

Package ‘dimensio’

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Title Multivariate Data Analysis

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Description Simple Principal Components Analysis (PCA) and Correspondence Analysis (CA) based on the Singular Value Decomposition (SVD). This package provides S4 classes and methods to compute, extract, summarize and visualize results of multivariate data analysis. It also includes methods for partial bootstrap validation described in Greenacre (1984) <isbn: 978-0-12-299050-2> and Lebart et al. (2006) <isbn: 978-2-10-049616-7>.

License GPL (>= 3)

URL <https://dimensio.tesselle.org>,

<https://github.com/tesselle/dimensio>

BugReports <https://github.com/tesselle/dimensio/issues>

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bootstrap	<i>Partial Bootstrap Analysis</i>
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Description

Checks analysis with partial bootstrap resampling.

Usage

```
bootstrap(object, ...)

## S4 method for signature 'CA'
bootstrap(object, n = 30)

## S4 method for signature 'PCA'
bootstrap(object, n = 30)
```

Arguments

object	A CA or PCA object.
...	Currently not used.
n	A non-negative integer giving the number of bootstrap replications.

Value

A [BootstrapCA](#) or [BootstrapPCA](#) object.

Author(s)

N. Frerebeau

References

Greenacre, Michael J. *Theory and Applications of Correspondence Analysis*. London: Academic Press, 1984.

Lebart, L., Piron, M. and Morineau, A. *Statistique exploratoire multidimensionnelle: visualisation et inférence en fouille de données*. Paris: Dunod, 2006.

See Also

Other multivariate analysis: [ca\(\)](#), [pca\(\)](#), [predict\(\)](#)

Examples

```
library(ggrepel)

## Partial bootstrap on CA
## Data from Lebart et al. 2006, p. 170-172
color <- data.frame(
  brun = c(68, 15, 5, 20),
  chatain = c(119, 54, 29, 84),
  roux = c(26, 14, 14, 17),
  blond = c(7, 10, 16, 94),
  row.names = c("marron", "noisette", "vert", "bleu")
)

## Compute correspondence analysis
X <- ca(color)

## Plot results
plot(X) +
  ggrepel::geom_label_repel()

## Bootstrap (30 replicates)
Y <- bootstrap(X, n = 30)

## Get replicated coordinates
get_replications(Y, margin = 1)
get_replications(Y, margin = 2)

## Plot with ellipses
plot_rows(Y) +
  ggplot2::stat_ellipse()

plot_columns(Y) +
  ggplot2::stat_ellipse()
```

```
## Partial bootstrap on PCA
## Compute principal components analysis
data(iris)
X <- pca(iris)

## Plot results
plot_columns(X) +
  ggrepel::geom_label_repel()

## Bootstrap (30 replicates)
Y <- bootstrap(X, n = 30)

## Plot with ellipses
plot_columns(Y) +
  ggplot2::stat_ellipse()
```

ca

Correspondence Analysis

Description

Computes a simple correspondence analysis based on the singular value decomposition.

Usage

```
ca(object, ...)
```

S4 method for signature 'data.frame'

```
ca(object, rank = NULL, sup_row = NULL, sup_col = NULL)
```

S4 method for signature 'matrix'

```
ca(object, rank = NULL, sup_row = NULL, sup_col = NULL)
```

Arguments

object	A $m \times p$ numeric matrix or a data.frame .
...	Currently not used.
rank	An integer value specifying the maximal number of components to be kept in the results. If NULL (the default), $\min(m, p) - 1$ components will be returned.
sup_row	A numeric or logical vector specifying the indices of the supplementary rows.
sup_col	A numeric or logical vector specifying the indices of the supplementary columns.

Value

A [CA](#) object.

Author(s)

N. Frerebeau

References

Greenacre, Michael J. *Theory and Applications of Correspondence Analysis*. London: Academic Press, 1984.

Lebart, L., Piron, M. and Morineau, A. *Statistique exploratoire multidimensionnelle: visualisation et inférence en fouille de données*. Paris: Dunod, 2006.

