

# Package ‘distrEx’

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**Title** Extensions of Package 'distr'

**Description** Extends package 'distr' by functionals, distances, and conditional distributions.

**Depends** R(>= 2.10.0), methods, distr(>= 2.2)

**Imports** startupmsg, utils, stats

**Suggests** tcltk

**ByteCompile** yes

**License** LGPL-3

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distrEx-package

*distrEx – Extensions of Package distr*


---

## Description

**distrEx** provides some extensions of package **distr**:

- expectations in the form
  - $E(X)$  for the expectation of a distribution object  $X$
  - $E(X, f)$  for the expectation of  $f(X)$  where  $X$  is some distribution object and  $f$  some function in  $X$

- further functionals: var, sd, IQR, mad, median, skewness, kurtosis
- truncated moments,
- distances between distributions (Hellinger, Cramer von Mises, Kolmogorov, total variation, "convex contamination")
- lists of distributions,
- conditional distributions in factorized form
- conditional expectations in factorized form

Support for extreme value distributions has moved to package **RobExtremes**

## Details

```

Package:      distrEx
Version:     2.6
Date:        2016-04-23
Depends:     R(>= 2.10.0), methods, distr(>= 2.2)
Imports:     startupmsg, utils, stats
Suggests:    tcltk
LazyLoad:    yes
License:     LGPL-3
URL:         http://distr.r-forge.r-project.org/
SVNRevision: 1089

```

## Classes

### Distribution Classes

```

"Distribution" (from distr)
|>"UnivariateDistribution" (from distr)
|>|>"AbscontDistribution" (from distr)
|>|>|"Gumbel"
|>|>|"Pareto"
|>|>|"GPareto"
|>"MultivariateDistribution"
|>|>"DiscreteMVDistribution-class"
|>"UnivariateCondDistribution"
|>|>"AbscontCondDistribution"
|>|>|"PrognCondDistribution"
|>|>"DiscreteCondDistribution"

```

### Condition Classes

```
"Condition"
|>"EuclCondition"
|>"PrognCondition"
```

#### Parameter Classes

```
"OptionalParameter" (from distr)
|>"Parameter" (from distr)
|>|>"LMPParameter"
|>|>"GumbelParameter"
|>|>"ParetoParameter"
```

### Functions

Integration:	
GLIntegrate	Gauss-Legendre quadrature
distrExIntegrate	Integration of one-dimensional functions
Options:	
distrExOptions	Function to change the global variables of the package 'distrEx'
Standardization:	
make01	Centering and standardization of univariate distributions

### Generating Functions

Distribution Classes	
ConvexContamination	Generic function for generating convex contaminations
DiscreteMVDistribution	Generating function for DiscreteMVDistribution-class
Gumbel	Generating function for Gumbel-class
LMCondDistribution	Generating function for the conditional distribution of a linear regression model.
Condition Classes	
EuclCondition	Generating function for EuclCondition-class
Parameter Classes	
LMPParameter	Generating function for LMPParameter-class

**Methods**

## Distances:

ContaminationSize	Generic function for the computation of the convex contamination (Pseudo-)distance of two distributions
HellingerDist	Generic function for the computation of the Hellinger distance of two distributions
KolmogorovDist	Generic function for the computation of the Kolmogorov distance of two distributions
TotalVarDist	Generic function for the computation of the total variation distance of two distributions
AsymTotalVarDist	Generic function for the computation of the asymmetric total variation distance of two distributions (for given ratio rho of negative to positive part of deviation)
OAsymTotalVarDist	Generic function for the computation of the minimal (in rho) asymmetric total variation distance of two distributions
vonMisesDist	Generic function for the computation of the von Mises distance of two distributions
liesInSupport	Generic function for testing the support of a distribution

## Functionals:

E	Generic function for the computation of (conditional) expectations
var	Generic functions for the computation of functionals
IQR	Generic functions for the computation of functionals
sd	Generic functions for the computation of functionals
mad	Generic functions for the computation of functionals
median	Generic functions for the computation of functionals
skewness	Generic functions for the computation of functionals
kurtosis	Generic functions for the computation of Functionals

## truncated Moments:

m1df	Generic function for the computation of clipped first moments
m2df	Generic function for the computation of clipped second moments

## Demos

Demos are available — see `demo(package="distrEx")`.

## Acknowledgement

G. Jay Kerns, <gkerns@ysu.edu>, has provided a major contribution, in particular the functionals `skewness` and `kurtosis` are due to him. Natalyia Horbenko, <natalyia.horbenko@itwm.fraunhofer.de> has ported the **actuar** code for the Pareto distribution to this setup.

## Start-up-Banner

You may suppress the start-up banner/message completely by setting `options("StartupBanner"="off")` somewhere before loading this package by `library` or `require` in your R-code / R-session.

If option `"StartupBanner"` is not defined (default) or setting `options("StartupBanner"=NULL)` or `options("StartupBanner"="complete")` the complete start-up banner is displayed.

For any other value of option `"StartupBanner"` (i.e., not in `c(NULL, "off", "complete")`) only the version information is displayed.

The same can be achieved by wrapping the `library` or `require` call into either `suppressStartupMessages()` or `onlytypeStartupMessages(. , atypes="version")`.

As for general packageStartupMessage's, you may also suppress all the start-up banner by wrapping the `library` or `require` call into `suppressPackageStartupMessages()` from **startupmsg**-version 0.5 on.

## Package versions

Note: The first two numbers of package versions do not necessarily reflect package-individual development, but rather are chosen for the `distrXXX` family as a whole in order to ease updating "depends" information.

## Note

Some functions of package **stats** have intentionally been masked, but completely retain their functionality — see `distrExMASK()`.

If any of the packages **e1071**, **moments**, **fBasics** is to be used together with **distrEx** the latter must be attached *after* any of the first mentioned. Otherwise `kurtosis()` and `skewness()` defined as *methods* in **distrEx** may get masked.

To re-mask, you may use `kurtosis <- distrEx::kurtosis`; `skewness <- distrEx::skewness`. See also `distrExMASK()`

## Author(s)

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*Maintainer:* Matthias Kohl <Matthias.Kohl@stamats.de>

## References

P. Ruckdeschel, M. Kohl, T. Stabla, F. Camphausen (2006): S4 Classes for Distributions, *R News*, 6(2), 2-6. [http://CRAN.R-project.org/doc/Rnews/Rnews\\_2006-2.pdf](http://CRAN.R-project.org/doc/Rnews/Rnews_2006-2.pdf)

a vignette for packages **distr**, **distrSim**, **distrTEst**, and **distrEx** is included into the mere documentation package **distrDoc** and may be called by `require("distrDoc");vignette("distr")`

a homepage to this package is available under <http://distr.r-forge.r-project.org/>

M. Kohl (2005): *Numerical Contributions to the Asymptotic Theory of Robustness*. PhD Thesis. Bayreuth. Available as <http://www.stamats.de/ThesisMKohl.pdf>

## See Also

[distr-package](#)

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AbscontCondDistribution-class

*Absolutely continuous conditional distribution*

---

## Description

The class of absolutely continuous conditional univariate distributions.

## Objects from the Class

Objects can be created by calls of the form `new("AbscontCondDistribution", ...)`.

## Slots

`cond` Object of class "Condition": condition

`img` Object of class "rSpace": the image space.

`param` Object of class "OptionalParameter": an optional parameter.

`r` Object of class "function": generates random numbers.

`d` Object of class "OptionalFunction": optional conditional density function.

`p` Object of class "OptionalFunction": optional conditional cumulative distribution function.

`q` Object of class "OptionalFunction": optional conditional quantile function.

`.withArith` logical: used internally to issue warnings as to interpretation of arithmetics

`.withSim` logical: used internally to issue warnings as to accuracy

`.logExact` logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function

`.lowerExact` logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function

`Symmetry` object of class "DistributionSymmetry"; used internally to avoid unnecessary calculations.

**Extends**

Class "UnivariateCondDistribution", directly.  
 Class "Distribution", by class "UnivariateCondDistribution".

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[UnivariateCondDistribution-class](#), [Distribution-class](#)

**Examples**

```
new("AbscontCondDistribution")
```

---

AsymTotalVarDist	<i>Generic function for the computation of asymmetric total variation distance of two distributions</i>
------------------	---------------------------------------------------------------------------------------------------------

---

**Description**

Generic function for the computation of asymmetric total variation distance  $d_v(\rho)$  of two distributions  $P$  and  $Q$  where the distributions may be defined for an arbitrary sample space  $(\Omega, \mathcal{A})$ . For given ratio of inlier and outlier probability  $\rho$ , this distance is defined as

$$d_v(\rho)(P, Q) = \int (dQ - c dP)_+$$

for  $c$  defined by

$$\rho \int (dQ - c dP)_+ = \int (dQ - c dP)_-$$

It coincides with total variation distance for  $\rho = 1$ .

**Usage**

```
AsymTotalVarDist(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
AsymTotalVarDist(e1,e2, rho = 1,
  rel.tol = .Machine$double.eps^0.3, maxiter=1000, Ngrid = 10000,
  TruncQuantile = getdistrOption("TruncQuantile"),
  IQR.fac = 15)
## S4 method for signature 'AbscontDistribution,DiscreteDistribution'
AsymTotalVarDist(e1,e2, rho = 1, ...)
## S4 method for signature 'DiscreteDistribution,AbscontDistribution'
AsymTotalVarDist(e1,e2, rho = 1, ...)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
AsymTotalVarDist(e1,e2, rho = 1, ...)
```



```

## S4 method for signature 'numeric,DiscreteDistribution'
AsymTotalVarDist(e1, e2, rho = 1, ...)
## S4 method for signature 'DiscreteDistribution,numeric'
AsymTotalVarDist(e1, e2, rho = 1, ...)
## S4 method for signature 'numeric,AbscontDistribution'
AsymTotalVarDist(e1, e2, rho = 1, asis.smooth.discretize = "discretize",
                 n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e2),
                 up.discr = getUp(e2), h.smooth = getdistrExOption("hSmooth"),
                 rel.tol = .Machine$double.eps^0.3, maxiter=1000, Ngrid = 10000,
                 TruncQuantile = getdistrOption("TruncQuantile"),
                 IQR.fac = 15)
## S4 method for signature 'AbscontDistribution,numeric'
AsymTotalVarDist(e1, e2, rho = 1,
                 asis.smooth.discretize = "discretize",
                 n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e1),
                 up.discr = getUp(e1), h.smooth = getdistrExOption("hSmooth"),
                 rel.tol = .Machine$double.eps^0.3, maxiter=1000, Ngrid = 10000,
                 TruncQuantile = getdistrOption("TruncQuantile"),
                 IQR.fac = 15)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
AsymTotalVarDist(e1, e2,
                 rho = 1, rel.tol = .Machine$double.eps^0.3, maxiter=1000, Ngrid = 10000,
                 TruncQuantile = getdistrOption("TruncQuantile"),
                 IQR.fac = 15)

```

## Arguments

e1	object of class "Distribution" or "numeric"
e2	object of class "Distribution" or "numeric"
asis.smooth.discretize	possible methods are "asis", "smooth" and "discretize". Default is "discretize".
n.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the number of lattice points used to discretize the abs. cont. distribution.
low.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the lower end point of the lattice used to discretize the abs. cont. distribution.
up.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the upper end point of the lattice used to discretize the abs. cont. distribution.
h.smooth	if asis.smooth.discretize is equal to "smooth" – i.e., the empirical distribution of the provided data should be smoothed – one has to specify this parameter.
rho	ratio of inlier/outlier radius
rel.tol	relative tolerance for distrExIntegrate and uniroot
maxiter	parameter for uniroot
Ngrid	How many grid points are to be evaluated to determine the range of the likelihood ratio?
TruncQuantile	Quantile the quantile based integration bounds (see details)

IQR.fac            Factor for the scale based integration bounds (see details)  
 ...                further arguments to be used in particular methods (not in package **distrEx**)

### Details

For distances between absolutely continuous distributions, we use numerical integration; to determine sensible bounds we proceed as follows: by means of  $\min(\text{getLow}(e1, \text{eps}=\text{TruncQuantile}), \text{getLow}(e2, \text{eps}=\text{TruncQuantile}))$  and  $\max(\text{getUp}(e1, \text{eps}=\text{TruncQuantile}), \text{getUp}(e2, \text{eps}=\text{TruncQuantile}))$  we determine quantile based bounds  $c(\text{low.0}, \text{up.0})$ , and by means of  $s1 \leftarrow \max(\text{IQR}(e1), \text{IQR}(e2))$ ;  $m1 \leftarrow \text{median}(e1)$ ;  $m2 \leftarrow \text{median}(e2)$  and  $\text{low.1} \leftarrow \min(m1, m2) - s1 * \text{IQR.fac}$ ,  $\text{up.1} \leftarrow \max(m1, m2) + s1 * \text{IQR.fac}$  we determine scale based bounds; these are combined by  $\text{low} \leftarrow \max(\text{low.0}, \text{low.1})$ ,  $\text{up} \leftarrow \max(\text{up.0}, \text{up.1})$ .

Again in the absolutely continuous case, to determine the range of the likelihood ratio, we evaluate this ratio on a grid constructed as follows:  $\text{x.range} \leftarrow c(\text{seq}(\text{low}, \text{up}, \text{length}=\text{Ngrid}/3),$

Finally, for both discrete and absolutely continuous case, we clip this ratio downwards by  $1e-10$  and upwards by  $1e10$

In case we want to compute the total variation distance between (empirical) data and an abs. cont. distribution, we can specify the parameter `asis.smooth.discretize` to avoid trivial distances (distance = 1).

