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Description Detailed functionality for working
with the univariate and multivariate Generalized Hyperbolic
distribution and its special cases (Hyperbolic (hyp), Normal
Inverse Gaussian (NIG), Variance Gamma (VG), skewed Student-t
and Gaussian distribution). Especially, it contains fitting
procedures, an AIC-based model selection routine, and functions
for the computation of density, quantile, probability, random
variates, expected shortfall and some portfolio optimization
and plotting routines as well as the likelihood ratio test. In
addition, it contains the Generalized Inverse Gaussian
distribution. See Chapter 3 of A. J. McNeil, R. Frey, and P. Embrechts.
Quantitative risk management: Concepts, techniques and tools.
Princeton University Press, Princeton (2005).

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R topics documented:

ghyp-package 2

coef-method . . . 6
ESghyp.attribution . . . 8
fit.ghypmv . . . 9
fit.ghypuv . . . 11
ghyp-constructors . . . 14
ghyp-distribution . . . 18
ghyp-get . . . 20
ghyp-mle.ghyp-classes . . . 22
ghyp-risk-performance . . . 25
ghyp.attribution-class . . . 27
ghyp.moment . . . 28
gig-distribution . . . 30
hist-methods . . . 32
indices . . . 33
lik.ratio.test . . . 34
logLik-AIC-methods . . . 35
mean-vcov-skew-kurt-methods . . . 37
pairs-methods . . . 38
plot-ghyp.attribution . . . 39
plot-lines-methods . . . 41
portfolio.optimize . . . 42
qq-ghyp . . . 44
scale-methods . . . 46
smi.stocks . . . 47
stepAIC.ghyp . . . 48
summary-method . . . 49
transform-extract-methods . . . 50

Index **52**

`ghyp-package` *A package on the generalized hyperbolic distribution and its special cases*

Description

This package provides detailed functionality for working with the univariate and multivariate Generalized Hyperbolic distribution and its special cases (Hyperbolic (hyp), Normal Inverse Gaussian (NIG), Variance Gamma (VG), skewed Student-t and Gaussian distribution). Especially, it contains fitting procedures, an AIC-based model selection routine, and functions for the computation of density, quantile, probability, random variates, expected shortfall and some portfolio optimization and plotting routines as well as the likelihood ratio test. In addition, it contains the Generalized Inverse Gaussian distribution.

Details

Package:	ghyp
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Initialize:

ghyp	Initialize a generalized hyperbolic distribution.
hyp	Initialize a hyperbolic distribution.
NIG	Initialize a normal inverse gaussian distribution.
VG	Initialize a variance gamma distribution.
student.t	Initialize a Student-t distribution.
gauss	Initialize a Gaussian distribution.

Density, distribution function, quantile function and random generation:

dghyp	Density of a generalized hyperbolic distribution.
pghyp	Distribution function of a generalized hyperbolic distribution.
qghyp	Quantile of a univariate generalized hyperbolic distribution.
rghyp	Random generation of a generalized hyperbolic distribution.

Fit to data:

fit.ghypuv	Fit a generalized hyperbolic distribution to univariate data.
fit.hypuv	Fit a hyperbolic distribution to univariate data.
fit.NIGuv	Fit a normal inverse gaussian distribution to univariate data.
fit.VGuv	Fit a variance gamma distribution to univariate data.
fit.tuv	Fit a skewed Student-t distribution to univariate data.
fit.gaussuv	Fit a Gaussian distribution to univariate data.
fit.ghypmv	Fit a generalized hyperbolic distribution to multivariate data.
fit.hypmv	Fit a hyperbolic distribution to multivariate data.
fit.NIGmv	Fit a normal inverse gaussian distribution to multivariate data.
fit.VGmv	Fit a variance gamma distribution to multivariate data.
fit.tmv	Fit a skewed Student-t distribution to multivariate data.
fit.gaussmv	Fit a Gaussian distribution to multivariate data.
stepAIC.ghyp	Perform a model selection based on the AIC.

Risk, performance and portfolio optimization:

ESghyp	Expected shortfall of a univariate generalized hyperbolic distribution.

ghyp.omega	Performance measure *Omega* based on a univariate ghyp distribution.
portfolio.optimize	Calculate optimal portfolios with respect to alternative risk measures.

Utilities:

mean	Returns the expected value.
vcov	Returns the variance(-covariance).
ghyp.skewness	Skewness of a univariate ghyp distribution.
ghyp.kurtosis	Kurtosis of a univariate ghyp distribution.
logLik	Returns Log-Likelihood of fitted ghyp objects.
AIC	Returns the Akaike's Information Criterion of fitted ghyp objects.
lik.ratio.test	Performs a likelihood-ratio test on fitted ghyp distributions.
[	Extract certain dimensions of a multivariate ghyp distribution.
scale	Scale ghyp distribution objects to zero expectation and/or unit variance.
transform	Transform a multivariate generalized hyperbolic distribution.
ghyp.moment	Moments of the univariate ghyp distribution.
coef	Parameters of a generalized hyperbolic distribution.
ghyp.data	Data of a (fitted) generalized hyperbolic distribution.
ghyp.fit.info	Information about the fitting procedure, log-likelihood and AIC value.
ghyp.name	Returns the name of the ghyp distribution or a subclass of it.
ghyp.dim	Returns the dimension of a ghyp object.
summary	Summary of a fitted generalized hyperbolic distribution.

Plot functions:

qqghyp	Perform a quantile-quantile plot of a (fitted) univariate ghyp distribution.
hist	Plot a histogram of a (fitted) univariate generalized hyperbolic distribution.
pairs	Produce a matrix of scatterplots with quantile-quantile plots on the diagonal.
plot	Plot the density of a univariate ghyp distribution.
lines	Add the density of a univariate ghyp distribution to a graphics device.

Generalized inverse gaussian distribution:

dgig	Density of a generalized inverse gaussian distribution
pgig	Distribution function of a generalized inverse gaussian distribution
qgig	Quantile of a generalized inverse gaussian distribution
ESgig	Expected shortfall of a generalized inverse gaussian distribution
rgig	Random generation of a generalized inverse gaussian distribution

Package vignette:
A document about generalized hyperbolic distributions can be found in the doc folder of this package or on https://cran.r-project.org/package=ghyp.

Existing solutions

There are packages like `GeneralizedHyperbolic`, `HyperbolicDist`, `SkewHyperbolic`, `VarianceGamma` and `fBasics` which cover the univariate generalized hyperbolic distribution and/or some of its special cases. However, the univariate case is contained in this package as well because we aim to provide a uniform interface to deal with generalized hyperbolic distribution. Recently an R port of the S-Plus library `QRMlib` was released. The package `QRMlib` contains fitting procedures for the multivariate NIG, hyp and skewed Student-t distribution but not for the generalized hyperbolic case. The package `fMultivar` implements a fitting routine for multivariate skewed Student-t distributions as well.

Object orientation

We follow an object-oriented programming approach in this package and introduce distribution objects. There are mainly four reasons for that:

- Unlike most distributions the GH distribution has quite a few parameters which have to fulfill some consistency requirements. Consistency checks can be performed uniquely when an object is initialized.
- Once initialized the common functions belonging to a distribution can be called conveniently by passing the distribution object. A repeated input of the parameters is avoided.
- Distributions returned from fitting procedures can be directly passed to, e.g., the density function since fitted distribution objects add information to the distribution object and consequently inherit from the class of the distribution object.
- Generic method dispatching can be used to provide a uniform interface to, e.g., plot the probability density of a specific distribution like `plot(distribution.object)`. Additionally, one can take advantage of generic programming since R provides virtual classes and some forms of polymorphism.

Acknowledgement

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Author(s)

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References

Quantitative Risk Management: Concepts, Techniques and Tools by Alexander J. McNeil, Ruediger Frey and Paul Embrechts

Princeton Press, 2005

Intermediate probability: A computational approach by Marc Paolella
Wiley, 2007

S-Plus and R *Library for Quantitative Risk Management QRMlib* by Alexander J. McNeil (2005) and Scott Ulman (R-port) (2007)

`coef-method` *Extract parameters of generalized hyperbolic distribution objects*

Description

The function `coef` returns the parameters of a generalized hyperbolic distribution object as a list. The user can choose between the "chi/psi", the "alpha.bar" and the "alpha/delta" parametrization. The function `coefficients` is a synonym for `coef`.

Usage

```
## S4 method for signature 'ghyp'
coef(object, type = c("chi.psi", "alpha.bar", "alpha.delta"))

## S4 method for signature 'ghyp'
coefficients(object, type = c("chi.psi", "alpha.bar", "alpha.delta"))
```

Arguments

`object`	An object inheriting from class ghyp.
`type`	According to `type` the parameters of either the "chi/psi", the "alpha.bar" or the "alpha/delta" parametrization will be returned. If `type` is missing, the parameters belonging to the parametrization of the construction are returned.

Details

Internally, the "chi/psi" parametrization is used. However, fitting is only possible in the "alpha.bar" parametrization as it provides the most convenient parameter constraints.

Value

If `type` is "chi.psi" a list with components:

`lambda`	Shape parameter.
`chi`	Shape parameter.
`psi`	Shape parameters.
`mu`	Location parameter.
`sigma`	Dispersion parameter.
`gamma`	Skewness parameter.

If type is "alpha.bar" a list with components:

lambda	Shape parameter.
alpha.bar	Shape parameter.
mu	Location parameter.
sigma	Dispersion parameter.
gamma	Skewness parameter.

If type is "alpha.delta" a list with components:

lambda	Shape parameter.
alpha	Shape parameter.
delta	Shape parameter.
mu	Location parameter.
Delta	Dispersion matrix with a determinant of 1 (only returned in the multivariate case).
beta	Shape and skewness parameter.

Note

A switch from either the "chi/psi" to the "alpha.bar" or from the "alpha/delta" to the "alpha.bar" parametrization is not yet possible.

Author(s)

David Luethi

See Also

ghyp, fit.ghypuv, fit.ghypmv, ghyp.fit.info, transform, [.ghyp

Examples

```
ghyp.mv <- ghyp(lambda = 1, alpha.bar = 0.1, mu = rep(0,2), sigma = diag(rep(1,2)),
                gamma = rep(0,2), data = matrix(rt(1000, df = 4), ncol = 2))
## Get parameters
coef(ghyp.mv, type = "alpha.bar")
coefficients(ghyp.mv, type = "chi.psi")

## Simple modification (do not modify slots directly e.g. object@mu <- 0:1)
param <- coef(ghyp.mv, type = "alpha.bar")
param$mu <- 0:1
do.call("ghyp", param) # returns a new 'ghyp' object
```

`ESghyp.attribution` *Risk attribution.*

Description

Functions to get the *contribution* of each asset to the portfolio's *Expected Shortfall* based on multivariate generalized hyperbolic distributions as well as the expected shortfall *sensitivity* to marginal changes in portfolio allocation.

Usage

```
ESghyp.attribution(
  alpha,
  object = ghyp(),
  distr = c("return", "loss"),
  weights = NULL,
  ...
)
```

Arguments

`alpha`	a vector of confidence levels for ES.
`object`	a multivariate fitted ghyp object inheriting from class ghyp.
`distr`	whether the ghyp-object specifies a return or a loss-distribution (see **Details**).
`weights`	vector of portfolio weights. Default is an equally-weighted portfolio.
`...`	optional arguments passed from ghyp.attribution to `qghyp` and `integrate`.

