples

```r
library(GWASdata)
data(illuminaScanADF)
blfile <- system.file("extdata", "illumina_bl.gds", package="GWASdata")
blgds <- GdsIntensityReader(blfile)
intenData <- IntensityData(blgds, scanAnnot=illuminaScanADF)

scanID <- getScanID(illuminaScanADF, index=1)
pseudoautoIntensityPlot(intenData=intenData, scan.ids=scanID)
close(intenData)
```

pseudoautosomal  Pseudoautosomal region base positions

Description

Pseudoautosomal region (XTR, PAR1, PAR2) base positions for the X and Y chromosomes from the GRCh36/hg18, GRCh37/hg19 and GRCh38/hg38 genome builds.

Usage

```r
pseudoautosomal.hg18
pseudoautosomal.hg19
pseudoautosomal.hg38
```

Format

A data.frame with the following columns.

- `chrom` chromosome (X or Y)
- `region` region (XTR, PAR1, or PAR2)
- `start.base` starting base position of region
- `end.base` ending base position of region

Details

The XTR region on X is defined as DXS1217 to DXS3. The XTR region on Y is defined as SY20 to DXYS1.

Source

hg18 and hg19: UCSC genome browser (http://genome.ucsc.edu)

References


qqPlot

QQ plot for genome wide association studies

Description

Generates a Quantile-Quantile plot for -log10 p-values from genome wide association tests.

Usage

qqPlot(pval, truncate = FALSE, ylim = NULL, thinThreshold = NULL, ci=TRUE, ...)

Arguments

pval Vector of p-values
truncate Either a logical value indicating whether the y-axis should be truncated to the same range as the x-axis, or a numeric value indicating where to truncate the y-axis. See details.
ylim Limits for the y axis. Ignored if truncate=TRUE or truncate is numeric.
thinThreshold if not NULL, -log10(pval) threshold for thinning points.
clogical indicator for whether to add confidence intervals to plots?
... Other parameters to be passed directly to plot.

Details

The function generates a Quantile-Quantile plot of p-values on a -log10 scale, with the option of truncating the y-axis to the range of the x-axis (0, -log10(1/length(pval))). If the y-axis is truncated, then points off the top of the plot are denoted by triangles at the upper edge. The 95% confidence interval is shaded in gray.

If truncate is set to a numeric value, then ylim is set to c(0, truncate) only if the value of truncate is bigger than the maximum -log10(pval). (Use the ylim argument if alternative behavior is desired.)

If requested with thinThreshold, points with p-values < -log10(thinThreshold) are thinned before plotting. All points with -log10(pval) >= thinThreshold plus 10,000 points with -log10(pval) < thinThreshold (randomly selected in uniformly-spaced bins of -log10(pval)) are displayed.

Author(s)

Cathy Laurie, Matthew P. Conomos, Adrienne Stilp

Examples

pvals <- seq(0, 1, 0.001)
nqPloT(pvals)
nqPloT(pvals, thinThreshold=2)
nqPloT(pvals, truncate=TRUE)
nqPloT(pvals, truncate=10)
**Description**

This function calculates the mean and median quality score, over all SNPs with a non-missing genotype call, for each scan.

**Usage**

```r
qualityScoreByScan(intenData, genoData, 
                     snp.exclude = NULL, 
                     verbose = TRUE)
```

**Arguments**

- `intenData` \( \text{IntensityData\ object} \)
- `genoData` \( \text{GenotypeData\ object} \)
- `snp.exclude` An integer vector containing the id’s of SNPs to be excluded.
- `verbose` Logical value specifying whether to show progress information.

**Details**

`intenData` and `genoData` must have matching `snpID` and `scanID`. Y chromosome SNPs are excluded for females. A "sex" variable must be present in the scan annotation slot of `intenData` or `genoData`.

**Value**

The function returns a matrix with the following columns:

- `mean.quality` A vector of mean quality scores for each scan
- `median.quality` A vector of median quality scores for each scan.

**Author(s)**

Cathy Laurie

**See Also**

`IntensityData`, `GenotypeData`, `qualityScoreBySnp`

**Examples**

```r
library(GWASdata)
qualfile <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
qual <- GdsIntensityReader(qualfile)
# need scan annotation with sex
data(illuminaScanADF)
qualData <- IntensityData(qual, scanAnnot=illuminaScanADF)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
```
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno, scanAnnot=illuminaScanADF)

quality <- qualityScoreByScan(qualData, genoData)
close(qualData)
close(genoData)

qualityScoreBySnp

Mean and median quality score for SNPs

Description
This function calculates the mean and median quality score, over all scans with a non-missing genotype call, for each SNP.

Usage
qualityScoreBySnp(intenData, genoData, scan.exclude = NULL,
                   block.size = 5000, verbose = TRUE)

Arguments
intenData  IntensityData object
genoData   GenotypeData object
scan.exclude An integer vector containing the id’s of scans to be excluded.
block.size  Number of SNPs to be read from intenData and genoData at once.
verbose     Logical value specifying whether to show progress information.

Details
intenData and genoData must have matching snpID and scanID.

Value
The function returns a matrix with the following columns:
mean.quality  A vector of mean quality scores for each snp.
median.quality A vector of median quality scores for each snp.

Author(s)
Cathy Laurie

See Also
IntensityData, GenotypeData, qualityScoreByScan
Examples

```r
qualfile <- system.file("extdata", "illumina_qxy.gds", package="GWASdata")
qual <- GdsIntensityReader(qualfile)
qualData <- IntensityData(qual)

genofile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
geno <- GdsGenotypeReader(genofile)
genoData <- GenotypeData(geno)

quality <- qualityScoreBySnp(qualData, genoData)
close(qualData)
close(genoData)
```

---

**readWriteFirst**

*Read and write the first n lines of a file*

**Description**

Read first n lines of filein and write them to fileout, where filein and fileout are file names.

**Usage**

```r
readWriteFirst(filein, fileout, n)
```

**Arguments**

- `filein`: input file
- `fileout`: output file
- `n`: number of lines to write

**Author(s)**

Cathy Laurie

**Examples**

```r
path <- system.file("extdata", "affy_raw_data", package="GWASdata")
file <- paste(path, list.files(path)[1], sep="/"
outf <- tempfile()
readWriteFirst(file, outf, 20)
file.remove(outf)
```
relationsMeanVar

Mean and Variance information for full-sibs, half-sibs, first-cousins

**Description**

Computes theoretical mean and covariance matrix for \( k_0 \) vs. \( k_1 \) ibd coefficients for full-sib relationship along with inverse and eigenvalues/vectors of the covariance matrix.

Computes theoretical means and variances for half-sib relationship and for first-cousin relationship.

**Usage**

relationsMeanVar

**Format**

A list with the following entries:

- **FullSibs** list with following entries:
  - mean: mean of \((k_0,k_1)\) for full-sibs
  - cov: covariance matrix for full-sibs
  - invCov: inverse of the covariance matrix
  - eigvals: eigenvalues of the inverse covariance matrix
  - eigvectors: eigenvectors of the inverse covariance matrix

- **HalfSibs** list with following entries:
  - mean: mean of \((k_0,k_1)\) for half-sibs
  - var: variance for half-sibs

- **FirstCousins** list with following entries:
  - mean: mean of \((k_0,k_1)\) for first-cousins
  - var: variance for first-cousin

**Source**

computed by Cecelia Laurie using the referenced papers

**References**


**Examples**

```r
data(relationsMeanVar)
FS<-relationsMeanVar$FullSibs
FScov<-FS$cov  # gives covariance matrix for full-sibs
HS<-relationsMeanVar$HalfSibs
HSvar<-HS$var  # gives variance for half-sibs
```
**saveas**

*Save an R object with a new name*

**Description**

Saves an R object as name in an Rdata file called path/name.RData.