Using `asis.smooth.discretize = "discretize"`, which is the default, leads to a discretization of the provided abs. cont. distribution and the distance is computed between the provided data and the discretized distribution.

Using `asis.smooth.discretize = "smooth"` causes smoothing of the empirical distribution of the provided data. This is, the empirical data is convoluted with the normal distribution  $\text{Norm}(\text{mean} = 0, \text{sd} = \text{h.smooth})$  which leads to an abs. cont. distribution. Afterwards the distance between the smoothed empirical distribution and the provided abs. cont. distribution is computed.

### Value

Asymmetric Total variation distance of  $e1$  and  $e2$

### Methods

**e1 = "AbscontDistribution", e2 = "AbscontDistribution"**: total variation distance of two absolutely continuous univariate distributions which is computed using `distrExIntegrate`.

**e1 = "AbscontDistribution", e2 = "DiscreteDistribution"**: total variation distance of absolutely continuous and discrete univariate distributions (are mutually singular; i.e., have distance =1).

**e1 = "DiscreteDistribution", e2 = "DiscreteDistribution"**: total variation distance of two discrete univariate distributions which is computed using `support` and `sum`.

**e1 = "DiscreteDistribution", e2 = "AbscontDistribution"**: total variation distance of discrete and absolutely continuous univariate distributions (are mutually singular; i.e., have distance =1).

**e1 = "numeric", e2 = "DiscreteDistribution"**: Total variation distance between (empirical) data and a discrete distribution.

**e1 = "DiscreteDistribution", e2 = "numeric"**: Total variation distance between (empirical) data and a discrete distribution.

**e1 = "numeric", e2 = "AbscontDistribution"**: Total variation distance between (empirical) data and an abs. cont. distribution.

**e1 = "AbscontDistribution", e1 = "numeric"**: Total variation distance between (empirical) data and an abs. cont. distribution.

**e1 = "AcDeLcDistribution", e2 = "AcDeLcDistribution"**: Total variation distance of mixed discrete and absolutely continuous univariate distributions.

### Author(s)

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

### References

to be filled; Agostinelli, C and Ruckdeschel, P. (2009): A simultaneous inlier and outlier model by asymmetric total variation distance.

### See Also

[TotalVarDist-methods](#), [ContaminationSize](#), [KolmogorovDist](#), [HellingerDist](#), [Distribution-class](#)

### Examples

```
AsymTotalVarDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)), rho=0.3)
AsymTotalVarDist(Norm(), Td(10), rho=0.3)
AsymTotalVarDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100), rho=0.3) # mutually singular
AsymTotalVarDist(Pois(10), Binom(size = 20), rho=0.3)

x <- rnorm(100)
AsymTotalVarDist(Norm(), x, rho=0.3)
AsymTotalVarDist(x, Norm(), asis.smooth.discretize = "smooth", rho=0.3)

y <- (rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5)
AsymTotalVarDist(y, Norm(), rho=0.3)
AsymTotalVarDist(y, Norm(), asis.smooth.discretize = "smooth", rho=0.3)

AsymTotalVarDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5), rho=0.3)
```

---

Condition-class

*Conditions*

---

### Description

The class of conditions.

### Objects from the Class

Objects can be created by calls of the form `new("Condition", ...)`.

### Slots

name Object of class "character": name of the condition

**Methods**

**name** signature(object = "Condition"): accessor function for slot name.

**name<-** signature(object = "Condition"): replacement function for slot name.

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[UnivariateCondDistribution-class](#)

**Examples**

```
new("Condition")
```

---

ContaminationSize	<i>Generic Function for the Computation of the Convex Contamination (Pseudo-)Distance of Two Distributions</i>
-------------------	----------------------------------------------------------------------------------------------------------------

---

**Description**

Generic function for the computation of convex contamination (pseudo-)distance of two probability distributions  $P$  and  $Q$ . That is, the minimal size  $\varepsilon \in [0, 1]$  is computed such that there exists some probability distribution  $R$  with

$$Q = (1 - \varepsilon)P + \varepsilon R$$

**Usage**

```
ContaminationSize(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
ContaminationSize(e1,e2)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
ContaminationSize(e1,e2)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
ContaminationSize(e1,e2)
```

**Arguments**

**e1** object of class "Distribution"  
**e2** object of class "Distribution"  
**...** further arguments to be used in particular methods (not in package **distrEx**)

**Details**

Computes the distance from **e1** to **e2** respectively  $P$  to  $Q$ . This is not really a distance as it is not symmetric!

**Value**

A list containing the following components:

e1                    object of class "Distribution"; ideal distribution  
 e2                    object of class "Distribution"; 'contaminated' distribution  
 size.of.contamination  
                       size of contamination

**Methods**

**e1 = "AbscontDistribution", e2 = "AbscontDistribution"**: convex contamination (pseudo-)distance of two absolutely continuous univariate distributions.

**e1 = "DiscreteDistribution", e2 = "DiscreteDistribution"**: convex contamination (pseudo-)distance of two discrete univariate distributions.

**e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution"**: convex contamination (pseudo-)distance of two discrete univariate distributions.

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>,  
 Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**References**

Huber, P.J. (1981) *Robust Statistics*. New York: Wiley.

**See Also**

[KolmogorovDist](#), [TotalVarDist](#), [HellingerDist](#), [Distribution-class](#)

**Examples**

```
ContaminationSize(Norm(), Norm(mean=0.1))
ContaminationSize(Pois(), Pois(1.5))
```

---

ConvexContamination    *Generic Function for Generating Convex Contaminations*

---

**Description**

Generic function for generating convex contaminations. This is also known as *gross error model*. Given two distributions  $P$  (ideal distribution),  $R$  (contaminating distribution) and the size  $\varepsilon \in [0, 1]$  the convex contaminated distribution

$$Q = (1 - \varepsilon)P + \varepsilon R$$

is generated.

**Usage**

```
ConvexContamination(e1, e2, size)
```

**Arguments**

e1	object of class "Distribution": ideal distribution
e2	object of class "Distribution": contaminating distribution
size	size of contamination (amount of gross errors)

**Value**

Object of class "Distribution".

**Methods**

**e1 = "UnivariateDistribution", e2 = "UnivariateDistribution", size = "numeric":** convex combination of two univariate distributions

**e1 = "AbscontDistribution", e2 = "AbscontDistribution", size = "numeric":** convex combination of two absolutely continuous univariate distributions

**e1 = "DiscreteDistribution", e2 = "DiscreteDistribution", size = "numeric":** convex combination of two discrete univariate distributions

**e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution", size = "numeric":** convex combination of two univariate distributions which may be coerced to "UnivarLebDecDistribution".

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**References**

Huber, P.J. (1981) *Robust Statistics*. New York: Wiley.

**See Also**

[ContaminationSize](#), [Distribution-class](#)

**Examples**

```
# Convex combination of two normal distributions
C1 <- ConvexContamination(e1 = Norm(), e2 = Norm(mean = 5), size = 0.1)
plot(C1)
```

---

CvMDist	<i>Generic function for the computation of the Cramer - von Mises distance of two distributions</i>
---------	-----------------------------------------------------------------------------------------------------

---

### Description

Generic function for the computation of the Cramer - von Mises distance  $d_\mu$  of two distributions  $P$  and  $Q$  where the distributions are defined on a finite-dimensional Euclidean space  $(\mathbb{R}^m, \mathcal{B}^m)$  with  $\mathcal{B}^m$  the Borel- $\sigma$ -algebra on  $\mathbb{R}^m$ . The Cramer - von Mises distance is defined as

$$d_\mu(P, Q)^2 = \int (P(\{y \in \mathbb{R}^m \mid y \leq x\}) - Q(\{y \in \mathbb{R}^m \mid y \leq x\}))^2 \mu(dx)$$

where  $\leq$  is coordinatewise on  $\mathbb{R}^m$ .

### Usage

```
CvMDist(e1, e2, ...)
## S4 method for signature 'UnivariateDistribution,UnivariateDistribution'
CvMDist(e1, e2, mu = e1, useApply = FALSE, ...)
## S4 method for signature 'numeric,UnivariateDistribution'
CvMDist(e1, e2, mu = e1, ...)
```

### Arguments

e1	object of class "Distribution" or class "numeric"
e2	object of class "Distribution"
...	further arguments to be used e.g. by E()
useApply	logical; to be passed to E()
mu	object of class "Distribution"; integration measure; defaulting to e2

### Value

Cramer - von Mises distance of e1 and e2

### Methods

**e1 = "UnivariateDistribution", e2 = "UnivariateDistribution"**: Cramer - von Mises distance of two univariate distributions.

**e1 = "numeric", e2 = "UnivariateDistribution"**: Cramer - von Mises distance between the empirical formed from a data set (e1) and a univariate distribution.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>,  
Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**References**

Rieder, H. (1994) *Robust Asymptotic Statistics*. New York: Springer.

**See Also**

[ContaminationSize](#), [TotalVarDist](#), [HellingerDist](#), [KolmogorovDist](#), [Distribution-class](#)

**Examples**

```
CvMDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)))
CvMDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)),mu=Norm())
CvMDist(Norm(), Td(10))
CvMDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100))
CvMDist(Pois(10), Binom(size = 20))
CvMDist(rnorm(100),Norm())
CvMDist((rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5), Norm())
CvMDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5))
CvMDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5), mu = Pois())
```

---

dim-methods

*Methods for Function dim in Package 'distrEx'*

---

**Description**

dim-methods

**Methods**

**dim** signature(object = "DiscreteMVDistribution"): returns the dimension of the distribution

**See Also**

[dim-methods](#),  
[dim](#)



---

DiscreteCondDistribution-class  
*Discrete conditional distribution*

---

### Description

The class of discrete conditional univariate distributions.

### Objects from the Class

Objects can be created by calls of the form `new("DiscreteCondDistribution", ...)`.

### Slots

support Object of class "function": conditional support.  
 cond Object of class "Condition": condition  
 img Object of class "rSpace": the image space.  
 param Object of class "OptionalParameter": an optional parameter.  
 r Object of class "function": generates random numbers.  
 d Object of class "OptionalFunction": optional conditional density function.  
 p Object of class "OptionalFunction": optional conditional cumulative distribution function.  
 q Object of class "OptionalFunction": optional conditional quantile function.  
 .withArith logical: used internally to issue warnings as to interpretation of arithmetics  
 .withSim logical: used internally to issue warnings as to accuracy  
 .logExact logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function  
 .lowerExact logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function  
 Symmetry object of class "DistributionSymmetry"; used internally to avoid unnecessary calculations.

### Extends

Class "UnivariateCondDistribution", directly.  
 Class "Distribution", by class "UnivariateCondDistribution".

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### See Also

[UnivariateCondDistribution-class](#)

**Examples**

```
new("DiscreteCondDistribution")
```

---

DiscreteMVDistribution

*Generating function for multivariate discrete distribution*

---

**Description**

Generates an object of class "DiscreteMVDistribution".

**Usage**

```
DiscreteMVDistribution(supp, prob, Symmetry = NoSymmetry())
```

**Arguments**

supp	numeric matrix whose rows form the support of the discrete multivariate distribution.
prob	vector of probability weights for the elements of supp.
Symmetry	you may help R in calculations if you tell it whether the distribution is non-symmetric (default) or symmetric with respect to a center.

**Details**

Typical usages are

```
DiscreteMVDistribution(supp, prob)
DiscreteMVDistribution(supp)
```

Identical rows are collapsed to unique support values. If prob is missing, all elements in supp are equally weighted.

**Value**

Object of class "DiscreteMVDistribution"

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[DiscreteMVDistribution-class](#)

**Examples**

```
# Dirac-measure at (0,0,0)
D1 <- DiscreteMVDistribution(supp = c(0,0,0))
support(D1)

# simple discrete distribution
D2 <- DiscreteMVDistribution(supp = matrix(c(0,1,0,2,2,1,1,0), ncol=2),
                                prob = c(0.3, 0.2, 0.2, 0.3))
support(D2)
r(D2)(10)
```

---

DiscreteMVDistribution-class

*Discrete Multivariate Distributions*


---

**Description**

The class of discrete multivariate distributions.

**Objects from the Class**

Objects can be created by calls of the form `new("DiscreteMVDistribution", ...)`. More frequently they are created via the generating function `DiscreteMVDistribution`.

**Slots**

`img` Object of class "rSpace". Image space of the distribution. Usually an object of class "EuclideanSpace".

`param` Object of class "OptionalParameter". Optional parameter of the multivariate distribution.

`r` Object of class "function": generates (pseudo-)random numbers

`d` Object of class "OptionalFunction": optional density function

`p` Object of class "OptionalFunction": optional cumulative distribution function

`q` Object of class "OptionalFunction": optional quantile function

`support` numeric matrix whose rows form the support of the distribution

`.withArith` logical: used internally to issue warnings as to interpretation of arithmetics

`.withSim` logical: used internally to issue warnings as to accuracy

`.logExact` logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function

`.lowerExact` logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function

**Extends**

Class "MultivariateDistribution", directly.

Class "Distribution", by class "MultivariateDistribution".

