Package ‘TestIndVars’

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Type Package

Title Testing the Independence of Variables for Specific Covariance Structures

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Description Test the nullity of covariances, in a set of variables, using a simple univariate procedure. See Marques, Diago, Norouzirad, Bispo (2023) <doi:10.1002/mma.9130>.

License GPL (>= 2)

URL https://github.com/mnrzrad/TestIndVars

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 Depends R (>= 3.5)

 Imports stats, matrixcalc, MASS

 NeedsCompilation no

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covMatAR

Generate a covariance matrix with Autoregressive (AR) structure.

Description

This function generates an Autoregressive (AR) covariance structure matrix of size \( p \times p \) based on the specified autoregressive coefficient \((\rho)\) and variance \((\sigma^2)\).

Usage

\[
\text{covMatAR}(p, \sigma^2 = 1, \rho)
\]

Arguments

- **p**: An integer specifying the number of dimensions of the covariance matrix.
- **sigma2**: A numeric value specifying the variance parameter (default = 1).
- **rho**: A numeric value specifying the autoregressive coefficient. If not provided, a random value between 0 and 1 will be generated.

The Autoregressive structure is defined as follows:

\[
\Sigma = \Sigma_{AR} = \sigma^2 \begin{bmatrix}
1 & \rho & \rho^2 & \cdots & \rho^{p-1} \\
\rho & 1 & \rho & \cdots & \rho^{p-2} \\
\vdots & \vdots & \ddots & \ddots & \vdots \\
\rho^{p-1} & \rho^{p-2} & \cdots & 1 & \rho \\
\end{bmatrix}
\]

where \(\Sigma\) is the covariance matrix, \(\sigma^2\) is the variance parameter, and \(\rho\) is the correlation parameter.

Value

A \(p \times p\) numeric matrix representing the Autoregressive (AR) covariance structure.

Examples

```r
# generate a covariance matrix for \(p = 5\), \(\sigma^2 = 1\), and \(\rho = 0.9\).
covMatAR(p = 5, rho = 0.9)

# generate a covariance matrix for \(p = 5\), \(\sigma^2 = 5\), and \(\rho = 0.9\).
covMatAR(p = 5, sigma2 = 5, rho = 0.9)

# generate covariance matrix for \(p = 5\), and no value is considered for \(\rho\)
covMatAR(p = 5)
```
covMatC

Generate a covariance matrix with Circular (C) structure.

Description
This function generates an Circular (C) covariance structure matrix of size \( p \times p \) based on the specified sequence of \( \{b_1, b_2, \ldots, b_{\lfloor p/2 \rfloor}\} \) where \( \lfloor \cdot \rfloor \) represents the largest integer that is not greater than the argument and \( b_j = b_{p-j} \) that this sequence in this function is created by a controlling parameter \( \rho \) as well as variance (\( \sigma^2 \)).

Usage
covMatC(p, sigma2 = 1, rho = NULL)

Arguments
- \( p \) An integer specifying the number of dimensions of the covariance matrix.
- \( \sigma^2 \) A numeric value specifying the variance parameter (default = 1).
- \( \rho \) Parameter controlling the circular pattern. If not provided, a random value between 0 and 1 will be generated.

The Circular structure is defined as follows:

\[
\Sigma = \Sigma_C = \begin{bmatrix}
\sigma^2 & b_1 & b_2 & \cdots & b_{p-1} \\
b_{p-1} & \sigma^2 & b_1 & \cdots & b_{p-2} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
b_1 & b_2 & b_3 & \cdots & \sigma^2
\end{bmatrix}
\]

where \( \Sigma \) is the covariance matrix, \( \sigma^2 \) is the variance parameter, and \( b_j \) is the sequence that \( b_j = b_{p-j} \) for \( j = 1, 2, \ldots, \lfloor p/2 \rfloor \) where \( \lfloor \cdot \rfloor \) represents the largest integer that is not greater than the argument.

Value
A \( p \times p \) numeric matrix representing the Circular (C) covariance structure.

Examples
# generate a covariance matrix for \( p = 5 \), \( \sigma^2 = 1 \), and \( \rho = 0.9 \).
covMatC(p = 5, rho = 0.9)

# generate a covariance matrix for \( p = 5 \), \( \sigma^2 = 5 \), and \( \rho = 0.9 \).
covMatC(p = 5, sigma2 = 5, rho = 0.9)

# generate a covariance matrix for \( p = 5 \), and no value is considered for \( \rho \).
covMatC(p = 5)
covMatCS

Generate a covariance matrix with equivariance-equicorrelation or compound symmetry structure.

Description
This function generates a covariance matrix with equivariance-equicorrelation

Usage
covMatCS(p, sigma2 = 1, rho = NULL)

Arguments
p
An integer specifying the number of dimensions of the covariance matrix.
sigma2
A numeric value specifying the variance parameter (default = 1).
rho
A numeric value specifying the correlation parameter. If not provided, a random value between 0 and 1 will be generated.