Details

The parameter `distr` specifies whether the ghyp-object describes a return or a loss-distribution. In case of a return distribution the expected-shortfall on a confidence level α is defined as $\text{ES}_\alpha := \text{E}(X|X \leq F_X^{-1}(\alpha))$ while in case of a loss distribution it is defined on a confidence level α as $\text{ES}_\alpha := \text{E}(X|X > F_X^{-1}(\alpha))$.

Value

`ESghyp.attribution` is an object of class ghyp.attribution.

Author(s)

Marc Weibel

See Also

`contribution,ghyp.attribution-method`, `sensitivity,ghyp.attribution-method` and `weights` for Expected Shortfall.

Examples

```
## Not run:
data(smi.stocks)
## Fit a NIG model to Novartis, CS and Nestle log-returns
assets.fit <- fit.NIGmv(smi.stocks[, c("Novartis", "CS", "Nestle")], silent = TRUE)
## Define Weights of the Portfolio
weights <- c(0.2, 0.5, 0.3)
## Confidence level for Expected Shortfall
es.levels <- c(0.01)

portfolio.attrib <- ESghyp.attribution(alpha=es.levels, object=assets.fit, weights=weights)

## End(Not run)
```

`fit.ghypmv` *Fitting generalized hyperbolic distributions to multivariate data*

Description

Perform a maximum likelihood estimation of the parameters of a multivariate generalized hyperbolic distribution by using an Expectation Maximization (EM) based algorithm.

Usage

```
fit.ghypmv(data, lambda = 1, alpha.bar = 1, mu = NULL, sigma = NULL,
           gamma = NULL, opt.pars = c(lambda = TRUE, alpha.bar = TRUE, mu = TRUE,
                                      sigma = TRUE, gamma = !symmetric),
            symmetric = FALSE, standardize = FALSE, nit = 2000, reltol = 1e-8,
           abstol = reltol * 10, na.rm = FALSE, silent = FALSE, save.data = TRUE,
            trace = TRUE, ...)

fit.hypmv(data,
       opt.pars = c(alpha.bar = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
          symmetric = FALSE, ...)

fit.NIGmv(data,
       opt.pars = c(alpha.bar = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
          symmetric = FALSE, ...)

fit.VGmv(data, lambda = 1,
        opt.pars = c(lambda = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
         symmetric = FALSE, ...)

fit.tmv(data, nu = 3.5,
       opt.pars = c(lambda = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
        symmetric = FALSE, ...)

fit.gaussmv(data, na.rm = TRUE, save.data = TRUE)
```

Arguments

data	An object coercible to a matrix.
lambda	Starting value for the shape parameter lambda.
alpha.bar	Starting value for the shape parameter alpha.bar.
nu	Starting value for the shape parameter nu (only used in case of a student-t distribution. It determines the degree of freedom and is defined as -2*lambda.)
mu	Starting value for the location parameter mu.
sigma	Starting value for the dispersion matrix sigma.
gamma	Starting value for the skewness vecotr gamma.
opt.pars	A named logical vector which states which parameters should be fitted.
symmetric	If TRUE the skewness parameter gamma keeps zero.
standardize	If TRUE the sample will be standardized before fitting. Afterwards, the parameters and log-likelihood et cetera will be back-transformed.
save.data	If TRUE data will be stored within the mle.ghyp object (cf. ghyp.data).
trace	If TRUE the evolution of the parameter values during the fitting procedure will be traced and stored (cf. ghyp.fit.info).
na.rm	If TRUE missing values will be removed from data.
silent	If TRUE no prompts will appear in the console.
nit	Maximal number of iterations of the expectation maximation algorithm.
reltol	Relative convergence tolerance.
abstol	Absolute convergence tolerance.
...	Arguments passed to optim and to fit.ghypmv when fitting special cases of the generalized hyperbolic distribution.

Details

This function uses a modified EM algorithm which is called Multi-Cycle Expectation Conditional Maximization (MCECM) algorithm. This algorithm is sketched in the vignette of this package which can be found in the doc folder. A more detailed description is provided by the book *Quantitative Risk Management, Concepts, Techniques and Tools* (see "References").

The general-purpose optimization routine optim is used to maximize the loglikelihood function of the univariate mixing distribution. The default method is that of Nelder and Mead which uses only function values. Parameters of optim can be passed via the ... argument of the fitting routines.

Value

An object of class mle.ghyp.

Note

The variance gamma distribution becomes singular when $\mathbf{x} - \mu = 0$. This singularity is catched and the reduced density function is computed. Because the transition is not smooth in the numerical implementation this can rarely result in nonsensical fits.

Providing both arguments, `opt.pars` and `symmetric` respectively, can result in a conflict when `opt.pars['gamma']` and `symmetric` are `TRUE`. In this case `symmetric` will dominate and `opt.pars['gamma']` is set to `FALSE`.

Author(s)

Wolfgang Breymann, David Luethi

References

Alexander J. McNeil, Ruediger Frey, Paul Embrechts (2005) *Quantitative Risk Management, Concepts, Techniques and Tools*

ghyp-package vignette in the doc folder or on https://cran.r-project.org/package=ghyp.

S-Plus and R library *QRMlib*)

See Also

`fit.ghypuv`, `fit.hypuv`, `fit.NIGuv`, `fit.VGuv`, `fit.tuv` for univariate fitting routines. `ghyp.fit.info` for information regarding the fitting procedure.

Examples

```
data(smi.stocks)

fit.ghypmv(data = smi.stocks, opt.pars = c(lambda = FALSE), lambda = 2,
           control = list(rel.tol = 1e-5, abs.tol = 1e-5), reltol = 0.01)
```

`fit.ghypuv` *Fitting generalized hyperbolic distributions to univariate data*

Description

This function performs a maximum likelihood parameter estimation for univariate generalized hyperbolic distributions.

Usage

```
fit.ghypuv(data, lambda = 1, alpha.bar = 0.5, mu = median(data),
           sigma = mad(data), gamma = 0,
           opt.pars = c(lambda = TRUE, alpha.bar = TRUE, mu = TRUE,
                        sigma = TRUE, gamma = !symmetric),
           symmetric = FALSE, standardize = FALSE, save.data = TRUE,
           na.rm = TRUE, silent = FALSE, ...)

fit.hypuv(data,
       opt.pars = c(alpha.bar = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
          symmetric = FALSE, ...)

fit.NIGuv(data,
       opt.pars = c(alpha.bar = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
          symmetric = FALSE, ...)

fit.VGuv(data, lambda = 1,
        opt.pars = c(lambda = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
         symmetric = FALSE, ...)

fit.tuv(data, nu = 3.5,
        opt.pars = c(nu = TRUE, mu = TRUE, sigma = TRUE, gamma = !symmetric),
        symmetric = FALSE, ...)

fit.gaussuv(data, na.rm = TRUE, save.data = TRUE)
```

Arguments

data	An object coercible to a vector.
lambda	Starting value for the shape parameter lambda.
alpha.bar	Starting value for the shape parameter alpha.bar.
nu	Starting value for the shape parameter nu (only used in case of a student-t distribution. It determines the degree of freedom and is defined as -2*lambda.)
mu	Starting value for the location parameter mu.
sigma	Starting value for the dispersion parameter sigma.
gamma	Starting value for the skewness parameter gamma.
opt.pars	A named logical vector which states which parameters should be fitted.
symmetric	If TRUE the skewness parameter gamma keeps zero.
standardize	If TRUE the sample will be standardized before fitting. Afterwards, the parameters and log-likelihood et cetera will be back-transformed.
save.data	If TRUE data will be stored within the mle.ghyp object.
na.rm	If TRUE missing values will be removed from data.
silent	If TRUE no prompts will appear in the console.
...	Arguments passed to optim and to fit.ghypuv when fitting special cases of the generalized hyperbolic distribution.

Details

The general-purpose optimization routine optim is used to maximize the loglikelihood function. The default method is that of Nelder and Mead which uses only function values. Parameters of optim can be passed via the ... argument of the fitting routines.

Value

An object of class mle.ghyp.

Note

The variance gamma distribution becomes singular when $x - \mu = 0$. This singularity is catched and the reduced density function is computed. Because the transition is not smooth in the numerical implementation this can rarely result in nonsensical fits.

Providing both arguments, opt.pars and symmetric respectively, can result in a conflict when opt.pars['gamma'] and symmetric are TRUE. In this case symmetric will dominate and opt.pars['gamma'] is set to FALSE.

Author(s)

Wolfgang Breymann, David Luethi

References

ghyp-package vignette in the doc folder or on https://cran.r-project.org/package=ghyp.

See Also

fit.ghypmv, fit.hypmv, fit.NIGmv, fit.VGmv, fit.tmv for multivariate fitting routines. ghyp.fit.info for information regarding the fitting procedure.

Examples

```
data(smi.stocks)

nig.fit <- fit.NIGuv(smi.stocks[,"SMI"], opt.pars = c(alpha.bar = FALSE),
                     alpha.bar = 1, control = list(abstol = 1e-8))
nig.fit

summary(nig.fit)

hist(nig.fit)
```

ghyp-constructors *Create generalized hyperbolic distribution objects*

Description

Constructor functions for univariate and multivariate generalized hyperbolic distribution objects and their special cases in one of the parametrizations "chi/psi", "alpha.bar" and "alpha/delta".

Usage

```
ghyp(lambda = 0.5, chi = 0.5, psi = 2, mu = 0, sigma = diag(rep(1, length(mu))),
     gamma = rep(0, length(mu)), alpha.bar = NULL, data = NULL)

ghyp.ad(lambda = 0.5, alpha = 1.5, delta = 1, beta = rep(0, length(mu)),
        mu = 0, Delta = diag(rep(1, length(mu))), data = NULL)


hyp(chi = 0.5, psi = 2, mu = 0, sigma = diag(rep(1, length(mu))),
    gamma = rep(0, length(mu)), alpha.bar = NULL, data = NULL)

hyp.ad(alpha = 1.5, delta = 1, beta = rep(0, length(mu)), mu = 0,
       Delta = diag(rep(1, length(mu))), data = NULL)


NIG(chi = 2, psi = 2, mu = 0, sigma = diag(rep(1, length(mu))),
    gamma = rep(0, length(mu)), alpha.bar = NULL, data = NULL)

NIG.ad(alpha = 1.5, delta = 1, beta = rep(0, length(mu)), mu = 0,
       Delta = diag(rep(1, length(mu))), data = NULL)


student.t(nu = 3.5, chi = nu - 2, mu = 0, sigma = diag(rep(1, length(mu))),
          gamma = rep(0, length(mu)), data = NULL)

student.t.ad(lambda = -2, delta = 1, beta = rep(0, length(mu)), mu = 0,
             Delta = diag(rep(1, length(mu))), data = NULL)


VG(lambda = 1, psi = 2*lambda, mu = 0, sigma = diag(rep(1, length(mu))),
   gamma = rep(0, length(mu)), data = NULL)

VG.ad(lambda = 2, alpha = 1.5, beta = rep(0, length(mu)), mu = 0,
      Delta = diag(rep(1, length(mu))), data = NULL)

gauss(mu = 0, sigma = diag(rep(1, length(mu))), data = NULL)
```

Arguments

lambda	Shape parameter. Common for all parametrizations.
nu	Shape parameter only used in case of a Student-t distribution in the "chi/psi" and "alpha.bar" parametrization . It determines the degree of freedom.
chi	Shape parameter of the "chi/psi" parametrization.
psi	Shape parameter of the "chi/psi" parametrization.
alpha	Shape parameter of the "alpha/delta" parametrization.
delta	Shape parameter of the "alpha/delta" parametrization.
alpha.bar	Shape parameter of the "alpha.bar" parametrization. Supplying "alpha.bar" makes the parameters "chi" and "psi" redundant.
mu	Location parameter. Either a scalar or a vector. Common for all parametrizations.
sigma	Dispersion parameter of the "chi/psi" parametrization. Either a scalar or a matrix.
Delta	Dispersion parameter. Must be a matrix with a determinant of 1. This parameter is only used in the multivariate case of the "alpha.beta" parametrization.
gamma	Skewness parameter of the "chi/psi" parametrization. Either a scalar or a vector.
beta	Skewness parameter of the "alpha/delta" parametrization. Either a scalar or a vector.
data	An object coercible to a vector (univariate case) or matrix (multivariate case).