See Also

[get_*\(\)](#), [stats::predict\(\)](#), [svd\(\)](#)

Other multivariate analysis: [bootstrap\(\)](#), [pca\(\)](#), [predict\(\)](#)

Examples

```
## Load data
data("zuni", package = "folio")

## The chi square of independence between the two variables
stats::chisq.test(zuni)

## Compute correspondence analysis
X <- ca(zuni)

## Get row coordinates
get_coordinates(X, margin = 1)

## Get column coordinates
get_coordinates(X, margin = 2)

## Get row distances to centroid
get_distances(X, margin = 1)

## Get row inertias
get_inertia(X, margin = 1)

## Get row contributions
get_contributions(X, margin = 1)

## Get eigenvalues
get_eigenvalues(X)
```

CA-class

CA Results

Description

An S4 class to store the results of a simple correspondence analysis.

Author(s)

N. Frerebeau

See Also

Other class: [MultivariateAnalysis](#), [MultivariateBootstrap](#), [MultivariateResults](#), [MultivariateSummary](#), [PCA-class](#)

Examples

```
## Load data
data("zuni", package = "folio")

## The chi square of independence between the two variables
stats::chisq.test(zuni)

## Compute correspondence analysis
X <- ca(zuni)

## Get row coordinates
get_coordinates(X, margin = 1)

## Get column coordinates
get_coordinates(X, margin = 2)

## Get row distances to centroid
get_distances(X, margin = 1)

## Get row inertias
get_inertia(X, margin = 1)

## Get row contributions
get_contributions(X, margin = 1)

## Get eigenvalues
get_eigenvalues(X)
```

MultivariateAnalysis *Output of Multivariate Data Analysis*

Description

A virtual S4 class to store the output of a multivariate data analysis.

Slots

data A [numeric matrix](#).

dimension An [integer](#) giving the dimension of the solution.

singular_values A [numeric](#) vector giving the singular values.

rows A [MultivariateResults](#) object.

columns A [MultivariateResults](#) object.

Subset

In the code snippets below, x is a MultivariateAnalysis object.

x[[i]] Extracts information from a slot selected by subscript i. i is a length-one [character](#) vector.

Author(s)

N. Frerebeau

See Also

Other class: [CA-class](#), [MultivariateBootstrap](#), [MultivariateResults](#), [MultivariateSummary](#), [PCA-class](#)

MultivariateBootstrap *Output of Bootstrap Replications*

Description

A virtual S4 class to store the output of a bootstrap analysis.

Slots

replications An [integer](#) giving the number of bootstrap replications.

Author(s)

N. Frerebeau

See Also

Other class: [CA-class](#), [MultivariateAnalysis](#), [MultivariateResults](#), [MultivariateSummary](#), [PCA-class](#)

MultivariateResults *Multivariate Data Analysis Results*

Description

An S4 class to store the results of a multivariate data analysis.

Slots

names A [character](#) vector specifying the row names.

principal A [numeric matrix](#) giving the principal coordinates.

standard A [numeric matrix](#) giving the standard coordinates.

contributions A [numeric matrix](#) giving the contributions to the definition of the dimensions.

cosine A [numeric matrix](#) giving the \cos^2 values.

distances A [numeric](#) vector giving the distances to centroid.

weights A [numeric](#) vector giving the masses/weights.

supplement A [logical](#) vector specifying the supplementary points.

order An [integer](#) vector giving the original indices of the data (computation moves all supplementary points at the end of the results).

groups A [character](#) vector specifying the class for each observation.

Author(s)

N. Frerebeau

See Also

Other class: [CA-class](#), [MultivariateAnalysis](#), [MultivariateBootstrap](#), [MultivariateSummary](#), [PCA-class](#)

MultivariateSummary *Summary of Multivariate Data Analysis*

Description

A virtual S4 class to store the summary of a multivariate data analysis.

Slots

data A [numeric matrix](#).

eigenvalues A [numeric matrix](#).

results A [numeric matrix](#).

supplement A [logical](#) vector specifying the supplementary points.

margin An [integer](#).

Author(s)

N. Frerebeau

See Also

Other class: [CA-class](#), [MultivariateAnalysis](#), [MultivariateBootstrap](#), [MultivariateResults](#), [PCA-class](#)

mutator *Get Results*

Description

Getters to retrieve parts of an object.

