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Type Package

Title Concurrent Generation of Ordinal and Normal Data with Given Correlation Matrix and Marginal Distributions

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Author Anup Amatya, Hakan Demirtas, Ran Gao

Maintainer Ran Gao <rgao8@uic.edu>

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Description Implementation of a procedure for generating samples from a mixed distribution of ordinal and normal random variables with a pre-specified correlation matrix and marginal distributions. The details of the method are explained in Demirtas et al. (2015) <DOI:10.1080/10543406.2014.920868>.

License GPL

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Contents

`OrdNor-package` *Concurrently generates ordinal and normal variables with a specified correlation matrix and marginal distributions*

Description

The package implements a procedure for concurrently generating samples from ordinal and normal random variables with a pre-specified correlation matrix and marginal distributions. It is accomplished by first calculating an intermediate correlations (`cmat.star`) which is used to generate a sample from multivariate normal distribution. Then, the first few components (corresponding to number of ordinal variables) are ordinalized. The resulting data are composed of a mixture of ordinal and normal variables that conform with a pre-specified marginal distributions and correlation structure. The function `valid.limits` returns the lower and upper bounds of the correlation coefficients of ordinal-ordinal (OO) and ordinal-normal (ON) pairs given their marginal distributions, i.e. returns the range of feasible pairwise correlations. The function `validate.target.cormat` checks the validity of the values of pairwise correlations. Additionally, it checks positive definiteness, symmetry and correct dimension. The engine function `genOrdNor` generates mixed data in accordance with the specified marginal and correlational quantities.

Details

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Author(s)

Anup Amatya, Hakan Demirtas, Ran Gao

Maintainer: Ran Gao <rgao8@uic.edu>

`cmat.star` *Computes the correlation of intermediate multivariate normal data before subsequent ordinalization*

Description

The function computes an intermediate correlation matrix which leads to the target correlation matrix after ordinalization of the samples generated from a multivariate normal distribution with the intermediate correlation matrix.

Usage

```
cmat.star(plist, CorrMat, no.ord, no.norm)
```

Arguments

`plist`	A list of probability vectors corresponding to each ordinal variable. The i-th element of `plist` is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the `plist` will contain k-1 probability values. The k-th element is implicitly 1.
`CorrMat`	The target correlation matrix which must be positive definite and within the valid limits.
`no.ord`	Number of ordinal variables in the data.
`no.norm`	Number of normal variables in the data.

Value

An intermediate correlation matrix of size $(no.ord + no.norm) \times (no.ord + no.norm)$

See Also

`validate.target.cormat`

Examples

```
Sigma = diag(4)
Sigma[lower.tri(Sigma)] = c(0.42, 0.78, 0.29, 0.37, 0.14, 0.26)
Sigma = Sigma + t(Sigma)
diag(Sigma)=1

marginal = list( c(0.2, 0.5), c(0.4, 0.7, 0.9))
cmat.star(marginal, Sigma, 2, 2)
```

genOrdNor *Generates a data set with ordinal and normal variables*

Description

The function simulates a data set with ordinal and normal components with a pre-specified correlation matrix and marginals.

Usage

```
genOrdNor(n, plist, cmat.star, mean.vec, sd.vec, no.ord, no.norm)
```

Arguments

n	Number of rows
plist	A list of probability vectors corresponding to each ordinal variable. The i-th element of plist is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the plist will contain k-1 probability values. The k-th element is implicitly 1.
cmat.star	The intermediate correlation matrix obtained from cmat.star function.
mean.vec	A vector of means for the normal variables.
sd.vec	A vector of standard deviations for the normal variables.
no.ord	Number of ordinal variables.
no.norm	Number of normal variables.

Value

A matrix of size $n \times (no.ord + no.norm)$, of which first no.ord are ordinal variables.

References

Demirtas, H., Yavuz, Y. (2015). Concurrent generation of ordinal and normal data. *Journal of Biopharmaceutical Statistics*; **25(4)**, 635-650.