**Usage**

```r
saveas(obj, name, path=".")
```

**Arguments**

- `obj` R object to save
- `name` character string with the new name for the R object
- `path` path for the Rdata file (saved file will be path/name.RData)

**Details**

The suffix ".RData" will be appended to the new object name to create the file name, and the file will be written to the path directory.

**Author(s)**

Stephanie Gogarten

**See Also**

`getobj`

**Examples**

```r
x <- 1:10
path <- tempdir()
saveas(x, "myx", path)
newfile <- paste(path, "/myx", ".RData", sep="")
load(newfile) # myx now loaded
unlink(newfile)
```

---

**ScanAnnotationDataFrame**

*Class ScanAnnotationDataFrame*

**Description**

The ScanAnnotationDataFrame class stores annotation data associated with subjects in a genotyping study, where there may be multiple scans per subject, as well as metadata describing each column. It extends the AnnotatedDataFrame class.
ScanAnnotationDataFrame

**Extends**

AnnotatedDataFrame

**Constructor**

ScanAnnotationDataFrame(data, metadata):

data must be a data.frame containing the scan annotation. It must contain at least the following column:

- "scanID": vector containing unique scan ids.

If a column representing sex is present, it must have the following format:

- "sex": character vector with values 'M' or 'F'.

metadata is an optional data.frame containing a description for each column in data. It should contain a column "labelDescription", with row.names(metadata) == names(data). The ScanAnnotationDataFrame constructor creates and returns a ScanAnnotationDataFrame instance.

**Accessors**

In the code snippets below, object is a ScanAnnotationDataFrame object.

getScanID(object, index): A unique vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract.

getSex(object, index): A character vector of sex, with values 'M' or 'F'. The optional index is a logical or integer vector specifying elements to extract.

hasSex(object): Returns TRUE if the column 'sex' is present in object.

getVariable(object, varname, index): A vector of the column varname, with values 'M' or 'F'. The optional index is a logical or integer vector specifying elements to extract. If varname is itself a vector, returns a data.frame. Returns NULL if varname is not found in object.

hasVariable(object, varname): Returns TRUE if varname is a column in object, FALSE if not.

getVariableNames(object): Returns a character vector with the names of all columns in object.

getAnnotation(object): Returns all annotation variables as a data frame.

getMetadata(object): Returns metadata describing the annotation variables as a data frame.

Inherited methods from AnnotatedDataFrame:

varLabels(object): Returns a character vector with the names of all columns in object.

pData(object): Returns all annotation variables as a data frame, or sets the annotation variables with pData(object) <- df.

varMetadata(object): Returns metadata describing the annotation variables as a data frame, or sets the metadata with varMetadata(object) <- df.

The operators $ and [ work just as they do in standard data frames, for both retrieval and assignment.

**Author(s)**

Stephanie Gogarten

**See Also**

AnnotatedDataFrame, SnpAnnotationDataFrame, GenotypeData, IntensityData
Examples

library(GWASdata)
data(illumina_scan_annot)
scanAnnot <- ScanAnnotationDataFrame(illumina_scan_annot)

scanID <- getScanID(scanAnnot)
sex <- getSex(scanAnnot)
if (hasVariable(scanAnnot, "plate")) plate <- getVariable(scanAnnot, "plate")
subjectID <- getVariable(scanAnnot, "subjectID", index=(sex == "M"))

# list columns
varLabels(scanAnnot)

# add metadata
meta <- varMetadata(scanAnnot)
meta["scanID", "labelDescription"] <- "unique scan ID"
varMetadata(scanAnnot) <- meta

# display data
head(pData(scanAnnot))

# standard operators
scanID <- scanAnnot$scanID
sex <- scanAnnot[["sex"]]
subset <- scanAnnot[1:10, 1:5]
scanAnnot$newVar <- rep(1, nrow(scanAnnot))

# replace data
df <- pData(scanAnnot)
pData(scanAnnot) <- df

ScanAnnotationSQLite Class ScanAnnotationSQLite

Description

The ScanAnnotationSQLite class stores annotation data associated with scans, as well as metadata describing each column, in an SQLite database.

Constructor

ScanAnnotationSQLite(dbpath):

  dbpath is the path to a SQLite database with tables "Annotation" and "Metadata." "Annotation" must contain at least the following column:
  • "scanID": vector containing unique scan ids.

  If a column representing sex is present, it must have the following format:
  • "sex": character vector with values 'M' or 'F'.

  "Metadata" must contain at least the following columns:
  • "varname": name of variable in annotation
  • "description": description of column in annotation
If the database does not yet exist, a database is created with tables "Annotation" and "Metadata."
The ScanAnnotationSQLite constructor creates and returns a ScanAnnotationSQLite instance.

Accessors

In the code snippets below, object is a ScanAnnotationSQLite object.

open(object): Opens a connection to the database.
close(object): Closes the database connection.
nscan(object): The number of scans in the database.
getScanID(object, index, condition): A unique vector of scan IDs. The optional index is a logical or integer vector specifying elements to extract. The optional condition is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE sex='M'").
getSex(object, index, condition): A character vector of sex, with values 'M' or 'F'. The optional index is a logical or integer vector specifying elements to extract. The optional condition is a character string with an SQL clause used to select data.
hasSex(object): Returns TRUE if the column 'sex' is present in object.
getVariable(object, varname, index, condition): A vector of the column varname. The optional index is a logical or integer vector specifying elements to extract. The optional condition is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE sex='M'"). Returns NULL if varname is not found in object.
hasVariable(object, varname): Returns TRUE if varname is a column in object, FALSE if not.
getVariableNames(object): Returns a character vector with the names of all columns in object.
getAnnotation(object): Returns all annotation variables as a data frame.
getMetadata(object): Returns metadata describing the annotation variables as a data frame.
getQuery(object, statement): Returns result of the SQL query statement.
writeAnnotation(object, value, append=FALSE, overwrite=TRUE): Writes value to the scan annotation table. value must be a data.frame containing a column "scanID".
writeMetadata(object, value, append=FALSE, overwrite=TRUE): Writes value to the metadata table. value should be a data.frame containing columns "varname" and "description".

Author(s)

Stephanie Gogarten

See Also

SnpAnnotationSQLite, ScanAnnotationDataFrame, GenotypeData, IntensityData

Examples

library(GWASdata)
dbpath <- tempfile()
scanAnnot <- ScanAnnotationSQLite(dbpath)
data(illumina_scan_annot)
writeAnnotation(scanAnnot, illumina_scan_annot)
# list columns
t <- getVariableNames(scanAnnot)

# add metadata
metadf <- data.frame(varname=t, description=rep(NA, length(t)), row.names=t, stringsAsFactors=FALSE)
metadf["scanID", "description"] <- "unique id"
writeMetadata(scanAnnot, metadf)

scanID <- getScanID(scanAnnot)
sex <- getSex(scanAnnot)
if (hasVariable(scanAnnot, "plate")) plate <- getVariable(scanAnnot, "plate")
subjectID <- getVariable(scanAnnot, "subjectID", condition="WHERE sex='M'")

# display data
head(getAnnotation(scanAnnot))
getMetadata(scanAnnot)
close(scanAnnot)
file.remove(dbpath)

---

**setMissingGenotypes**  
*Write a new netCDF or GDS file, setting certain SNPs to missing*

**Description**

setMissingGenotypes copies an existing GDS or netCDF genotype file to a new one, setting SNPs in specified regions to missing.