Usage

`get_coordinates(x, ...)`

`get_replications(x, ...)`

`get_contributions(x, ...)`

`get_correlations(x, ...)`

`get_cos2(x, ...)`

`get_data(x, ...)`

```
get_distances(x, ...)  
  
get_eigenvalues(x)  
  
get_inertia(x, ...)  
  
get_variance(x, ...)  
  
## S4 method for signature 'MultivariateAnalysis'  
dim(x)  
  
## S4 method for signature 'MultivariateAnalysis'  
rownames(x)  
  
## S4 method for signature 'MultivariateAnalysis'  
colnames(x)  
  
## S4 method for signature 'MultivariateAnalysis'  
dimnames(x)  
  
## S4 method for signature 'MultivariateAnalysis'  
get_contributions(x, margin = 1)  
  
## S4 method for signature 'MultivariateAnalysis'  
get_coordinates(x, margin = 1, sup_name = ".sup")  
  
## S4 method for signature 'MultivariateBootstrap'  
get_replications(x, margin = 1)  
  
## S4 method for signature 'BootstrapPCA'  
get_replications(x)  
  
## S4 method for signature 'PCA'  
get_correlations(x, sup_name = ".sup")  
  
## S4 method for signature 'MultivariateAnalysis'  
get_cos2(x, margin = 1, sup_name = ".sup")  
  
## S4 method for signature 'MultivariateAnalysis'  
get_data(x)  
  
## S4 method for signature 'MultivariateAnalysis'  
get_distances(x, margin = 1)  
  
## S4 method for signature 'MultivariateAnalysis'  
get_eigenvalues(x)
```

```
## S4 method for signature 'MultivariateAnalysis'
get_inertia(x, margin = 1)

## S4 method for signature 'MultivariateAnalysis'
get_variance(x, digits = 2)

## S4 method for signature 'PCA'
loadings(x)
```

Arguments

x	An object from which to get element(s) (a CA or PCA object).
...	Currently not used.
margin	A length-one numeric vector giving the subscript which the data will be returned: 1 indicates individuals/rows (the default), 2 indicates variables/columns.
sup_name	A character string specifying the name of the column to create for supplementary points attribution (see below).
digits	An integer indicating the number of decimal places to be used.

Details

`get_data()` returns a `data.frame` of original data.

`get_contributions()` returns a `data.frame` of contributions to the definition of the principal dimensions.

`get_coordinates()` returns a `data.frame` of coordinates. An extra column (named after `sup_name`) is added specifying whether an observation is a supplementary point or not.

`get_replications()` returns an array of replicated coordinates (see `bootstrap()`).

`get_correlations()` returns a `data.frame` of correlations between variables and dimensions (PCA). An extra column (named after `sup_name`) is added specifying whether an observation is a supplementary point or not.

`get_cos2()` returns a `data.frame` of \cos^2 values (i.e. quality of the representation of the points on the factor map). An extra column (named after `sup_name`) is added specifying whether an observation is a supplementary point or not.

`get_eigenvalues()` returns a `data.frame` with the following columns: `eigenvalues`, `variance` (percentage of variance) and `cumulative` (cumulative percentage of variance).

`get_variance()` returns a numeric vector giving the percentage of explained variance of each dimension.

`loadings()` returns variable loadings (i.e. the coefficients of the linear combination of the original variables). `loadings()` is only implemented for consistency with `[stats][stats::loadings]`.

Value

`get_*`() returns a [numeric](#) vector or a `data.frame`.

`loadings()` returns of a [matrix](#) of class `stats::loadings`.

Author(s)

N. Frerebeau

See AlsoOther mutator: [subset\(\)](#)

pca

Principal Components Analysis

Description

Computes a principal components analysis based on the singular value decomposition.

Usage

```
pca(object, ...)  
  
## S4 method for signature 'data.frame'  
pca(  
  object,  
  center = TRUE,  
  scale = TRUE,  
  rank = NULL,  
  sup_row = NULL,  
  sup_col = NULL,  
  weight_row = NULL,  
  weight_col = NULL  
)  
  
## S4 method for signature 'matrix'  
pca(  
  object,  
  center = TRUE,  
  scale = TRUE,  
  rank = NULL,  
  sup_row = NULL,  
  sup_col = NULL,  
  weight_row = NULL,  
  weight_col = NULL  
)
```

Arguments

object	A $m \times p$ numeric matrix or a data.frame .
...	Currently not used.

center	A logical scalar: should the variables be shifted to be zero centered?
scale	A logical scalar: should the variables be scaled to unit variance?
rank	An integer value specifying the maximal number of components to be kept in the results. If NULL (the default), $p - 1$ components will be returned.
sup_row	A numeric or logical vector specifying the indices of the supplementary rows (individuals).
sup_col	A numeric or logical vector specifying the indices of the supplementary columns (variables).
weight_row	A numeric vector specifying the active row (individual) weights. If NULL (the default), no weights are used.
weight_col	A numeric vector specifying the active column (variable) weights. If NULL (the default), no weights are used.

