# Package 'MomTrunc'

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**Type** Package

**Title** Moments of Folded and Doubly Truncated Multivariate Distributions

**Version** 1.41

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**Imports** matrixcalc, mvtnorm

**Suggests** TTmoment

**Description** It computes the raw moments for the folded and truncated multivariate normal and Student's t-distribution. It also offers specific functions to compute the mean and variance-covariance matrix as well as the cumulative distribution function (cdf) for the folded normal and folded t-distribution. Algorithms are extensions based on Kan, R., & Robotti, C. (2017) <doi:10.1080/10618600.2017.1322092>.



**NeedsCompilation** no

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cdfFMD *Cumulative distribution function for folded multivariate distributions*

## Description

It computes the cumulative distribution function on x for a folded p-variate Normal and Student's t-distribution.

## Usage

```
cdfFMD(x,mu,Sigma,dist = "normal",nu = NULL)
```

## Arguments

| | |
|---|---|
| x | vector of length $p$ where the cdf is evaluated. |
| mu | a numeric vector of length $p$ representing the location parameter. |
| Sigma | a numeric positive definite matrix with dimension $p$x$p$ representing the scale parameter. |
| dist | represents the folded distribution to be computed. The values are normal (by default) for the folded Normal distribution and t for the folded Student's t-distribution. |
| nu | It represents the degrees of freedom for the Student's t-distribution. |

## Details

Normal case by default, i.e., when dist is not provided. Univariate case is also considered, where Sigma will be the variance $\sigma^2$.

## Value

It returns the distribution value for a single point x.

## Note

Degree of freedom must be a positive integer. If nu >= 100, Normal case is considered."

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## References

Psarakis, S., & Panaretos, J. (2001). On some bivariate extensions of the folded normal and the folded-t distributions.

Chakraborty, A. K., & Chatterjee, M. (2013). On multivariate folded normal distribution. Sankhya B, 75(1), 1-15.

## See Also

momentsFMD, meanvarFMD

## Examples

```
mu = c(0.1,0.2,0.3,0.4)
Sigma = matrix(data = c(1,0.2,0.3,0.1,0.2,1,0.4,-0.1,0.3,0.4,1,0.2,0.1,-0.1,0.2,1),
               nrow = length(mu),ncol = length(mu),byrow = TRUE)
nu = 4
cdfFMD(x = c(0.5,0.2,1.0,1.3),mu,Sigma) #normal case
cdfFMD(x = c(0.5,0.2,1.0,1.3),mu,Sigma,dist = "t",nu) #t case
```

---

# meanvarFMD *Mean and variance for folded multivariate distributions*

---

## Description

It computes the mean vector and variance-covariance matrix for the folded p-variate Normal and Student's t-distribution.

## Usage

```
meanvarFMD(mu,Sigma,dist = "normal",nu = NULL)
```

## Arguments

| | |
|---|---|
| mu | a numeric vector of length $p$ representing the location parameter. |
| Sigma | a numeric positive definite matrix with dimension $p$x$p$ representing the scale parameter. |
| dist | represents the folded distribution to be computed. The values are normal (by default) for the folded Normal distribution and t for the folded Student's t-distribution. |
| nu | It represents the degrees of freedom for the Student's t-distribution. |

## Details

Normal case by default, i.e., when dist is not provided. Univariate case is also considered, where Sigma will be the variance $\sigma^2$.

## Value

It returns a list with two elements:

| | |
|---|---|
| mean | the mean vector of length $p$ |
| varcov | the variance-covariance matrix of dimensions $p$x$p$ |

### Warning

The mean can only be computed when nu is larger than 2. By the other hand, the varcov matrix can only be computed when nu is larger than 3.

### Note

Degree of freedom must be a positive integer. If `nu >= 100`, Normal case is considered."

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### References

Kan, R., & Robotti, C. (2017). On Moments of Folded and Truncated Multivariate Normal Distributions. Journal of Computational and Graphical Statistics, (just-accepted).

Galarza C.E. & Lachos, V.H. (2018). On moments of folded and truncated multivariate Student-t distribution: A recurrence approach.