**Usage**

```r
setMissingGenotypes(parent.file, new.file, regions, file.type=c("gds", "ncdf"),
    sample.include=NULL, compress="ZIP_RA",
    copy.attributes=TRUE, verbose=TRUE)
```

**Arguments**

- **parent.file** Name of the parent file
- **new.file** Name of the new file
- **regions** Data.frame of chromosome regions with columns "scanID", "chromosome", "left.base", "right.base",
- **file.type** The type of parent.file and new.file ("gds" or "ncdf")
- **sample.include** Vector of sampleIDs to include in new.file
- **compress** The compression level for variables in a GDS file (see add.gdsn for options).
- **copy.attributes** Logical value specifying whether to copy chromosome attributes to the new file.
- **verbose** Logical value specifying whether to show progress information.
setMissingGenotypes removes chromosome regions by setting SNPs that fall within the anomaly regions to NA (i.e., the missing value in the netCDF/GDS file). Optionally, entire samples may be excluded from the netCDF/GDS file as well: if the sample.include argument is given, only the scanIDs in this vector will be written to the new file, so the sample dimension will be length(sample.include). For regions with whole.chrom=TRUE, the entire chromosome will be set to NA for that sample. For other regions, only the region between left.base and right.base will be set to NA.

Author(s)

Stephanie Gogarten

See Also

gdsSubset, anomSegStats for chromosome anomaly regions

Examples

gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
gds <- GdsGenotypeReader(gdsfile)
sample.sel <- getScanID(gds, index=1:10)
close(gds)

regions <- data.frame("scanID"=sample.sel[1:3], "chromosome"=c(21, 22, 23),
"left.base"=c(14000000, 30000000, NA), "right.base"=c(20000000, 45000000, NA),
whole.chrom=c(FALSE, FALSE, TRUE))

newgds <- tempfile()
setMissingGenotypes(gdsfile, newgds, regions, file.type="gds", sample.include=sample.sel)
file.remove(newgds)

simulateGenotypeMatrix

Simulate Genotype or Intensity Matrix & Load into GDS/NetCDF File

Description

These functions create a simulated genotype or intensity file for test and examples.

Usage

simulateGenotypeMatrix(n.snps=10, n.chromosomes=10,
n.samples=1000, filename,
file.type=c("gds", "ncdf"), silent=TRUE)

Arguments

n.snps An integer corresponding to the number of SNPs per chromosome, the default value is 10. For this function, the number of SNPs is assumed to be the same for every chromosome.

n.chromosomes An integer value describing the total number of chromosomes with default value 10.
simulateGenotypeMatrix

n.samples  An integer representing the number of samples for our data. The default value is 1000 samples.
filename   A string that will be used as the name of the file. This is to be used later when opening and retrieving data generated from this function.
file.type  The type of file to create ("gds" or "ncdf")
silent     Logical value. If FALSE, the function returns a table of genotype counts generated. The default is TRUE; no data will be returned in this case.

Details

The resulting netCDF file will have the following characteristics:
Dimensions:
'snp': n.snps*n.chromosomes length
'sample': n.samples length
Variables:
'sampleID': sample dimension, values 1-n.samples
'position': snp dimension, values [1,2,...,n.chromosomes] n.snps times
'chromosome': snp dimension, values [1,1,...]n.snps times, [2,2,...]n.snps times, ..., [n.chromosomes,n.chromosomes,...]n.snps times
'genotype': 2-dimensional snp x sample, values 0, 1, 2 chosen from allele frequencies that were generated from a uniform distribution on (0,1). The missing rate is 0.05 (constant across all SNPs) and is denoted by -1.
OR
'quality': 2-dimensional snp x sample, values between 0 and 1 chosen randomly from a uniform distribution. There is one quality value per snp, so this value is constant across all samples.
'X': 2-dimensional snp x sample, value of X intensity taken from a normal distribution. The mean of the distribution for each SNP is based upon the sample genotype. Mean is 0,2 if sample is homozygous, 1 if heterozygous.
'Y': 2-dimensional snp x sample, value of Y intensity also chosen from a normal distribution, where the mean is chosen according to the mean of X so that sum of means = 2.

Value

simulateGenotypeMatrix returns a table of genotype calls if the silent variable is set to FALSE, where 2 indicates an AA genotype, 1 is AB, 0 is BB and -1 corresponds to a missing genotype call.
simulateIntensityMatrix returns a list if the silent variable is set to FALSE, which includes:

het        Heterozygosity table
nmiss      Number of missing values

A file is created and written to disk.

Author(s)
Caitlin McHugh

See Also
GdsGenotypeReader, GdsIntensityReader, NcdfGenotypeReader, NcdfIntensityReader
Examples

filenm <- tempfile()
simulateGenotypeMatrix(filename=filenm)

data <- GdsGenotypeReader(filenm)
data #notice the dimensions and variables listed

genot <- getGenotype(data)
table(genot) #can see the number of missing calls

chrom <- getChromosome(data)
unique(chrom) #there are indeed 10 chromosomes, as specified in the function call

close(data)

simulateIntensityMatrix(filename=filenm, silent=FALSE)

data <- GdsIntensityReader(filenm)
data #notice the dimensions and variables listed

xint <- getX(data)
yint <- getY(data)
print("Number missing is: "); sum(is.na(xint))

chrom <- getChromosome(data)
unique(chrom) #there are indeed 10 chromosomes, as specified in the function call

close(data)

unlink(filenm)

SnpAnnotationDataFrame

Class SnpAnnotationDataFrame

Description

The SnpAnnotationDataFrame class stores annotation data associated with SNPs, as well as metadata describing each column. It extends the AnnotatedDataFrame class.

Extends

AnnotatedDataFrame

Constructor

SnpAnnotationDataFrame(data, metadata):

data must be a data.frame containing the SNP annotation. It must contain at least the following columns:

• "snpID": integer vector containing unique SNP ids.
• "chromosome": integer vector containing chromosome codes.
SnpAnnotationDataFrame

- "position": integer vector containing position (in base pairs) on the chromosome.

Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments autosomeCode, XchromCode, XYchromCode, YchromCode, and MchromCode.

metadata is an optional data.frame containing a description for each column in data. It should contain a column "labelDescription", with rownames(metadata) == names(data). The SnpAnnotationDataFrame constructor creates and returns a SnpAnnotationDataFrame instance.