**Methods**

**support** signature(object = "DiscreteMVDistribution"): accessor function for slot support.

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Distribution-class](#), [MultivariateDistribution-class](#), [DiscreteMVDistribution](#), [E-methods](#)

**Examples**

```
(D1 <- new("MultivariateDistribution")) # Dirac measure in (0,0)
r(D1)(5)

(D2 <- DiscreteMVDistribution(supp = matrix(c(1:5, rep(3, 5)), ncol=2, byrow=TRUE)))
support(D2)
r(D2)(10)
d(D2)(support(D2))
p(D2)(lower = c(1,1), upper = c(3,3))
q(D2)
param(D2)
img(D2)

e1 <- E(D2) # expectation
```

---

distrExIntegrate      *Integration of One-Dimensional Functions*

---

**Description**

Numerical integration via integrate. In case integrate fails a Gauss-Legendre quadrature is performed.

**Usage**

```
distrExIntegrate(f, lower, upper, subdivisions = 100,
                 rel.tol = .Machine$double.eps^0.25,
                 abs.tol = rel.tol, stop.on.error = TRUE,
                 distr, order, ...)
```

**Arguments**

f	an R function taking a numeric first argument and returning a numeric vector of the same length. Returning a non-finite element will generate an error.
lower	lower limit of integration. Can be $-\text{Inf}$ .
upper	upper limit of integration. Can be $\text{Inf}$ .

subdivisions	the maximum number of subintervals.
rel.tol	relative accuracy requested.
abs.tol	absolute accuracy requested.
stop.on.error	logical. If TRUE (the default) an error stops the function. If false some errors will give a result with a warning in the message component.
distr	object of class UnivariateDistribution.
order	order of Gauss-Legendre quadrature.
...	additional arguments to be passed to f. Remember to use argument names not matching those of integrate and GLIntegrate!

### Details

This function calls `integrate`. In case `integrate` returns an error a Gauss-Legendre integration is performed using `GLIntegrate`. If `lower` or (and) `upper` are infinite the `GLIntegrateTruncQuantile`, respectively the `1-GLIntegrateTruncQuantile` quantile of `distr` is used instead.

### Value

Estimate of the integral.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### References

Based on QUADPACK routines `dqags` and `dqagi` by R. Piessens and E. deDoncker-Kapenga, available from Netlib.

R. Piessens, E. deDoncker-Kapenga, C. Uberhuber, D. Kahaner (1983) *Quadpack: a Subroutine Package for Automatic Integration*. Springer Verlag.

W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery (1992) *Numerical Recipes in C. The Art of Scientific Computing*. Second Edition. Cambridge University Press.

### See Also

[integrate](#), [GLIntegrate](#), [distrExOptions](#)

### Examples

```
fkt <- function(x){x*dchisq(x+1, df = 1)}
integrate(fkt, lower = -1, upper = 3)
GLIntegrate(fkt, lower = -1, upper = 3)
try(integrate(fkt, lower = -1, upper = 5))
distrExIntegrate(fkt, lower = -1, upper = 5)
```

---

distrExMASK	<i>Masking off/by other functions in package "distrEx"</i>
-------------	------------------------------------------------------------

---

**Description**

Provides information on the (intended) masking of and (non-intended) masking by other other functions in package **distrEx**

**Usage**

```
distrExMASK(library = NULL)
```

**Arguments**

library	a character vector with path names of R libraries, or NULL. The default value of NULL corresponds to all libraries currently known. If the default is used, the loaded packages are searched before the libraries
---------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Value**

no value is returned

**Author(s)**

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**Examples**

```
distrExMASK()
```

---

distrExMOVED	<i>Moved functionality from package "distrEx"</i>
--------------	---------------------------------------------------

---

**Description**

Provides information on moved of functionality from package **distrEx**.

**Usage**

```
distrExMOVED(library = NULL)
```

**Arguments**

library	a character vector with path names of R libraries, or NULL. The default value of NULL corresponds to all libraries currently known. If the default is used, the loaded packages are searched before the libraries
---------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Value**

no value is returned

**Author(s)**

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**Examples**

```
distrExMOVED()
```

---

distrExOptions	<i>Function to change the global variables of the package 'distrEx'</i>
----------------	-------------------------------------------------------------------------

---

**Description**

With `distrExOptions` you can inspect and change the global variables of the package **distrEx**.

**Usage**

```
distrExOptions(...)  
distrExoptions(...)  
getdistrExOption(x)
```

**Arguments**

...	any options can be defined, using name = value or by passing a list of such tagged values.
x	a character string holding an option name.

**Value**

`distrExOptions()` returns a list of the global variables.  
`distrExOptions(x)` returns the global variable `x`.  
`getdistrExOption(x)` returns the global variable `x`.  
`distrExOptions(x=y)` sets the value of the global variable `x` to `y`.

**distrExoptions**

For compatibility with spelling in package **distr**, `distrExoptions` is just a synonym to `distrExOptions`.

## Global Options

- MCIterations:** number of Monte-Carlo iterations used for crude Monte-Carlo integration; defaults to 1e5.
- GLIntegrateTruncQuantile:** If integrate fails and there are infinite integration limits, the function GLIntegrate is called inside of distrExIntegrate with the corresponding quantiles GLIntegrateTruncQuantile respectively, 1 - GLIntegrateTruncQuantile as finite integration limits; defaults to  $10 \times \text{Machine\$double.eps}$ .
- GLIntegrateOrder:** The order used for the Gauss-Legendre integration inside of distrExIntegrate; defaults to 500.
- ElowerTruncQuantile:** The lower limit of integration used inside of E which corresponds to the ElowerTruncQuantile-quantile; defaults to  $1e-7$ .
- EupperTruncQuantile:** The upper limit of integration used inside of E which corresponds to the  $(1 - \text{ElowerTruncQuantile})$ -quantile; defaults to  $1e-7$ .
- ErelativeTolerance:** The relative tolerance used inside of E when calling distrExIntegrate; defaults to  $\text{Machine\$double.eps}^{0.25}$ .
- m1dfLowerTruncQuantile:** The lower limit of integration used inside of m1df which corresponds to the m1dfLowerTruncQuantile-quantile; defaults to 0.
- m1dfRelativeTolerance:** The relative tolerance used inside of m1df when calling distrExIntegrate; defaults to  $\text{Machine\$double.eps}^{0.25}$ .
- m2dfLowerTruncQuantile:** The lower limit of integration used inside of m2df which corresponds to the m2dfLowerTruncQuantile-quantile; defaults to 0.
- m2dfRelativeTolerance:** The relative tolerance used inside of m2df when calling distrExIntegrate; defaults to  $\text{Machine\$double.eps}^{0.25}$ .
- nDiscretize:** number of support values used for the discretization of objects of class "AbscontDistribution"; defaults to 100.
- hSmooth:** smoothing parameter to smooth objects of class "DiscreteDistribution". This is done via convolution with the normal distribution  $\text{Norm}(\text{mean} = 0, \text{sd} = \text{hSmooth})$ ; defaults to 0.05.
- IQR.fac:** for determining sensible integration ranges, we use both quantile and scale based methods; for the scale based method we use the median of the distribution  $\pm \text{IQR} \times \text{IQR} \times \text{IQR}$ ; defaults to 15.

## Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

## See Also

[options](#), [getOption](#)

## Examples

```
distrExOptions()
distrExOptions("ElowerTruncQuantile")
distrExOptions("ElowerTruncQuantile" = 1e-6)
```



```
# or
distrExOptions(ElowerTruncQuantile = 1e-6)
getdistrExOption("ElowerTruncQuantile")
```

E

---

*Generic Function for the Computation of (Conditional) Expectations*

---

### Description

Generic function for the computation of (conditional) expectations.

### Usage

```
E(object, fun, cond, ...)

## S4 method for signature 'UnivariateDistribution,missing,missing'
E(object,
    low = NULL, upp = NULL, Nsim = getdistrExOption("MCIterations"), ...)

## S4 method for signature 'UnivariateDistribution,function,missing'
E(object, fun,
    useApply = TRUE, low = NULL, upp = NULL,
    Nsim = getdistrExOption("MCIterations"), ...)

## S4 method for signature 'AbscontDistribution,function,missing'
E(object, fun, useApply = TRUE,
    low = NULL, upp = NULL,
    rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = getdistrExOption("IQR.fac"), ...)

## S4 method for signature 'UnivarMixingDistribution,missing,missing'
E(object, low = NULL,
    upp = NULL, rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = getdistrExOption("IQR.fac"), ...)

## S4 method for signature 'UnivarMixingDistribution,function,missing'
E(object, fun,
    useApply = TRUE, low = NULL, upp = NULL,
    rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = getdistrExOption("IQR.fac"), ...)
```

```

## S4 method for signature 'UnivarMixingDistribution,missing,ANY'
E(object, cond, low = NULL,
    upp = NULL, rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = getdistrExOption("IQR.fac"), ...)

## S4 method for signature 'UnivarMixingDistribution,function,ANY'
E(object, fun, cond,
    useApply = TRUE, low = NULL, upp = NULL,
    rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = getdistrExOption("IQR.fac"), ...)

## S4 method for signature 'DiscreteDistribution,function,missing'
E(object, fun, useApply = TRUE,
    low = NULL, upp = NULL, ...)

## S4 method for signature 'AffLinDistribution,missing,missing'
E(object, low = NULL, upp = NULL,
    ...)

## S4 method for signature 'AffLinUnivarLebDecDistribution,missing,missing'
E(object, low = NULL,
    upp = NULL, ...)

## S4 method for signature 'MultivariateDistribution,missing,missing'
E(object,
    Nsim = getdistrExOption("MCIterations"), ...)
## S4 method for signature 'MultivariateDistribution,function,missing'
E(object, fun,
    useApply = TRUE, Nsim = getdistrExOption("MCIterations"), ...)

## S4 method for signature 'DiscreteMVDistribution,missing,missing'
E(object, low = NULL,
    upp = NULL, ...)

## S4 method for signature 'DiscreteMVDistribution,function,missing'
E(object, fun,
    useApply = TRUE, ...)

## S4 method for signature 'AbscontCondDistribution,missing,numeric'
E(object, cond,
    useApply = TRUE, low = NULL, upp = NULL,
    rel.tol= getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),

```

```

IQR.fac = getdistrExOption("IQR.fac"), ...)

## S4 method for signature 'DiscreteCondDistribution,missing,numeric'
E(object, cond,
  useApply = TRUE, low = NULL, upp = NULL, ...)

## S4 method for signature 'UnivariateCondDistribution,function,numeric'
E(object, fun, cond,
  withCond = FALSE, useApply = TRUE, low = NULL, upp = NULL,
  Nsim = getdistrExOption("MCIterations"), ...)

## S4 method for signature 'AbscontCondDistribution,function,numeric'
E(object, fun, cond,
  withCond = FALSE, useApply = TRUE, low = NULL, upp = NULL,
  rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac")
  , ...)

## S4 method for signature 'DiscreteCondDistribution,function,numeric'
E(object, fun, cond,
  withCond = FALSE, useApply = TRUE, low = NULL, upp = NULL,...)

## S4 method for signature 'DiscreteCondDistribution,function,numeric'
E(object, fun, cond,
  withCond = FALSE, useApply = TRUE, low = NULL, upp = NULL,...)

## S4 method for signature 'UnivarLebDecDistribution,missing,missing'
E(object, low = NULL,
  upp = NULL, rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ... )

## S4 method for signature 'UnivarLebDecDistribution,function,missing'
E(object, fun,
  useApply = TRUE, low = NULL, upp = NULL,
  rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ... )

## S4 method for signature 'UnivarLebDecDistribution,missing,ANY'
E(object, cond, low = NULL,
  upp = NULL, rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ... )

## S4 method for signature 'UnivarLebDecDistribution,function,ANY'

```

```

E(object, fun, cond,
  useApply = TRUE, low = NULL, upp = NULL,
  rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ... )

## S4 method for signature 'AcDcLcDistribution,ANY,ANY'
E(object, fun, cond, low = NULL,
  upp = NULL, rel.tol= getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ... )

## S4 method for signature 'CompoundDistribution,missing,missing'
E(object, low = NULL,
  upp = NULL, ...)

## S4 method for signature 'Arcsine,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Beta,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Binom,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Cauchy,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Chisq,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Dirac,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'DExp,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Exp,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Fd,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Gammad,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Gammad,function,missing'
E(object, fun, low = NULL, upp = NULL,
  rel.tol = getdistrExOption("ErelativeTolerance"),
  lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
  upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
  IQR.fac = getdistrExOption("IQR.fac"), ...)
## S4 method for signature 'Geom,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Gumbel,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'GPareto,missing,missing'

```

```

E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'GPareto,function,missing'
E(object, fun, low = NULL, upp = NULL,
    rel.tol = getdistrExOption("ErelativeTolerance"),
    lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
    upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
    IQR.fac = max(10000, getdistrExOption("IQR.fac")), ...)
## S4 method for signature 'Hyper,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Logis,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Lnorm,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Nbinom,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Norm,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Pareto,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Pois,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Unif,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Td,missing,missing'
E(object, low = NULL, upp = NULL, ...)
## S4 method for signature 'Weibull,missing,missing'
E(object, low = NULL, upp = NULL, ...)

```

## Arguments

object	object of class "Distribution"
fun	if missing the (conditional) expectation is computed else the (conditional) expectation of fun is computed.
cond	if not missing the conditional expectation given cond is computed.
Nsim	number of MC simulations used to determine the expectation.
rel.tol	relative tolerance for distrExIntegrate.
low	lower bound of integration range.
upp	upper bound of integration range.
lowerTruncQuantile	lower quantile for quantile based integration range.
upperTruncQuantile	upper quantile for quantile based integration range.
IQR.fac	factor for scale based integration range (i.e.; median of the distribution $\pm$ IQR.fac $\times$ IQR).
...	additional arguments to fun
useApply	logical: should sapply, respectively apply be used to evaluate fun.
withCond	logical: is cond in the argument list of fun.