The compound symmetry structure is defined as follows:

\[
\Sigma = \Sigma_{CS} = \sigma^2 \begin{bmatrix}
1 & \rho & \cdots & \rho \\
\rho & 1 & \cdots & \rho \\
\vdots & \vdots & \ddots & \vdots \\
\rho & \rho & \cdots & 1
\end{bmatrix}
\]

where \(\Sigma\) is the covariance matrix, \(\sigma^2\) is the variance parameter, and \(\rho\) is the correlation parameter.

Value
A \(p \times p\) numeric matrix representing the covariance matrix with equivariance-equicorrelation or compound symmetry structure.

Examples
# generate a covariance matrix for \(p = 5\), \(\sigma^2 = 1\), and \(\rho = 0.9\).
covMatCS(p = 5, rho = 0.9)
# generate a covariance matrix for \(p = 5\), \(\sigma^2 = 5\), and \(\rho = 0.9\).
covMatCS(p = 5, sigma2 = 5, rho = 0.9)
# generate covariance matrix for \(p = 5\), and no value is considered for \(\rho\).
covMatCS(p = 5)
**Description**

Performs an independent test for a set of variables both for low and high dimensional data.

**Usage**

```r
indTest(X, covMat = NULL, alpha = 0.05)
```

**Arguments**

- **X**
  A numeric matrix or data frame containing the measurements on the variables.

- **covMat**
  Optional. A numeric matrix representing the population covariance matrix used in the test. If NULL, the sample covariance matrix is used (default is NULL).

- **alpha**
  The significance level for the test (default is 0.05).

**Value**

A data frame containing the observed value of the test statistic, degrees of freedom, alpha value, p-value, and test result.

**Examples**

```r
# Example usage:

library(MASS)

n = 50 # Sample Size
p = 5  # number of variables
rho = 0.4
# Building a Covariance structure with Autoregressive structure
cov_mat <- covMatAR(p = p, rho = rho)
# Simulated data
data <- mvnrnorm(n = n, mu = rep(0, p), Sigma = cov_mat)
# Performing the test assuming that the population covariance matrix is unknown
indTest(data)
# Performing the test assuming that the population covariance matrix is known
indTest(data, covMat = cov_mat)

# Example for data with missing values
# Generating data with 10% of missing values
missing_rate <- 0.1
missing_index_row <- sample(1:n, size = round(n * missing_rate))
missing_index_col <- sample(1:p, size = 1)
```
data[missing_index_row, missing_index_col] <- NA  # Introducing missing values
# Performing the test assuming that the population covariance matrix is unknown
indTest(data)
# Performing the test assuming that the population covariance matrix is known
indTest(data, covMat = cov_mat)

# Building a Covariance structure with Compound Symmetry structure
cov_mat <- covMatCS(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test assuming that the population covariance matrix is unknown
indTest(data)
# Performing the test assuming that the population covariance matrix is known
indTest(data, covMat = cov_mat)

# Building a Covariance structure with Circular structure
cov_mat <- covMatC(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test assuming that the population covariance matrix is unknown
indTest(data)
# Performing the test assuming that the population covariance matrix is known
indTest(data, covMat = cov_mat)

---

**lrTest**

*Likelihood Ratio Test for Covariance Matrix*

**Description**

Performs a likelihood ratio test for the covariance matrix to assess if the covariance matrix is significantly different from an identity matrix.

**Usage**

```
lrTest(X, alpha = 0.05)
```

**Arguments**

- **X**: A numeric matrix or data frame containing the variables.
- **alpha**: The significance level for the test. (default is 0.05).

**Value**

A data frame containing the test statistic, degrees of freedom, critical value, p-value, and test result.
Examples

```r
library(MASS)

n = 50 # Sample Size
p = 5
rho = 0.1

# Building a Covariance structure with Autoregressive structure
cov_mat <- covMatAR(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
lrTest(data, alpha = 0.01)

# Building a Covariance structure with Compound Symmetry structure
cov_mat <- covMatCS(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
lrTest(data)

# Building a Covariance structure with Circular structure
cov_mat <- covMatC(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
lrTest(data)
```

---

**schottTest**  
*Schott's Test for testing independency*

**Description**

Performs Schott’s test for the correlation matrix to assess if the correlation matrix is significantly different from an identity matrix.

**Usage**

```r
schottTest(X, alpha = 0.05)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>X</code></td>
<td>A numeric matrix or data frame containing the variables.</td>
</tr>
<tr>
<td><code>alpha</code></td>
<td>The significance level for the test (default is 0.05).</td>
</tr>
</tbody>
</table>

**Value**

A data frame containing the test statistic, alpha value, p-value, and test result.
References


Examples

library(MASS)

n = 50 # Sample Size
p = 5
rho = 0.1
# Building a Covariance structure with Autoregressive structure
cov_mat <- covMatAR(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
schottTest(data)

# Building a Covariance structure with Compound Symmetry structure
cov_mat <- covMatCS(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
schottTest(data)

# Building a Covariance structure with Circular structure
cov_mat <- covMatC(p = p, rho = rho)
# Simulated data
data <- mvrnorm(n = n, mu = rep(0,p), Sigma = cov_mat)
# Performing the test
schottTest(data)
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