Package ‘MN’

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Description Density computation, random matrix generation, maximum likelihood estimation, and regression for the matrix normal distribution. References: Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. <doi:10.48550/arXiv.1910.02859> and the relevant wikipedia page.

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Contents

`MN-package` *Matrix Normal Distribution*

Description

Density computation, random matrix generation and maximum likelihood estimation of the matrix normal distribution. For references see: Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859 and the relevant wikipedia page.

Details

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Maintainers

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Author(s)

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References

Pocuca, N., Gallaugher, M. P., Clark, K. M., & McNicholas, P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

`Density of the matrix normal distribution`
Density of the matrix normal distribution

Description

Density of the matrix normal distribution.

Usage

```
dmn(X, M, U, V, logged = FALSE)
```

Arguments

`X`	A list with k elements, k matrices of dimension $n\ timesp$ each. In the case of one matrix only, this may be given as a numerical matrix and not as an element in a list.
`M`	The mean matrix of the distribution, a numerical matrix of dimensions $n \times p$.
`U`	The covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
`V`	The covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.
`logged`	Should the logarithm of the density be computed?

Value

A numeric vector with the (logged) density values.

Author(s)

Omar Alzeley.

R implementation and documentation: Omar Alzeley `<oazeley@uqu.edu.sa>`.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

Pocuca, N., Gallaugher, M. P., Clark, K. M., & McNicholas, P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

`rmn`, `mn.mle`, `ddplot`

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
X <- rmn(10, M, U, V)
dmn(X, M, U, V, TRUE)
```

Distance-Distance Plot

Distance-Distance Plot

Description

Distance-Distance Plot

Usage

```
ddplot(X, M, U, V)
```

Arguments

X	A list with k elements, k matrices of dimension $n\ timesp$ each. In the case of one matrix only, this may be given as a numerical matrix and not as an element in a list.
M	The mean matrix of the distribution, a numerical matrix of dimensions $n \times p$.
U	The covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
V	The covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.

Details

The distance-distance plot is produced. This is a scatter plot of the Mahalanobis distances computed using the estimated parameters from the multivariate normal and matrix normal distribution. See Pocuca et al. (2019) for more details.

Value

A scatter plot of the Mahalanobis distances.

Author(s)

Michail Tsagris and Omar Alzeley.

R implementation and documentation: Michail Tsagris <mtsagris@uoc.gr> and Omar Alzeley <oazeley@uqu.edu.sa>.

References

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

rmn, mn.mle, dmn, ddkstest

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
X <- rmn(100, M, U, V)
ddplot(X, M, U, V)
```

`Kolmogorov-Smirnov test for matrix normality`
Kolmogorov-Smirnov test for matrix normality

Description

Kolmogorov-Smirnov test for matrix normality

Usage

```
ddkstest(X, M, U, V, alpha = 0.05)
```

Arguments

`X`	A list with k elements, k matrices of dimension $n\ times p$ each. In the case of one matrix only, this may be given as a numerical matrix and not as an element in a list.
`M`	The mean matrix of the distribution, a numerical matrix of dimensions $n \times p$.
`U`	The covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
`V`	The covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.
`alpha`	The significance level for the test, set by default equal to 0.05.

Details

The Kolmogorov-Smirnov test for matrix normality is performed. See Pocuca (2019) for more details.

Value

A message. If the Kronecker product covariance structure is not present, the message reads "Reject" and "Not reject otherwise".

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris `<mtsagris@uoc.gr>`.

References

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

rmn, mn.mle, dmn, ddplot

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
X <- rmn(200, M, U, V)
ddkstest(X, M, U, V)
```

Log-likelihood ratio test for equality of all parameters
Log-likelihood ratio test for equality of all parameters

Description

Log-likelihood ratio test for equality of all parameters.

Usage

```
mn.equaltest(Y1, Y2, tol = 1e-6)
```

Arguments

Y1	The observations of the first sample. A list with k1 elements (k1 is the sample size), k1 matrices of dimension $n \times p$ each.
Y2	The observations of the first sample. A list with k2 elements (k2 is the sample size), k2 matrices of dimension $n \times p$ each.
tol	The tolerance value to terminate the iterative algorithm.

Details

A log-likelihood ratio test comparing the equality of all parameters, mean matrices and covariance matrices mean matrices is performed.

Value

This is an "htest"class object. Thus it returns a list including:

`statistic`	The test statistic value.
`parameter`	The degrees of freedom of the test.
`p.value`	The p-value of the test.
`alternative`	A character with the alternative hypothesis.
`method`	A character with the test used.
`data.name`	A character vector with two elements.

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris <`mtsagris@uoc.gr`>.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

`mn.mle`, `mn.reg`

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
Y1 <- MN::rmn(250, M, U, V)
Y2 <- MN::rmn(200, M, U, V)
mn.equaltest(Y1, Y2)
```

`Log-likelihood ratio test for equality of mean matrices`
Log-likelihood ratio test for equality of mean matrices

Description

Log-likelihood ratio test for equality of mean matrices.

Usage

```
mn.ttest(Y1, Y2, tol = 1e-6, maxiter = 100)
```

Arguments

`Y1`	The observations of the first sample. A list with k1 elements (k1 is the sample size), k1 matrices of dimension $n \times p$ each.
`Y2`	The observations of the first sample. A list with k2 elements (k2 is the sample size), k2 matrices of dimension $n \times p$ each.
`tol`	The tolerance value to terminate the iterative algorithm.
`maxiter`	The maximum number of iterations allowed.