Value

A [PCA](#) object.

Author(s)

N. Frerebeau

References

Lebart, L., Piron, M. and Morineau, A. *Statistique exploratoire multidimensionnelle: visualisation et inférence en fouille de données*. Paris: Dunod, 2006.

See Also

[get_*\(\)](#), [stats::predict\(\)](#), [svd\(\)](#)

Other multivariate analysis: [bootstrap\(\)](#), [ca\(\)](#), [predict\(\)](#)

Examples

```
## Load data
data("compiegne", package = "folio")

## Compute principal components analysis
X <- pca(compiegne, scale = TRUE, sup_col = 7:10)

## Get row coordinates
get_coordinates(X, margin = 1)

## Get column coordinates
get_coordinates(X, margin = 2)

## Get row contributions
get_contributions(X, margin = 1)

## Get correlations between variables and dimensions
```

```
get_correlations(X)

## Get eigenvalues
get_eigenvalues(X)
```

PCA-class

PCA Results

Description

An S4 class to store the results of a principal components analysis.

Slots

`center` A **numeric** vector giving the column mean of the initial dataset (active individuals only).
`scale` A **numeric** vector giving the column standard deviations of the initial dataset (active individuals only).

Author(s)

N. Frerebeau

See Also

Other class: [CA-class](#), [MultivariateAnalysis](#), [MultivariateBootstrap](#), [MultivariateResults](#), [MultivariateSummary](#)

Examples

```
## Load data
data("compiegne", package = "folio")

## Compute principal components analysis
X <- pca(compiegne, scale = TRUE, sup_col = 7:10)

## Get row coordinates
get_coordinates(X, margin = 1)

## Get column coordinates
get_coordinates(X, margin = 2)

## Get row contributions
get_contributions(X, margin = 1)

## Get correlations between variables and dimensions
get_correlations(X)

## Get eigenvalues
get_eigenvalues(X)
```

plot_contributions *Visualize Contributions and cos²*

Description

Plots contributions histogram and \cos^2 scatterplot.

Usage

```
plot_contributions(object, ...)  
  
plot_cos2(object, ...)  
  
## S4 method for signature 'MultivariateAnalysis'  
plot_contributions(  
  object,  
  margin = 2,  
  axes = 1,  
  sort = TRUE,  
  decreasing = TRUE,  
  limit = 10,  
  fill = "grey30",  
  border = "grey10"  
)  
  
## S4 method for signature 'MultivariateAnalysis'  
plot_cos2(  
  object,  
  margin = 2,  
  axes = c(1, 2),  
  active = TRUE,  
  sup = TRUE,  
  sort = TRUE,  
  decreasing = TRUE,  
  limit = 10,  
  fill = "grey30",  
  border = "grey10"  
)
```

Arguments

object	A CA or PCA object.
...	Currently not used.
margin	A length-one numeric vector giving the subscript which the data will be returned: 1 indicates individuals/rows (the default), 2 indicates variables/columns.
axes	A length-one numeric vector giving the dimensions to be plotted.

sort	A logical scalar: should the data be sorted?
decreasing	A logical scalar: should the sort order be decreasing? Only used if sort is TRUE.
limit	An integer specifying the number of top elements to be displayed.
fill, border	A character string specifying the bars infilling and border colors.
active	A logical scalar: should the active observations be plotted?
sup	A logical scalar: should the supplementary observations be plotted?

Author(s)

N. Frerebeau

See Also

[ggplot2::ggplot\(\)](#)

Other plot: [plot_coordinates](#), [plot_eigenvalues](#)

Examples

```
## Load data
data("zuni", package = "folio")

## Compute correspondence analysis
X <- ca(zuni)

## Plot observations
plot(X)

## Screeplot
plot_variance(X)
```

plot_coordinates *Visualize Factor Map*

Description

Plots factor map.

