Package ‘Harman’

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Type Package

Title The removal of batch effects from datasets using a PCA and constrained optimisation based technique

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Description Harman is a PCA and constrained optimisation based technique that maximises the removal of batch effects from datasets, with the constraint that the probability of overcorrection (i.e. removing genuine biological signal along with batch noise) is kept to a fraction which is set by the end-user.

NeedsCompilation yes

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LinkingTo Rcpp

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VignetteBuilder knitr

URL http://www.bioinformatics.csiro.au/harman/

BugReports https://github.com/JasonR055/Harman/issues

RoxygenNote 5.0.1

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### Description

Generates an arrow plot for an instance of `harmanresults`. The tail of the arrow is the starting point (original) in principle coordinates, while the arrow head is the new point (corrected) in principle coordinates. It can be observed that on principle components that have undergone correction (codemunresults$stats$correction < 1.0), the samples within a batch will be coordinately moved towards 0 on that principle component.

### Usage

```r
arrowPlot(harmanresults, pc_x = 1, pc_y = 2, colBy = "batch",
          palette = "rainbow", col, length = 0.1, legend = TRUE, ...)
```

### Arguments

- `harmanresults`: an instance of `harmanresults`.
- `pc_x`: integer, principle component for the plot x dimension.
- `pc_y`: integer, principle component for the plot y dimension.
- `colBy`: string, colour the points by the experimental or batch variable; legal values are `expt` and `batch`. The palette function specified in `palette` is used. This parameter is overridden by `col`.
- `palette`: string, the function to call to create a vector of contiguous colours with the levels of factor in `colBy` steps.
- `col`: colour vector for the points. This parameter overrides `palette`.
- `length`: length of the arrow heads, default is 0.1.
- `legend`: logical, whether to display a legend on the plot
- `...`: further arguments passed to or from other methods.
callHarman

Details
Generates a Principle Component plot for an instance of harmanresults. If a vector of colours is supplied via the col argument, then a legend will not be drawn.

Value
None

See Also
harmanresults plot.harmanresults

Examples
library(HarmanData)
data(OLF)
ext <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
arroPlot(olf.harman, pc_x=2, pc_y=3, length=0.2)

callHarman
Wrapper function to call the shared C/C++ library code

Description
This wrapper should probably not be addressed directly except for debugging. Instead use harman. Input of PCA scores and the experiment structure (treatments and batches) and returns a batch corrected version of the PCA scores matrix

Usage
.callHarman(pc_data_scores, group, limit, numrepeats, randseed, forceRand, printInfo)

Arguments
pc_data_scores 2D NumericMatrix of PCA scores data (from the prcomp$x slot), rows = samples, cols = PC scores
group The structure of the experiment, consisting of batch numbers and treatment numbers forming 2 rows or columns (HarmanMain works out which). Each entry for a sample describes what batch it came from and what treatment it was given. Has to be integer formatted data.
limit A double precision value indicating the limit of confidence in which to stop removing a batch effect
numrepeats The number of repeats in which to run the simulated batch mean distribution estimator. Probably should be greater than 100,000.
randseed Random seed to pass to the random number generator (0 for use default from system time)
forceRand Force algorithm
printInfo Print update information to screen
Value

SEXP R list: scores.corrected = harman_res_list["corrected_scores"]
correction = harman_res_list["correction"]
confidence = harman_res_list["confidence"]

Note

A data matrix with samples in columns must be transposed before PCA analysis and these scores in turn are tweaked a little before handing over to .callHarman. See the example below.

---

detachHarman

*Detach the Harman package and its shared C/C++ library code*

Description

A helper function that can be called if `harman` had to be aborted.

Usage

```
detachHarman()
```

Value

None

---

harman

*Harman batch correction method*

Description

Harman is a PCA and constrained optimisation based technique that maximises the removal of batch effects from datasets, with the constraint that the probability of overcorrection (i.e. removing genuine biological signal along with batch noise) is kept to a fraction which is set by the end-user (Oytam et al, 2016; [http://dx.doi.org/10.1186/s12859-016-1212-5](http://dx.doi.org/10.1186/s12859-016-1212-5)).

Harman expects unbounded data, so for example, with HumanMethylation450 arrays do not use the Beta statistic (with values constrained between 0 and 1), instead use the logit transformed M-values.

