

# Package ‘ARRmNormalization’

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**Type** Package

**Title** Adaptive Robust Regression normalization for Illumina  
methylation data

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**Depends** R (>= 2.15.1), ARRmData

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**Description** Perform the Adaptive Robust Regression method (ARRm) for the normaliza-  
tion of methylation data from the Illumina Infinium HumanMethylation 450k assay.

**License** Artistic-2.0

**biocViews** DNAMethylation, TwoChannel, Preprocessing, Microarray

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`ARRmNormalization-package`*ARRm normalization for Illumina methylation data*

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**Description**

Normalize Illumina methylation data from the Infinium HumanMethylation 450k assay with the Adaptive Robust Regression method. The normalization takes care of background intensity, dye bias, chip effects and spatial positions. The normalization can be applied to Beta values, M-values or other metrics as well.

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`ARRmNormalization-internal`*Internal ARRmNormalization Functions*

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**Description**

Internal ARRmNormalization functions

**Details**

These are not to be called by the user.

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`getBackground`*Estimate background intensity from the negative control probes*

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**Description**

This function estimates background intensity for the two colors by taking the median of the negative control probes in each color channel.

**Usage**

```
getBackground(greenControlMatrix, redControlMatrix)
```

**Arguments**

`greenControlMatrix`  
matrix of negative control probes intensities in the green channel. Rows are probes, columns are samples.

`redControlMatrix`  
matrix of the negative control probes intensities in the red channel. Rows are probes, columns are samples.

**Value**

Returns a data.frame with two columns; "green" contains the background intensity in the green channel for each sample and "red" contains the background intensity in the red channel for each sample

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```
data(greenControlMatrix)
data(redControlMatrix)
getBackground(greenControlMatrix, redControlMatrix)
```

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getCoefficients	<i>Return the coefficients from the ARRM linear model</i>
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**Description**

For each probe type, it returns the coefficients of the linear model used in the ARRM normalization. Since the model is applied to each percentile separately, different coefficients are returned for every percentile. Residuals are returned as well.

**Usage**

```
getCoefficients(quantiles, designInfo, backgroundInfo, outliers.perc=0.02)
```

**Arguments**

`quantiles` A list containing three matrices. "\$green", "\$red" and "\$II" must contain respectively the matrices of percentiles obtained from a "betaMatrix" for the Type I Green probes, Type I Red probes and Type II probes. See [getQuantiles](#).

`designInfo` matrix returned by [getDesignInfo](#)

`backgroundInfo` matrix returned by [getBackground](#)

`outliers.perc` Percentage of outliers to be removed in the regression. By default, set to 0.02

**Value**

Returns a list containing three lists of coefficients for each probe type. (`$green` to access coefficients for Type I green probes, `$red` to access coefficients for Type I red probes and `$II` to access coefficients for Type II probes). Each list of coefficients contains five subfields. `res` is a matrix of residuals for the linear model across percentiles (a vector of residuals for each percentile), `background.vector` is a vector containing the regression coefficients for background intensity across percentiles; `dyebias.vector` is a vector containing the regression coefficients for dye bias across percentiles; `chip.variations` is a matrix of chip variations estimated by the linear model; rows correspond to percentiles, columns correspond to chips; `position.variations` is a matrix of position deviation from the chip mean estimated by the linear model; rows correspond to percentiles, columns correspond to positions.

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```
data(greenControlMatrix)
data(redControlMatrix)
data(sampleNames)
data(betaMatrix)
backgroundInfo=getBackground(greenControlMatrix,redControlMatrix)
designInfo=getDesignInfo(sampleNames)
quantiles=getQuantiles(betaMatrix)
coefficients=getCoefficients(quantiles,designInfo,backgroundInfo)
```

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getDesignInfo

*Build the chip and position indices*


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**Description**

If a vector of sample names of the form "6793856729\_R03C02" is given, the function builds a data frame containing chip and position indices for the samples. If no samples names are provided by the user but explicit position and chip vectors are provided, the data frame is built with these explicit indices.

**Usage**

```
getDesignInfo(sampleNames = NULL, chipVector = NULL, positionVector = NULL)
```

**Arguments**

<code>sampleNames</code>	Names of the samples of the form "6793856729_R03C02" (Chip ID, Row, Column)
<code>chipVector</code>	Numeric vector of chip indices (one chip contains 12 samples)
<code>positionVector</code>	Numeric vector of on-chip position indices (between 1 and 12)

**Value**

A data.frame containing a column named chipInfo containing the chip indices, a column named positionInfo containing the position indices, and a column sampleNames if sample names were provided.

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```
data(sampleNames)
getDesignInfo(sampleNames)
```

---

getQuantiles	<i>Return the percentiles of a betaMatrix for each probe type</i>
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**Description**

It returns the percentiles of a betaMatrix for Type I Green, Type I Red and Type II probes. If no list of probes is provided, all probes are taken into account to compute the percentiles.

**Usage**

```
getQuantiles(betaMatrix,goodProbes=NULL)
```

**Arguments**

betaMatrix	matrix containing the Beta values. Rows are probes, columns are samples.
goodProbes	Ids of the probes to be normalized (Id. of the form "cg00000029").

**Value**

Returns a list of three matrices of percentiles. For Type I green and Type I red probes, the corresponding matrices can be accessed by \$green and \$red. For Type II probes, the matrix can be accessed by \$II

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```
data(greenControlMatrix)
data(redControlMatrix)
data(sampleNames)
data(betaMatrix)
quantiles=getQuantiles(betaMatrix)
```

---

normalizeARRm	<i>Perform ARRm normalization</i>
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### Description

This function perform Adaptive Robust Regression method (ARRm) normalization on Beta values. The method corrects for background intensity, dye bias and spatial on-chip position. By default, chip mean correction is also performed.