Details

These functions serve as constructors for univariate and multivariate objects.

ghyp, hyp and NIG are constructor functions for both the "chi/psi" and the "alpha.bar" parametrization. Whenever alpha.bar is not NULL it is assumed that the "alpha.bar" parametrization is used and the parameters "chi" and "psi" become redundant.

Similarly, the variance gamma (VG) and the Student-t distribution share the same constructor function for both the chi/psi and alpha.bar parametrization. To initialize them in the alpha.bar parametrization simply omit the argument psi and chi, respectively. If psi or chi are submitted, the "chi/psi" parametrization will be used.

ghyp.ad, hyp.ad, NIG.ad, student.t.ad and VG.ad use the "alpha/delta" parametrization.

The following table gives the constructors for each combination of distribution and parametrization.

	Parametrization		
Distribution	"chi/psi"	"alpha.bar"	"alpha/delta"
GH	ghyp(...)	ghyp(..., alpha.bar=x)	ghyp.ad(...)
hyp	hyp(...)	hyp(..., alpha.bar=x)	hyp.ad(...)
NIG	NIG(...)	NIG(..., alpha.bar=x)	NIG.ad(...)
Student-t	student.t(..., chi=x)	student.t(...)	student.t.ad(...)
VG	VG(..., psi=x)	VG(...)	VG.ad(...)

Have a look on the vignette of this package in the doc folder for further information regarding the parametrization and for the domains of variation of the parameters.

Value

An object of class ghyp.

Note

The Student-t parametrization obtained via the "alpha.bar" parametrization slightly differs from the common Student-t parametrization: The parameter sigma denotes the standard deviation in the univariate case and the variance in the multivariate case. Thus, set $\sigma = \sqrt{\nu/(\nu-2)}$ in the univariate case to get the same results as with the standard R implementation of the Student-t distribution.

In case of non-finite variance, the "alpha.bar" parametrization does not work because sigma is defined to be the standard deviation. In this case the "chi/psi" parametrization can be used by submitting the parameter chi. To obtain equal results as the standard R implmentation use student.t(nu = nu, chi = nu) (see **Examples**).

Have a look on the vignette of this package in the doc folder for further information.

Once an object of class ghyp is created the methods Xghyp have to be used even when the distribution is a special case of the GH distribution. E.g. do not use dVG. Use dghyp and submit a variance gamma distribution created with VG().

Author(s)

David Luethi

References

ghyp-package vignette in the doc folder or on https://cran.r-project.org/package=ghyp

See Also

ghyp-class for a summary of generic methods assigned to ghyp objects, coef for switching between different parametrizations, d/p/q/r/ES/gyhp for density, distribution function et cetera, fit.ghypuv and fit.ghypmv for fitting routines.

Examples

```
## alpha.bar parametrization of a univariate GH distribution
ghyp(lambda=2, alpha.bar=0.1, mu=0, sigma=1, gamma=0)
## lambda/chi parametrization of a univariate GH distribution
ghyp(lambda=2, chi=1, psi=0.5, mu=0, sigma=1, gamma=0)
## alpha/delta parametrization of a univariate GH distribution
ghyp.ad(lambda=2, alpha=0.5, delta=1, mu=0, beta=0)

## alpha.bar parametrization of a multivariate GH distribution
ghyp(lambda=1, alpha.bar=0.1, mu=2:3, sigma=diag(1:2), gamma=0:1)
```

```
## lambda/chi parametrization of a multivariate GH distribution
ghyp(lambda=1, chi=1, psi=0.5, mu=2:3, sigma=diag(1:2), gamma=0:1)
## alpha/delta parametrization of a multivariate GH distribution
ghyp.ad(lambda=1, alpha=2.5, delta=1, mu=2:3, Delta=diag(c(1,1)), beta=0:1)

## alpha.bar parametrization of a univariate hyperbolic distribution
hyp(alpha.bar=0.3, mu=1, sigma=0.1, gamma=0)
## lambda/chi parametrization of a univariate hyperbolic distribution
hyp(chi=1, psi=2, mu=1, sigma=0.1, gamma=0)
## alpha/delta parametrization of a univariate hyperbolic distribution
hyp.ad(alpha=0.5, delta=1, mu=0, beta=0)

## alpha.bar parametrization of a univariate NIG distribution
NIG(alpha.bar=0.3, mu=1, sigma=0.1, gamma=0)
## lambda/chi parametrization of a univariate NIG distribution
NIG(chi=1, psi=2, mu=1, sigma=0.1, gamma=0)
## alpha/delta parametrization of a univariate NIG distribution
NIG.ad(alpha=0.5, delta=1, mu=0, beta=0)

## alpha.bar parametrization of a univariate VG distribution
VG(lambda=2, mu=1, sigma=0.1, gamma=0)
## alpha/delta parametrization of a univariate VG distribution
VG.ad(lambda=2, alpha=0.5, mu=0, beta=0)

## alpha.bar parametrization of a univariate t distribution
student.t(nu = 3, mu=1, sigma=0.1, gamma=0)
## alpha/delta parametrization of a univariate t distribution
student.t.ad(lambda=-2, delta=1, mu=0, beta=1)

## Obtain equal results as with the R-core parametrization
## of the t distribution:
nu <- 4
standard.R.chi.psi <- student.t(nu = nu, chi = nu)
standard.R.alpha.bar <- student.t(nu = nu, sigma = sqrt(nu  /(nu - 2)))

random.sample <- rnorm(3)
dt(random.sample, nu)
dghyp(random.sample, standard.R.chi.psi)   # all implementations yield...
dghyp(random.sample, standard.R.alpha.bar) # ...the same values

random.quantiles <- runif(4)
qt(random.quantiles, nu)
qghyp(random.quantiles, standard.R.chi.psi)   # all implementations yield...
qghyp(random.quantiles, standard.R.alpha.bar) # ...the same values

## If nu <= 2 the "alpha.bar" parametrization does not exist, but the
## "chi/psi" parametrization. The case of a Cauchy distribution:
nu <- 1
standard.R.chi.psi <- student.t(nu = nu, chi = nu)

dt(random.sample, nu)
dghyp(random.sample, standard.R.chi.psi)   # both give the same result
```

```
pt(random.sample, nu)
pghyp(random.sample, standard.R.chi.psi) # both give the same result
```

---

ghyp-distribution *The Generalized Hyperbolic Distribution*

Description

Density, distribution function, quantile function, expected-shortfall and random generation for the univariate and multivariate generalized hyperbolic distribution and its special cases.

Usage

```
dghyp(x, object = ghyp(), logvalue = FALSE)

pghyp(q, object = ghyp(), n.sim = 10000, subdivisions = 200,
      rel.tol = .Machine$double.eps^0.5, abs.tol = rel.tol,
      lower.tail = TRUE)

qghyp(p, object = ghyp(), method = c("integration", "splines"),
      spline.points = 200, subdivisions = 200,
      root.tol = .Machine$double.eps^0.5,
      rel.tol = root.tol^1.5, abs.tol = rel.tol)

rghyp(n, object = ghyp())
```

Arguments

p	A vector of probabilities.
x	A vector, matrix or data.frame of quantiles.
q	A vector, matrix or data.frame of quantiles.
n	Number of observations.
object	An object inheriting from class ghyp.
logvalue	If TRUE the logarithm of the density will be returned.
n.sim	The number of simulations when computing pghyp of a multivariate generalized hyperbolic distribution.
subdivisions	The number of subdivisions passed to integrate when computing the distribution function pghyp of a univariate generalized hyperbolic distribution.
rel.tol	The relative accuracy requested from integrate.
abs.tol	The absolute accuracy requested from integrate.
lower.tail	If TRUE (default), probabilities are $P[X \leq x]$, otherwise, $P[X > x]$.
method	The method how quantiles are computed (see **Details**).
spline.points	The number of support points when computing the quantiles with the method "splines" instead of "integration".
root.tol	The tolerance of uniroot.

Details

qghyp only works for univariate generalized hyperbolic distributions.

pghyp performs a numeric integration of the density in the univariate case. The multivariate cumulative distribution is computed by means of monte carlo simulation.

qghyp computes the quantiles either by using the "integration" method where the root of the distribution function is solved or via "splines" which interpolates the distribution function and solves it with `uniroot` afterwards. The "integration" method is recommended when only few quantiles are required. If more than approximately 20 quantiles are needed to be calculated the "splines" method becomes faster. The accuracy can be controlled with an adequate setting of the parameters `rel.tol`, `abs.tol`, `root.tol` and `spline.points`.

rghyp uses the random generator for generalized inverse Gaussian distributed random variates from the Rmetrics package *fBasics* (cf. `rgig`).

Value

dghyp gives the density,
pghyp gives the distribution function,
qghyp gives the quantile function,
rghyp generates random deviates.

Note

Objects generated with `hyp`, `NIG`, `VG` and `student.t` have to use `Xghyp` as well. E.g. `dNIG(0, NIG())` does not work but `dghyp(0, NIG())`.

When the skewness becomes very large the functions using qghyp may fail. The functions `qqghyp`, `pairs` and `portfolio.optimize` are based on qghyp.

Author(s)

David Luethi

References

ghyp-package vignette in the doc folder or on `https://cran.r-project.org/package=ghyp` and references therein.

See Also

`ghyp-class` definition, `ghyp` constructors, fitting routines `fit.ghypuv` and `fit.ghypmv`, risk and performance measurement `ESghyp` and `ghyp.omega`, `transformation` and `subsettting` of ghyp objects, `integrate`, `spline`.

Examples

```
## Univariate generalized hyperbolic distribution
univariate.ghyp <- ghyp()

par(mfrow=c(5, 1))

quantiles <- seq(-4, 4, length = 500)
plot(quantiles, dghyp(quantiles, univariate.ghyp))
plot(quantiles, pghyp(quantiles, univariate.ghyp))

probabilities <- seq(1e-4, 1-1e-4, length = 500)
plot(probabilities, qghyp(probabilities, univariate.ghyp, method = "splines"))

hist(rghyp(n=10000,univariate.ghyp),nclass=100)

## Mutivariate generalized hyperbolic distribution
multivariate.ghyp <- ghyp(sigma=var(matrix(rnorm(10),ncol=2)),mu=1:2,gamma=-(2:1))

par(mfrow=c(2, 1))

quantiles <- outer(seq(-4, 4, length = 50), c(1, 1))
plot(quantiles[, 1], dghyp(quantiles, multivariate.ghyp))
plot(quantiles[, 1], pghyp(quantiles, multivariate.ghyp, n.sim = 1000))

rghyp(n = 10, multivariate.ghyp)
```

---

ghyp-get *Get methods for objects inheriting from class ghyp*

Description

These functions simply return data stored within generalized hyperbolic distribution objects, i.e. slots of the classes ghyp and `mle.ghyp`. `ghyp.fit.info` extracts information about the fitting procedure from objects of class `mle.ghyp`. `ghyp.data` returns the data slot of a gyhp object. `ghyp.dim` returns the dimension of a gyhp object. `ghyp.name` returns the name of the distribution of a gyhp object.