Usage

```
plot_rows(object, ...)

plot_columns(object, ...)

## S4 method for signature 'MultivariateAnalysis'
plot_rows(
  object,
```



```
axes = c(1, 2),
active = TRUE,
sup = TRUE,
highlight = NULL,
group = NULL
)

## S4 method for signature 'CA,missing'
plot(
  x,
  margin = c(1, 2),
  axes = c(1, 2),
  active = TRUE,
  sup = TRUE,
  highlight = NULL,
  group = NULL
)

## S4 method for signature 'CA'
plot_columns(
  object,
  axes = c(1, 2),
  active = TRUE,
  sup = TRUE,
  highlight = NULL,
  group = NULL
)

## S4 method for signature 'PCA,missing'
plot(
  x,
  margin = 1,
  axes = c(1, 2),
  active = TRUE,
  sup = TRUE,
  highlight = NULL,
  group = NULL
)

## S4 method for signature 'PCA'
plot_columns(
  object,
  axes = c(1, 2),
  active = TRUE,
  sup = TRUE,
  highlight = NULL,
  group = NULL
)
```

```
## S4 method for signature 'BootstrapPCA'
plot_columns(
  object,
  axes = c(1, 2),
  active = TRUE,
  sup = TRUE,
  highlight = NULL,
  group = NULL
)
```

Arguments

object, x	A CA or PCA object.
...	Currently not used.
axes	A length-two numeric vector giving the dimensions to be plotted.
active	A logical scalar: should the active observations be plotted?
sup	A logical scalar: should the supplementary observations be plotted?
highlight	A character string giving XXX. It must be one of "coordinates", "contributions" or "cos2". Any unambiguous substring can be given. If NULL (the default), no highlighting is applied.
group	A vector of categories specifying the categorical variable from which to color the individuals (only used if <code>highlight</code> is NULL; see below).
margin	A length-one numeric vector giving the subscript which the data will be returned: 1 indicates individuals/rows (the default), 2 indicates variables/columns, <code>c(1, 2)</code> indicates rows and columns (CA).

Aesthetic

Point shapes and line types are set whether an observation is a row/individual or a column/variable and is active or supplementary.

Colors are set according to `highlight` and `group`:

- If `highlight` is not NULL, the color gradient will vary according to the value of the selected parameter.
- If `group` is a numeric vector, the color gradient and size will vary by the value of `group`.
- If `group` is not a numeric vector, the colors will be mapped to the levels of `group`.
- If both are NULL (the default), then the same rule as for shapes is used.

Author(s)

N. Frerebeau

See Also

[ggplot2::ggplot\(\)](#)

Other plot: [plot_contributions\(\)](#), [plot_eigenvalues](#)

Examples

```
## Load data
data("zuni", package = "folio")

## Compute correspondence analysis
X <- ca(zuni)

## Plot observations
plot(X)

## Screeplot
plot_variance(X)
```

plot_eigenvalues	<i>Visualize Eigenvalues</i>
------------------	------------------------------

Description

Plot eigenvalues or variances histogram.

Usage

```
plot_variance(object, ...)
```

```
## S4 method for signature 'MultivariateAnalysis'
plot_variance(
  object,
  variance = TRUE,
  cumulative = TRUE,
  fill = "grey30",
  border = "grey10",
  color = "red"
)
```

Arguments

object	A CA or PCA object.
...	Currently not used.
variance	A logical scalar: should the percentages of variance be plotted instead of the eigenvalues?
cumulative	A logical scalar: should the cumulative percentages of variance be plotted?
fill, border	A character string specifying the bars infilling and border colors.
color	A character string specifying the line color.

Author(s)

N. Frerebeau

See Also

[ggplot2::ggplot\(\)](#)

Other plot: [plot_contributions\(\)](#), [plot_coordinates](#)

Examples

```
## Load data
data("zuni", package = "folio")

## Compute correspondence analysis
X <- ca(zuni)

## Plot observations
plot(X)

## Screeplot
plot_variance(X)
```

predict

Predict New Coordinates

Description

Predict the projection of new individuals/rows or variables/columns.