Usage

```
harman(datamatrix, expt, batch, limit = 0.95, numrepeats = 100000L,
        randseed, forceRand = FALSE, printInfo = FALSE)
```
Arguments

datamatrix  matrix or data.frame, the data values to correct with samples in columns and data values in rows. Internally, a data.frame will be coerced to a matrix. Matrices need to be of type integer or double.

expt    vector or factor with the experimental variable of interest (variance to be kept).

batch    vector or factor with the batch variable (variance to be removed).

limit    numeric, confidence limit. Indicates the limit of confidence in which to stop removing a batch effect. Must be between 0 and 1.

numrepeats    integer, the number of repeats in which to run the simulated batch mean distribution estimator using the random selection algorithm. (N.B. 32 bit Windows versions may have an upper limit of 300000 before catastrophic failure)

randseed    integer, the seed for random number generation.

forceRand    logical, to enforce Harman to use a random selection algorithm to compute corrections. Force the simulated mean code to use random selection of scores to create the simulated batch mean (rather than full explicit calculation from all permutations).

printInfo    logical, whether to print information during computation or not.

Details

The datamatrix needs to be of type integer or numeric, or alternatively a data.frame that can be coerced into one using `as.matrix`. The matrix is to be constructed with data values (typically microarray probes or sequencing counts) in rows and samples in columns, much like the ‘assayData’ slot in the canonical Bioconductor eSet object, or any object which inherits from it. The data should have normalisation and any other global adjustment for noise reduction (such as background correction) applied prior to using Harman. For converge, the number of simulations, numrepeats parameter should probably should be at least 100,000. The underlying principle of Harman rests upon PCA, which is a parametric technique. This implies Harman should be optimal when the data is normally distributed. However, PCA is known to be rather robust to very non-normal data.

Value

A `harmanresults` S3 object.

References


See Also

`harman, reconstructData, pcaPlot, arrowPlot`

Examples

```r
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
plot(olf.harman)
olf.data.corrected <- reconstructData(olf.harman)
```
## Reading from a csv file

datafile <- system.file("extdata", "NPM_data_first_1000_rows.csv.gz", package="Harman")
infofile <- system.file("extdata", "NPM_info.csv.gz", package="Harman")
datamatrix <- read.table(datafile, header=TRUE, sep="", row.names="probeID")
batches <- read.table(infofile, header=TRUE, sep="", row.names="Sample")
res <- harman(datamatrix, expt=batches$Treatment, batch=batches$Batch)
arowPlot(res, 1, 3)

---

### Harman results object

**Description**

The S3 object returned after running `harman`.

**Details**

`harmanresults` is the S3 object used to store the results from `harman`. This object may be presented to summary and data exploration functions such as `plot.harmanresults` and `summary.harmanresults` as well as the `reconstructData` function which creates a corrected matrix of data with the batch effect removed.

**Slots**

- `factors` A data.frame of the `expt` and `batch` vectors.
- `parameters` The harman runtime parameters. See `harman` for details.
- `stats` Confidence intervals and the degree of correction for each principal component.
- `center` The centering vector returned by `prcomp` with `center=TRUE`.
- `rotation` The matrix of eigenvectors (by column) returned from `prcomp`.
- `original` The original PC scores returned by `prcomp`.
- `corrected` The harman corrected PC scores.

**See Also**

`harman`, `reconstructData`, `pcaPlot`, `arrowPlot`

**Examples**

```r
## HarmanResults
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(as.matrix(olf.data), expt, batch)
plot(olf.harman)
summary(olf.harman)
pcaPlot(olf.harman, pc_x=2, pc_y=3)
pcaPlot(olf.harman, pc_x=2, pc_y=3, colBy='expt', pch=1)
olf.data.corrected <- reconstructData(olf.harman)
```
**Description**
A tweaking of `stats::prcomp` such that for the svd, the transpose of u is used instead of v when the number of assays is less than the number of samples.

**Usage**
```r
harmanScores(x)
```

**Arguments**
- **x**: matrix, data matrix of values to perform PCA on.

**Value**
scores, a `prcomp`-like object with rotation, scores and the center values. The scores are corrected, but all three are needed later to reconstruct the data.

---

**pcaPlot**

**PCA plot for harman results**

**Description**
Generates a Principle Component plot for an instance of `harmanresults`.

**Usage**
```r
pcaPlot(harmanresults, pc_x = 1, pc_y = 2, this = "corrected",
        colBy = "batch", pchBy = "expt", palette = "rainbow", legend = TRUE,
        col, pch, ...)
```

**Arguments**
- **harmanresults**: An instance of `harmanresults`.
- **pc_x**: integer, principle component for the plot x dimension.
- **pc_y**: integer, principle component for the plot y dimension.
- **this**: string, colour the points by the experimental or batch variable; legal values are `original` or `corrected`.
- **colBy**: string, point-type by the experimental or batch variable; legal values are `expt` and `batch`. The palette function specified in `palette` is used. This parameter is overridden by `col`.
- **pchBy**: string, point-type by the experimental or batch variable; legal values are `expt` and `batch`. This parameter is overridden by `pch`.
- **palette**: string, the function to call to create a vector of contiguous colours with the levels of factor in `colBy` steps.
- **legend**: logical, whether to display a legend on the plot.
colour vector for the points. This parameter overrides colBy and palette.

integer vector giving the point type. This parameter overrides pchBy.

further arguments passed to or from other methods.