## Details

The precision of the computations can be controlled via certain global options; cf. `distrExOptions`. Also note that arguments `low` and `upp` should be given as named arguments in order to prevent them to be matched by arguments `fun` or `cond`. Also the result, when arguments `low` or `upp` is given, is the *unconditional value* of the expectation; no conditioning with respect to `low <= object <= upp` is done.

## Value

The (conditional) expectation is computed.

## Methods

- object = "UnivariateDistribution", fun = "missing", cond = "missing":** expectation of univariate distributions using crude Monte-Carlo integration.
- object = "AbscontDistribution", fun = "missing", cond = "missing":** expectation of absolutely continuous univariate distributions using `distrExIntegrate`.
- object = "DiscreteDistribution", fun = "missing", cond = "missing":** expectation of discrete univariate distributions using support and sum.
- object = "MultivariateDistribution", fun = "missing", cond = "missing":** expectation of multivariate distributions using crude Monte-Carlo integration.
- object = "DiscreteMVDistribution", fun = "missing", cond = "missing":** expectation of discrete multivariate distributions. The computation is based on support and sum.
- object = "UnivariateDistribution", fun = "missing", cond = "missing":** expectation of univariate Lebesgue decomposed distributions by separate calculations for discrete and absolutely continuous part.
- object = "AffLinDistribution", fun = "missing", cond = "missing":** expectation of an affine linear transformation  $aX+b$  as  $aE[X]+b$  for  $X$  either "DiscreteDistribution" or "AbscontDistribution".
- object = "AffLinUnivarLebDecDistribution", fun = "missing", cond = "missing":** expectation of an affine linear transformation  $aX+b$  as  $aE[X]+b$  for  $X$  either "UnivarLebDecDistribution".
- object = "UnivariateDistribution", fun = "function", cond = "missing":** expectation of fun under univariate distributions using crude Monte-Carlo integration.
- object = "UnivariateDistribution", fun = "function", cond = "missing":** expectation of fun under univariate Lebesgue decomposed distributions by separate calculations for discrete and absolutely continuous part.
- object = "AbscontDistribution", fun = "function", cond = "missing":** expectation of fun under absolutely continuous univariate distributions using `distrExIntegrate`.
- object = "DiscreteDistribution", fun = "function", cond = "missing":** expectation of fun under discrete univariate distributions using support and sum.
- object = "MultivariateDistribution", fun = "function", cond = "missing":** expectation of multivariate distributions using crude Monte-Carlo integration.
- object = "DiscreteMVDistribution", fun = "function", cond = "missing":** expectation of fun under discrete multivariate distributions. The computation is based on support and sum.

- object = "UnivariateCondDistribution", fun = "missing", cond = "numeric":** conditional expectation for univariate conditional distributions given cond. The integral is computed using crude Monte-Carlo integration.
- object = "AbscontCondDistribution", fun = "missing", cond = "numeric":** conditional expectation for absolutely continuous, univariate conditional distributions given cond. The computation is based on `distrExIntegrate`.
- object = "DiscreteCondDistribution", fun = "missing", cond = "numeric":** conditional expectation for discrete, univariate conditional distributions given cond. The computation is based on `support` and `sum`.
- object = "UnivariateCondDistribution", fun = "function", cond = "numeric":** conditional expectation of `fun` under univariate conditional distributions given cond. The integral is computed using crude Monte-Carlo integration.
- object = "AbscontCondDistribution", fun = "function", cond = "numeric":** conditional expectation of `fun` under absolutely continuous, univariate conditional distributions given cond. The computation is based on `distrExIntegrate`.
- object = "DiscreteCondDistribution", fun = "function", cond = "numeric":** conditional expectation of `fun` under discrete, univariate conditional distributions given cond. The computation is based on `support` and `sum`.
- object = "UnivarLebDecDistribution", fun = "missing", cond = "missing":** expectation by separate evaluation of expectation of discrete and abs. continuous part and subsequent weighting.
- object = "UnivarLebDecDistribution", fun = "function", cond = "missing":** expectation by separate evaluation of expectation of discrete and abs. continuous part and subsequent weighting.
- object = "UnivarLebDecDistribution", fun = "missing", cond = "ANY":** expectation by separate evaluation of expectation of discrete and abs. continuous part and subsequent weighting.
- object = "UnivarLebDecDistribution", fun = "function", cond = "ANY":** expectation by separate evaluation of expectation of discrete and abs. continuous part and subsequent weighting.
- object = "UnivarMixingDistribution", fun = "missing", cond = "missing":** expectation is computed component-wise with subsequent weighting acc. to `mixCoeff`.
- object = "UnivarMixingDistribution", fun = "function", cond = "missing":** expectation is computed component-wise with subsequent weighting acc. to `mixCoeff`.
- object = "UnivarMixingDistribution", fun = "missing", cond = "ANY":** expectation is computed component-wise with subsequent weighting acc. to `mixCoeff`.
- object = "UnivarMixingDistribution", fun = "function", cond = "ANY":** expectation is computed component-wise with subsequent weighting acc. to `mixCoeff`.
- object = "AcDcLcDistribution", fun = "ANY", cond = "ANY":** expectation by first coercing to class "UnivarLebDecDistribution" and using the corresponding method.
- object = "CompoundDistribution", fun = "missing", cond = "missing":** if we are in i.i.d. situation (i.e., slot `SummandsDistr` is of class `UnivariateDistribution`) the formula  $E[N]E[S]$  for  $N$  the frequency distribution and  $S$  the summand distribution; else we coerce to "UnivarLebDecDistribution".
- object = "Arcsine", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.
- object = "Beta", fun = "missing", cond = "missing":** for noncentrality 0 exact evaluation using explicit expressions.

**object = "Binom", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Cauchy", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Chisq", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Dirac", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "DExp", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Exp", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Fd", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Gammad", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Gammad", fun = "function", cond = "missing":** use substitution method ( $y := \log(x)$ ) for numerical integration.

**object = "Geom", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Gumbel", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "GPareto", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "GPareto", fun = "function", cond = "missing":** use substitution method ( $y := \log(x)$ ) for numerical integration.

**object = "Hyper", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Logis", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Lnorm", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Nbinom", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Norm", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Pareto", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Pois", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Unif", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Td", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

**object = "Weibull", fun = "missing", cond = "missing":** exact evaluation using explicit expressions.

#### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de> and Peter Ruckdeschel <peter.ruckdeschel@uni-bayreuth.de>



**See Also**

[distrExIntegrate](#), [m1df](#), [m2df](#), [Distribution-class](#)

**Examples**

```
# mean of Exp(1) distribution
E <- Exp()

E(E) ## uses explicit terms
E(as(E,"AbscontDistribution")) ## uses numerical integration
E(as(E,"UnivariateDistribution")) ## uses simulations
E(E, fun = function(x){2*x^2}) ## uses simulations

# the same operator for discrete distributions:
P <- Pois(lambda=2)

E(P) ## uses explicit terms
E(as(P,"DiscreteDistribution")) ## uses sums
E(as(P,"UnivariateDistribution")) ## uses simulations
E(P, fun = function(x){2*x^2}) ## uses simulations

# second moment of N(1,4)
E(Norm(mean=1, sd=2), fun = function(x){x^2})
E(Norm(mean=1, sd=2), fun = function(x){x^2}, useApply = FALSE)

# conditional distribution of a linear model
D1 <- LMCondDistribution(theta = 1)
E(D1, cond = 1)
E(Norm(mean=1))
E(D1, function(x){x^2}, cond = 1)
E(Norm(mean=1), fun = function(x){x^2})
E(D1, function(x, cond){cond*x^2}, cond = 2, withCond = TRUE, useApply = FALSE)
E(Norm(mean=2), function(x){2*x^2})

E(as(Norm(mean=2),"AbscontDistribution"))
### somewhat less accurate:
E(as(Norm(mean=2),"AbscontDistribution"),
  lowerTruncQuantil=1e-4,upperTruncQuantil=1e-4, IQR.fac= 4)
### even less accurate:
E(as(Norm(mean=2),"AbscontDistribution"),
  lowerTruncQuantil=1e-2,upperTruncQuantil=1e-2, IQR.fac= 4)
### no good idea, but just as an example:
E(as(Norm(mean=2),"AbscontDistribution"),
  lowerTruncQuantil=1e-2,upperTruncQuantil=1e-2, IQR.fac= .1)

### truncation of integration range; see also m1df...
E(Norm(mean=2), low=2,upp=4)

E(Cauchy())
E(Cauchy(),upp=3,low=-2)
# some Lebesgue decomposed distribution
```

```
mymix <- UnivarLebDecDistribution(acPart = Norm(), discretePart = Binom(4,.4),
                                acWeight = 0.4)
E(mymix)
```

---

EmpiricalMVDistribution

*Generating function for multivariate discrete distribution*

---

### Description

Generates an object of class "DiscreteMVDistribution".

### Usage

```
EmpiricalMVDistribution(data, Symmetry = NoSymmetry())
```

### Arguments

data	numeric matrix with data where the rows are interpreted as observations.
Symmetry	you may help <b>R</b> in calculations if you tell it whether the distribution is non-symmetric (default) or symmetric with respect to a center.

### Details

The function is a simple utility function providing a wrapper to the generating function [DiscreteDistribution](#).

Typical usages are

```
EmpiricalMVDistribution(data)
```

Identical rows are collapsed to unique support values. If prob is missing, all elements in supp are equally weighted.

### Value

Object of class "DiscreteMVDistribution"

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### See Also

[DiscreteMVDistribution](#)

**Examples**

```
## generate some data
X <- matrix(rnorm(50), ncol = 5)

## empirical distribution of X
D1 <- EmpiricalMVDistribution(data = X)
support(D1)
r(D1)(10)
```

---

EuclCondition

*Generating function for EuclCondition-class*

---

**Description**

Generates an object of class "EuclCondition".

**Usage**

```
EuclCondition(dimension)
```

**Arguments**

dimension      positive integer: dimension of the Euclidean space

**Value**

Object of class "EuclCondition"

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[EuclCondition-class](#)

**Examples**

```
EuclCondition(dimension = 3)

## The function is currently defined as
function(dimension){
  new("EuclCondition", Range = EuclideanSpace(dimension = dimension))
}
```

---

EuclCondition-class    *Conditioning by an Euclidean space.*

---

**Description**

Conditioning by an Euclidean space.

**Objects from the Class**

Objects can be created by calls of the form `new("EuclCondition", ...)`. More frequently they are created via the generating function `EuclCondition`.

**Slots**

`Range` Object of class "EuclideanSpace".

`name` Object of class "character": name of condition.

**Extends**

Class "Condition", directly.

**Methods**

**Range** `signature(object = "EuclCondition")` accessor function for slot `Range`.

**show** `signature(object = "EuclCondition")`

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Condition-class](#), [EuclCondition](#)

**Examples**

```
new("EuclCondition")
```

---

GLIntegrate

*Gauss-Legendre Quadrature*

---

### Description

Gauss-Legendre quadrature over a finite interval.

### Usage

```
GLIntegrate(f, lower, upper, order = 500, ...)
```

### Arguments

f	an R function taking a numeric first argument and returning a numeric vector of the same length. Returning a non-finite element will generate an error.
lower	finite lower limit of integration.
upper	finite upper limit of integration.
order	order of Gauss-Legendre quadrature.
...	additional arguments to be passed to f. Remember to use argument names not matching those of GLIntegrate!

### Details

In case `order = 100, 500, 1000` saved abscissas and weights are used. Otherwise the corresponding abscissas and weights are computed using the algorithm given in Section 4.5 of Press et al. (1992).

### Value

Estimate of the integral.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### References

W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery (1992) *Numerical Recipes in C*. The Art of Scientific Computing. Second Edition. Cambridge University Press.

### See Also

[integrate](#), [distrExIntegrate](#)

### Examples

```
integrate(dnorm, -1.96, 1.96)
GLIntegrate(dnorm, -1.96, 1.96)
```

---

HellingerDist	<i>Generic function for the computation of the Hellinger distance of two distributions</i>
---------------	--------------------------------------------------------------------------------------------

---

### Description

Generic function for the computation of the Hellinger distance  $d_h$  of two distributions  $P$  and  $Q$  which may be defined for an arbitrary sample space  $(\Omega, \mathcal{A})$ . The Hellinger distance is defined as

$$d_h(P, Q) = \frac{1}{2} \int |\sqrt{dP} - \sqrt{dQ}|^2$$

where  $\sqrt{dP}$ , respectively  $\sqrt{dQ}$  denotes the square root of the densities.