Usage

```
ghyp.fit.info(object)

ghyp.data(object)

ghyp.name(object, abbr = FALSE, skew.attr = TRUE)

ghyp.dim(object)
```

Arguments

object	An object inheriting from class ghyp.
abbr	If TRUE the abbreviation of the ghyp distribution will be returned.
skew.attr	If TRUE an attribute will be added to the name of the ghyp distribution stating whether the distribution is symmetric or not.

Value

ghyp.fit.info returns list with components:

logLikelihood	The maximized log-likelihood value.
aic	The Akaike information criterion.
fitted.params	A boolean vector stating which parameters were fitted.
converged	A boolean whether optim converged or not.
n.iter	The number of iterations.
error.code	Error code from optim.
error.message	Error message from optim.
parameter.variance	Parameter variance (only for univariate fits).
trace.pars	Trace values of the parameters during the fitting procedure.

ghyp.data returns NULL if no data is stored within the object, a vector if it is an univariate generalized hyperbolic distribution and matrix if it is an multivariate generalized hyperbolic distribution.

ghyp.name returns the name of the ghyp distribution which can be the name of a special case. Depending on the arguments abbr and skew.attr one of the following is returned.

abbr == FALSE & skew.attr == TRUE	abbr == TRUE & skew.attr == TRUE
(A)symmetric Generalized Hyperbolic	(A)symm ghyp
(A)symmetric Hyperbolic	(A)symm hyp
(A)symmetric Normal Inverse Gaussian	(A)symm NIG
(A)symmetric Variance Gamma	(A)symm VG
(A)symmetric Student-t	(A)symm t
Gaussian	Gauss
abbr == FALSE & skew.attr == FALSE	abbr == TRUE & skew.attr == FALSE
Generalized Hyperbolic	ghyp
Hyperbolic	hyp
Normal Inverse Gaussian	NIG
Variance Gamma	VG
Student-t	t
Gaussian	Gauss

ghyp.dim returns the dimension of a ghyp object.

Note

ghyp.fit.info requires an object of class mle.ghyp. In the univariate case the parameter variance is returned as well. The parameter variance is defined as the inverse of the negative hesse-matrix computed by optim. Note that this makes sense only in the case that the estimates are asymptotically normal distributed.

The class ghyp contains a data slot. Data can be stored either when an object is initialized or via the fitting routines and the argument save.data.

Author(s)

David Luethi

See Also

coef, mean, vcov, logLik, AIC for other accessor functions, fit.ghypmv, fit.ghypuv, ghyp for constructor functions, optim for possible error messages.

Examples

```
## multivariate generalized hyperbolic distribution
ghyp.mv <- ghyp(lambda = 1, alpha.bar = 0.1, mu = rep(0, 2), sigma = diag(rep(1, 2)),
                gamma = rep(0, 2), data = matrix(rt(1000, df = 4), ncol = 2))

## Get data
ghyp.data(ghyp.mv)

## Get the dimension
ghyp.dim(ghyp.mv)

## Get the name of the ghyp object
ghyp.name(ghyp(alpha.bar = 0))
ghyp.name(ghyp(alpha.bar = 0, lambda = -4), abbr = TRUE)

## 'ghyp.fit.info' does only work when the object is of class 'mle.ghyp',
## i.e. is created by 'fit.ghypuv' etc.
mv.fit <- fit.tmv(data = ghyp.data(ghyp.mv), control = list(abs.tol = 1e-3))
ghyp.fit.info(mv.fit)
```

---

ghyp-mle.ghyp-classes *Classes ghyp and mle.ghyp*

Description

The class "ghyp" basically contains the parameters of a generalized hyperbolic distribution. The class "mle.ghyp" inherits from the class "ghyp". The class "mle.ghyp" adds some additional slots which contain information about the fitting procedure. Namely, these are the number of iterations (n.iter), the log likelihood value (llh), the Akaike Information Criterion (aic), a boolean

vector (fitted.params) stating which parameters were fitted, a boolean converged whether the fitting procedure converged or not, an error.code which stores the status of a possible error and the corresponding error.message. In the univariate case the parameter variance is also stored in parameter.variance.

Objects from the Class

Objects should only be created by calls to the constructors ghyp, hyp, NIG, VG, student.t and gauss or by calls to the fitting routines like fit.ghypuv, fit.ghypmv, fit.hypuv, fit.hypmv et cetera.

Slots

Slots of class ghyp:

call: The function-call of class call.

lambda: Shape parameter of class numeric.

alpha.bar: Shape parameter of class numeric.

chi: Shape parameter of an alternative parametrization. Object of class numeric.

psi: Shape parameter of an alternative parametrization. Object of class numeric.

mu: Location parameter of lass numeric.

sigma: Dispersion parameter of class matrix.

gamma: Skewness parameter of class numeric.

model: Model, i.e., (a)symmetric generalized hyperbolic distribution or (a)symmetric special case. Object of class character.

dimension: Dimension of the generalized hyperbolic distribution. Object of class numeric.

expected.value: The expected value of a generalized hyperbolic distribution. Object of class numeric.

variance: The variance of a generalized hyperbolic distribution of class matrix.

data: The data-slot is of class matrix. When an object of class ghypmv is instantiated the user can decide whether data should be stored within the object or not. This is the default and may be useful when fitting eneralized hyperbolic distributions to data and perform further analysis afterwards.

parametrization: Parametrization of the generalized hyperbolic distribution of class character. These are currently either "chi.psi", "alpha.bar" or "alpha.delta".

Slots added by class mle.ghyp:

n.iter: The number of iterations of class numeric.

llh: The log likelihood value of class numeric.

converged: A boolean whether converged or not. Object of class logical.

error.code: An error code of class numeric.

error.message: An error message of class character.

fitted.params: A boolean vector stating which parameters were fitted of class logical.

`aic`: The value of the Akaike Information Criterion of class `numeric`.

`parameter.variance`: The parameter variance is the inverse of the fisher information matrix. This slot is filled only in the case of an univariate fit. This slot is of class `matrix`.

`trace.pars`: Contains the parameter value evolution during the fitting procedure. `trace.pars` of class `list`.

Extends

Class "mle.ghyp" extends class "ghyp", directly.

Methods

A "pairs" method (see `pairs`).
A "hist" method (see `hist`).
A "plot" method (see `plot`).
A "lines" method (see `lines`).
A "coef" method (see `coef`).
A "mean" method (see `mean`).
A "vcov" method (see `vcov`).
A "scale" method (see `scale`).
A "transform" method (see `transform`).
A "[.ghyp" method (see `[`).
A "logLik" method for objects of class "mle.ghyp" (see `logLik`).
An "AIC" method for objects of class "mle.ghyp" (see `AIC`).
A "summary" method for objects of class "mle.ghyp" (see `summary`).

Note

When showing special cases of the generalized hyperbolic distribution the corresponding fixed parameters are not printed.

Author(s)

David Luethi

See Also

`optim` for an interpretation of `error.code`, `error.message` and `parameter.variance`.
`ghyp`, `hyp`, `NIG`, `VG`, `student.t` and `gauss` for constructors of the class ghyp in the "alpha.bar" and "chi/psi" parametrization. `xxx.ad` for all the constructors in the "alpha/delta" parametrization. `fit.ghypuv`, `fit.ghypmv` et cetera for the fitting routies and constructors of the class `mle.ghyp`.

Examples

```
data(smi.stocks)
multivariate.fit <- fit.ghypmv(data = smi.stocks,
                               opt.pars = c(lambda = FALSE, alpha.bar = FALSE),
                               lambda = 2)
summary(multivariate.fit)
```

```
vcov(multivariate.fit)
mean(multivariate.fit)
logLik(multivariate.fit)
AIC(multivariate.fit)
coef(multivariate.fit)

univariate.fit <- multivariate.fit[1]
hist(univariate.fit)

plot(univariate.fit)
lines(multivariate.fit[2])
```

`ghyp-risk-performance` *Risk and Performance Measures*

Description

Functions to compute the risk measure *Expected Shortfall* and the performance measure *Omega* based on univariate generalized hyperbolic distributions.

Usage

```
ESghyp(alpha, object = ghyp(), distr = c("return", "loss"), ...)

ghyp.omega(L, object = ghyp(), ...)
```

Arguments

`alpha`	A vector of confidence levels.
`L`	A vector of threshold levels.
`object`	A univarite generalized hyperbolic distribution object inheriting from class `ghyp`.
`distr`	Whether the ghyp-object specifies a return or a loss-distribution (see **Details**).
`...`	Arguments passed from `ESghyp` to `qghyp` and from `ghyp.omega` `integrate`.

Details

The parameter `distr` specifies whether the ghyp-object describes a return or a loss-distribution. In case of a return distribution the expected-shortfall on a confidence level α is defined as $\text{ES}_\alpha := \text{E}(X|X \leq F_X^{-1}(\alpha))$ while in case of a loss distribution it is defined on a confidence level α as $\text{ES}_\alpha := \text{E}(X|X > F_X^{-1}(\alpha))$.

Omega is defined as the ratio of a European call-option price divided by a put-option price with strike price L (see **References**): $\Omega(L) := \frac{C(L)}{P(L)}$.

Value

`ESghyp` gives the expected shortfall and
`ghyp.omega` gives the performance measure Omega.

Author(s)

David Luethi

References

Omega as a Performance Measure by Hossein Kazemi, Thomas Schneeweis and Raj Gupta
University of Massachusetts, 2003

See Also

ghyp-class definition, ghyp constructors, univariate fitting routines, fit.ghypuv, portfolio.optimize for portfolio optimization with respect to alternative risk measures, integrate.

Examples

```
data(smi.stocks)

## Fit a NIG model to Credit Suisse and Swiss Re log-returns
cs.fit <- fit.NIGuv(smi.stocks[, "CS"], silent = TRUE)
swiss.re.fit <- fit.NIGuv(smi.stocks[, "Swiss.Re"], silent = TRUE)

## Confidence levels for expected shortfalls
es.levels <- c(0.001, 0.01, 0.05, 0.1)

cs.es <- ESghyp(es.levels, cs.fit)
swiss.re.es <- ESghyp(es.levels, swiss.re.fit)

## Threshold levels for Omega
threshold.levels <- c(0, 0.01, 0.02, 0.05)

cs.omega <- ghyp.omega(threshold.levels, cs.fit)
swiss.re.omega <- ghyp.omega(threshold.levels, swiss.re.fit)

par(mfrow = c(2, 1))

barplot(rbind(CS = cs.es, Swiss.Re = swiss.re.es), beside = TRUE,
        names.arg = paste(100 * es.levels, "percent"), col = c("gray40", "gray80"),
        ylab = "Expected Shortfalls (return distribution)", xlab = "Level")

legend("bottomright", legend = c("CS", "Swiss.Re"), fill = c("gray40", "gray80"))

barplot(rbind(CS = cs.omega, Swiss.Re = swiss.re.omega), beside = TRUE,
        names.arg = threshold.levels, col = c("gray40", "gray80"),
        ylab = "Omega", xlab = "Threshold level")
legend("topright", legend = c("CS", "Swiss.Re"), fill = c("gray40", "gray80"))

## => the higher the performance, the higher the risk (as it should be)
```

ghyp.attribution-class
Class ghyp.attribution

Description

The class "ghyp.attribution" contains the Expected Shortfall of the portfolio as well as the contribution of each asset to the total risk and the sensitivity of each Asset. The sensitivity gives an information about the overall risk modification of the portfolio if the weight in a given asset is marginally increased or decreased (1 percent).

