

Package ‘condTruncMVN’

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Type Package

Title Conditional Truncated Multivariate Normal Distribution

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Description Computes the density and probability for the conditional truncated multivariate normal (Horrace (2005) p. 4, <[doi:10.1016/j.jmva.2004.10.007](https://doi.org/10.1016/j.jmva.2004.10.007)>). Also draws random samples from this distribution.

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condtMVN

*Conditional Truncated Multivariate Normal Parameters***Description**

Suppose that $\mathbf{Z} = (\mathbf{X}, \mathbf{Y})$ is from a fully-joint multivariate normal distribution of dimension n with mean and covariance matrix `sigma` truncated between lower and upper. This function provides the parameters for the conditional mean and covariance matrix of \mathbf{Y} given \mathbf{X} . See the vignette for more information.

Usage

```
condtMVN(
  mean,
  sigma,
  lower,
  upper,
  dependent.ind,
  given.ind,
  X.given,
  init = rep(0, length(mean))
)
```

Arguments

<code>mean</code>	the mean vector for \mathbf{Z} of length of n
<code>sigma</code>	the symmetric and positive-definite covariance matrix of dimension $n \times n$ of \mathbf{Z} .
<code>lower</code>	a vector of lower bounds of length n that truncate \mathbf{Z}
<code>upper</code>	a vector of upper bounds of length n that truncate \mathbf{Z}
<code>dependent.ind</code>	a vector of integers denoting the indices of dependent variable \mathbf{Y} .
<code>given.ind</code>	a vector of integers denoting the indices of conditioning variable \mathbf{X} . If specified as integer vector of length zero or left unspecified, the unconditional density is returned.
<code>X.given</code>	a vector of reals denoting the conditioning value of \mathbf{X} . This should be of the same length as <code>given.ind</code>
<code>init</code>	initial value used for random generation of truncated multivariate normal in a Gibbs sampler. Default: A vector of zeros, equal to the number of components. For details, see <code>tmvmixnorm::rtmvmn()</code> .

Details

The first four arguments are the parameters of multivariate normal and the truncation space. `dependent.ind`, `given.ind`, `X.given`, `init` are all arguments that determines the conditional truncated MVN.

Using the full data \mathbf{Z} , the conditional mean and conditional variance of $\mathbf{Y}|\mathbf{X}$ are determined (Wang, 2006). Additionally, to reflect the reduced dimension of $\mathbf{Y}|\mathbf{X}$, the truncation limits are also adjusted.

See the vignette for more information.

Value

Returns a list of:

- condMean - conditional mean of $Y|X$
- condVar - conditional variance of $Y|X$
- condLower - the lower bound of $Y|X$
- condUpper - the upper bound of $Y|X$
- condInit - the initial values adjusted to match the dimension of $Y|X$. These are used to randomly generate the truncated multivariate normal [rcmvtruncnorm](#).

Note

This function is based on [condMVN](#) from the **condMVNorm** package.

References

Wang, R. 2006. Appendix A: Marginal and conditional distributions of multivariate normal distribution. <http://fourier.eng.hmc.edu/e161/lectures/gaussianprocess/node7.html>.

See Also

[cmvnorm](#), [pmvnorm](#), [Mvnorm](#)

Examples

```
# Suppose  $X_2, X_3, X_5 | X_2, X_4 \sim N_3(1, \Sigma)$  and truncated between -10 and 10.
d <- 5
rho <- 0.9
Sigma <- matrix(0, nrow = d, ncol = d)
Sigma <- rho^abs(row(Sigma) - col(Sigma))

# Conditional Truncated Normal Parameters
condtMVN(mean = rep(1, d),
  sigma = Sigma,
  lower = rep(-10, d),
  upper = rep(10, d),
  dependent.ind = c(2, 3, 5),
  given.ind = c(1, 4), X.given = c(1, -1)
)
```

dcmvtruncnorm

Density of the Conditional Truncated Multivariate Normal

Description

Calculates the density of truncated conditional multivariate normal $Y|X$: $f(Y = y|X = X.given)$. See the vignette for more information.