### Usage

```
normalizeARRm(betaMatrix, designInfo, backgroundInfo, outliers.perc = 0.02,  
goodProbes = NULL, chipCorrection=TRUE)
```

### Arguments

betaMatrix	matrix containing the Beta values. Rows are probes, columns are samples.
designInfo	A data.frame containing a column named chipInfo containing the chip indices and a column named positionInfo containing the position indices
backgroundInfo	A data.frame containing two columns: green contains the background intensity in the green channel for each sample and red contains the background intensity in the red channel for each sample
outliers.perc	Proportion (between 0 and 1) of outliers to be removed from the ARRm regression
goodProbes	Ids of the probes to be normalized (Id. of the form "cg00000029")
chipCorrection	logical, should normalization correct for chip mean?

### Value

A matrix containing the normalized Beta values

### Author(s)

Jean-Philippe Fortin <jfortin@jhsph.edu>

### See Also

[getBackground](#) to see how to obtain background information from control probes, and [getDesignInfo](#) to see how to obtain position and chip indices

**Examples**

```

data(greenControlMatrix)
data(redControlMatrix)
data(sampleNames)
data(betaMatrix)
backgroundInfo=getBackground(greenControlMatrix, redControlMatrix)
designInfo=getDesignInfo(sampleNames)
normMatrix=normalizeARRm(betaMatrix, designInfo, backgroundInfo, outliers.perc = 0.02)

```

---

positionPlots

*Plots to evaluate chip position effects on different percentiles*


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**Description**

For each probe type, and for each sample, deviations from the chip mean are computed for a given percentile. These deviations are plotted against on-chip position.

**Usage**

```
positionPlots(quantiles,designInfo,percentiles=c(25,50,75))
```

**Arguments**

quantiles	A list containing three matrices. list\$green, list\$red and list\$II must contain respectively the matrices of percentiles obtained from a betaMatrix for the Type I Green probes, Type I Red probes and Type II probes. See <a href="#">getQuantiles</a> .
designInfo	designInfo matrix returned by <a href="#">getDesignInfo</a>
percentiles	Vector of percentiles to be plotted. By default, the 25th, 50th and 75th percentiles are plotted. (percentiles=c(25,50,75)).

**Value**

Plots are produced and saved as pdf in the current directory.

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```

data(greenControlMatrix)
data(redControlMatrix)
data(sampleNames)
data(betaMatrix)
quantiles=getQuantiles(betaMatrix)
backgroundInfo=getBackground(greenControlMatrix, redControlMatrix)
designInfo=getDesignInfo(sampleNames)
positionPlots(quantiles, designInfo, percentiles=c(25,50,75))

```

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ProbesType	<i>Probe Design information for the 450k methylation assay</i>
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**Description**

Probe Design information for the Illumina Infinium HumanMethylation 450k array. To each probe is associated the design type, either Infinium I Green, Infinium I Red or Infinium II. Probe names follows Illumina’s annotation (names of the form "cg00000029").

**Usage**

data(ProbesType)

**Format**

A data frame containing two columns. \$Probe\_Name contains the names of the probes, and \$Design\_Type contains the design information ("I Green", "I Red" or "II").

**Examples**

data(ProbesType)

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quantilePlots	<i>Diagnostic plots for evaluation of background effects and dye bias effects on different percentiles</i>
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**Description**

For each probe type, and for each sample, several percentiles are plotted against background intensity, and also against dye bias.

**Usage**

quantilePlots(quantiles,backgroundInfo,designInfo,percentilesI=NULL,percentilesII=NULL)

**Arguments**

- |                |  |
|----------------|--|
| quantiles      | A list containing three matrices. list\$green, list\$red and list\$II must contain respectively the matrices of percentiles obtained from a betaMatrix for the Type I Green probes, Type I Red probes and Type II probes. See <a href="#">getQuantiles</a> . |
| designInfo     | designInfo matrix returned by <a href="#">getDesignInfo</a>  |
| backgroundInfo | "backgroundInfo" matrix returned by <a href="#">getBackground</a>  |
| percentilesI   | List of percentiles to be plotted for Type I probes. Must be a vector of integers from 1 to 100. If set to NULL (by default), the sequence (5,10,...,95) of percentiles is plotted.  |



**percentilesII** List of percentiles to be plotted for Type II probes. Must be a vector of integers from 1 to 100. If set to NULL (by default), the sequence (10,20,...,90) of percentiles is plotted.

**Value**

Plots are produced and saved as pdf in the current directory.

**Author(s)**

Jean-Philippe Fortin <jfortin@jhsph.edu>

**Examples**

```
data(greenControlMatrix)
data(redControlMatrix)
data(sampleNames)
data(betaMatrix)
quantiles=getQuantiles(betaMatrix)
backgroundInfo=getBackground(greenControlMatrix, redControlMatrix)
designInfo=getDesignInfo(sampleNames)
quantilePlots(quantiles, backgroundInfo, designInfo)
```

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