See Also

cmat.star, validate.target.cormat, validate.plist

Examples

```
Sigma = diag(4)
Sigma[lower.tri(Sigma)] = c(0.42, 0.78, 0.29, 0.37, 0.14, 0.26)
Sigma = Sigma + t(Sigma)
diag(Sigma)=1
```

```
marginal = list( c(0.2, 0.5), c(0.4, 0.7, 0.9))
cmat= cmat.star(marginal, Sigma, 2, 2)
mean.vec = c(2,4)
sd.vec = c(0.5, 1.5)
Y=genOrdNor(10000,marginal, cmat, mean.vec, sd.vec, 2, 2)
cor(Y)
```

`IntermediateON` *Computes intermediate correlations for ordinal-normal pairs before ordinalization*

Description

The function computes the intermediate correlation values of pairwise correlations between ordinal and normal variables.

Usage

```
IntermediateON(plist, ONCorrMat)
```

Arguments

`plist`	A list of probability vectors corresponding to each ordinal variable. The i-th element of `plist` is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the `plist` will contain k-1 probability values. The k-th element is implicitly 1.
`ONCorrMat`	A matrix of pairwise target correlations between ordinal and normal variables. This is a submatrix of the overall correlation matrix, and it is pertinent to the ordinal-normal part. Hence, the matrix may or may not be square. Even when it is square, it may not be symmetric.

Value

A pairwise correlation matrix of intermediate correlations.

See Also

`IntermediateOO`, `cmat.star`

Examples

```
no.ord=3
no.norm =4
n = 200
q=no.ord + no.norm
set.seed(12345)

Sigma = diag(q)
```

```
Sigma[lower.tri(Sigma)] = runif( (q*(q-1)/2),-0.4,0.4 )
Sigma = Sigma + t(Sigma)
diag(Sigma)=1
Sigma=as.matrix( nearPD(Sigma,corr = TRUE, keepDiag = TRUE)$mat )

marginal = list( 0.3, cumsum( c(0.30, 0.40) ), cumsum(c(0.4, 0.2, 0.3) ) )

ONCorrMat = Sigma[4:7, 1:3]
 IntermediateON(marginal, ONCorrMat)
```

`IntermediateOO` *Computes intermediate correlations for ordinal-ordinal pairs before ordinalization*

Description

This function computes the correlation of normal-normal pairs before ordinalizing both components.

Usage

```
IntermediateOO(plist, OOCorrMat)
```

Arguments

`plist`	A list of probability vectors corresponding to each ordinal variable. The i-th element of `plist` is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the `plist` will contain k-1 probability values. The k-th element is implicitly 1.
`OOCorrMat`	A matrix of pairwise target correlations between ordinal variables. It is a symmetric square matrix whose diagonal elements are 1.

Value

A pairwise correlation matrix of intermediate correlations for ordinal variables.

See Also

`IntermediateON`, `cmat.star`

Examples

```
no.ord=3
no.norm =4
n = 200
q=no.ord + no.norm
set.seed(12345)
```

```
Sigma = diag(q)
Sigma[lower.tri(Sigma)] = runif( (q*(q-1)/2),-0.4,0.4 )
Sigma = Sigma + t(Sigma)
diag(Sigma)=1
Sigma=as.matrix( nearPD(Sigma,corr = TRUE, keepDiag = TRUE)$mat )

marginal = list( 0.3, cumsum( c(0.30, 0.40) ), cumsum(c(0.4, 0.2, 0.3) ) )

OOCorrMat = Sigma[1:3, 1:3]
 IntermediateOO(marginal, OOCorrMat)
```

`LimitforON` *Finds the feasible correlation range for a pair of ordinal and normal variable*

Description

The function computes the lower and upper bounds of a pairwise correlation between an ordinal and a normal variable via the method of Demirtas and Hedeker (2011).

Usage

```
LimitforON(pvec1)
Limit_forON(pvec1) #deprecated
```

Arguments

`pvec1`	A vector of marginal probabilities for an ordinal variable of the pair.

Value

A vector of two elements. The first element is the lower bound and the second element is the upper bound.

References

Demirtas, H., Hedeker, D. (2011). A practical way for computing approximate lower and upper correlation bounds. The American Statistician, **65(2)**, 104-109.

Examples

```
pvec = cumsum( c(0.30, 0.40) )
 LimitforON(pvec)
```

LimitforOO *Finds the feasible correlation range for a pair of ordinal variables*

Description

The function computes the lower and upper bounds of correlation between two ordinal variables via the method of Demirtas and Hedeker (2011).