Usage

```
dcmvtruncnorm(
  y,
  mean,
  sigma,
  lower,
  upper,
  dependent.ind,
  given.ind,
  X.given,
  log = FALSE
)
```

Arguments

y	vector or matrix of quantiles of Y. If a matrix, each row is taken to be a quantile. This is the quantity that the density is calculated from.
mean	the mean vector for Z of length of n
sigma	the symmetric and positive-definite covariance matrix of dimension n x n of Z.
lower	a vector of lower bounds of length n that truncate Z
upper	a vector of upper bounds of length n that truncate Z
dependent.ind	a vector of integers denoting the indices of dependent variable Y.
given.ind	a vector of integers denoting the indices of conditioning variable X. If specified as integer vector of length zero or left unspecified, the unconditional density is returned.
X.given	a vector of reals denoting the conditioning value of X. This should be of the same length as given.ind
log	logical; if TRUE, densities d are given as log(d).

References

Horrace, W.C. 2005. Some results on the multivariate truncated normal distribution. *Journal of Multivariate Analysis*, 94, 209–221. <https://surface.syr.edu/cgi/viewcontent.cgi?article=1149&context=ecn>

Examples

```
# Example 1: X2,X3,X5|X2,X4 ~ N_3(1, Sigma)
# truncated between -10 and 10.
d <- 5
rho <- 0.9
Sigma <- matrix(0, nrow = d, ncol = d)
Sigma <- rho^abs(row(Sigma) - col(Sigma))

# Log-density of 0
dcmvtruncnorm(
  rep(0, 3),
  mean = rep(1, 5),
  sigma = Sigma,
  lower = rep(-10, 5),
  upper = rep(10, d),
  dependent.ind = c(2, 3, 5),
  given.ind = c(1, 4), X.given = c(1, -1),
  log = TRUE
)
```

pcmvtruncnorm

*CDF for the Conditional Truncated Multivariate Normal***Description**

Computes the distribution function for a conditional truncated multivariate normal random variate **Y|X**.

Usage

```
pcmvtruncnorm(
  lowerY,
  upperY,
  mean,
  sigma,
  lower,
  upper,
  dependent.ind,
  given.ind,
  X.given,
  ...
)
```

Arguments

lowerY the vector of lower limits for **Y|X**. Passed to `tmvtnorm::ptmvnorm()`.

upperY the vector of upper limits for **Y|X**. Must be greater than **lowerY**. Passed to `tmvtnorm::ptmvnorm()`.

mean	the mean vector for Z of length of n
sigma	the symmetric and positive-definite covariance matrix of dimension n x n of Z.
lower	a vector of lower bounds of length n that truncate Z
upper	a vector of upper bounds of length n that truncate Z
dependent.ind	a vector of integers denoting the indices of dependent variable Y.
given.ind	a vector of integers denoting the indices of conditioning variable X. If specified as integer vector of length zero or left unspecified, the unconditional density is returned.
X.given	a vector of reals denoting the conditioning value of X. This should be of the same length as given.ind
...	Additional arguments passed to <code>tmvtnorm::ptmvnorm()</code> . The CDF is calculated using the Genz algorithm based on these arguments: <code>maxpts</code> , <code>abseps</code> , and <code>releps</code> .

Details

Calculates the probability that $Y|X$ is between `lowerY` and `upperY`. $Z = (X, Y)$ is the fully joint multivariate normal distribution with mean equal mean and covariance matrix `sigma`, truncated between `lower` and `upper`. See the vignette for more information.

Note

For one-dimension conditionals $Y|X$, this function uses the `ptruncnorm()` function in the `truncnorm` package. Otherwise, this function uses `tmvtnorm::ptmvnorm()`.