### See Also

momentsFMD, meanvarTMD, cdfFMD

### Examples

```
mu = c(0.1,0.2,0.3)
Sigma = matrix(data = c(1,0.2,0.3,0.2,1,0.4,0.3,0.4,1),
               nrow = length(mu),ncol = length(mu),byrow = TRUE)
nu = 4
value1 = meanvarFMD(mu,Sigma) #normal case
value2 = meanvarFMD(mu,Sigma,dist = "t",nu) #t case
```

---

## meanvarTMD *Mean and variance for doubly truncated multivariate distributions*

---

### Description

It computes the mean vector and variance-covariance matrix for the doubly truncated p-variate Normal and Student's t-distribution.

### Usage

```
meanvarTMD(lower = NULL,upper = NULL,mu,Sigma,dist = "normal",nu = NULL)
```

## Arguments

| | |
|---|---|
| `lower` | the vector of lower limits of length $p$. |
| `upper` | the vector of upper limits of length $p$. |
| `mu` | a numeric vector of length $p$ representing the location parameter. |
| `Sigma` | a numeric positive definite matrix with dimension $p$x$p$ representing the scale parameter. |
| `dist` | represents the truncated distribution to be computed. The values are `normal` (by default) for the doubly truncated Normal distribution and `t` for the truncated Student's t-distribution. |
| `nu` | It represents the degrees of freedom for the Student's t-distribution. |

## Details

Normal case by default, i.e., when `dist` is not provided. Univariate case is also considered, where `Sigma` will be the variance $\sigma^2$. Normal case code is an R adaptation of the Matlab available function `dtmvnmom.m` from Kan & Robotti (2017).

## Value

It returns a list with two elements:

| | |
|---|---|
| `mean` | the mean vector of length $p$ |
| `varcov` | the variance-covariance matrix of dimensions $p$x$p$ |

## Warning

The mean can only be computed when `nu` is larger than 2. By the other hand, the varcov matrix can only be computed when `nu` is larger than 3.

## Note

Degree of freedom must be a positive integer. If `nu >= 100`, Normal case is considered."

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Galarza C.E. & Lachos, V.H. (2018). On moments of folded and doubly truncated multivariate Student-t distribution: A recurrence approach.

## See Also

`momentsTMD`, `meanvarFMD`, `momentsFMD`

## Examples

```
a = c(-0.8,-0.7,-0.6)
b = c(0.5,0.6,0.7)
mu = c(0.1,0.2,0.3)
Sigma = matrix(data = c(1,0.2,0.3,0.2,1,0.4,0.3,0.4,1),
               nrow = length(mu),ncol = length(mu),byrow = TRUE)
nu = 4
value1 = meanvarTMD(a,b,mu,Sigma) #normal case
value2 = meanvarTMD(a,b,mu,Sigma,dist = "t",nu) #t case
```

---

momentsFMD *Moments for folded multivariate distributions*

---

## Description

It computes the kappa-th raw moment for the folded p-variate Normal and Student's t-distribution. It also output some other lower moments (than kappa) involved in the recurrence approach.

## Usage

```
momentsFMD(kappa,mu,Sigma,dist = "normal",nu = NULL)
```

## Arguments

| | |
|---|---|
| kappa | moments vector of length $p$. All its elements must be integers greater or equal to 0. |
| mu | a numeric vector of length $p$ representing the location parameter. |
| Sigma | a numeric positive definite matrix with dimension $pxp$ representing the scale parameter. |
| dist | represents the folded distribution to be computed. The values are normal (by default) for the folded Normal distribution and t for the folded Student's t-distribution. |
| nu | It represents the degrees of freedom for the Student's t-distribution. |

## Details

Normal case by default, i.e., when dist is not provided. Univariate case is also considered, where Sigma will be the variance $\sigma^2$.

## Value

A data frame containing $p + 1$ columns. The $p$ first containing the set of moments involved in the recursive approach and the last column containing the expected value.

Normal case returns prod(kappa)+1 moments while the Student's t-distribution case returns sum(kappa)+1. See example section.

### Warning

The kappa-$th$ moment can only be computed when sum(kappa) $\leq$ nu-2.

### Note

Degree of freedom must be a positive integer. If nu >= 100, Normal case is considered."

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Galarza C.E. & Lachos, V.H. (2018). On moments of folded and truncated multivariate Student-t distribution: A recurrence approach.