Details

If a vector of colours is supplied via the col argument, then a legend will not be drawn.

Value

None

See Also

harmanresults plot.harmanresults

Examples

library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(as.matrix(olf.data), expt, batch)
pcaPlot(olf.harman)
pcaPlot(olf.harman, colBy='Var1')
pcaPlot(olf.harman, pc_x=2, pc_y=3, this='original', pch=17)

plot.harmanresults

Plot method for harman

Description

Plot method for instances of harmanresults.

Usage

## S3 method for class 'harmanresults'
plot(x, ...)

Arguments

x An instance of harmanresults.

... further plotting parameters.

Value

None

See Also

harmanresults pcaPlot
**prcompPlot**

**Examples**

```r
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
plot(olf.harman)
```

---

**Description**

Generates a Principle Component plot for data.frames, matrices, or a pre-made `prcomp` object.

**Usage**

```r
prcompPlot(object, pc_x = 1, pc_y = 2, scale = FALSE, colFactor = NULL,
pchFactor = NULL, palette = "rainbow", legend = TRUE, ...)
```

**Arguments**

- `object`: data.frame, matrix or `prcomp` object.
- `pc_x`: integer, principle component for the plot x dimension.
- `pc_y`: integer, principle component for the plot y dimension.
- `scale`: logical, whether to scale to unit variance before PCA.
- `colFactor`: factor or vector, colour the points by this factor, default is NULL.
- `pchFactor`: factor or vector, point-type by this factor, default is NULL.
- `palette`: string, the function to call to create a vector of contiguous colours with `levels(colFactor)` steps.
- `legend`: logical, whether to display a legend on the plot.
- `...`: further arguments passed to or from other methods.

**Details**

A data.frame object will be coerced internally to a matrix. Matrices must be of type double or integer. The `prcompPlot` function will then perform a principle component analysis on the data prior to plotting. The function is call is `prcomp(t(object), retx=TRUE, center=TRUE, scale.=scale)`. Instead of specifying a data.frame or matrix, a pre-made `prcomp` object can be given to `prcompPlot`. In this case, care should be taken in setting the appropriate value of `scale`. If a vector is given to `colFactor` or `pchFactor`, they will be coerced internally to factors.

For the default NULL values of `colFactor` and `pchFactor`, all colours will be black and circles the point type, respectively.

**Value**

None
See Also

prcomp, rainbow

Examples

library(HarmanData)
data(IMR90)
expt <- imr90.info$Treatment
batch <- imr90.info$Batch
prcompPlot(imr90.data, colFactor=expt)
pca <- prcomp(t(imr90.data), scale.=TRUE)
prcompPlot(pca, 1, 3, colFactor=batch, pchFactor=expt, palette='topo.colors',
main='IMR90 PCA plot of Dim 1 and 3')

print.summary.harmanresults

Printing Harmanresults summaries.

Description

Print method for summary.harmanresults.

Usage

## S3 method for class 'summary.harmanresults'
print(x, ...)

Arguments

x an object of class summary.harmanresults, usually, a result of a call to summary.harmanresults.

... further parameters.

Value

Prints summary information from an object of class summary.harmanresults.

reconstructData

Reconstruct corrected data from Harman results

Description

Method which reverts the PCA factorisation for instances of harmanresults. This allows the original or corrected data to be returned back from the PCA domain into the original data domain.

Usage

reconstructData(object, this = "corrected")
shiftBetas

Arguments

- object: An instance of harmanresults.
- this: string, legal values are original or corrected.

Value

matrix of data

See Also

harman, harmanresults

Examples

library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
olf.data.corrected <- reconstructData(olf.harman)

shiftBetas(betas, shiftBy = 1e-04)

Description

A convenience function for methylation data.

Usage

shiftBetas(betas, shiftBy = 1e-04)

Arguments

- betas: matrix, beta values.
- shiftBy: numeric, the amount to shift values of 0 and 1 by.

Value

None

Examples

betas <- seq(0, 1, by=0.05)
range(betas)
newBetas <- shiftBetas(betas, shiftBy=1e-4)
newBetas
range(newBetas)
**summary.harmanresults**  
*Summarizing harman results.*

**Description**  
Summary method for class `harmanresults`.

**Usage**  
```r
## S3 method for class 'harmanresults'
summary(object, ...)  
```

**Arguments**  
- `object`  
  An object of class `harmanresults`.
- `...`  
  Further parameters.

**Value**  
Returns an object of class `summary.harmanresults`.

**See Also**  
`harmanresults`

**Examples**  
```r
library(HarmanData)
data(OLF)
expt <- olf.info$Treatment
batch <- olf.info$Batch
olf.harman <- harman(olf.data, expt, batch)
summary(olf.harman)
```
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