Examples

```
# Example 1: Let X2,X3,X5|X2,X4 ~ N_3(1, Sigma)
# truncated between -10 and 10.
d <- 5
rho <- 0.9
Sigma <- matrix(0, nrow = d, ncol = d)
Sigma <- rho^abs(row(Sigma) - col(Sigma))

# Find P(-0.5 < X2,X3,X5 < 0 | X2,X4)
pcmvtruncnorm(rep(-0.5, 3), rep(0, 3),
  mean = rep(1, d),
  sigma = Sigma,
  lower = rep(-10, d),
  upper = rep(10, d),
  dependent.ind = c(2, 3, 5),
  given.ind = c(1, 4), X.given = c(1, -1)
)

# Example 2: Let X1| X2 = 1, X3 = -1, X4 = 1, X5 = -1 ~ N(1, Sigma) truncated
# between -10 and 10. Find P(-0.5 < X1 < 0 | X2 = 1, X3 = -1, X4 = 1, X5 = -1).
pcmvtruncnorm(-0.5, 0,
  mean = rep(1, d),
  sigma = Sigma,
  lower = rep(-10, d),
```

```

upper = rep(10, d),
dependent.ind = 1,
given.ind = 2:5, X.given = c(1, -1, 1, -1)
)

```

rcmvtruncnorm

*Random Sample from Conditional Truncated Multivariate Normal***Description**

Randomly samples from conditional truncated multivariate normal distribution variate, $\mathbf{Y}|\mathbf{X}$, where $\mathbf{Z} = (\mathbf{X}, \mathbf{Y})$ is the fully joint multivariate normal distribution with mean, covariance matrix `sigma`, and truncated between lower and upper. See the vignette for more information.

Usage

```

rcmvtruncnorm(
  n,
  mean,
  sigma,
  lower,
  upper,
  dependent.ind,
  given.ind,
  X.given,
  init = rep(0, length(mean)),
  burn = 10L,
  thin = 1
)

```

Arguments

<code>n</code>	number of random samples desired (sample size).
<code>mean</code>	the mean vector for \mathbf{Z} of length of <code>n</code>
<code>sigma</code>	the symmetric and positive-definite covariance matrix of dimension $n \times n$ of \mathbf{Z} .
<code>lower</code>	a vector of lower bounds of length <code>n</code> that truncate \mathbf{Z}
<code>upper</code>	a vector of upper bounds of length <code>n</code> that truncate \mathbf{Z}
<code>dependent.ind</code>	a vector of integers denoting the indices of dependent variable \mathbf{Y} .
<code>given.ind</code>	a vector of integers denoting the indices of conditioning variable \mathbf{X} . If specified as integer vector of length zero or left unspecified, the unconditional density is returned.
<code>X.given</code>	a vector of reals denoting the conditioning value of \mathbf{X} . This should be of the same length as <code>given.ind</code>
<code>init</code>	initial value used for random generation of truncated multivariate normal in a Gibbs sampler. Default: A vector of zeros, equal to the number of components. For details, see <code>tmvmixnorm::rtmvmn()</code> .

burn the burn-in, which is the number of initial iterations to be discarded. Default: 10. Passed to `rtmvm()`.

thin thinning lag (default as 1).

Note

Uses `rtmvm` from the `tmvmixnorm` package to find the random variate.

Examples

```
# Generate 2 random numbers from  $X_2, X_3, X_5 | X_2, X_4 \sim N_3(1, \Sigma)$ 
# truncated between -10 and 10.
d <- 5
rho <- 0.9
Sigma <- matrix(0, nrow = d, ncol = d)
Sigma <- rho^abs(row(Sigma) - col(Sigma))

set.seed(2342)
rcmvtruncnorm(2,
  mean = rep(1, d),
  sigma = Sigma,
  lower = rep(-10, d),
  upper = rep(10, d),
  dependent.ind = c(2, 3, 5),
  given.ind = c(1, 4), X.given = c(1, -1)
)

# Example 2: Generate two random numbers from
#  $X_1 | X_2, X_3, X_4, X_5 \sim N(1, \Sigma)$  truncated between -10 and 10.
set.seed(2342)
rcmvtruncnorm(2,
  mean = rep(1, d),
  sigma = Sigma,
  lower = rep(-10, d),
  upper = rep(10, d),
  dependent.ind = 1,
  given.ind = 2:5, X.given = c(1, -1, 1, -1)
)
```

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