Accessors

In the code snippets below, object is a SnpAnnotationDataFrame object.

getSnpID(object, index): A unique integer vector of snp IDs. The optional index is a logical or integer vector specifying elements to extract.

getChromosome(object, index, char=FALSE): A vector of chromosomes. The optional index is a logical or integer vector specifying elements to extract. If char=FALSE (default), returns an integer vector. If char=TRUE, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.

getPosition(object, index): An integer vector of base pair positions. The optional index is a logical or integer vector specifying elements to extract.

getAlleleA(object, index): A character vector of A alleles. The optional index is a logical or integer vector specifying elements to extract.

getAlleleB(object, index): A character vector of B alleles. The optional index is a logical or integer vector specifying elements to extract.

getVariable(object, varname, index): A vector of the column varname. The optional index is a logical or integer vector specifying elements to extract. If varname is itself a vector, returns a data.frame. Returns NULL if varname is not found in object.

hasVariable(object, varname): Returns TRUE if varname is a column in object, FALSE if not.

getVariableNames(object): Returns a character vector with the names of all columns in object.

getAnnotation(object): Returns all annotation variables as a data frame.

getMetadata(object): Returns metadata describing the annotation variables as a data frame.

Inherited methods from AnnotatedDataFrame:

varLabels(object): Returns a character vector with the names of all columns in object.
pData(object): Returns all annotation variables as a data frame, or sets the annotation variables with pData(object) <- df.

varMetadata(object): Returns metadata describing the annotation variables as a data frame, or sets the metadata with varMetadata(object) <- df.

The operators [], $, and [[ work just as they do in standard data frames, for both retrieval and assignment.

autosomeCode(object): Returns the integer codes for the autosomes.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.
Author(s)

Stephanie Gogarten

See Also

AnnotatedDataFrame, ScanAnnotationDataFrame, GenotypeData, IntensityData

Examples

```r
library(GWASdata)
data(illumina_snp_annot)
snpAnnot <- SnpAnnotationDataFrame(illumina_snp_annot)

# list columns
varLabels(snpAnnot)

# add metadata
meta <- varMetadata(snpAnnot)
meta["snpID", "labelDescription"] <- "unique integer ID"
varMetadata(snpAnnot) <- meta

# get snpID and chromosome
snpID <- getSNPID(snpAnnot)
chrom <- getChromosome(snpAnnot)

# get positions only for chromosome 22
pos22 <- getPosition(snpAnnot, index=(chrom == 22))

# get rsID
if (hasVariable(snpAnnot, "rsID")) rsID <- getVariable(snpAnnot, "rsID")

# display data
head(pData(snpAnnot))

# standard operators
snpID <- snpAnnot$snpID
chrom <- snpAnnot[["chromosome"]]
subset <- snpAnnot[1:10, 1:5]
snpAnnot$newVar <- rep(1, nrow(snpAnnot))

# replace data
df <- pData(snpAnnot)
pData(snpAnnot) <- df

# PLINK chromosome coding
snpID <- 1:10
chrom <- c(rep(1L,5), 23:27)
pos <- 101:110
df <- data.frame(snpID=snpID, chromosome=chrom, position=pos)
snpAnnot <- SnpAnnotationDataFrame(df, YchromCode=24L, XYchromCode=25L)
getChromosome(snpAnnot, char=TRUE)
```
**Description**

The SnpAnnotationSQLite class stores annotation data associated with SNPs, as well as metadata describing each column, in an SQLite database.

**Constructor**

`SnpAnnotationSQLite(dbpath)`:
- `dbpath` is the path to a SQLite database with tables "Annotation" and "Metadata." "Annotation" must contain at least the following columns:
  - "snpID": integer vector containing unique SNP ids.
  - "chromosome": integer vector containing chromosome codes.
  - "position": integer vector containing position (in base pairs) on the chromosome.
- Default values for chromosome codes are 1-22=autosome, 23=X, 24=XY, 25=Y, 26=M. The defaults may be changed with the arguments `autosomeCode`, `XchromCode`, `XYchromCode`, `YchromCode`, and `MchromCode`.
- "Metadata" must contain at least the following columns:
  - "varname": name of variable in annotation
  - "description": description of column in annotation
- If the database does not yet exist, a database is created with tables "Annotation" and "Metadata."
- The `SnpAnnotationSQLite` constructor creates and returns a `SnpAnnotationSQLite` instance.

**Accessors**

In the code snippets below, `object` is a `SnpAnnotationSQLite` object.

- `open(object)`: Opens a connection to the database.
- `close(object)`: Closes the database connection.
- `nsnp(object)`: The number of SNPs in the database.
- `getSnpID(object, index, condition)`: A unique integer vector of snp IDs. The optional `index` is a logical or integer vector specifying elements to extract. The optional `condition` is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1").
- `getChromosome(object, index, condition, char=FALSE)`: A vector of chromosomes. The optional `index` is a logical or integer vector specifying elements to extract. The optional `condition` is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1"). If `char=FALSE` (default), returns an integer vector. If `char=TRUE`, returns a character vector with elements in (1:22,X,XY,Y,M,U). "U" stands for "Unknown" and is the value given to any chromosome code not falling in the other categories.
- `getPosition(object, index, condition)`: An integer vector of base pair positions. The optional `index` is a logical or integer vector specifying elements to extract. The optional `condition` is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1").
getAlleleA(object, index): A character vector of A alleles. The optional condition is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1").

getAlleleB(object, index): A character vector of B alleles. The optional condition is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1").

getVariable(object, varname, index, condition): A vector of the column varname. The optional index is a logical or integer vector specifying elements to extract. The optional condition is a character string with an SQL clause used to select data (e.g., "LIMIT 10", "WHERE chromosome=1"). Returns NULL if varname is not found in object.

hasVariable(object, varname): Returns TRUE if varname is a column in object, FALSE if not.

getVariableNames(object): Returns a character vector with the names of all columns in object.

getAnnotation(object): Returns all annotation variables as a data frame.

getMetadata(object): Returns metadata describing the annotation variables as a data frame.

getQuery(object, statement): Returns result of the SQL query statement.

writeAnnotation(object, value, append=FALSE, overwrite=TRUE): Writes value to the SNP annotation table. value must be a data.frame containing columns "snpID", "chromosome", and "position".

writeMetadata(object, value, append=FALSE, overwrite=TRUE): Writes value to the metadata table. value should be a data.frame containing columns "varname" and "description".

autosomalCode(object): Returns the integer codes for the autosomes.

XchromCode(object): Returns the integer code for the X chromosome.

XYchromCode(object): Returns the integer code for the pseudoautosomal region.

YchromCode(object): Returns the integer code for the Y chromosome.

MchromCode(object): Returns the integer code for mitochondrial SNPs.

Author(s)
Stephanie Gogarten

See Also
ScanAnnotationSQLite, SnpAnnotationDataFrame, GenotypeData, IntensityData

Examples
library(GWASdata)
dbpath <- tempfile()
snpAnnot <- SnpAnnotationSQLite(dbpath)
data(illumina_snp_annot)
writeAnnotation(snpAnnot, illumina_snp_annot)

# list columns
vars <- getVariableNames(snpAnnot)

# add metadata
metadf <- data.frame(varname=vars, description=rep(NA, length(vars)),
  row.names=vars, stringsAsFactors=FALSE)
metadf["snpID", "description"] <- "integer id"
writeMetadata(snpAnnot, metadf)

# get snpID and chromosome
snpID <- getSnpID(snpAnnot)
chrom <- getChromosome(snpAnnot)

# get positions only for chromosome 22
pos22 <- getPosition(snpAnnot, condition="WHERE chromosome = 22")

# get rsID
if (hasVariable(snpAnnot, "rsID")) rsID <- getVariable(snpAnnot, "rsID")

# display data
head(getAnnotation(snpAnnot))
getMetadata(snpAnnot)

close(snpAnnot)
file.remove(dbpath)

---

snpCorrelationPlot  SNP correlation plot

Description
Plots SNP correlation versus chromosome.