Usage

```
LimitforOO(pvec1, pvec2)
Limit_forOO(pvec1, pvec2) #deprecated
```

Arguments

pvec1	A vector of marginal probabilities for the first ordinal variable.
pvec2	A vector of marginal probabilities for the second ordinal variable.

Value

A vector of two elements. The first element is the lower bound and the second element is the upper bound.

References

Demirtas, H., Hedeker, D. (2011). A practical way for computing approximate lower and upper correlation bounds. The American Statistician, **65(2)**, 104-109.

Examples

```
pvec1 = cumsum( c(0.30, 0.40) )
pvec2=cumsum(c(0.4, 0, 0.3) ) # The second category is skipped in this setting
 LimitforOO(pvec1, pvec2)
```

ordinalize *Ordinalizes the standard normal variable*

Description

The function transforms the standard normal variable to an ordinal variable with a specified probability for each category.

Usage

```
ordinalize(pvec, z)
```

Arguments

pvec	A vector of probabilities for an ordinal variable. The i-th element of the pvec is the cumulative probability defining the marginal distribution of the ordinal variable. If the variable has k categories, the i-th element of pvec will contain k-1 probabilities. The k-th element is implicitly 1.
z	A vector of samples from the standard normal distribution.

Value

A vector of ordinalized variates.

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valid.limits *Computes the lower and upper bounds of correlation in the form of two matrices*

Description

The function computes the lower and upper bounds for the target correlation based on the marginal probabilities.

Usage

```
valid.limits(plist, no.ord, no.norm)
```

Arguments

plist	A list of probability vectors corresponding to each ordinal variable. The i-th element of plist is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the plist will contain k-1 probability values. The k-th element is implicitly 1.
no.ord	Number of ordinal variables.
no.norm	Number of normal variables.

Details

The function returns a list of two matrices. The lower contains the lower bounds and the upper contains the upper bounds of the feasible correlations.

Examples

```
marginal = list( c(0.2, 0.5), c(0.4, 0.7, 0.9))
valid.limits (marginal, 2,2)
```

validate.plist *Checks the validity of ordinal probabilities*

Description

The function checks the validity of the probability vectors of the ordinal variables. It verifies that the elements in the vectors are cumulative probabilities and the values are between 0 and 1. It also checks a number of vectors within the list matches the specified number of ordinal variables.

Usage

```
validate.plist(plist, no.ord)
```

Arguments

plist	A list of probability vectors corresponding to each ordinal variable. The i-th element of plist is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the plist will contain k-1 probability values. The k-th element is implicitly 1.
no.ord	Number of ordinal variables.

Details

The function returns error message if there are any violations. No message is displayed for the correct specifications.

Examples

```
marginal = list( c(0.2, 0.5), c(0.4, 0.7, 0.9))
validate.plist(marginal, 2)
```

validate.target.cormat *Checks the target correlation matrix*

Description

The function checks the validity of the values of pairwise correlations. Additionally, it checks positive definitiveness, symmetry and correct dimension.

Usage

```
validate.target.cormat(plist, CorrMat, no.ord, no.norm)
```

Arguments

plist	A list of probability vectors corresponding to each ordinal variable. The i-th element of plist is a vector of the cumulative probabilities defining the marginal distribution of the i-th ordinal component of the multivariate variables. If the i-th ordinal variable has k categories, the i-th vector of the plist will contain k-1 probability values. The k-th element is implicitly 1.
CorrMat	The target correlation matrix which must be positive definite and within the valid limits.
no.ord	Number of ordinal variables.
no.norm	Number of normal variables.

Details

In addition to being positive definite and symmetric, the values of pairwise correlations in the target correlation matrix must also fall within the limits imposed by the marginal distributions of the ordinal variables.The function ensures that the supplied correlation matrix is valid for simulation. If a violation occurs, an error message is displayed that identifies the violation. The function returns a logical value TRUE when no such violation occurs.

Examples

```
Sigma = diag(4)
Sigma[lower.tri(Sigma)] = c(0.42, 0.78, 0.29, 0.37, 0.14, 0.26)
Sigma = Sigma + t(Sigma)
diag(Sigma)=1

marginal = list( c(0.2, 0.5), c(0.4, 0.7, 0.9))
validate.target.cormat(marginal, Sigma, 2,2)
```

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