### See Also

meanvarFMD,momentsTMD,meanvarTMD,cdfFMD

### Examples

```
mu = c(0.1,0.2,0.3)
Sigma = matrix(data = c(1,0.2,0.3,0.2,1,0.4,0.3,0.4,1),
               nrow = length(mu),ncol = length(mu),byrow = TRUE)
nu = 7
value1 = momentsFMD(c(2,0,1),mu,Sigma) #normal case
value2 = momentsFMD(c(0,2,0),mu,Sigma,dist = "t",nu) #t case
```

---

## momentsTMD *Moments for doubly truncated multivariate distributions*

---

### Description

It computes the kappa-th raw moment for the doubly truncated p-variate Normal and Student's t-distribution. It also output some other lower moments (than kappa) involved in the recurrence approach.

### Usage

```
momentsTMD(kappa,lower = NULL,upper = NULL,mu,Sigma,dist = "normal",nu = NULL)
```

## Arguments

| | |
|---|---|
| kappa | moments vector of length $p$. All its elements must be integers greater or equal to 0. |
| lower | the vector of lower limits of length $p$. |
| upper | the vector of upper limits of length $p$. |
| mu | a numeric vector of length $p$ representing the location parameter. |
| Sigma | a numeric positive definite matrix with dimension $p$x$p$ representing the scale parameter. |
| dist | represents the truncated distribution to be computed. The values are normal (by default) for the doubly truncated Normal distribution and t for the doubly truncated Student's t-distribution. |
| nu | It represents the degrees of freedom for the Student's t-distribution. |

## Details

Normal case by default, i.e., when dist is not provided. Univariate case is also considered, where Sigma will be the variance $\sigma^2$.

## Value

A data frame containing $p + 2$ columns. The $p$ first containing the set of moments involved in the recursive approach and the last two columns containing the $F$ function value (see Galarza and Lachos, 2018) and the expected value. Normal case returns prod(kappa)+1 moments while the Student's t-distribution case returns sum(kappa)+1. See example section.

Henceforth, we HIGHLY recomend to check the pdf manual instead because of formulae.

The $F$ function is simply

$$F_\kappa(\mathbf{a}, \mathbf{b}, \mu, \Sigma, \nu) = \int_{\mathbf{a}}^{\mathbf{b}} \mathbf{x}^\kappa f(\mathbf{x}) \mathrm{d}\mathbf{x},$$

where $\mathbf{a}$ and $\mathbf{b}$ are vectors of length $p$ representing the lower and upper bounds. We have used the short notation $\mathbf{x}^\kappa = x_1^{\kappa_1} x_2^{\kappa_2} \dots x_p^{\kappa_p}$. It is easy to see that $P(\mathbf{a} \leq \mathbf{X} \leq \mathbf{b}) = F_{\mathbf{0}}(\mathbf{a}, \mathbf{b}, \mu, \Sigma, \nu)$, i.e., the normalizing constant for the doubly truncated density. Then the expected value will be given by $E[\mathbf{x}^\kappa] = F_\kappa(\mathbf{a}, \mathbf{b}, \mu, \Sigma, \nu)/F_{\mathbf{0}}(\mathbf{a}, \mathbf{b}, \mu, \Sigma, \nu)$.

Normal case returns prod(kappa)+1 moments while the Student's t-distribution case returns sum(kappa)+1. See example section.

## Warning

The kappa-$th$ moment can only be computed when sum(kappa) $\leq$ nu-2.

## Note

Degree of freedom must be a positive integer. If nu >= 100, Normal case is considered."

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Galarza C.E. & Lachos, V.H. (2018). On moments of folded and doubly truncated multivariate Student-t distribution: A recurrence approach.

## See Also

meanvarTMD,momentsFMD,meanvarFMD

## Examples

```
a = c(-0.8,-0.7,-0.6)
b = c(0.5,0.6,0.7)
mu = c(0.1,0.2,0.3)
Sigma = matrix(data = c(1,0.2,0.3,0.2,1,0.4,0.3,0.4,1),
               nrow = length(mu),ncol = length(mu),byrow = TRUE)
nu = 7
value1 = momentsTMD(c(2,0,1),a,b,mu,Sigma) #normal case
value2 = momentsTMD(c(2,0,1),a,b,mu,Sigma,dist = "t",nu) #t case
```

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