Usage
snpCorrelationPlot(correlations, chromosome,
ylim=c(0,1), ylab = "abs(correlation)", ...)

Arguments
- correlations  A vector of correlations.
- chromosome  A vector containing the chromosome for each SNP.
- ylim  The limits of the y axis.
- ylab  The label for the y axis.
- ...  Other parameters to be passed directly to plot.

Details
Plots SNP correlations (from, e.g., PCA), versus chromosome.
correlations must have the same length as chromosome and is assumed to be in order of position on each chromosome. Values within each chromosome are evenly spaced along the X axis.

Author(s)
Cathy Laurie

See Also
manhattanPlot
Examples

correlations <- sample(0.001*(0:1000), 1000, replace=TRUE)
chromosome <- c(rep(1,400), rep(2,350), rep("X",200), rep("Y",50))
snpCorrelationPlot(correlations, chromosome)

vcfWrite Utility to write VCF file

description

vcfWrite creates a VCF file from a GenotypeData object.

Usage

vcfWrite(genoData, vcf.file="out.vcf", sample.col="scanID", id.col="snpID", qual.col=NULL, filter.cols=NULL, info.cols=NULL, scan.exclude=NULL, snp.exclude=NULL, scan.order=NULL, ref.allele=NULL, block.size=1000, verbose=TRUE)

vcfCheck(genoData, vcf.file, sample.col="scanID", id.col="snpID", block.size=1000, verbose=TRUE)

Arguments

genodata A GenotypeData object with scan and SNP annotation.
vcf.file Filename for the output VCF file.
sample.col name of the column in the scan annotation to use as sample IDs in the VCF file
id.col name of the column in the SNP annotation to use as "ID" column in the VCF file
qual.col name of the column in the SNP annotation to use as "QUAL" column in the VCF file
filter.cols vector of column names in the SNP annotation to use as "FILTER" column in the VCF file. These columns should be logical vectors, with TRUE for SNPs to be filtered. Any SNPs with a value of FALSE for all filter columns will be set to "PASS".
info.cols vector of column names in the SNP annotation to concatenate for the "INFO" column in the VCF file.
scan.exclude vector of scanIDs to exclude from VCF file
snp.exclude vector of snpIDs to exclude from VCF file
scan.order vector of scanIDs to include in VCF file, in the order in which they should be written
ref.allele vector of "A" or "B" values indicating where allele A or allele B should be the reference allele for each SNP. Default is to use allele A as the reference allele.
block.size Number of SNPs to read from genoData at a time
verbose logical for whether to show progress information.
vcfWrite

Details

REF will be alleleA and ALT will be alleleB.

vcfCheck compares the genotypes (diploid only) in a VCF file to the corresponding genotypes in genoData. It stops with an error when it detects a discordant genotype. It assumes that the "ID" column of the VCF file has unique values that can be matched with a column in the SNP annotation, and that all SNPs in the VCF file are present in genoData.

Author(s)

Stephanie Gogarten

References


See Also

snpgdsVCF2GDS

Examples

library(GWASdata)
library(VariantAnnotation)
gdsfile <- system.file("extdata", "illumina_geno.gds", package="GWASdata")
data(illuminaSnpADF, illuminaScanADF)
genoData <- GenotypeData(GdsGenotypeReader(gdsfile),
scanAnnot=illuminaScanADF, snpAnnot=illuminaSnpADF)
vcffile <- tempfile()
vcfWrite(genoData, vcffile, id.col="rsID", info.cols="IntensityOnly")
vcf <- readVcf(vcffile, "hg18")
vcf
vcfCheck(genoData, vcffile, id.col="rsID")
close(genoData)
unlink(vcffile)
Index

*Topic **IO**
  readWriteFirst, 123
*Topic **Mendelian**
  mende1Err, 94
  mendellist, 96
*Topic **classes**
  GdsGenotypeReader, 57
  GdsIntensityReader, 60
  GdsReader, 62
  GenotypeData-class, 67
  IntensityData-class, 85
  MatrixGenotypeReader, 91
  NcdfGenotypeReader, 100
  NcdfIntensityReader, 102
  NcdfReader, 105
  ScanAnnotationDataFrame, 125
  ScanAnnotationSQLite, 127
  SnpAnnotationDataFrame, 132
  SnpAnnotationSQLite, 135
*Topic **datagen**
  BAFfromClusterMeans, 30
  BAFfromGenotypes, 32
  simulateGenotypeMatrix, 130
*Topic **datasets**
  centromeres, 36
  HLA, 77
  pcaSnpFilters, 107
  pseudoautosomal, 119
  relationsMeanVar, 124
*Topic **distribution**
  duplicateDiscordanceProbability, 52
*Topic **file**
  readWriteFirst, 123
*Topic **hplot**
  anomSegStats, 18
  chromIntensityPlot, 37
  genoClusterPlot, 65
  ibdPlot, 78
  intensityOutliersPlot, 88
  manhattanPlot, 89
  pseudoautoIntensityPlot, 118
  qqPlot, 120
  snpCorrelationPlot, 137
*Topic **htest**
  batchTest, 33
*Topic **logic**
  allequal, 5
*Topic **manip**
  alleleFrequency, 4
  anomDetectBAF, 6
  anomDetectLOH, 11
  anomIdentifyLowQuality, 15
  anomSegStats, 18
  apartSnpSelection, 22
  asSnpMatrix, 23
  BAFfromClusterMeans, 30
  BAFfromGenotypes, 32
  convertNcdfGds, 39
  createDataFile, 40
  duplicateDiscordance, 45
  duplicateDiscordanceAcrossDatasets, 47
  exactHWE, 53
  findBAFvariance, 55
  gdsSubset, 64
  genotypeToCharacter, 71
  hetByScanChrom, 75
  hetBySnpSex, 76
  ibdPlot, 78
  imputedDosageFile, 81
  pasteSorted, 106
  pedigreeCheck, 108
  pedigreeDeleteDuplicates, 110
  pedigreeMaxUnrelated, 111
  pedigreePairwiseRelatedness, 114
  plinkUtils, 115
  setMissingGenotypes, 129
  vcfWrite, 138
*Topic **methods**
  GdsGenotypeReader, 57
  GdsIntensityReader, 60
  GdsReader, 62
  GenotypeData-class, 67
  getVariable, 73
  IntensityData-class, 85
INDEX

MatrixGenotypeReader, 91
NcdfGenotypeReader, 100
NcdfIntensityReader, 102
NcdfReader, 105
ScanAnnotationDataFrame, 125
ScanAnnotationSQLite, 127
SnpAnnotationDataFrame, 132
SnpAnnotationSQLite, 135

*Topic models
assocRegression, 27

*Topic package
GWASTools-package, 3

*Topic regression
assocRegression, 27

*Topic survival
assocCoxPH, 25

*Topic univar
meanIntensityByScanChrom, 93
missingGenotypeByScanChrom, 98
missingGenotypeBySnpSex, 99
qualityScoreByScan, 121
qualityScoreBySnp, 122