### Usage

```
HellingerDist(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
HellingerDist(e1,e2,
               rel.tol=.Machine$double.eps^0.3,
               TruncQuantile = getdistrOption("TruncQuantile"),
               IQR.fac = 15, ...)
## S4 method for signature 'AbscontDistribution,DiscreteDistribution'
HellingerDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,AbscontDistribution'
HellingerDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
HellingerDist(e1,e2, ...)
## S4 method for signature 'numeric,DiscreteDistribution'
HellingerDist(e1, e2, ...)
## S4 method for signature 'DiscreteDistribution,numeric'
HellingerDist(e1, e2, ...)
## S4 method for signature 'numeric,AbscontDistribution'
HellingerDist(e1, e2, asis.smooth.discretize = "discretize",
              n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e2),
              up.discr = getUp(e2), h.smooth = getdistrExOption("hSmooth"),
              rel.tol=.Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"),
              IQR.fac = 15, ...)
## S4 method for signature 'AbscontDistribution,numeric'
HellingerDist(e1, e2, asis.smooth.discretize = "discretize",
              n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e1),
              up.discr = getUp(e1), h.smooth = getdistrExOption("hSmooth"),
              rel.tol=.Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"),
              IQR.fac = 15, ...)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
```

```
HellingerDist(e1,e2,
              rel.tol=.Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"),
              IQR.fac = 15, ...)
```

### Arguments

e1	object of class "Distribution" or class "numeric"
e2	object of class "Distribution" or class "numeric"
asis.smooth.discretize	possible methods are "asis", "smooth" and "discretize". Default is "discretize".
n.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the number of lattice points used to discretize the abs. cont. distribution.
low.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the lower end point of the lattice used to discretize the abs. cont. distribution.
up.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the upper end point of the lattice used to discretize the abs. cont. distribution.
h.smooth	if asis.smooth.discretize is equal to "smooth" – i.e., the empirical distribution of the provided data should be smoothed – one has to specify this parameter.
rel.tol	relative accuracy requested in integration
TruncQuantile	Quantile the quantile based integration bounds (see details)
IQR.fac	Factor for the scale based integration bounds (see details)
...	further arguments to be used in particular methods (not in package <b>distrEx</b> )

### Details

For distances between absolutely continuous distributions, we use numerical integration; to determine sensible bounds we proceed as follows: by means of  $\min(\text{getLow}(e1, \text{eps}=\text{TruncQuantile}), \text{getLow}(e2, \text{eps}=\text{TruncQuantile}))$  and  $\max(\text{getUp}(e1, \text{eps}=\text{TruncQuantile}), \text{getUp}(e2, \text{eps}=\text{TruncQuantile}))$  we determine quantile based bounds  $c(\text{low.}\theta, \text{up.}\theta)$ , and by means of  $s1 \leftarrow \max(\text{IQR}(e1), \text{IQR}(e2))$ ;  $m1 \leftarrow \text{median}(e1)$ ;  $m2 \leftarrow \text{median}(e2)$  and  $\text{low.}1 \leftarrow \min(m1, m2) - s1 * \text{IQR.}fac$ ,  $\text{up.}1 \leftarrow \max(m1, m2) + s1 * \text{IQR.}fac$  we determine scale based bounds; these are combined by  $\text{low} \leftarrow \max(\text{low.}\theta, \text{low.}1)$ ,  $\text{up} \leftarrow \max(\text{up.}\theta, \text{up.}1)$ .

In case we want to compute the Hellinger distance between (empirical) data and an abs. cont. distribution, we can specify the parameter `asis.smooth.discretize` to avoid trivial distances (distance = 1).

Using `asis.smooth.discretize = "discretize"`, which is the default, leads to a discretization of the provided abs. cont. distribution and the distance is computed between the provided data and the discretized distribution.

Using `asis.smooth.discretize = "smooth"` causes smoothing of the empirical distribution of the provided data. This is, the empirical data is convoluted with the normal distribution  $\text{Norm}(\text{mean} = \theta, \text{sd} = \text{h.smooth})$  which leads to an abs. cont. distribution. Afterwards the distance between the smoothed empirical distribution and the provided abs. cont. distribution is computed.

### Value

Hellinger distance of e1 and e2

## Methods

- e1 = "AbscontDistribution", e2 = "AbscontDistribution"**: Hellinger distance of two absolutely continuous univariate distributions which is computed using `distrExIntegrate`.
- e1 = "AbscontDistribution", e2 = "DiscreteDistribution"**: Hellinger distance of absolutely continuous and discrete univariate distributions (are mutually singular; i.e., have distance =1).
- e1 = "DiscreteDistribution", e2 = "DiscreteDistribution"**: Hellinger distance of two discrete univariate distributions which is computed using `support` and `sum`.
- e1 = "DiscreteDistribution", e2 = "AbscontDistribution"**: Hellinger distance of discrete and absolutely continuous univariate distributions (are mutually singular; i.e., have distance =1).
- e1 = "numeric", e2 = "DiscreteDistribution"**: Hellinger distance between (empirical) data and a discrete distribution.
- e1 = "DiscreteDistribution", e2 = "numeric"**: Hellinger distance between (empirical) data and a discrete distribution.
- e1 = "numeric", e2 = "AbscontDistribution"**: Hellinger distance between (empirical) data and an abs. cont. distribution.
- e1 = "AbscontDistribution", e1 = "numeric"**: Hellinger distance between (empirical) data and an abs. cont. distribution.
- e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution"**: Hellinger distance of mixed discrete and absolutely continuous univariate distributions.

## Author(s)

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 Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

## References

- Huber, P.J. (1981) *Robust Statistics*. New York: Wiley.
- Rieder, H. (1994) *Robust Asymptotic Statistics*. New York: Springer.

## See Also

[distrExIntegrate](#), [ContaminationSize](#), [TotalVarDist](#), [KolmogorovDist](#), [Distribution-class](#)

## Examples

```
HellingerDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)))
HellingerDist(Norm(), Td(10))
HellingerDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100)) # mutually singular
HellingerDist(Pois(10), Binom(size = 20))

x <- rnorm(100)
HellingerDist(Norm(), x)
HellingerDist(x, Norm(), asis.smooth.discretize = "smooth")

y <- (rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5)
```



```
HellingerDist(y, Norm())
HellingerDist(y, Norm(), asis.smooth.discretize = "smooth")

HellingerDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5))
```

---

KolmogorovDist	<i>Generic function for the computation of the Kolmogorov distance of two distributions</i>
----------------	---------------------------------------------------------------------------------------------

---

### Description

Generic function for the computation of the Kolmogorov distance  $d_\kappa$  of two distributions  $P$  and  $Q$  where the distributions are defined on a finite-dimensional Euclidean space  $(\mathbf{R}^m, \mathcal{B}^m)$  with  $\mathcal{B}^m$  the Borel- $\sigma$ -algebra on  $\mathbf{R}^m$ . The Kolmogorov distance is defined as

$$d_\kappa(P, Q) = \sup\{|P(\{y \in \mathbf{R}^m \mid y \leq x\}) - Q(\{y \in \mathbf{R}^m \mid y \leq x\})| \mid x \in \mathbf{R}^m\}$$

where  $\leq$  is coordinatewise on  $\mathbf{R}^m$ .

### Usage

```
KolmogorovDist(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
KolmogorovDist(e1,e2)
## S4 method for signature 'AbscontDistribution,DiscreteDistribution'
KolmogorovDist(e1,e2)
## S4 method for signature 'DiscreteDistribution,AbscontDistribution'
KolmogorovDist(e1,e2)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
KolmogorovDist(e1,e2)
## S4 method for signature 'numeric,UnivariateDistribution'
KolmogorovDist(e1, e2)
## S4 method for signature 'UnivariateDistribution,numeric'
KolmogorovDist(e1, e2)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
KolmogorovDist(e1, e2)
```

### Arguments

e1	object of class "Distribution" or class "numeric"
e2	object of class "Distribution" or class "numeric"
...	further arguments to be used in particular methods (not in package <b>distrEx</b> )

### Value

Kolmogorov distance of e1 and e2

## Methods

- e1 = "AbscontDistribution", e2 = "AbscontDistribution":** Kolmogorov distance of two absolutely continuous univariate distributions which is computed using a union of a (pseudo-)random and a deterministic grid.
- e1 = "DiscreteDistribution", e2 = "DiscreteDistribution":** Kolmogorov distance of two discrete univariate distributions. The distance is attained at some point of the union of the supports of e1 and e2.
- e1 = "AbscontDistribution", e2 = "DiscreteDistribution":** Kolmogorov distance of absolutely continuous and discrete univariate distributions. It is computed using a union of a (pseudo-)random and a deterministic grid in combination with the support of e2.
- e1 = "DiscreteDistribution", e2 = "AbscontDistribution":** Kolmogorov distance of discrete and absolutely continuous univariate distributions. It is computed using a union of a (pseudo-)random and a deterministic grid in combination with the support of e1.
- e1 = "numeric", e2 = "UnivariateDistribution":** Kolmogorov distance between (empirical) data and a univariate distribution. The computation is based on `ks.test`.
- e1 = "UnivariateDistribution", e2 = "numeric":** Kolmogorov distance between (empirical) data and a univariate distribution. The computation is based on `ks.test`.
- e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution":** Kolmogorov distance of mixed discrete and absolutely continuous univariate distributions. It is computed using a union of the discrete part, a (pseudo-)random and a deterministic grid in combination with the support of e1.

## Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>  
 Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

## References

- Huber, P.J. (1981) *Robust Statistics*. New York: Wiley.
- Rieder, H. (1994) *Robust Asymptotic Statistics*. New York: Springer.

## See Also

[ContaminationSize](#), [TotalVarDist](#), [HellingerDist](#), [Distribution-class](#)

## Examples

```
KolmogorovDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)))
KolmogorovDist(Norm(), Td(10))
KolmogorovDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100))
KolmogorovDist(Pois(10), Binom(size = 20))
KolmogorovDist(Norm(), rnorm(100))
KolmogorovDist((rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5), Norm())
KolmogorovDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5))
```

---

`liesInSupport`*Generic Function for Testing the Support of a Distribution*

---

**Description**

The function tests if `x` lies in the support of the distribution object.

**Usage**

```
## S4 method for signature 'DiscreteMVDistribution,numeric'  
liesInSupport(object, x)  
## S4 method for signature 'DiscreteMVDistribution,matrix'  
liesInSupport(object, x)
```

**Arguments**

<code>object</code>	object of class "Distribution"
<code>x</code>	numeric vector or matrix

**Value**

logical vector

**Methods**

**object = "DiscreteMVDistribution", x = "numeric":** does `x` lie in the support of object.

**object = "DiscreteMVDistribution", x = "matrix":** does `x` lie in the support of object.

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Distribution-class](#)

**Examples**

```
M <- matrix(rpois(30, lambda = 10), ncol = 3)  
D1 <- DiscreteMVDistribution(M)  
M1 <- rbind(r(D1)(10), matrix(rpois(30, lam = 10), ncol = 3))  
liesInSupport(D1, M1)
```

---

LMCondDistribution      *Generating function for the conditional distribution of a linear regression model.*

---

### Description

Generates an object of class "AbscontCondDistribution" which is the conditional distribution of a linear regression model (given the regressor).

### Usage

```
LMCondDistribution(Error = Norm(), theta = 0, intercept = 0, scale = 1)
```

### Arguments

Error	Object of class "AbscontDistribution": error distribution.
theta	numeric vector: regression parameter.
intercept	real number: intercept parameter.
scale	positive real number: scale parameter.

### Value

Object of class "AbscontCondDistribution"

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### See Also

[AbscontCondDistribution-class, E-methods](#)

### Examples

```
# normal error distribution
(D1 <- LMCondDistribution(theta = 1)) # corresponds to Norm(cond, 1)
plot(D1)
r(D1)
d(D1)
p(D1)
q(D1)
param(D1)
cond(D1)

d(D1)(0, cond = 1)
d(Norm(mean=1))(0)

E(D1, cond = 1)
```

```
E(D1, function(x){x^2}, cond = 2)
E(Norm(mean=2), function(x){x^2})
```

---

LMParameter

*Generating function for LMParameter-class*

---

## Description

Generates an object of class "LMParameter".

## Usage

```
LMParameter(theta = 0, intercept = 0, scale = 1)
```

## Arguments

theta	numeric vector: regression parameter (default =0).
intercept	real number: intercept parameter (default =0).
scale	positive real number: scale parameter (default =1).

## Value

Object of class "LMParameter"

## Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

## See Also

[LMParameter-class](#)

## Examples

```
LMParameter(theta = c(1,1), intercept = 2, scale = 0.5)

## The function is currently defined as
function(theta = 0, intercept = 0, scale = 1){
  new("LMParameter", theta = theta, intercept = intercept, scale = 1)
}
```

---

LMPParameter-class      *Parameter of a linear regression model*

---

**Description**

Parameter of a linear regression model

$$y = \mu + x^T \theta + \sigma u$$

with intercept  $\mu$ , regression parameter  $\theta$  and error scale  $\sigma$ .

**Objects from the Class**

Objects can be created by calls of the form `new("LMPParameter", ...)`. More frequently they are created via the generating function `LMPParameter`.

**Slots**

`theta` numeric vector: regression parameter.

`intercept` real number: intercept parameter.

`scale` positive real number: scale parameter.

`name` character vector: the default name is "parameter of a linear regression model".

**Extends**

Class "Parameter", directly.

Class "OptionalParameter", by class "Parameter".

**Methods**

`show` signature(object = "LMPParameter")

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Parameter-class](#), [LMPParameter](#)

**Examples**

```
new("LMPParameter")
```

**Description**

Generic function for the computation of clipped first moments. The moments are clipped at upper.