The function `contribution` returns the contribution of the assets to the portfolio expected shortfall.

Usage

```
contribution(object, ...)

## S4 method for signature 'ghyp.attribution'
contribution(object, percentage = FALSE)

sensitivity(object)

## S4 method for signature 'ghyp.attribution'
sensitivity(object)

## S4 method for signature 'ghyp.attribution'
weights(object)
```

Arguments

`object`	an object inheriting from class `ghyp.attribution`.
`...`	additional parameters.
`percentage`	boolean. Display figures in percent. (Default=FALSE).

Details

Expected shortfall enjoys homogeneity, sub-additivity, and co-monotonic additivity. Its associated function is continuously differentiable under moderate assumptions on the joint distribution of the assets.

Value

contribution of each asset to portfolio's overall expected shortfall.

sensitivity of each asset to portfolio's overall expected shortfall.

weights of each asset within portfolio.

Slots

`ES` Portfolio's expected shortfall (ES) for a given confidence level. Class `matrix`.

`contribution` Contribution of each asset to the overall ES. Class `matrix`.

`sensitivity` Sensitivity of each asset. Class `matrix`.

`weights` Weight of each asset.

Objects from the Class

Objects should only be created by calls to the constructors `ESghyp.attribution`.

Note

When showing special cases of the generalized hyperbolic distribution the corresponding fixed parameters are not printed.

Author(s)

Marc Weibel

Marc Weibel

See Also

`ESghyp.attribution`, `ghyp.attribution-class` to compute the expected shortfall attribution.

Examples

```
## Not run:
data(smi.stocks)
multivariate.fit <- fit.ghypmv(data = smi.stocks,
opt.pars = c(lambda = FALSE, alpha.bar = FALSE),
lambda = 2)

portfolio <- ESghyp.attribution(0.01, multivariate.fit)
summary(portfolio)

## End(Not run)
```

---

ghyp.moment *Compute moments of generalized hyperbolic distributions*

Description

This function computes moments of arbitrary orders of the univariate generalized hyperbolic distribution. The expectation of $f(X-c)^k$ is calculated. f can be either the absolute value or the identity. c can be either zero or $E(X)$.

Usage

```
ghyp.moment(object, order = 3:4, absolute = FALSE, central = TRUE, ...)
```

Arguments

object	A univarite generalized hyperbolic object inheriting from class ghyp.
order	A vector containing the order of the moments.
absolute	Indicate whether the absolute value is taken or not. If absolute = TRUE then $E(\|X - c\|^k)$ is computed. Otherwise $E((X - c)^k)$. c depends on the argument central. absolute must be TRUE if order is not integer.
central	If TRUE the moment around the expected value $E((X - E(X))^k)$ is computed. Otherwise $E(X^k)$.
...	Arguments passed to integrate.

Details

In general ghyp.moment is based on numerical integration. For the special cases of either a "ghyp", "hyp" or "NIG" distribution analytic expressions (see **References**) will be taken if non-absolute and non-centered moments of integer order are requested.

Value

A vector containing the moments.

Author(s)

David Luethi

References

Moments of the Generalized Hyperbolic Distribution by David J. Scott, Diethelm Wuertz and Thanh Tam Tran
Working paper, 2008

See Also

mean, vcov, Egig

Examples

```
nig.uv <- NIG(alpha.bar = 0.1, mu = 1.1, sigma = 3, gamma = -2)

# Moments of integer order
ghyp.moment(nig.uv, order = 1:6)

# Moments of fractional order
ghyp.moment(nig.uv, order = 0.2 * 1:20, absolute = TRUE)
```

gig-distribution *The Generalized Inverse Gaussian Distribution*

Description

Density, distribution function, quantile function, random generation, expected shortfall and expected value and variance for the generalized inverse gaussian distribution.

Usage

```
dgig(x, lambda = 1, chi = 1, psi = 1, logvalue = FALSE)

pgig(q, lambda = 1, chi = 1, psi = 1, ...)

qgig(p, lambda = 1, chi = 1, psi = 1, method = c("integration", "splines"),
     spline.points = 200, subdivisions = 200,
     root.tol = .Machine$double.eps^0.5,
     rel.tol = root.tol^1.5, abs.tol = rel.tol, ...)

rgig(n = 10, lambda = 1, chi = 1, psi = 1)

ESgig(alpha, lambda = 1, chi = 1, psi = 1, distr = c("return", "loss"), ...)

Egig(lambda, chi, psi, func = c("x", "logx", "1/x", "var"), check.pars = TRUE)
```

Arguments

x	A vector of quantiles.
q	A vector of quantiles.
p	A vector of probabilities.
alpha	A vector of confidence levels.
n	Number of observations.
lambda	A shape and scale and parameter.
chi, psi	Shape and scale parameters. Must be positive.
logvalue	If TRUE the logarithm of the density will be returned.
distr	Whether the ghyp-object specifies a return or a loss-distribution (see **Details**).
subdivisions	The number of subdivisions passed to integrate when computing the the distribution function pgig.
rel.tol	The relative accuracy requested from integrate.
abs.tol	The absolute accuracy requested from integrate.
method	Determines which method is used when calculating quantiles.

spline.points	The number of support points when computing the quantiles with the method "splines" instead of "integration".
root.tol	The tolerance of uniroot.
func	The transformation function when computing the expected value. x is the expected value (default), log x returns the expected value of the logarithm of x, 1/x returns the expected value of the inverse of x and var returns the variance.
check.pars	If TRUE the parameters are checked first.
...	Arguments passed form ESgig to qgig.

Details

qgig computes the quantiles either by using the "integration" method where the root of the distribution function is solved or via "splines" which interpolates the distribution function and solves it with uniroot afterwards. The "integration" method is recommended when few quantiles are required. If more than approximately 20 quantiles are needed to be calculated the "splines" method becomes faster. The accuracy can be controlled with an adequate setting of the parameters rel.tol, abs.tol, root.tol and spline.points.

rgig relies on the C function with the same name kindly provided by Ester Pantaleo and Robert B. Gramacy.

Egig with func = "log x" uses grad from the R package *numDeriv*. See the package vignette for details regarding the expectation of GIG random variables.

Value

dgig gives the density,
pgig gives the distribution function,
qgig gives the quantile function,
ESgig gives the expected shortfall,
rgig generates random deviates and
Egig gives the expected value of either x, 1/x, log(x) or the variance if func equals var.

Author(s)

David Luethi and Ester Pantaleo

References

Dagpunar, J.S. (1989). *An easily implemented generalised inverse Gaussian generator.* Commun. Statist. -Simula., **18**, 703–710.

Michael, J. R, Schucany, W. R, Haas, R, W. (1976). *Generating random variates using transformations with multiple roots*, The American Statistican, **30**, 88–90.

See Also

fit.ghypuv, fit.ghypmv, integrate, uniroot, spline

Examples

```
dgig(1:40, lambda = 10, chi = 1, psi = 1)
qgig(1e-5, lambda = 10, chi = 1, psi = 1)

ESgig(c(0.19,0.3), lambda = 10, chi = 1, psi = 1, distr = "loss")
ESgig(alpha=c(0.19,0.3), lambda = 10, chi = 1, psi = 1, distr = "ret")

Egig(lambda = 10, chi = 1, psi = 1, func = "x")
Egig(lambda = 10, chi = 1, psi = 1, func = "var")
Egig(lambda = 10, chi = 1, psi = 1, func = "1/x")
```

---

hist-methods *Histogram for univariate generalized hyperbolic distributions*

Description

The function `hist` computes a histogram of the given data values and the univariate generalized hyperbolic distribution.

Usage

```
## S4 method for signature 'ghyp'
hist(x, data = ghyp.data(x), gaussian = TRUE,
     log.hist = F, ylim = NULL, ghyp.col = 1, ghyp.lwd = 1,
     ghyp.lty = "solid", col = 1, nclass = 30, plot.legend = TRUE,
     location = if (log.hist) "bottom" else "topright", legend.cex = 1, ...)
```

Arguments

`x`	Usually a fitted univariate generalized hyperbolic distribution of class `mle.ghyp`. Alternatively an object of class `ghyp` and a data vector.
`data`	An object coercible to a `vector`.
`gaussian`	If `TRUE` the probability density of the normal distribution is plotted as a reference.
`log.hist`	If `TRUE` the logarithm of the histogramm is plotted.
`ylim`	The "y" limits of the plot.
`ghyp.col`	The color of the density of the generalized hyperbolic distribution.
`ghyp.lwd`	The line width of the density of the generalized hyperbolic distribution.
`ghyp.lty`	The line type of the density of the generalized hyperbolic distribution.
`col`	The color of the histogramm.
`nclass`	A single number giving the number of cells for the histogramm.
`plot.legend`	If `TRUE` a legend is drawn.
`location`	The location of the legend. See `legend` for possible values.
`legend.cex`	The character expansion of the legend.
`...`	Arguments passed to `plot` and `qqghyp`.

Value

No value is returned.

Author(s)

David Luethi

See Also

qqghyp, fit.ghypuv, hist, legend, plot, lines.

Examples

```
data(smi.stocks)
univariate.fit <- fit.ghypuv(data = smi.stocks[,"SMI"],
                             opt.pars = c(mu = FALSE, sigma = FALSE),
                             symmetric = TRUE)
hist(univariate.fit)
```

---

indices *Monthly returns of five indices*

Description

Monthly returns of indices representing five asset/investment classes *Bonds*, *Stocks*, *Commodities*, *Emerging Markets* and *High Yield Bonds*.

Usage

```
data(indices)
```

Format

`hy.bond` JPMorgan High Yield Bond A (Yahoo symbol "OHYAX").

`emerging.mkt` Morgan Stanley Emerging Markets Fund Inc. (Yahoo symbol "MSF").

`commodity` Dow Jones-AIG Commodity Index (Yahoo symbol "DJI").

`bond` Barclays Global Investors Bond Index (Yahoo symbol "WFBIX").

`stock` Vanguard Total Stock Mkt Idx (Yahoo symbol "VTSMX").

See Also

smi.stocks

Examples

```
data(indices)

pairs(indices)
```

`lik.ratio.test` *Likelihood-ratio test*

Description

This function performs a likelihood-ratio test on fitted generalized hyperbolic distribution objects of class `mle.ghyp`.

Usage

```
lik.ratio.test(x, x.subclass, conf.level = 0.95)
```

Arguments

`x`	An object of class `mle.ghyp`.
`x.subclass`	An object of class `mle.ghyp` whose parameters form a subset of those of `x`.
`conf.level`	Confidence level of the test.

Details

The likelihood-ratio test can be used to check whether a special case of the generalized hyperbolic distribution is the "true" underlying distribution.