*Topic utilities
getobj, 72
saveas, 125
add.gdsn, 31, 32, 39, 42, 64, 82, 129
all, 6
all.equal, 6
alleleFrequency, 4, 46
allequal, 5
AnnotatedDataFrame, 4, 125, 126, 132–134
anomDetectBAF, 6, 11, 16–18, 21, 22
anomDetectLOH, 10, 11, 14, 16–18, 22
anomFilterBAF (anomDetectBAF), 6
anomIdentifyLowQuality, 15
anomSegmentBAF (anomDetectBAF), 6
anomSegStats, 18, 130
anomStatsPlot (anomSegStats), 18
apartSnpSelection, 22
asSnpMatrix, 23
assocCoxPH, 25, 75
assocRegression, 27, 75, 83
assocTestCoxPH (GWASTools-defunct), 75
assocTestFisherExact (GWASTools-defunct), 75
assocTestRegression (GWASTools-defunct), 75
autosomalCode, GdsGenotypeReader-method
(GdsGenotypeReader-class), 67
autosomalCode, IntensityData-method
(IntensityData-class), 75
autosomalCode, MatrixGenotypeReader-method
(MatrixGenotypeReader-class), 85
autosomalCode, NcdfGenotypeReader-method
(NcdfGenotypeReader-class), 91
autosomalCode, NcdfIntensityReader-method
(NcdfIntensityReader-class), 100
autosomalCode, ScanAnnotationDataFrame-method
(ScanAnnotationDataFrame-class), 127
autosomalCode, ScanAnnotationSQLite-method
(ScanAnnotationSQLite-class), 127
autosomalCode, SnpAnnotationDataFrame-method
(SnpAnnotationDataFrame-class), 132
autosomalCode, SnpAnnotationSQLite-method
(SnpAnnotationSQLite-class), 135

BAFfromClusterMeans, 30, 31, 33, 57
BAFfromGenotypes, 32, 38, 57, 118
batchChisqTest (batchTest), 33
batchFisherTest, 75
batchFisherTest (batchTest), 33
batchTest, 33

centromeres, 7, 11, 18, 36
checkGenotypeFile, 75
checkGenotypeFile (createDataFile), 40
checkImputedDosageFile, 75
checkImputedDosageFile (imputedDosageFile), 81
checkIntensityFile, 75
checkIntensityFile (createDataFile), 40
checkNcdfGds (convertNcdfGds), 39
chisq.test, 35
chromIntensityPlot, 33, 37
close, GdsReader-method (GdsReader), 62
close, GenotypeData-method
(GenotypeData-class), 67
close, IntensityData-method
(IntensityData-class), 85
close, NcdfReader-method (NcdfReader), 105
close, ScanAnnotationSQLite-method
(ScanAnnotationSQLite-class), 127
close, SnpAnnotationSQLite-method
(SnpAnnotationSQLite-class), 135
convertGdsNcdf (convertNcdfGds), 39
convertNcdfGds, 39
convertVcfGds (GWASTools-defunct), 75
coxph, 26
createAffyIntensityFile, 75
createAffyIntensityFile
(createDataFile), 40
creatDataFrame, 40, 65, 75, 83
INDEX

getDimension, NcdfReader-method (NcdfReader), 105
getDimensionNames, NcdfReader-method (NcdfReader), 105
getGenotype, getVariable, 73
getGenotype, GdsGenotypeReader-method (GdsGenotypeReader), 57
getGenotype, GenotypeData-method (GenotypeData-class), 67
getGenotype, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getGenotypeSelection, getVariable, 73
getLogRRatio, GdsIntensityReader-method (GdsIntensityReader), 73
getLogRRatio, IntensityData-method (IntensityData-class), 67
getLogRRatio, NcdfIntensityReader-method (NcdfIntensityReader), 102
getMetadata, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 73
getMetadata, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getMetadata, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getMetadata, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getMetadata, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getNodeDescription, getVariable, 73
getNodeDescription, GdsReader-method (GdsReader), 62
getobj, 72, 125
getPosition, NcdfGenotypeReader-method (NcdfGenotypeReader), 105
getPosition, NcdfIntensityReader-method (NcdfIntensityReader), 102
getPosition, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getPosition, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getQuality, getVariable, 73
getQuality, GdsIntensityReader-method (GdsIntensityReader), 60
getQuality, IntensityData-method (IntensityData-class), 85
getQuality, NcdfIntensityReader-method (NcdfIntensityReader), 102
getScanID, getVariable, 73
getScanID, GdsGenotypeReader-method (GdsGenotypeReader), 57
getScanID, GenotypeData-method (GenotypeData-class), 67
getScanID, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getScanID, NcdfIntensityReader-method (NcdfIntensityReader), 102
getScanAnnotation, GenotypeData-method (GenotypeData-class), 67
getQuery, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getScanAnnotation, GenotypeData-method (GenotypeData-class), 67
getQuery, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getQuery, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getQuery, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getScanID, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getScanID, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getScanVariable, getVariable, 73
getScanVariable, GenotypeData-method (GenotypeData-class), 67
getScanVariable, IntensityData-method (IntensityData-class), 85
getScanVariableNames, getVariable, 73
getScanVariableNames, GenotypeData-method (GenotypeData-class), 67
getScanVariableNames, IntensityData-method (IntensityData-class), 85