**Usage**

```
m1df(object, upper, ...)
## S4 method for signature 'AbscontDistribution'
m1df(object, upper,
      lowerTruncQuantile = getdistrExOption("m1dfLowerTruncQuantile"),
      rel.tol = getdistrExOption("m1dfRelativeTolerance"), ...)
```

**Arguments**

object	object of class "Distribution"
upper	clipping bound
rel.tol	relative tolerance for distrExIntegrate.
lowerTruncQuantile	lower quantile for quantile based integration range.
...	additional arguments to E

**Details**

The precision of the computations can be controlled via certain global options; cf. [distrExOptions](#).

**Value**

The first moment of object clipped at upper is computed.

**Methods**

**object = "UnivariateDistribution"**: uses call `E(object, upp=upper, ...)`.

**object = "AbscontDistribution"**: clipped first moment for absolutely continuous univariate distributions which is computed using `integrate`.

**object = "LatticeDistribution"**: clipped first moment for discrete univariate distributions which is computed using `support` and `sum`.

**object = "AffLinDistribution"**: clipped first moment for affine linear distributions which is computed on basis of slot `X0`.

**object = "Binom"**: clipped first moment for Binomial distributions which is computed using `pbinom`.

**object = "Pois"**: clipped first moment for Poisson distributions which is computed using `ppois`.

**object = "Norm"**: clipped first moment for normal distributions which is computed using `dnorm` and `pnorm`.

**object = "Exp"**: clipped first moment for exponential distributions which is computed using `pexp`.

**object = "Chisq"**: clipped first moment for  $\chi^2$  distributions which is computed using `pchisq`.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### See Also

[distrExIntegrate](#), [m2df](#), [E](#)

### Examples

```
# standard normal distribution
N1 <- Norm()
m1df(N1, 0)

# Poisson distribution
P1 <- Pois(lambda=2)
m1df(P1, 3)
m1df(P1, 3, fun = function(x)sin(x))

# absolutely continuous distribution
D1 <- Norm() + Exp() # convolution
m1df(D1, 2)
m1df(D1, Inf)
E(D1)
```

---

m2df

*Generic function for the computation of clipped second moments*

---

### Description

Generic function for the computation of clipped second moments. The moments are clipped at upper.

### Usage

```
m2df(object, upper, ...)
## S4 method for signature 'AbscontDistribution'
m2df(object, upper,
      lowerTruncQuantile = getdistrExOption("m2dfLowerTruncQuantile"),
      rel.tol = getdistrExOption("m2dfRelativeTolerance"), ...)
```



### Arguments

object	object of class "Distribution"
upper	clipping bound
rel.tol	relative tolerance for distrExIntegrate.
lowerTruncQuantile	lower quantile for quantile based integration range.
...	additional arguments to E

### Details

The precision of the computations can be controlled via certain global options; cf. [distrExOptions](#).

### Value

The second moment of object clipped at upper is computed.

### Methods

- object = "UnivariateDistribution"**: uses call `E(object, upp=upper, fun = function, ...)`.
- object = "AbscontDistribution"**: clipped second moment for absolutely continuous univariate distributions which is computed using `integrate`.
- object = "LatticeDistribution"**: clipped second moment for discrete univariate distributions which is computed using `support` and `sum`.
- object = "AffLinDistribution"**: clipped second moment for affine linear distributions which is computed on basis of slot `X0`.
- object = "Binom"**: clipped second moment for Binomial distributions which is computed using `pbinom`.
- object = "Pois"**: clipped second moment for Poisson distributions which is computed using `ppois`.
- object = "Norm"**: clipped second moment for normal distributions which is computed using `dnorm` and `pnorm`.
- object = "Exp"**: clipped second moment for exponential distributions which is computed using `pexp`.
- object = "Chisq"**: clipped second moment for  $\chi^2$  distributions which is computed using `pchisq`.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>

### See Also

[m2df-methods](#), [E-methods](#)

**Examples**

```
# standard normal distribution
N1 <- Norm()
m2df(N1, 0)

# Poisson distribution
P1 <- Pois(lambda=2)
m2df(P1, 3)
m2df(P1, 3, fun = function(x)sin(x))

# absolutely continuous distribution
D1 <- Norm() + Exp() # convolution
m2df(D1, 2)
m2df(D1, Inf)
E(D1, function(x){x^2})
```

---

make01

*Centering and Standardization of Univariate Distributions*

---

**Description**

The function `make01` produces a new centered and standardized univariate distribution.

**Usage**

```
make01(x)
```

**Arguments**

`x` an object of class "UnivariateDistribution"

**Details**

Thanks to the functionals provided in this package, the code is a one-liner:  $(x - E(x)) / sd(x)$ .

**Value**

Object of class "UnivariateDistribution" with expectation 0 and variance 1.

**Author(s)**

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**See Also**

E, Var

**Examples**

```
X <- sin(exp(2*log(abs( Norm())))) ## something weird
X01 <- make01(X)
print(X01)
plot(X01)
sd(X01); E(X01)
```

---

MultivariateDistribution-class  
*Multivariate Distributions*

---

**Description**

The class of multivariate distributions. One has at least to specify the image space of the distribution and a function generating (pseudo-)random numbers. The slot `q` is usually filled with `NULL` for dimensions  $> 1$ .

**Objects from the Class**

Objects can be created by calls of the form `new("MultivariateDistribution", ...)`.

**Slots**

`img` Object of class "rSpace". Image space of the distribution. Usually an object of class "EuclideanSpace".

`param` Object of class "OptionalParameter". Optional parameter of the multivariate distribution.

`r` Object of class "function": generates (pseudo-)random numbers

`d` Object of class "OptionalFunction": optional density function

`p` Object of class "OptionalFunction": optional cumulative distribution function

`q` Object of class "OptionalFunction": optional quantile function

`.withArith` logical: used internally to issue warnings as to interpretation of arithmetics

`.withSim` logical: used internally to issue warnings as to accuracy

`.logExact` logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function

`.lowerExact` logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function

`Symmetry` object of class "DistributionSymmetry"; used internally to avoid unnecessary calculations.

**Extends**

Class "Distribution", directly.

**Methods**

```
show signature(object = "MultivariateDistribution")
plot signature(object = "MultivariateDistribution"): not yet implemented.
```

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Distribution-class](#)

**Examples**

```
# Dirac-measure in (0,0)
new("MultivariateDistribution")
```

---

OAsymTotalVarDist	<i>Generic function for the computation of (minimal) asymmetric total variation distance of two distributions</i>
-------------------	-------------------------------------------------------------------------------------------------------------------

---

**Description**

Generic function for the computation of (minimal) asymmetric total variation distance  $d_v^*$  of two distributions  $P$  and  $Q$  where the distributions may be defined for an arbitrary sample space  $(\Omega, \mathcal{A})$ . This distance is defined as

$$d_v^*(P, Q) = \min_c \int |dQ - c dP|$$

**Usage**

```
OAsymTotalVarDist(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
OAsymTotalVarDist(e1,e2,
  rel.tol = .Machine$double.eps^0.3, Ngrid = 10000,
  TruncQuantile = getdistrOption("TruncQuantile"),
  IQR.fac = 15)
## S4 method for signature 'AbscontDistribution,DiscreteDistribution'
OAsymTotalVarDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,AbscontDistribution'
OAsymTotalVarDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
OAsymTotalVarDist(e1,e2, ...)
## S4 method for signature 'numeric,DiscreteDistribution'
OAsymTotalVarDist(e1, e2, ...)
## S4 method for signature 'DiscreteDistribution,numeric'
OAsymTotalVarDist(e1, e2, ...)
```

```

## S4 method for signature 'numeric,AbscontDistribution'
OAsymTotalVarDist(e1, e2, asis.smooth.discretize = "discretize",
  n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e2),
  up.discr = getUp(e2), h.smooth = getdistrExOption("hSmooth"),
  rel.tol = .Machine$double.eps^0.3, Ngrid = 10000,
  TruncQuantile = getdistrOption("TruncQuantile"),
  IQR.fac = 15)
## S4 method for signature 'AbscontDistribution,numeric'
OAsymTotalVarDist(e1, e2,
  asis.smooth.discretize = "discretize",
  n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e1),
  up.discr = getUp(e1), h.smooth = getdistrExOption("hSmooth"),
  rel.tol = .Machine$double.eps^0.3, Ngrid = 10000,
  TruncQuantile = getdistrOption("TruncQuantile"),
  IQR.fac = 15)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
OAsymTotalVarDist(e1, e2,
  rel.tol = .Machine$double.eps^0.3, Ngrid = 10000,
  TruncQuantile = getdistrOption("TruncQuantile"),
  IQR.fac = 15)

```

## Arguments

e1	object of class "Distribution" or "numeric"
e2	object of class "Distribution" or "numeric"
asis.smooth.discretize	possible methods are "asis", "smooth" and "discretize". Default is "discretize".
n.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the number of lattice points used to discretize the abs. cont. distribution.
low.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the lower end point of the lattice used to discretize the abs. cont. distribution.
up.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the upper end point of the lattice used to discretize the abs. cont. distribution.
h.smooth	if asis.smooth.discretize is equal to "smooth" – i.e., the empirical distribution of the provided data should be smoothed – one has to specify this parameter.
rel.tol	relative tolerance for distrExIntegrate and uniroot
Ngrid	How many grid points are to be evaluated to determine the range of the likelihood ratio?
TruncQuantile	Quantile the quantile based integration bounds (see details)
IQR.fac	Factor for the scale based integration bounds (see details)
...	further arguments to be used in particular methods (not in package <b>distrEx</b> )

## Details

For distances between absolutely continuous distributions, we use numerical integration; to determine sensible bounds we proceed as follows: by means of `min(getLow(e1, eps=TruncQuantile), getLow(e2, eps=TruncQuantile))`

`max(getUp(e1,eps=TruncQuantile),getUp(e2,eps=TruncQuantile))` we determine quantile based bounds `c(low.0,up.0)`, and by means of `s1 <- max(IQR(e1),IQR(e2))`; `m1<- median(e1)`; `m2 <- median(e2)` and `low.1 <- min(m1,m2)-s1*IQR.fac`, `up.1 <- max(m1,m2)+s1*IQR.fac` we determine scale based bounds; these are combined by `low <- max(low.0,low.1)`, `up <- max(up.0,up1)`.

Again in the absolutely continuous case, to determine the range of the likelihood ratio, we evaluate this ratio on a grid constructed as follows: `x.range <- c(seq(low, up, length=Ngrid/3),`

`q(e1)(se`

Finally, for both discrete and absolutely continuous case, we clip this ratio downwards by `1e-10` and upwards by `1e10`

In case we want to compute the total variation distance between (empirical) data and an abs. cont. distribution, we can specify the parameter `asis.smooth.discretize` to avoid trivial distances (distance = 1).

Using `asis.smooth.discretize = "discretize"`, which is the default, leads to a discretization of the provided abs. cont. distribution and the distance is computed between the provided data and the discretized distribution.

Using `asis.smooth.discretize = "smooth"` causes smoothing of the empirical distribution of the provided data. This is, the empirical data is convoluted with the normal distribution `Norm(mean = 0, sd = h.smooth)` which leads to an abs. cont. distribution. Afterwards the distance between the smoothed empirical distribution and the provided abs. cont. distribution is computed.

## Value

OAsymmetric Total variation distance of e1 and e2

## Methods

**e1 = "AbscontDistribution", e2 = "AbscontDistribution"**: total variation distance of two absolutely continuous univariate distributions which is computed using `distrExIntegrate`.

**e1 = "AbscontDistribution", e2 = "DiscreteDistribution"**: total variation distance of absolutely continuous and discrete univariate distributions (are mutually singular; i.e., have distance =1).

**e1 = "DiscreteDistribution", e2 = "DiscreteDistribution"**: total variation distance of two discrete univariate distributions which is computed using `support` and `sum`.

**e1 = "DiscreteDistribution", e2 = "AbscontDistribution"**: total variation distance of discrete and absolutely continuous univariate distributions (are mutually singular; i.e., have distance =1).

**e1 = "numeric", e2 = "DiscreteDistribution"**: Total variation distance between (empirical) data and a discrete distribution.

**e1 = "DiscreteDistribution", e2 = "numeric"**: Total variation distance between (empirical) data and a discrete distribution.

**e1 = "numeric", e2 = "AbscontDistribution"**: Total variation distance between (empirical) data and an abs. cont. distribution.

**e1 = "AbscontDistribution", e1 = "numeric"**: Total variation distance between (empirical) data and an abs. cont. distribution.

**e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution"**: Total variation distance of mixed discrete and absolutely continuous univariate distributions.

**Author(s)**

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

**References**

to be filled; Agostinelli, C and Ruckdeschel, P. (2009): A simultaneous inlier and outlier model by asymmetric total variation distance.

**See Also**

[TotalVarDist-methods](#), [ContaminationSize](#), [KolmogorovDist](#), [HellingerDist](#), [Distribution-class](#)

**Examples**

```
OAsymTotalVarDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
  mixCoeff=c(0.2,0.8)))
OAsymTotalVarDist(Norm(), Td(10))
OAsymTotalVarDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100)) # mutually singular
OAsymTotalVarDist(Pois(10), Binom(size = 20))

x <- rnorm(100)
OAsymTotalVarDist(Norm(), x)
OAsymTotalVarDist(x, Norm(), asis.smooth.discretize = "smooth")

y <- (rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5)
OAsymTotalVarDist(y, Norm())
OAsymTotalVarDist(y, Norm(), asis.smooth.discretize = "smooth")

OAsymTotalVarDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5))
```

---

plot-methods

*Methods for Function plot in Package 'distrEx'*

---

**Description**

plot-methods

**Usage**

```
plot(x, y, ...)
## S4 method for signature 'UnivariateCondDistribution,missing'
plot(x, y, ...)
## S4 method for signature 'MultivariateDistribution,missing'
plot(x, y, ...)
```

**Arguments**

x	object of class "UnivariateCondDistribution" or class "MultivariateDistribution": distribution(s) which should be plotted
y	missing
...	additional arguments

**Details**

upto now only warnings are issued that the corresponding method is not yet implemented;

---

PrognCondDistribution *Generating function for PrognCondDistribution-class*

---

**Description**

Generates an object of class "PrognCondDistribution".