The likelihood-ratio is defined as

$$\Lambda = \frac{sup\{L(\theta|\mathbf{X}) : \theta \in \Theta_0\}}{sup\{L(\theta|\mathbf{X}) : \theta \in \Theta\}}.$$

Where L denotes the likelihood function with respect to the parameter θ and data $\mathbf{X}$, and Θ_0 is a subset of the parameter space Θ. The null hypothesis `H0` states that $\theta \in \Theta_0$. Under the null hypothesis and under certain regularity conditions it can be shown that $-2\log(\Lambda)$ is asymtotically chi-squared distributed with ν degrees of freedom. ν is the number of free parameters specified by Θ minus the number of free parameters specified by Θ_0.

The null hypothesis is rejected if $-2\log(\Lambda)$ exceeds the `conf.level`-quantile of the chi-squared distribution with ν degrees of freedom.

Value

A list with components:

`statistic`	The value of the L-statistic.
`p.value`	The p-value for the test.
`df`	The degrees of freedom for the L-statistic.
`H0`	A boolean stating whether the null hypothesis is `TRUE` or `FALSE`.

Author(s)

David Luethi

References

Linear Statistical Inference and Its Applications by C. R. Rao
Wiley, New York, 1973

See Also

`fit.ghypuv`, `logLik`, `AIC` and `stepAIC.ghyp`.

Examples

```
data(smi.stocks)

sample <- smi.stocks[, "SMI"]

t.symmetric <- fit.tuv(sample, silent = TRUE, symmetric = TRUE)
t.asymmetric <- fit.tuv(sample, silent = TRUE)

# Test symmetric Student-t against asymmetric Student-t in case
# of SMI log-returns
lik.ratio.test(t.asymmetric, t.symmetric, conf.level = 0.95)
# -> keep the null hypothesis

set.seed(1000)
sample <- rghyp(1000, student.t(gamma = 0.1))

t.symmetric <- fit.tuv(sample, silent = TRUE, symmetric = TRUE)
t.asymmetric <- fit.tuv(sample, silent = TRUE)

# Test symmetric Student-t against asymmetric Student-t in case of
# data simulated according to a slightly skewed Student-t distribution
lik.ratio.test(t.asymmetric, t.symmetric, conf.level = 0.95)
# -> reject the null hypothesis

t.symmetric <- fit.tuv(sample, silent = TRUE, symmetric = TRUE)
ghyp.asymmetric <- fit.ghypuv(sample, silent = TRUE)

# Test symmetric Student-t against asymmetric generalized
# hyperbolic using the same data as in the example above
lik.ratio.test(ghyp.asymmetric, t.symmetric, conf.level = 0.95)
# -> keep the null hypothesis
```

---

logLik-AIC-methods *Extract Log-Likelihood and Akaike's Information Criterion*

Description

The functions `logLik` and `AIC` extract the Log-Likelihood and the Akaike's Information Criterion from fitted generalized hyperbolic distribution objects. The Akaike information criterion is calculated according to the formula $-2 \cdot \text{log-likelihood} + k \cdot n_{par}$, where n_{par} represents the number of parameters in the fitted model, and $k = 2$ for the usual AIC.

Usage

```
## S4 method for signature 'mle.ghyp'
logLik(object, ...)

## S4 method for signature 'mle.ghyp'
AIC(object, ..., k = 2)
```

Arguments

object	An object of class mle.ghyp.
k	The "penalty" per parameter to be used; the default k = 2 is the classical AIC.
...	An arbitrary number of objects of class mle.ghyp.

Value

Either the Log-Likelihood or the Akaike's Information Criterion.

Note

The Log-Likelihood as well as the Akaike's Information Criterion can be obtained from the function ghyp.fit.info. However, the benefit of logLik and AIC is that these functions allow a call with an arbitrary number of objects and are better known because they are generic.

Author(s)

David Luethi

See Also

fit.ghypuv, fit.ghypmv, lik.ratio.test, ghyp.fit.info, mle.ghyp-class

Examples

```
data(smi.stocks)

## Multivariate fit
fit.mv <- fit.hypmv(smi.stocks, nit = 10)
AIC(fit.mv)
logLik(fit.mv)

## Univariate fit
fit.uv <- fit.tuv(smi.stocks[, "CS"], control = list(maxit = 10))
AIC(fit.uv)
logLik(fit.uv)

# Both together
AIC(fit.uv, fit.mv)
logLik(fit.uv, fit.mv)
```

mean-vcov-skew-kurt-methods *Expected value, variance-covariance, skewness and kurtosis of generalized hyperbolic distributions*

Description

The function mean returns the expected value. The function vcov returns the variance in the univariate case and the variance-covariance matrix in the multivariate case. The functions ghyp.skewness and ghyp.kurtosis only work for univariate generalized hyperbolic distributions.

Usage

```
## S4 method for signature 'ghyp'
mean(x)

## S4 method for signature 'ghyp'
vcov(object)

ghyp.skewness(object)

ghyp.kurtosis(object)
```

Arguments

x, object	An object inheriting from class ghyp.

Details

The functions ghyp.skewness and ghyp.kurtosis are based on the function ghyp.moment. Numerical integration will be used in case a Student.t or variance gamma distribution is submitted.

Value

Either the expected value, variance, skewness or kurtosis.

Author(s)

David Luethi

See Also

ghyp, ghyp-class, Egig to compute the expected value and the variance of the generalized inverse gaussian mixing distribution distributed and its special cases.

Examples

```
## Univariate: Parametric
vg.dist <- VG(lambda = 1.1, mu = 10, sigma = 10, gamma = 2)
mean(vg.dist)
vcov(vg.dist)
ghyp.skewness(vg.dist)
ghyp.kurtosis(vg.dist)

## Univariate: Empirical
vg.sim <- rghyp(10000, vg.dist)
mean(vg.sim)
var(vg.sim)

## Multivariate: Parametric
vg.dist <- VG(lambda = 0.1, mu = c(55, 33), sigma = diag(c(22, 888)), gamma = 1:2)
mean(vg.dist)
vcov(vg.dist)

## Multivariate: Empirical
vg.sim <- rghyp(50000, vg.dist)
colMeans(vg.sim)
var(vg.sim)
```

`pairs-methods` *Pairs plot for multivariate generalized hyperbolic distributions*

Description

This function is intended to be used as a graphical diagnostic tool for fitted multivariate generalized hyperbolic distributions. An array of graphics is created and qq-plots are drawn into the diagonal part of the graphics array. The upper part of the graphics matrix shows scatter plots whereas the lower part shows 2-dimensional histogramms.

Usage

```
## S4 method for signature 'ghyp'
pairs(x, data = ghyp.data(x), main = "'ghyp' pairwise plot",
      nbins = 30, qq = TRUE, gaussian = TRUE,
      hist.col = c("white", topo.colors(100)),
      spline.points = 150, root.tol = .Machine$double.eps^0.5,
      rel.tol = root.tol, abs.tol = root.tol^1.5, ...)
```

Arguments

`x`	Usually a fitted multivariate generalized hyperbolic distribution of class `mle.ghyp`. Alternatively an object of class `ghyp` and a data matrix.
`data`	An object coercible to a `matrix`.
`main`	The title of the plot.

nbins	The number of bins of the 2-d histogram.
qq	If TRUE qq-plots are drawn.
gaussian	If TRUE qq-plots with the normal distribution are plotted.
hist.col	A vector of colors of the 2-d histgram.
spline.points	The number of support points when computing the quantiles used by the qq-plot. Passed to qqghyp.
root.tol	The tolerance of the quantiles. Passed to uniroot via qqghyp.
rel.tol	The tolerance of the quantiles. Passed to integrate via qqghyp.
abs.tol	The tolerance of the quantiles. Passed to integrate via qqghyp.
...	Arguments passed to plot and axis.

Author(s)

David Luethi

See Also

pairs, fit.ghypmv, qqghyp

Examples

```
data(smi.stocks)
fitted.smi.stocks <- fit.NIGmv(data = smi.stocks[1:200, ])
pairs(fitted.smi.stocks)
```

---

plot-ghyp.attribution *Plot ES contribution*

Description

These functions plot the contribution of each asset to the overall portfolio expected shortfall.

Usage

```
plot.ghyp.attrib(
  x,
  metrics = c("contribution", "sensitivity"),
  column.index = NULL,
  percentage = FALSE,
  colorset = NULL,
  horiz = FALSE,
  unstacked = TRUE,
  pie.chart = FALSE,
  sub = NULL,
  ...
)
```

Arguments

x	A ghyp.attribution object.
metrics	either the contribution or sensitivity will be plotted.
column.index	which column of the object.
percentage	plot contribution or sensitivity in percent.
colorset	vector of colors for the chart.
horiz	plot horizontally.
unstacked	unstacked plot.
pie.chart	should a pie chart be plotted.
sub	subtitle.
...	arguments passed to plot function.

Author(s)

Marc Weibel

See Also

ESghyp.attribution.

Examples

```
## Not run:
 data(smi.stocks)

 ## Fit a NIG model to Novartis, CS and Nestle log-returns
 assets.fit <- fit.NIGmv(smi.stocks[, c("Novartis", "CS", "Nestle")], silent = TRUE)

 ## Define Weights of the Portfolio
 weights <- c(0.2, 0.5, 0.3)

 ## Confidence level for Expected Shortfall
 es.levels <- c(0.01)
 portfolio.attrib <- ESghyp.attribution(alpha=es.levels, object=assets.fit, weights=weights)

 ## Plot Risk Contribution for each Asset
 plot(portfolio.attrib, metrics='contribution')

## End(Not run)
```

plot-lines-methods *Plot univariate generalized hyperbolic densities*

Description

These functions plot probability densities of generalized hyperbolic distribution objects.

Usage

```
## S4 method for signature 'ghyp,missing'
plot(x, range = qghyp(c(0.001, 0.999), x), length = 1000, ...)
## S4 method for signature 'ghyp'
lines(x, range = qghyp(c(0.001, 0.999), x), length = 1000, ...)
```

Arguments

x	An univariate ghyp object.
range	The range over which the density will be plotted. The default is the range from the 0.1 % quantile to the 99.9 % quantile. When range has a length greater than 2 it is assumed to be the vector of quantiles and the density is computed on range.
length	The desired length of the density vector.
...	Arguments passed to plot and lines respectively.

Details

When the density is very skewed, the computation of the quantile may fail. See qghyp for details.

Author(s)

David Luethi

See Also

hist, qqghyp, pairs, plot, lines.

Examples

```
data(smi.stocks)

smi.fit   <-  fit.tuv(data = smi.stocks[,"SMI"], symmetric = TRUE)
nestle.fit <- fit.tuv(data = smi.stocks[,"Nestle"], symmetric = TRUE)

## Student-t distribution
plot(smi.fit, type = "l", log = "y")
lines(nestle.fit, col = "blue")

## Empirical
```

```
lines(density(smi.stocks[,"SMI"]), lty = "dashed")
lines(density(smi.stocks[,"Nestle"]), lty = "dashed", col = "blue")
```

`portfolio.optimize` *Portfolio optimization with respect to alternative risk measures*

Description

This function performs a optimization of a portfolio with respect to one of the risk measures "sd", "value.at.risk" or "expected.shortfall". The optimization task is either to find the *global minimum risk* portfolio, the *tangency* portfolio or the *minimum risk* portfolio given a target-return.