Details

A log-likelihood ratio test comparing the equality of mean matrices, $M_1 = M_2$ is performed, and the alternative is that the mean matrices are not equal.

Value

This is an "htest"class object. Thus it returns a list including:

`statistic`	The test statistic value.
`parameter`	The degrees of freedom of the test.
`p.value`	The p-value of the test.
`alternative`	A character with the alternative hypothesis.
`method`	A character with the test used.
`data.name`	A character vector with two elements.

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris <mtsagris@uoc.gr>.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

`mn.mle`, `mn.reg`

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
Y1 <- MN::rmn(150, M, U, V)
Y2 <- MN::rmn(100, M, U, V)
mn.ttest(Y1, Y2)
```

Matrix normal regression

Matrix normal regression

Description

Matrix normal regression.

Usage

```
mn.reg(Y, X, tol = 1e-6, maxiter = 100, Xnew = NULL)
mn.reg2(Y, x, tol = 1e-6, maxiter = 100, xnew = NULL)
mn.reg_null(Y, tol = 1e-6, maxiter = 100)
```

Arguments

`Y`	A list with k elements (k is the sample size), k matrices of dimension $n \times p$ each.
`X`	A list with the matrix covariates. A list with k elements (k is the sample size), k matrices of dimension $n \times dx$ each, each matrix is the matrix covariate to the matrix response.
`x`	A matrix with covariates, where the i-th row represents the covariate vector is related to the i-th response matrix Y.
`tol`	The tolerance value to terminate the iterative algorithm.
`maxiter`	The maximum number of iterations allowed.
`Xnew`	If you have new X values (list of matrices or a list with a single matrix) and want to predict the values of the response matrices pass them here.
`xnew`	If you have new x values (matrix or vector) and want to predict the values of the response matrices pass them here.

Details

The function mn.reg() performs matrix normal regression with matrix covariates. The function mn.reg2() performs matrix normal regression with a matrix of covariates. The function mn.reg_null() performs matrix normal regression with the constant only. This is useful for performing a log-likelihood ratio test of a regression model against the constant term.

Value

A list including:

`runtime`	The runtime required for the whole fitting procedure.
`iters`	The number of iterations required for the estimation of the U and V matrices.
`loglik`	The log-likelihood value.
`B`	The estimated matrix of coefficients.

U	The estimated covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
V	The estimated covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.
est	The estimated matrix responses for the new x values, otherwise this is NULL.

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris <mtsagris@uoc.gr>.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

mn.mle

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
Y <- MN::rmn(150, M, U, V)
x <- iris[, 1:2]
colnames(x) <- c("sepal-length", "sepal-width")
mod2 <- mn.reg2(Y, x)


M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
X <- MN::rmn(150, M/3, U, V)

mod <- mn.reg(Y, X)
```

Maximum likelihood estimation of the matrix normal distribution

Maximum likelihood estimation of the matrix normal distribution

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Description

Maximum likelihood estimation of the matrix normal distribution.

Usage

```
mn.mle(Y, tol = 1e-6)
```

Arguments

`Y`	A list with k elements (k is the sample size), k matrices of dimension $n \times p$ each.
`tol`	The tolerance value to terminate the iterative algorithm.

Value

A list including:

`runtime`	The runtime required for the whole fitting procedure.
`iters`	The number of iterations required for the estimation of the U and V matrices.
`loglik`	The log-likelihood value.
`M`	The estimated mean matrix of the distribution, a numerical matrix of dimensions $n \times p$.
`U`	The estimated covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
`V`	The estimated covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris <mtsagris@uoc.gr>.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

Pocuca N., Gallaugher M. P., Clark K. M. & McNicholas P. D. (2019). Assessing and Visualizing Matrix Variate Normality. arXiv:1910.02859.

See Also

dmn, rmn, ddplot

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
Y <- rmn(200, M, U, V)
mod <- mn.mle(Y)
```

`Random matrices simulation from the matrix normal distribution`
Random matrices simulation from the matrix normal distribution

Description

Random matrices simulation from the matrix normal distribution.

Usage

```
rmn(k, M, U, V)
```

Arguments

`k`	The sample size, the number of matrices to simulate.
`M`	The mean matrix of the distribution, a numerical matrix of dimensions $n \times p$.
`U`	The covariance matrix associated with the rows, a numerical matrix of dimensions $n \times n$.
`V`	The covariance matrix associated with the columns, a numerical matrix of dimensions $p \times p$.

Value

A list with k elements, k matrices of dimension $n\ timesp$ each. These are the random matrices drawn from a matrix normal distribution.

Author(s)

Michail Tsagris.

R implementation and documentation: Michail Tsagris <mtsagris@uoc.gr>.

References

https://en.wikipedia.org/wiki/Matrix_normal_distribution#Definition

See Also

dmn, mn.mle, ddplot

Examples

```
M <- as.matrix(iris[1:8, 1:4])
U <- cov( matrix( rnorm(100 * 8), ncol = 8 ) )
V <- cov( iris[1:50, 1:4] )
X <- rmn(10, M, U, V)
```

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