**Usage**

```
PrognCondDistribution(Regr, Error,
                     rel.tol= getdistrExOption("ErelativeTolerance"),
                     lowerTruncQuantile = getdistrExOption("ElowerTruncQuantile"),
                     upperTruncQuantile = getdistrExOption("EupperTruncQuantile"),
                     IQR.fac = getdistrExOption("IQR.fac"))
```

**Arguments**

Regr	object of class AbscontDistribution; the distribution of X.
Error	object of class AbscontDistribution; the distribution of eps.
rel.tol	relative tolerance for distrExIntegrate.
lowerTruncQuantile	lower quantile for quantile based integration range.
upperTruncQuantile	upper quantile for quantile based integration range.
IQR.fac	factor for scale based integration range (i.e.; median of the distribution $\pm$ IQR.fac $\times$ IQR).

**Details**

For independent r.v.'s X,E with univariate, absolutely continuous (a.c.) distributions Regr and Error, respectively, PrognCondDistribution() returns the (factorized, conditional) posterior distribution of X given X+E=y. as an object of class PrognCondDistribution.

**Value**

Object of class "PrognCondDistribution"



**Author(s)**

Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>,

**See Also**

PrognCondDistribution-class; demo('Prognose.R').

**Examples**

```
PrognCondDistribution(Error = ConvexContamination(Norm(), Norm(4,1), size=0.1))
```

---

PrognCondDistribution-class

*Posterior distribution in convolution*

---

**Description**

The posterior distribution of  $X$  given  $(X+E)=y$

**Objects from the Class**

Objects can be created by calls of the form `PrognCondDistribution` where `Regr` and `error` are the respective (a.c.) distributions of  $X$  and  $E$  and the other arguments control accuracy in integration.

**Slots**

`cond`: Object of class "PrognCondition": condition

`img`: Object of class "rSpace": the image space.

`param`: Object of class "OptionalParameter": an optional parameter.

`r`: Object of class "function": generates random numbers.

`d`: Object of class "OptionalFunction": optional conditional density function.

`p`: Object of class "OptionalFunction": optional conditional cumulative distribution function.

`q`: Object of class "OptionalFunction": optional conditional quantile function.

`gaps`: (numeric) matrix or NULL

`.withArith`: logical: used internally to issue warnings as to interpretation of arithmetics

`.withSim`: logical: used internally to issue warnings as to accuracy

`.logExact`: logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function

`.lowerExact`: logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function

**Extends**

Class "AbscontCondDistribution", directly.

Class "Distribution", by classes "UnivariateCondDistribution" and "AbscontCondDistribution".

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[PrognCondition-class](#), [UnivariateCondDistribution-class](#) [AbscontCondDistribution-class](#), [Distribution-class](#)

**Examples**

```
PrognCondDistribution()
```

---

PrognCondition-class    *Conditions of class 'PrognCondition'*

---

**Description**

The class PrognCondition realizes the condition that  $X+E=y$  in a convolution setup

**Usage**

```
PrognCondition(range = EuclideanSpace())
```

**Arguments**

range            an object of class "EuclideanSpace"

**Value**

Object of class "PrognCondition"

**Objects from the Class**

Objects can be created by calls of the form PrognCondition(range).

**Slots**

name Object of class "character": name of the PrognCondition  
range Object of class "EuclideanSpace": range of the PrognCondition

**Extends**

Class "Condition", directly.

**Methods**

```
show signature(object = "PrognCondition")
```

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[PrognCondDistribution-class](#), [Condition-class](#)

**Examples**

```
PrognCondition()
```

---

TotalVarDist	<i>Generic function for the computation of the total variation distance of two distributions</i>
--------------	--------------------------------------------------------------------------------------------------

---

**Description**

Generic function for the computation of the total variation distance  $d_v$  of two distributions  $P$  and  $Q$  where the distributions may be defined for an arbitrary sample space  $(\Omega, \mathcal{A})$ . The total variation distance is defined as

$$d_v(P, Q) = \sup_{B \in \mathcal{A}} |P(B) - Q(B)|$$

**Usage**

```
TotalVarDist(e1, e2, ...)
## S4 method for signature 'AbscontDistribution,AbscontDistribution'
TotalVarDist(e1,e2,
              rel.tol=.Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"),
              IQR.fac = 15, ...)
## S4 method for signature 'AbscontDistribution,DiscreteDistribution'
TotalVarDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,AbscontDistribution'
TotalVarDist(e1,e2, ...)
## S4 method for signature 'DiscreteDistribution,DiscreteDistribution'
TotalVarDist(e1,e2, ...)
## S4 method for signature 'numeric,DiscreteDistribution'
TotalVarDist(e1, e2, ...)
## S4 method for signature 'DiscreteDistribution,numeric'
TotalVarDist(e1, e2, ...)
## S4 method for signature 'numeric,AbscontDistribution'
TotalVarDist(e1, e2, asis.smooth.discretize = "discretize",
             n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e2),
             up.discr = getUp(e2), h.smooth = getdistrExOption("hSmooth"),
             rel.tol = .Machine$double.eps^0.3,
             TruncQuantile = getdistrOption("TruncQuantile"), IQR.fac = 15, ...)
## S4 method for signature 'AbscontDistribution,numeric'
```

```
TotalVarDist(e1, e2, asis.smooth.discretize = "discretize",
              n.discr = getdistrExOption("nDiscretize"), low.discr = getLow(e1),
              up.discr = getUp(e1), h.smooth = getdistrExOption("hSmooth"),
              rel.tol = .Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"), IQR.fac = 15, ...)
## S4 method for signature 'AcDcLcDistribution,AcDcLcDistribution'
TotalVarDist(e1, e2,
              rel.tol = .Machine$double.eps^0.3,
              TruncQuantile = getdistrOption("TruncQuantile"),
              IQR.fac = 15, ...)
```

### Arguments

e1	object of class "Distribution" or "numeric"
e2	object of class "Distribution" or "numeric"
asis.smooth.discretize	possible methods are "asis", "smooth" and "discretize". Default is "discretize".
n.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the number of lattice points used to discretize the abs. cont. distribution.
low.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the lower end point of the lattice used to discretize the abs. cont. distribution.
up.discr	if asis.smooth.discretize is equal to "discretize" one has to specify the upper end point of the lattice used to discretize the abs. cont. distribution.
h.smooth	if asis.smooth.discretize is equal to "smooth" – i.e., the empirical distribution of the provided data should be smoothed – one has to specify this parameter.
rel.tol	relative accuracy requested in integration
TruncQuantile	Quantile the quantile based integration bounds (see details)
IQR.fac	Factor for the scale based integration bounds (see details)
...	further arguments to be used in particular methods (not in package <b>distrEx</b> )

### Details

For distances between absolutely continuous distributions, we use numerical integration; to determine sensible bounds we proceed as follows: by means of  $\min(\text{getLow}(e1, \text{eps}=\text{TruncQuantile}), \text{getLow}(e2, \text{eps}=\text{TruncQuantile}), \max(\text{getUp}(e1, \text{eps}=\text{TruncQuantile}), \text{getUp}(e2, \text{eps}=\text{TruncQuantile}))$  we determine quantile based bounds  $c(\text{low.}\theta, \text{up.}\theta)$ , and by means of  $s1 \leftarrow \max(\text{IQR}(e1), \text{IQR}(e2))$ ;  $m1 \leftarrow \text{median}(e1)$ ;  $m2 \leftarrow \text{median}(e2)$  and  $\text{low.}1 \leftarrow \min(m1, m2) - s1 * \text{IQR.}fac$ ,  $\text{up.}1 \leftarrow \max(m1, m2) + s1 * \text{IQR.}fac$  we determine scale based bounds; these are combined by  $\text{low} \leftarrow \max(\text{low.}\theta, \text{low.}1)$ ,  $\text{up} \leftarrow \max(\text{up.}\theta, \text{up.}1)$ .

In case we want to compute the total variation distance between (empirical) data and an abs. cont. distribution, we can specify the parameter `asis.smooth.discretize` to avoid trivial distances (distance = 1).

Using `asis.smooth.discretize = "discretize"`, which is the default, leads to a discretization of the provided abs. cont. distribution and the distance is computed between the provided data and the discretized distribution.

Using `asis.smooth.discretize = "smooth"` causes smoothing of the empirical distribution of the provided data. This is, the empirical data is convoluted with the normal distribution  $\text{Norm}(\text{mean} = 0, \text{sd} = \text{h.smooth})$  which leads to an abs. cont. distribution. Afterwards the distance between the smoothed empirical distribution and the provided abs. cont. distribution is computed.

### Value

Total variation distance of `e1` and `e2`

### Methods

- `e1 = "AbscontDistribution", e2 = "AbscontDistribution"`**: total variation distance of two absolutely continuous univariate distributions which is computed using `distrExIntegrate`.
- `e1 = "AbscontDistribution", e2 = "DiscreteDistribution"`**: total variation distance of absolutely continuous and discrete univariate distributions (are mutually singular; i.e., have distance =1).
- `e1 = "DiscreteDistribution", e2 = "DiscreteDistribution"`**: total variation distance of two discrete univariate distributions which is computed using `support` and `sum`.
- `e1 = "DiscreteDistribution", e2 = "AbscontDistribution"`**: total variation distance of discrete and absolutely continuous univariate distributions (are mutually singular; i.e., have distance =1).
- `e1 = "numeric", e2 = "DiscreteDistribution"`**: Total variation distance between (empirical) data and a discrete distribution.
- `e1 = "DiscreteDistribution", e2 = "numeric"`**: Total variation distance between (empirical) data and a discrete distribution.
- `e1 = "numeric", e2 = "AbscontDistribution"`**: Total variation distance between (empirical) data and an abs. cont. distribution.
- `e1 = "AbscontDistribution", e1 = "numeric"`**: Total variation distance between (empirical) data and an abs. cont. distribution.
- `e1 = "AcDcLcDistribution", e2 = "AcDcLcDistribution"`**: Total variation distance of mixed discrete and absolutely continuous univariate distributions.

### Author(s)

Matthias Kohl <Matthias.Kohl@stamats.de>,  
Peter Ruckdeschel <peter.ruckdeschel@uni-oldenburg.de>

### References

- Huber, P.J. (1981) *Robust Statistics*. New York: Wiley.
- Rieder, H. (1994) *Robust Asymptotic Statistics*. New York: Springer.

### See Also

[TotalVarDist-methods](#), [ContaminationSize](#), [KolmogorovDist](#), [HellingerDist](#), [Distribution-class](#)

**Examples**

```

TotalVarDist(Norm(), UnivarMixingDistribution(Norm(1,2),Norm(0.5,3),
      mixCoeff=c(0.2,0.8)))
TotalVarDist(Norm(), Td(10))
TotalVarDist(Norm(mean = 50, sd = sqrt(25)), Binom(size = 100)) # mutually singular
TotalVarDist(Pois(10), Binom(size = 20))

x <- rnorm(100)
TotalVarDist(Norm(), x)
TotalVarDist(x, Norm(), asis.smooth.discretize = "smooth")

y <- (rbinom(50, size = 20, prob = 0.5)-10)/sqrt(5)
TotalVarDist(y, Norm())
TotalVarDist(y, Norm(), asis.smooth.discretize = "smooth")

TotalVarDist(rbinom(50, size = 20, prob = 0.5), Binom(size = 20, prob = 0.5))

```

---

UnivariateCondDistribution-class

*Univariate conditional distribution*

---

**Description**

Class of univariate conditional distributions.

**Objects from the Class**

Objects can be created by calls of the form `new("UnivariateCondDistribution", ...)`.

**Slots**

`cond` Object of class "Condition": condition  
`img` Object of class "rSpace": the image space.  
`param` Object of class "OptionalParameter": an optional parameter.  
`r` Object of class "function": generates random numbers.  
`d` Object of class "OptionalFunction": optional conditional density function.  
`p` Object of class "OptionalFunction": optional conditional cumulative distribution function.  
`q` Object of class "OptionalFunction": optional conditional quantile function.  
`.withArith` logical: used internally to issue warnings as to interpretation of arithmetics  
`.withSim` logical: used internally to issue warnings as to accuracy  
`.logExact` logical: used internally to flag the case where there are explicit formulae for the log version of density, cdf, and quantile function  
`.lowerExact` logical: used internally to flag the case where there are explicit formulae for the lower tail version of cdf and quantile function  
`Symmetry` object of class "DistributionSymmetry"; used internally to avoid unnecessary calculations.

**Extends**

Class "UnivariateDistribution", directly.  
 Class "Distribution", by class "UnivariateDistribution".

**Methods**

**cond** signature(object = "UnivariateCondDistribution"): accessor function for slot cond.  
**show** signature(object = "UnivariateCondDistribution")  
**plot** signature(object = "UnivariateCondDistribution"): not yet implemented.