Usage

```
portfolio.optimize(object,
                   risk.measure = c("sd", "value.at.risk", "expected.shortfall"),
                     type = c("minimum.risk", "tangency", "target.return"),
                     level = 0.95, distr = c("loss", "return"),
                     target.return = NULL, risk.free = NULL,
                     silent = FALSE, ...)
```

Arguments

`object`	A multivariate `ghyp` object representing the loss distribution. In case `object` gives the return distribution set the argument `distr` to "return".
`risk.measure`	How risk shall be measured. Must be one of "sd" (standard deviation), "value.at.risk" or "expected.shortfall".
`type`	The tpye of the optimization problem. Must be one of "minimum.risk", "tangency" or "target.return" (see **Details**).
`level`	The confidence level which shall be used if `risk.measure` is either "value.at.risk" or "expected.shortfall".
`distr`	The default distribution is "loss". If `object` gives the return distribution set `distr` to "return".
`target.return`	A numeric scalar specifying the target return if the optimization problem is of `type` "target.return".
`risk.free`	A numeric scalar giving the risk free rate in case the optimization problem is of `type` "tangency".
`silent`	If `TRUE` no prompts will appear in the console.
`...`	Arguments passed to `optim`.

Details

If type is "minimum.risk" the global minimum risk portfolio is returned.

If type is "tangency" the portfolio maximizing the slope of "(expected return - risk free rate) / risk" will be returned.

If type is "target.return" the portfolio with expected return target.return which minimizes the risk will be returned.

Note that in case of an elliptical distribution (symmetric generalized hyperbolic distributions) it does not matter which risk measure is used. That is, minimizing the standard deviation results in a portfolio which also minimizes the value-at-risk et cetera.

Value

A list with components:

portfolio.dist	An univariate generalized hyperbolic object of class ghyp which represents the distribution of the optimal portfolio.
risk.measure	The risk measure which was used.
risk	The risk.
opt.weights	The optimal weights.
converged	Convergence returned from optim.
message	A possible error message returned from optim.
n.iter	The number of iterations returned from optim.

Note

In case object denotes a non-elliptical distribution and the risk measure is either "value.at.risk" or "expected.shortfall", then the type "tangency" optimization problem is not supported.

Constraints like avoiding short-selling are not supported yet.

Author(s)

David Luethi

See Also

transform, fit.ghypmv

Examples

```
data(indices)

t.object <- fit.tmv(-indices, silent = TRUE)
gauss.object <- fit.gaussmv(-indices)

t.ptf <- portfolio.optimize(t.object,
                            risk.measure = "expected.shortfall",
                            type = "minimum.risk",
                            level = 0.99,
                            distr = "loss",
                            silent = TRUE)

gauss.ptf <- portfolio.optimize(gauss.object,
                                risk.measure = "expected.shortfall",
                                type = "minimum.risk",
                                level = 0.99,
                                distr = "loss")

par(mfrow = c(1, 3))

plot(c(t.ptf$risk, gauss.ptf$risk),
     c(-mean(t.ptf$portfolio.dist), -mean(gauss.ptf$portfolio.dist)),
     xlim = c(0, 0.035), ylim = c(0, 0.004),
     col = c("black", "red"), lwd = 4,
     xlab = "99 percent expected shortfall",
     ylab = "Expected portfolio return",
     main = "Global minimum risk portfolios")

legend("bottomleft", legend = c("Asymmetric t", "Gaussian"),
       col = c("black", "red"), lty = 1)

plot(t.ptf$portfolio.dist, type = "l",
     xlab = "log-loss ((-1) * log-return)", ylab = "Density")
lines(gauss.ptf$portfolio.dist, col = "red")

weights <- cbind(Asymmetric.t = t.ptf$opt.weights,
                 Gaussian = gauss.ptf$opt.weights)

barplot(weights, beside = TRUE, ylab = "Weights")
```

---

qq-ghyp *Quantile-Quantile Plot*

Description

This function is intended to be used as a graphical diagnostic tool for fitted univariate generalized hyperbolic distributions. Optionally a qq-plot of the normal distribution can be added.

Usage

```
qqghyp(object, data = ghyp.data(object), gaussian = TRUE, line = TRUE,
       main = "Generalized Hyperbolic Q-Q Plot",
       xlab = "Theoretical Quantiles", ylab = "Sample Quantiles",
       ghyp.pch = 1, gauss.pch = 6, ghyp.lty = "solid",
       gauss.lty = "dashed", ghyp.col = "black", gauss.col = "black",
       plot.legend = TRUE, location = "topleft", legend.cex = 0.8,
       spline.points = 150, root.tol = .Machine$double.eps^0.5,
       rel.tol = root.tol, abs.tol = root.tol^1.5, add = FALSE, ...)
```

Arguments

object	Usually a fitted univariate generalized hyperbolic distribution of class mle.ghyp. Alternatively an object of class ghyp and a data vector.
data	An object coercible to a vector.
gaussian	If TRUE a qq-plot of the normal distribution is plotted as a reference.
line	If TRUE a line is fitted and drawn.
main	An overall title for the plot.
xlab	A title for the x axis.
ylab	A title for the y axis.
ghyp.pch	A plotting character, i.e., symbol to use for quantiles of the generalized hyperbolic distribution.
gauss.pch	A plotting character, i.e., symbol to use for quantiles of the normal distribution.
ghyp.lty	The line type of the fitted line to the quantiles of the generalized hyperbolic distribution.
gauss.lty	The line type of the fitted line to the quantiles of the normal distribution.
ghyp.col	A color of the quantiles of the generalized hyperbolic distribution.
gauss.col	A color of the quantiles of the normal distribution.
plot.legend	If TRUE a legend is drawn.
location	The location of the legend. See legend for possible values.
legend.cex	The character expansion of the legend.
spline.points	The number of support points when computing the quantiles. Passed to qghyp.
root.tol	The tolerance of the quantiles. Passed to uniroot.
rel.tol	The tolerance of the quantiles. Passed to integrate.
abs.tol	The tolerance of the quantiles. Passed to integrate.
add	If TRUE the points are added to an existing plot window. The legend argument then becomes deactivated.
...	Arguments passed to plot.

Author(s)

David Luethi

See Also

hist, fit.ghypuv, qghyp, plot, lines

Examples

```
data(smi.stocks)

smi <- fit.ghypuv(data = smi.stocks[, "Swiss.Re"])

qqghyp(smi, spline.points = 100)

qqghyp(fit.tuv(smi.stocks[, "Swiss.Re"], symmetric = TRUE),
       add = TRUE, ghyp.col = "red", line = FALSE)
```

---

scale-methods *Scaling and Centering of ghyp Objects*

Description

scale centers and/or scales a generalized hyperbolic distribution to zero expectation and/or unit variance.

Usage

```
## S4 method for signature 'ghyp'
scale(x, center = TRUE, scale = TRUE)
```

Arguments

x	An object inheriting from class ghyp.
center	A logical value stating whether the object shall be centered to zero expectation.
scale	A logical value stating whether the object shall be scaled to unit variance.

Value

An object of class ghyp.

Author(s)

David Luethi

See Also

transform, mean, vcov.

Examples

```
data(indices)

t.fit <- fit.tmv(indices)
gauss.fit <- fit.gaussmv(indices)

## Compare the fitted Student-t and Gaussian density.
par(mfrow = c(1, 2))

## Once on the real scale...
plot(t.fit[1], type = "l")
lines(gauss.fit[1], col = "red")

## ...and once scaled to expectation = 0, variance = 1
plot(scale(t.fit)[1], type = "l")
lines(scale(gauss.fit)[1], col = "red")
```

---

smi.stocks *Daily returns of five swiss blue chips and the SMI*

Description

Daily returns from January 2000 to January 2007 of five swiss blue chips and the Swiss Market Index (SMI).

Usage

```
data(smi.stocks)
```

Format

`SMI` Swiss Market Index.

`Novartis` Novartis pharma.

`CS` Credit Suisse.

`Nestle` Nestle.

`Swisscom` Swiss telecom company.

`Swiss.Re` Swiss reinsurer.

See Also

indices

Examples

```
data(smi.stocks)

pairs(smi.stocks)
```

stepAIC.ghyp *Perform a model selection based on the AIC*

Description

This function performs a model selection in the scope of the generalized hyperbolic distribution class based on the Akaike information criterion. stepAIC.ghyp can be used for the univariate as well as for the multivariate case.

Usage

```
stepAIC.ghyp(data, dist = c("ghyp", "hyp", "NIG", "VG", "t", "gauss"),
             symmetric = NULL, ...)
```

Arguments

data	A vector, matrix or data.frame.
dist	A character vector of distributions from where the best fit will be identified.
symmetric	Either NULL, TRUE or FALSE. NULL means that both symmetric and asymmetric models will be fitted. For symmetric models select TRUE and for asymmetric models select FALSE.
...	Arguments passed to fit.ghypuv or fit.ghypmv.

Value

A list with components:

best.model	The model minimizing the AIC.
all.models	All fitted models.
fit.table	A data.frame with columns model, symmetric, lambda, alpha.bar, aic, llh (log-Likelihood), converged, n.iter (number of iterations) sorted according to the aic. In the univariate case three additional columns containing the parameters mu, sigma and gamma are added.

Author(s)

David Luethi

See Also

lik.ratio.test, fit.ghypuv and fit.ghypmv.

Examples

```
data(indices)

# Multivariate case:
aic.mv <- stepAIC.ghyp(indices, dist = c("ghyp", "hyp", "t", "gauss"),
                       symmetric = NULL, control = list(maxit = 500),
                       silent = TRUE, nit = 500)

summary(aic.mv$best.model)

# Univariate case:
aic.uv <- stepAIC.ghyp(indices[, "stock"], dist = c("ghyp", "NIG", "VG", "gauss"),
                       symmetric = TRUE, control = list(maxit = 500), silent = TRUE)


# Test whether the ghyp-model provides a significant improvement with
# respect to the VG-model:
lik.ratio.test(aic.uv$all.models[[1]], aic.uv$all.models[[3]])
```

---

summary-method *mle.ghyp summary*

Description

Produces a formatted output of a fitted generalized hyperbolic distribution.

Usage

```
## S4 method for signature 'mle.ghyp'
summary(object)
```

Arguments

object	An object of class mle.ghyp.

Value

Nothing is returned.

Author(s)

David Luethi

See Also

Fitting functions fit.ghypuv and fit.ghypmv, coef, mean, vcov and ghyp.fit.info for accessor functions for mle.ghyp objects.

Examples

```
data(smi.stocks)
mle.ghyp.object <- fit.NIGmv(smi.stocks[, c("Nestle", "Swiss.Re", "Novartis")])
summary(mle.ghyp.object)
```

`transform-extract-methods` *Linear transformation and extraction of generalized hyperbolic distributions*

Description

The `transform` function can be used to linearly transform generalized hyperbolic distribution objects (see **Details**). The extraction operator `[` extracts some margins of a multivariate generalized hyperbolic distribution object.

Usage

```
## S4 method for signature 'ghyp'
transform(`_data`, summand, multiplier)

## S3 method for class 'ghyp'
x[i = c(1, 2)]
```

Arguments

`_data`	An object inheriting from class `ghyp`.
`summand`	A `vector`.
`multiplier`	A `vector` or a `matrix`.
`x`	A multivariate generalized hyperbolic distribution inheriting from class `ghyp`.
`i`	Index specifying which dimensions to extract.