Usage

```
## S4 method for signature 'CA'
predict(object, newdata, margin = 1)
```

```
## S4 method for signature 'PCA'
predict(object, newdata, margin = 1)
```

Arguments

object	A CA or PCA object.
newdata	An object of supplementary points coercible to a matrix for which to compute principal coordinates.
margin	A length-one numeric vector giving the subscript which the data will be predicted: 1 indicates individuals/rows (the default), 2 indicates variables/columns.

Value

A [data.frame](#) of coordinates.

Author(s)

N. Frerebeau

See Also

Other multivariate analysis: [bootstrap\(\)](#), [ca\(\)](#), [pca\(\)](#)

Examples

```
## Create a matrix
A <- matrix(data = sample(1:10, 100, TRUE), nrow = 10, ncol = 10)

## Compute correspondence analysis
X <- ca(A, sup_row = 8:10, sup_col = 7:10)

## Predict new row coordinates
Y <- matrix(data = sample(1:10, 120, TRUE), nrow = 20, ncol = 6)
predict(X, Y, margin = 1)

## Predict new column coordinates
Z <- matrix(data = sample(1:10, 140, TRUE), nrow = 7, ncol = 20)
predict(X, Z, margin = 2)
```

subset

Extract Parts of an Object

Description

Operators acting on objects to extract parts.

Usage

```
## S4 method for signature 'CA,ANY,missing'
x[[i]]

## S4 method for signature 'PCA,ANY,missing'
x[[i]]
```

Arguments

x An object from which to extract element(s) or in which to replace element(s).

i A [character](#) string specifying elements to extract. Any unambiguous substring can be given (see details).

Details

If **i** is "data", returns a list with the following elements:

data A [numeric](#) matrix of raw data.

mean A [numeric](#) vector giving the variables means (PCA).

sd A [numeric](#) vector giving the variables standard deviations (PCA).

If `i` is "rows", returns a list with the following elements:

`coord` A **numeric** matrix of rows/individuals coordinates.

`cos2` A **numeric** matrix of rows/individuals squared cosine.

`masses` A **numeric** vector giving the rows masses/individual weights.

`sup` A **logical** vector specifying whether a point is a supplementary observation or not.

If `i` is "columns", returns a list with the following elements:

`coord` A **numeric** matrix of columns/variables coordinates.

`cor` A **numeric** matrix of correlation between variables and the dimensions (PCA).

`cos2` A **numeric** matrix of columns/variables squared cosine.

`masses` A **numeric** vector giving the columns masses/variable weights.

`sup` A **logical** vector specifying whether a point is a supplementary observation or not.

If `i` is "eigenvalues", returns a **numeric** vector of eigenvalues.

Value

A **list**.

Author(s)

N. Frerebeau

See Also

Other mutator: [mutator](#)

Examples

```
## Load data
data("mississippi", package = "folio")

## Compute principal components analysis
X <- pca(mississippi, scale = TRUE, sup_row = 8:10, sup_col = 7:10)

## Get results for the individuals
X[["individuals"]]

## Compute correspondence analysis
Y <- ca(mississippi, sup_row = 8:10, sup_col = 7:10)

## Get results for the rows
Y[["rows"]]
```

Description

Provides a summary of the results of a multivariate data analysis.

Usage

```
## S4 method for signature 'CA'  
summary(object, margin = 1, active = TRUE, sup = TRUE, rank = 3)  
  
## S4 method for signature 'PCA'  
summary(object, margin = 1, active = TRUE, sup = TRUE, rank = 3)
```

Arguments

object	A CA or PCA object.
margin	A length-one numeric vector giving the subscript which the data will be summarized: 1 indicates individuals/rows (the default), 2 indicates variables/columns.
active	A logical scalar: should the active observations be summarized?
sup	A logical scalar: should the supplementary observations be summarized?
rank	An integer value specifying the maximal number of components to be kept in the results.

Author(s)

N. Frerebeau

Examples

```
## Load data  
data("zuni", package = "folio")  
  
## Compute correspondence analysis  
X <- ca(zuni, rank = 5, sup_row = 1:50)  
  
## Rows summary  
summary(X, margin = 1)  
  
## Columns summary  
summary(X, margin = 2)
```

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