**Author(s)**

Matthias Kohl <Matthias.Kohl@stamats.de>

**See Also**

[Distribution-class](#)

**Examples**

```
new("UnivariateCondDistribution")
```

---

 var

*Generic Functions for the Computation of Functionals*

---

**Description**

Generic functions for the computation of functionals on distributions.

**Usage**

```
IQR(x, ...)
```

```
## S4 method for signature 'UnivariateDistribution'
IQR(x)
## S4 method for signature 'UnivariateCondDistribution'
IQR(x,cond)
## S4 method for signature 'AffLinDistribution'
IQR(x)
## S4 method for signature 'DiscreteDistribution'
IQR(x)
## S4 method for signature 'Arcsine'
IQR(x)
## S4 method for signature 'Cauchy'
IQR(x)
## S4 method for signature 'Dirac'
IQR(x)
```

```
## S4 method for signature 'DExp'
IQR(x)
## S4 method for signature 'Exp'
IQR(x)
## S4 method for signature 'Geom'
IQR(x)
## S4 method for signature 'Logis'
IQR(x)
## S4 method for signature 'Norm'
IQR(x)
## S4 method for signature 'Unif'
IQR(x)

median(x, ...)

## S4 method for signature 'UnivariateDistribution'
median(x)
## S4 method for signature 'UnivariateCondDistribution'
median(x,cond)
## S4 method for signature 'AffLinDistribution'
median(x)
## S4 method for signature 'Arcsine'
median(x)
## S4 method for signature 'Cauchy'
median(x)
## S4 method for signature 'Dirac'
median(x)
## S4 method for signature 'DExp'
median(x)
## S4 method for signature 'Exp'
median(x)
## S4 method for signature 'Geom'
median(x)
## S4 method for signature 'Logis'
median(x)
## S4 method for signature 'Lnorm'
median(x)
## S4 method for signature 'Norm'
median(x)
## S4 method for signature 'Unif'
median(x)

mad(x, ...)

## S4 method for signature 'UnivariateDistribution'
mad(x)
## S4 method for signature 'AffLinDistribution'
mad(x)
```



```

## S4 method for signature 'Cauchy'
mad(x)
## S4 method for signature 'Dirac'
mad(x)
## S4 method for signature 'DExp'
mad(x)
## S4 method for signature 'Exp'
mad(x)
## S4 method for signature 'Geom'
mad(x)
## S4 method for signature 'Logis'
mad(x)
## S4 method for signature 'Norm'
mad(x)
## S4 method for signature 'Unif'
mad(x)
## S4 method for signature 'Arcsine'
mad(x)

sd(x, ...)

## S4 method for signature 'UnivariateDistribution'
sd(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'Norm'
sd(x, fun, cond, withCond = FALSE, useApply = TRUE, ...)

var(x, ...)

## S4 method for signature 'UnivariateDistribution'
var(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'AffLinDistribution'
var(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'CompoundDistribution'
var(x, ...)
## S4 method for signature 'Arcsine'
var(x, ...)
## S4 method for signature 'Binom'
var(x, ...)
## S4 method for signature 'Beta'
var(x, ...)
## S4 method for signature 'Cauchy'
var(x, ...)
## S4 method for signature 'Chisq'
var(x, ...)
## S4 method for signature 'Dirac'
var(x, ...)
## S4 method for signature 'DExp'
var(x, ...)

```

```
## S4 method for signature 'Exp'
var(x, ...)
## S4 method for signature 'Fd'
var(x, ...)
## S4 method for signature 'Gammad'
var(x, ...)
## S4 method for signature 'Geom'
var(x, ...)
## S4 method for signature 'Hyper'
var(x, ...)
## S4 method for signature 'Logis'
var(x, ...)
## S4 method for signature 'Lnorm'
var(x, ...)
## S4 method for signature 'Nbinom'
var(x, ...)
## S4 method for signature 'Norm'
var(x, ...)
## S4 method for signature 'Pois'
var(x, ...)
## S4 method for signature 'Td'
var(x, ...)
## S4 method for signature 'Unif'
var(x, ...)
## S4 method for signature 'Weibull'
var(x, ...)

skewness(x, ...)
## S4 method for signature 'UnivariateDistribution'
skewness(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'AffLinDistribution'
skewness(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'Arcsine'
skewness(x, ...)
## S4 method for signature 'Binom'
skewness(x, ...)
## S4 method for signature 'Beta'
skewness(x, ...)
## S4 method for signature 'Cauchy'
skewness(x, ...)
## S4 method for signature 'Chisq'
skewness(x, ...)
## S4 method for signature 'Dirac'
skewness(x, ...)
## S4 method for signature 'DExp'
skewness(x, ...)
## S4 method for signature 'Exp'
skewness(x, ...)
```

```
## S4 method for signature 'Fd'
skewness(x, ...)
## S4 method for signature 'Gammad'
skewness(x, ...)
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skewness(x, ...)
## S4 method for signature 'Norm'
skewness(x, ...)
## S4 method for signature 'Pois'
skewness(x, ...)
## S4 method for signature 'Td'
skewness(x, ...)
## S4 method for signature 'Unif'
skewness(x, ...)
## S4 method for signature 'Weibull'
skewness(x, ...)

kurtosis(x, ...)
## S4 method for signature 'UnivariateDistribution'
kurtosis(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'AffLinDistribution'
kurtosis(x, fun, cond, withCond, useApply, ...)
## S4 method for signature 'Arcsine'
kurtosis(x, ...)
## S4 method for signature 'Binom'
kurtosis(x, ...)
## S4 method for signature 'Beta'
kurtosis(x, ...)
## S4 method for signature 'Cauchy'
kurtosis(x, ...)
## S4 method for signature 'Chisq'
kurtosis(x, ...)
## S4 method for signature 'Dirac'
kurtosis(x, ...)
## S4 method for signature 'DExp'
kurtosis(x, ...)
## S4 method for signature 'Exp'
kurtosis(x, ...)
## S4 method for signature 'Fd'
kurtosis(x, ...)
```

```

## S4 method for signature 'Gammad'
kurtosis(x, ...)
## S4 method for signature 'Geom'
kurtosis(x, ...)
## S4 method for signature 'Hyper'
kurtosis(x, ...)
## S4 method for signature 'Logis'
kurtosis(x, ...)
## S4 method for signature 'Lnorm'
kurtosis(x, ...)
## S4 method for signature 'Nbinom'
kurtosis(x, ...)
## S4 method for signature 'Norm'
kurtosis(x, ...)
## S4 method for signature 'Pois'
kurtosis(x, ...)
## S4 method for signature 'Td'
kurtosis(x, ...)
## S4 method for signature 'Unif'
kurtosis(x, ...)
## S4 method for signature 'Weibull'
kurtosis(x, ...)

```

### Arguments

x	object of class "UnivariateDistribution"
fun	if missing the (conditional) variance resp. standard deviation is computed else the (conditional) variance resp. standard deviation of fun is computed.
cond	if not missing the conditional variance resp. standard deviation given cond is computed.
...	additional arguments to fun or E
useApply	logical: should sapply, respectively apply be used to evaluate fund.
withCond	logical: is cond in the argument list of fun.

### Value

The value of the corresponding functional at the distribution in the argument is computed.

### Methods

var, signature(x = "Any"): interface to the **stats**-function var — see [var](#) resp. `help(var, package="stats")`.

var, signature(x = "UnivariateDistribution"): variance of univariate distributions using corresponding `E()`-method.

var, signature(x = "AffLinDistribution"): if arguments fun, cond are missing:  $x@a^2 * var(x@X0)$  else uses method for signature(x = "UnivariateDistribution")

`var`, signature(x = "CompoundDistribution"): if we are in i.i.d. situation (i.e., slot `SummandsDistr` is of class `UnivariateDistribution`) the formula  $E[N]\text{var}[S] + (E[S]^2 + \text{var}(S))\text{var}(N)$  for  $N$  the frequency distribution and  $S$  the summand distribution; else we coerce to "UnivarLebDecDistribution".

`sd`, signature(x = "Any"): interface to the **stats**-function `sd` — see `sd` resp. `help(sd, package="stats")`.

`sd`, signature(x = "NormParameter"): returns the slot `sd` of the parameter of a normal distribution — see `sd` resp. `help(sd, package="distr")`.

`sd`, signature(x = "Norm"): returns the slot `sd` of the parameter of a normal distribution — see `sd` resp. `help(sd, package="distr")`.

`sd`, signature(x = "UnivariateDistribution"): standard deviation of univariate distributions using corresponding `E()`-method.

`IQR`, signature(x = "Any"): interface to the **stats**-function `IQR` — see `IQR` resp. `help(IQR, package="stats")`.

`IQR`, signature(x = "UnivariateDistribution"): interquartile range of univariate distributions using corresponding `q()`-method.

`IQR`, signature(x = "UnivariateCondDistribution"): interquartile range of univariate conditional distributions using corresponding `q()`-method.

`IQR`, signature(x = "DiscreteDistribution"): interquartile range of discrete distributions using corresponding `q()`-method but taking care that between upper and lower quartile there is 50% probability

`IQR`, signature(x = "AffLinDistribution"):  $\text{abs}(x@a) * \text{IQR}(x@X0)$

`median`, signature(x = "Any"): interface to the **stats**-function `median` — see `median` resp. `help(var, package="stats")`.

`median`, signature(x = "UnivariateDistribution"): median of univariate distributions using corresponding `q()`-method.

`median`, signature(x = "UnivariateCondDistribution"): median of univariate conditional distributions using corresponding `q()`-method.

`median`, signature(x = "AffLinDistribution"):  $x@a * \text{median}(x@X0) + x@b$

`mad`, signature(x = "Any"): interface to the **stats**-function `mad` — see `mad`.

`mad`, signature(x = "UnivariateDistribution"): mad of univariate distributions using corresponding `q()`-method applied to  $\text{abs}(x - \text{median}(x))$ .

`mad`, signature(x = "AffLinDistribution"):  $\text{abs}(x@a) * \text{mad}(x@X0)$

`skewness`, signature(x = "Any"): bias free estimation of skewness under normal distribution (default) as well as sample version (by argument `sample.version = TRUE`).

`skewness`, signature(x = "UnivariateDistribution"): skewness of univariate distributions using corresponding `E()`-method.

`skewness`, signature(x = "AffLinDistribution"): if arguments `fun`, `cond` are missing:  $\text{skewness}(x@X0)$  else uses method for signature(x = "UnivariateDistribution")

`kurtosis`, signature(x = "Any"): bias free estimation of kurtosis under normal distribution (default) as well as sample version (by argument `sample.version = TRUE`).

`kurtosis`, signature(x = "UnivariateDistribution"): kurtosis of univariate distributions using corresponding `E()`-method.

`kurtosis`, signature(x = "AffLinDistribution"): if arguments `fun`, `cond` are missing:  $\text{kurtosis}(x@X0)$  else uses method for signature(x = "UnivariateDistribution")

var, signature(x = "Arcsine"): exact evaluation using explicit expressions.  
var, signature(x = "Beta"): for noncentrality 0 exact evaluation using explicit expressions.  
var, signature(x = "Binom"): exact evaluation using explicit expressions.  
var, signature(x = "Cauchy"): exact evaluation using explicit expressions.  
var, signature(x = "Chisq"): exact evaluation using explicit expressions.  
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 skewness, signature(x = "Binom"): exact evaluation using explicit expressions.  
 skewness, signature(x = "Cauchy"): exact evaluation using explicit expressions.  
 skewness, signature(x = "Chisq"): exact evaluation using explicit expressions.  
 skewness, signature(x = "Dirac"): exact evaluation using explicit expressions.  
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kurtosis, signature(x = "Dirac"): exact evaluation using explicit expressions.  
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 kurtosis, signature(x = "Logis"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Lnorm"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Nbinom"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Norm"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Pois"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Td"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Unif"): exact evaluation using explicit expressions.  
 kurtosis, signature(x = "Weibull"): exact evaluation using explicit expressions.

### Caveat

If any of the packages **e1071**, **moments**, **fBasics** is to be used together with **distrEx** the latter must be attached *after* any of the first mentioned. Otherwise `kurtosis()` and `skewness()` defined as *methods* in **distrEx** may get masked.

To re-mask, you may use `kurtosis <- distrEx::kurtosis`; `skewness <- distrEx::skewness`. See also `distrExMASK()`.

### Acknowledgement

G. Jay Kerns, <gkerns@ysu.edu>, has provided a major contribution, in particular the functionals `skewness` and `kurtosis` are due to him.

### Author(s)

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### See Also

[distrExIntegrate](#), [m1df](#), [m2df](#), [Distribution-class](#),  
[sd](#), [var](#), [IQR](#),  
[median](#), [mad](#), [sd](#),  
[Sn](#), [Qn](#)



**Examples**

```
# Variance of Exp(1) distribution
var(Exp())

#median(Exp())
IQR(Exp())
mad(Exp())

# Variance of N(1,4)^2
var(Norm(mean=1, sd=2), fun = function(x){x^2})
var(Norm(mean=1, sd=2), fun = function(x){x^2}, useApply = FALSE)

## sd -- may equivalently be replaced by var
sd(Pois()) ## uses explicit terms
sd(as(Pois(),"DiscreteDistribution")) ## uses sums
sd(as(Pois(),"UnivariateDistribution")) ## uses simulations
sd(Norm(mean=2), fun = function(x){2*x^2}) ## uses simulations
#
mad(sin(exp(Norm()+2*Pois())))) ## weird
```

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