getDimensionNames, NcdfReader-method (NcdfReader), 105
getGenotype, getVariable, 73
getGenotype, GdsGenotypeReader-method (GdsGenotypeReader), 57
getGenotype, GenotypeData-method (GenotypeData-class), 67
getGenotype, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getGenotypeSelection, getVariable, 73
getLogRRatio, GdsIntensityReader-method (GdsIntensityReader), 73
getLogRRatio, IntensityData-method (IntensityData-class), 67
getLogRRatio, NcdfIntensityReader-method (NcdfIntensityReader), 102
getMetadata, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 73
getMetadata, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getMetadata, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getMetadata, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getMetadata, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getNodeDescription, getVariable, 73
getNodeDescription, GdsReader-method (GdsReader), 62
getobj, 72, 125
getPosition, NcdfGenotypeReader-method (NcdfGenotypeReader), 105
getPosition, NcdfIntensityReader-method (NcdfIntensityReader), 102
getPosition, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getPosition, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getQuality, getVariable, 73
getQuality, GdsIntensityReader-method (GdsIntensityReader), 60
getQuality, IntensityData-method (IntensityData-class), 85
getQuality, NcdfIntensityReader-method (NcdfIntensityReader), 102
getScanID, getVariable, 73
getScanID, GdsGenotypeReader-method (GdsGenotypeReader), 57
getScanID, GenotypeData-method (GenotypeData-class), 67
getScanID, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getScanID, NcdfIntensityReader-method (NcdfIntensityReader), 102
getScanAnnotation, GenotypeData-method (GenotypeData-class), 67
getQuery, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getScanAnnotation, GenotypeData-method (GenotypeData-class), 67
getQuery, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getQuery, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getQuery, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getScanID, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getScanID, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getScanVariable, getVariable, 73
getScanVariable, GenotypeData-method (GenotypeData-class), 67
getScanVariable, IntensityData-method (IntensityData-class), 85
getScanVariableNames, getVariable, 73
getScanVariableNames, GenotypeData-method (GenotypeData-class), 67
getScanVariableNames, IntensityData-method (IntensityData-class), 85
getSex (getVariable), 73
getSex, GenotypeData-method (GenotypeData-class), 67
getSex, IntensityData-method (IntensityData-class), 85
getSex, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getSex, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getSnpAnnotation (getVariable), 73
getSnpAnnotation, GenotypeData-method (GenotypeData-class), 67
getSnpAnnotation, IntensityData-method (IntensityData-class), 85
getSnpAnnotation, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
getSnpAnnotation, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getSnpAnnotation, NcdfIntensityReader-method (NcdfIntensityReader), 102
getSnpAnnotation, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getSnpAnnotation, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getSnpAnnotation, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getSnpAnnotation, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getSnpAnnotationNames (getVariable), 73
getSnpAnnotationNames, GenotypeData-method (GenotypeData-class), 67
getSnpAnnotationNames, IntensityData-method (IntensityData-class), 85
getSnpAnnotationNames, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
getSnpAnnotationNames, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getSnpAnnotationNames, NcdfIntensityReader-method (NcdfIntensityReader), 102
getSnpAnnotationNames, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getSnpAnnotationNames, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getSnpAnnotationNames, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getSnpAnnotationNames, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getSnpVariable (getVariable), 73
getSnpVariable, GenotypeData-method (GenotypeData-class), 67
getSnpVariable, IntensityData-method (IntensityData-class), 85
getSnpVariable, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
getSnpVariable, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getSnpVariable, NcdfIntensityReader-method (NcdfIntensityReader), 102
getSnpVariable, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getSnpVariable, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getSnpVariable, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getSnpVariable, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getSnpVariableNames (getVariable), 73
getSnpVariableNames, GenotypeData-method (GenotypeData-class), 67
getSnpVariableNames, IntensityData-method (IntensityData-class), 85
getSnpVariableNames, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
getSnpVariableNames, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getSnpVariableNames, NcdfIntensityReader-method (NcdfIntensityReader), 102
getSnpVariableNames, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getSnpVariableNames, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getSnpVariableNames, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getSnpVariableNames, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getX (getVariable), 73
getX, GenotypeData-method (GenotypeData-class), 67
getX, IntensityData-method (IntensityData-class), 85
getX, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getX, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getX, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getX, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getY (getVariable), 73
getY, GenotypeData-method (GenotypeData-class), 67
getY, IntensityData-method (IntensityData-class), 85
getY, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getY, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getY, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getY, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
hasBAlleleFreq (getVariable), 73
hasBAlleleFreq, GenotypeData-method (GenotypeData-class), 67
hasBAlleleFreq, IntensityData-method (IntensityData-class), 85
hasBAlleleFreq, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
hasBAlleleFreq, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasBAlleleFreq, NcdfReader-method (NcdfReader), 105
hasBAlleleFreq, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
hasBAlleleFreq, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
hasBAlleleFreq, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
hasBAlleleFreq, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
glm, 28, 29
GWASExactHW, 54
gwasExactHW (GWASTools-defunct), 75
GWASTools (GWASTools-package), 3
GWASTools-defunct, 75
GWASTools-package, 3
hasBAlleleFreq (getVariable), 73
hasBAlleleFreq, GdsIntensityReader-method (GdsIntensityReader), 60
hasBAlleleFreq, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
hasBAlleleFreq, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasBAlleleFreq, NcdfReader-method (NcdfReader), 105
hasBAlleleFreq, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
hasBAlleleFreq, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
hasBAlleleFreq, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
hasBAlleleFreq, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getVariable, GenotypeData-method (GenotypeData-class), 67
getVariable, IntensityData-method (IntensityData-class), 85
getVariable, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getVariable, NcdfIntensityReader-method (NcdfIntensityReader), 102
getVariable, NcdfReader-method (NcdfReader), 105
getVariable, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getVariable, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getVariable, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getVariable, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
getVariable Names (getVariable), 73
getVariable Names, GenotypeData-method (GenotypeData-class), 67
getVariable Names, IntensityData-method (IntensityData-class), 85
getVariable Names, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
getVariable Names, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
getVariable Names, NcdfIntensityReader-method (NcdfIntensityReader), 102
getVariable Names, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
getVariable Names, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
getVariable Names, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
getVariable Names, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
INDEX

hasBAlleleFreq, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasCoordVariable (NcdfReader), 105
hasCoordVariable, NcdfReader-method (NcdfReader), 105
hasLogRRatio (getVariable), 73
hasLogRRatio, GdsIntensityReader-method (GdsIntensityReader), 60
hasLogRRatio, IntensityData-method (IntensityData-class), 85
hasLogRRatio, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasQuality (getVariable), 73
hasQuality, GdsIntensityReader-method (GdsIntensityReader), 60
hasQuality, IntensityData-method (IntensityData-class), 85
hasQuality, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasScanAnnotation (getVariable), 73
hasScanAnnotation, GenotypeData-method (GenotypeData-class), 67
hasScanAnnotation, IntensityData-method (IntensityData-class), 85
hasScanVariable (getVariable), 73
hasScanVariable, GenotypeData-method (GenotypeData-class), 67
hasScanVariable, IntensityData-method (IntensityData-class), 85
hasSex (getVariable), 73
hasSex, GenotypeData-method (GenotypeData-class), 67
hasSex, IntensityData-method (IntensityData-class), 85
hasSex, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
hasSex, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
hasSnpAnnotation (getVariable), 73
hasSnpAnnotation, GenotypeData-method (GenotypeData-class), 67
hasSnpAnnotation, IntensityData-method (IntensityData-class), 85
hasVariable (getVariable), 73
hasVariable, GdsReader-method (GdsReader), 62
hasVariable, GenotypeData-method (GenotypeData-class), 67
hasVariable, IntensityData-method (IntensityData-class), 85
hasVariable, NcdfReader-method (NcdfReader), 105
hasVariable, ScanAnnotationDataFrame-method (ScanAnnotationDataFrame), 125
hasVariable, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
hasVariable, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
hasVariable, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
hasX (getVariable), 73
hasX, GdsIntensityReader-method (GdsIntensityReader), 60
hasX, IntensityData-method (IntensityData-class), 85
hasX, NcdfIntensityReader-method (NcdfIntensityReader), 102
hasY (getVariable), 73
hasY, GdsIntensityReader-method (GdsIntensityReader), 60
hasY, IntensityData-method (IntensityData-class), 85
hasY, NcdfIntensityReader-method (NcdfIntensityReader), 102
hetByScanChrom, 75, 77
hetBySnpSex, 76, 76
HLEffect, 54
ibdAreasDraw (ibdPlot), 78
ibdAssignRelatedness (ibdPlot), 78
ibdAssignRelatednessKing (ibdPlot), 78
ibdPlot, 78
identical, 6
imputedDosageFile, 75, 81, 82
IntensityData, 4, 7, 11, 18, 31–33, 37, 38, 55, 57, 62, 66, 69, 93, 102, 104, 118, 121, 122, 126, 128, 134, 136
IntensityData (IntensityData-class), 85
IntensityData-class, 85
intensityOutliersPlot, 88
kingIBS0FSCI (ibdPlot), 78
lm, 28, 29
logistf, 28, 29
lrtest, 29
manhattanPlot, 89, 137
MatrixGenotypeReader, 68, 69, 91
MatrixGenotypeReader-class (MatrixGenotypeReader), 91
MchromCode (getVariable), 73
MchromCode, GdsGenotypeReader-method (GdsGenotypeReader), 57
MchromCode, GdsIntensityReader-method (GdsIntensityReader), 60
MchromCode, GenotypeData-method (GenotypeData-class), 67
MchromCode, IntensityData-method (IntensityData-class), 85
MchromCode, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
MchromCode, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
MchromCode, NcdfIntensityReader-method (NcdfIntensityReader), 102
MchromCode, SnpAnnotationDataframe-method (SnpAnnotationDataframe), 132
MchromCode, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
mean, 93
meanIntensityByScanChrom, 88, 93
meanSdByChromWindow (findBAFvariance), 55
medianSdOverAutosomes, 7, 15
medianSdOverAutosomes (findBAFvariance), 55
mendelErr, 94, 97
mendellist, 94, 95, 96
mendellistAsDataFrame (mendellist), 96
minorAlleleDetectionAccuracy (duplicateDiscordanceAcrossDatasets), 47
missingGenotypeByScanChrom, 98, 100
missingGenotypeBySnpSex, 99, 99
ncdf4, 40, 44, 105, 106
ncdfAddData (GWASTools-defunct), 75
ncdfAddIntensity (GWASTools-defunct), 75
ncdfCheckGenotype (GWASTools-defunct), 75
ncdfCheckIntensity (GWASTools-defunct), 75
ncdfCreate (GWASTools-defunct), 75
NcdfGenotypeReader, 68, 69, 83, 92, 100, 104, 106, 131
NcdfGenotypeReader-class (NcdfGenotypeReader), 100
ncdfImputedDosage (GWASTools-defunct), 75
NcdfIntensityReader, 85, 87, 102, 102, 106, 131
NcdfIntensityReader-class (NcdfIntensityReader), 102
NcdfReader, 100–104, 105
NcdfReader, 100–104, 105
ncdfSetMissingGenotypes (GWASTools-defunct), 75
ncdfSubset (GWASTools-defunct), 75
ncdfSubsetCheck (GWASTools-defunct), 75
ncvar_change missval, 105
nscan (getVariable), 73
nscan, GdsGenotypeReader-method (GdsGenotypeReader), 57
nscan, GdsIntensityReader-method (GdsIntensityReader), 60
nscan, GenotypeData-method (GenotypeData-class), 67
nscan, IntensityData-method (IntensityData-class), 85
nscan, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
nscan, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
nscan, NcdfIntensityReader-method (NcdfIntensityReader), 102
nscan, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
nsnp (getVariable), 73
nsnp, GdsGenotypeReader-method (GdsGenotypeReader), 57
nsnp, GdsIntensityReader-method (GdsIntensityReader), 60
nsnp, GenotypeData-method (GenotypeData-class), 67
nsnp, IntensityData-method (IntensityData-class), 85
nsnp, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
nsnp, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
nsnp, NcdfIntensityReader-method (NcdfIntensityReader), 102
nsnp, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
open, GdsReader-method (GdsReader), 62
open, GenotypeData-method (GenotypeData-class), 67
open, IntensityData-method (IntensityData-class), 85
open, NcdfReader-method (NcdfReader), 105
open, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
INDEX

open, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
paste, 106
pasteSorted, 106
pcaSnpFilters, 107
pedigreeCheck, 75, 108, 111, 112, 114, 115
pedigreeDeleteDuplicates, 109, 110
pedigreeMaxUnrelated, 111, 115
pedigreePairwiseRelatedness, 79, 80, 109, 111, 112, 114
plinkCheck (plinkUtils), 115
plinkToNcdf (GWASTools-defunct), 75
plinkUtils, 115
plinkWrite (plinkUtils), 115
plot, 19, 38, 66, 79, 88, 90, 118, 120, 137
points, 79
pseudoautoIntensityPlot, 118
pseudoautosomal, 7, 11, 15, 18, 19, 118, 119
put.attr.gdsn, 63
qQPlot, 120
qualityScoreByScan, 121, 122
qualityScoreBySnp, 121, 122
readWriteFirst, 123
relationshipsMeanVar, 80, 124
saveas, 72, 125
scanAnnotationDataFrame, 4, 68, 69, 82, 85, 87, 125, 128, 134
scanAnnotationDataFrame-class (scanAnnotationDataFrame), 125
scanAnnotationSQLite, 4, 68, 69, 85, 87, 127, 136
scanAnnotationSQLite-class (scanAnnotationSQLite), 127
sd, 93
sdByScanChromWindow, 7
sdByScanChromWindow(findBAFvariance), 55
segment, 7, 8, 10, 11, 14
setMissingGenotypes, 75, 129
show, GdsReader-method (GdsReader), 62
show, GenotypeData-method (GenotypeData-class), 67
show, IntensityData-method (IntensityData-class), 85
show, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
show, NcdfReader-method (NcdfReader), 105
show, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 127
show, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
simulateGenotypeMatrix, 130
simulateIntensityMatrix (simulateGenotypeMatrix), 130
smooth.CNA, 7, 10, 11, 14
scanAnnotationDataFrame, 4, 15, 39, 68, 69, 82, 85, 87, 126, 132, 136
scanAnnotationDataFrame-class (scanAnnotationDataFrame), 132
scanAnnotationSQLite, 4, 68, 69, 85, 87, 128, 135
scanAnnotationSQLite-class (scanAnnotationSQLite), 135
snpgdsBED2GDS, 73, 117
snpgdsVCF2GDS, 73, 139
Surv, 26
survival, 26
writeAnnotation (getVariable), 73
writeAnnotation, scanAnnotationSQLite-method (scanAnnotationSQLite), 127
writeAnnotation, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
writeMetadata (getVariable), 73
writeMetadata, scanAnnotationSQLite-method (scanAnnotationSQLite), 127
writeMetadata, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
xChromCode (getVariable), 73
xChromCode, GdsGenotypeReader-method (GdsGenotypeReader), 57
xChromCode, GdsIntensityReader-method (GdsIntensityReader), 60
xChromCode, GenotypeData-method (GenotypeData-class), 67
xChromCode, IntensityData-method (IntensityData-class), 85
xChromCode, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
xChromCode, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
xChromCode, NcdfIntensityReader-method (NcdfIntensityReader), 102
xChromCode, ScanAnnotationSQLite-method (ScanAnnotationSQLite), 132
INDEX

XchromCode, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135
XYchromCode (getVariable), 73
XYchromCode, GdsGenotypeReader-method (GdsGenotypeReader), 57
XYchromCode, GdsIntensityReader-method (GdsIntensityReader), 60
XYchromCode, GenotypeData-method (GenotypeData-class), 67
XYchromCode, IntensityData-method (IntensityData-class), 85
XYchromCode, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
XYchromCode, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
XYchromCode, NcdfIntensityReader-method (NcdfIntensityReader), 102
XYchromCode, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
XYchromCode, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135

YchromCode (getVariable), 73
YchromCode, GdsGenotypeReader-method (GdsGenotypeReader), 57
YchromCode, GdsIntensityReader-method (GdsIntensityReader), 60
YchromCode, GenotypeData-method (GenotypeData-class), 67
YchromCode, IntensityData-method (IntensityData-class), 85
YchromCode, MatrixGenotypeReader-method (MatrixGenotypeReader), 91
YchromCode, NcdfGenotypeReader-method (NcdfGenotypeReader), 100
YchromCode, NcdfIntensityReader-method (NcdfIntensityReader), 102
YchromCode, SnpAnnotationDataFrame-method (SnpAnnotationDataFrame), 132
YchromCode, SnpAnnotationSQLite-method (SnpAnnotationSQLite), 135