Details

If $X \sim GH$, `transform` gives the distribution object of "multiplier * X + summand", where X is the argument named `_data`.

If the object is of class `mle.ghyp`, iformation concerning the fitting procedure (cf. `ghyp.fit.info`) will be lost as the return value is an object of class `ghyp`.

Value

An object of class `ghyp`.

Author(s)

David Luethi

See Also

scale, ghyp, fit.ghypuv and fit.ghypmv for constructors of ghyp objects.

Examples

```
## Mutivariate generalized hyperbolic distribution
multivariate.ghyp <- ghyp(sigma=var(matrix(rnorm(9),ncol=3)), mu=1:3, gamma=-2:0)

## Dimension reduces to 2
transform(multivariate.ghyp, multiplier=matrix(1:6,nrow=2), summand=10:11)

## Dimension reduces to 1
transform(multivariate.ghyp, multiplier=1:3)

## Simple transformation
transform(multivariate.ghyp, summand=100:102)

## Extract some dimension
multivariate.ghyp[1]
multivariate.ghyp[c(1, 3)]
```

Index

∗ **attribution**
ESghyp.attribution, 8
ghyp.attribution-class, 27
plot-ghyp.attribution, 39
∗ **classes**
ghyp-mle.ghyp-classes, 22
ghyp.attribution-class, 27
∗ **datagen**
ghyp-distribution, 18
ghyp-package, 2
gig-distribution, 30
∗ **datasets**
indices, 33
smi.stocks, 47
∗ **distribution**
fit.ghypmv, 9
fit.ghypuv, 11
ghyp-constructors, 14
ghyp-distribution, 18
ghyp-package, 2
gig-distribution, 30
∗ **hplot**
ghyp-package, 2
hist-methods, 32
pairs-methods, 38
plot-lines-methods, 41
qq-ghyp, 44
∗ **iteration**
fit.ghypmv, 9
fit.ghypuv, 11
ghyp-package, 2
portfolio.optimize, 42
∗ **methods**
coef-method, 6
hist-methods, 32
logLik-AIC-methods, 35
mean-vcov-skew-kurt-methods, 37
pairs-methods, 38
plot-lines-methods, 41
scale-methods, 46
summary-method, 49
transform-extract-methods, 50
∗ **misc**
ghyp-risk-performance, 25
∗ **models**
fit.ghypmv, 9
fit.ghypuv, 11
ghyp-constructors, 14
ghyp-distribution, 18
ghyp-package, 2
qq-ghyp, 44
∗ **multivariate**
fit.ghypmv, 9
ghyp-constructors, 14
ghyp-distribution, 18
ghyp-package, 2
pairs-methods, 38
portfolio.optimize, 42
∗ **optimize**
fit.ghypmv, 9
fit.ghypuv, 11
ghyp-package, 2
portfolio.optimize, 42
∗ **package**
ghyp-package, 2
∗ **risk**
ESghyp.attribution, 8
ghyp.attribution-class, 27
∗ **utilities**
coef-method, 6
ghyp-get, 20
ghyp-risk-performance, 25
ghyp.moment, 28
lik.ratio.test, 34
logLik-AIC-methods, 35
mean-vcov-skew-kurt-methods, 37
scale-methods, 46
stepAIC.ghyp, 48

transform-extract-methods, 50
[, *4*, *24*
[,ghyp,numeric,missing,missing-method (transform-extract-methods), 50
[.ghyp, *7*
[.ghyp (transform-extract-methods), 50

AIC, *4*, *22*, *24*, *35*
AIC,mle.ghyp-method (logLik-AIC-methods), 35
AIC.mle.ghyp (logLik-AIC-methods), 35
axis, *39*

coef, *4*, *16*, *22*, *24*, *49*
coef,ghyp-method (coef-method), 6
coef-method, 6
coef.ghyp (coef-method), 6
coefficients,ghyp-method (coef-method), 6
contribution (ghyp.attribution-class), 27
contribution,ghyp.attribution-method (ghyp.attribution-class), 27

d/p/q/r/ES/gyhp, *16*
dghyp, *3*, *16*
dghyp (ghyp-distribution), 18
dgig, *4*
dgig (gig-distribution), 30

Egig, *29*, *37*
Egig (gig-distribution), 30
ESghyp, *3*, *19*
ESghyp (ghyp-risk-performance), 25
ESghyp.attribution, 8, *28*, *40*
ESgig, *4*
ESgig (gig-distribution), 30

fit.gaussmv, *3*
fit.gaussmv (fit.ghypmv), 9
fit.gaussuv, *3*
fit.gaussuv (fit.ghypuv), 11
fit.ghypmv, *3*, *7*, 9, *13*, *16*, *19*, *22–24*, *31*, *36*, *39*, *43*, *48*, *49*, *51*
fit.ghypuv, *3*, *7*, *11*, 11, *16*, *19*, *22–24*, *26*, *31*, *33*, *35*, *36*, *46*, *48*, *49*, *51*
fit.hypmv, *3*, *13*, *23*
fit.hypmv (fit.ghypmv), 9
fit.hypuv, *3*, *11*, *23*
fit.hypuv (fit.ghypuv), 11
fit.NIGmv, *3*, *13*
fit.NIGmv (fit.ghypmv), 9
fit.NIGuv, *3*, *11*
fit.NIGuv (fit.ghypuv), 11
fit.tmv, *3*, *13*
fit.tmv (fit.ghypmv), 9
fit.tuv, *3*, *11*
fit.tuv (fit.ghypuv), 11
fit.VGmv, *3*, *13*
fit.VGmv (fit.ghypmv), 9
fit.VGuv, *3*, *11*
fit.VGuv (fit.ghypuv), 11

gauss, *3*, *23*, *24*
gauss (ghyp-constructors), 14
ghyp, *3*, *6–8*, *16*, *18*, *19*, *21–26*, *29*, *32*, *37*, *38*, *41–43*, *45*, *46*, *50*, *51*
ghyp (ghyp-constructors), 14
ghyp-class (ghyp-mle.ghyp-classes), 22
ghyp-constructors, 14
ghyp-distribution, 18
ghyp-get, 20
ghyp-mle.ghyp-classes, 22
ghyp-package, 2
ghyp-risk-performance, 25
ghyp.attribution, *8*, *27*
ghyp.attribution-class, 27
ghyp.data, *4*, *10*
ghyp.data (ghyp-get), 20
ghyp.dim, *4*
ghyp.dim (ghyp-get), 20
ghyp.fit.info, *4*, *7*, *10*, *11*, *13*, *36*, *49*, *50*
ghyp.fit.info (ghyp-get), 20
ghyp.kurtosis, *4*
ghyp.kurtosis (mean-vcov-skew-kurt-methods), 37
ghyp.moment, *4*, 28, *37*
ghyp.name, *4*
ghyp.name (ghyp-get), 20
ghyp.omega, *4*, *19*
ghyp.omega (ghyp-risk-performance), 25
ghyp.skewness, *4*
ghyp.skewness (mean-vcov-skew-kurt-methods), 37
gig-distribution, 30
grad, *31*

hist, *4*, *24*, *33*, *41*, *46*
hist,ghyp-method *(*hist-methods*)*, 32
hist-methods, 32
hist.ghyp *(*hist-methods*)*, 32
hyp, *3*, *19*, *23*, *24*
hyp *(*ghyp-constructors*)*, 14

indices, 33, *47*
integrate, *8*, *18*, *19*, *25*, *26*, *29–31*, *39*, *45*

legend, *32*, *33*, *45*
lik.ratio.test, *4*, 34, *36*, *48*
lines, *4*, *24*, *33*, *41*, *46*
lines,ghyp-method *(*plot-lines-methods*)*, 41
lines-methods *(*plot-lines-methods*)*, 41
lines.ghyp *(*plot-lines-methods*)*, 41
logLik, *4*, *22*, *24*, *35*
logLik,mle.ghyp-method *(*logLik-AIC-methods*)*, 35
logLik-AIC-methods, 35
logLik.mle.ghyp *(*logLik-AIC-methods*)*, 35

mean, *4*, *22*, *24*, *29*, *46*, *49*
mean,ghyp-method *(*mean-vcov-skew-kurt-methods*)*, 37
mean-methods *(*mean-vcov-skew-kurt-methods*)*, 37
mean-vcov-skew-kurt-methods, 37
mean.ghyp *(*mean-vcov-skew-kurt-methods*)*, 37
mle.ghyp, *10*, *12*, *13*, *20*, *22*, *32*, *36*, *38*, *45*, *49*, *50*
mle.ghyp-class *(*ghyp-mle.ghyp-classes*)*, 22

NIG, *3*, *19*, *23*, *24*
NIG *(*ghyp-constructors*)*, 14

optim, *10*, *12*, *13*, *21*, *22*, *24*, *42*, *43*

pairs, *4*, *19*, *24*, *39*, *41*
pairs,ghyp-method *(*pairs-methods*)*, 38
pairs-methods, 38
pairs.ghyp *(*pairs-methods*)*, 38
pghyp, *3*
pghyp *(*ghyp-distribution*)*, 18
pgig, *4*
pgig *(*gig-distribution*)*, 30
plot, *4*, *24*, *32*, *33*, *39*, *41*, *45*, *46*
plot,ghyp,missing-method *(*plot-lines-methods*)*, 41
plot,ghyp.attribution,ANY-method *(*plot-ghyp.attribution*)*, 39
plot-ghyp.attribution, 39
plot-lines-methods, 41
plot-methods *(*plot-lines-methods*)*, 41
plot.ghyp *(*plot-lines-methods*)*, 41
plot.ghyp.attrib *(*plot-ghyp.attribution*)*, 39
portfolio.optimize, *4*, *19*, *26*, 42

qghyp, *3*, *8*, *25*, *41*, *45*, *46*
qghyp *(*ghyp-distribution*)*, 18
qgig, *4*
qgig *(*gig-distribution*)*, 30
qq-ghyp, 44
qqghyp, *4*, *19*, *32*, *33*, *39*, *41*
qqghyp *(*qq-ghyp*)*, 44

rghyp, *3*
rghyp *(*ghyp-distribution*)*, 18
rgig, *4*, *19*
rgig *(*gig-distribution*)*, 30

scale, *4*, *24*, *51*
scale,ghyp-method *(*scale-methods*)*, 46
scale-methods, 46
scale.ghyp *(*scale-methods*)*, 46
sensitivity *(*ghyp.attribution-class*)*, 27
sensitivity,ghyp.attribution-method *(*ghyp.attribution-class*)*, 27
show,ghyp-method *(*ghyp-mle.ghyp-classes*)*, 22
show,mle.ghyp-method *(*ghyp-mle.ghyp-classes*)*, 22
show.ghyp *(*ghyp-mle.ghyp-classes*)*, 22
show.mle.ghyp *(*ghyp-mle.ghyp-classes*)*, 22
smi.stocks, *33*, 47
spline, *19*, *31*
stepAIC.ghyp, *3*, *35*, 48
student.t, *3*, *19*, *23*, *24*
student.t *(*ghyp-constructors*)*, 14
subsettting, *19*
summary, *4*, *24*

summary,mle.ghyp-method
(summary-method), 49
summary-method, 49
summary-methods (summary-method), 49
summary.mle.ghyp (summary-method), 49

transform, *4*, *7*, *24*, *43*, *46*
transform,ghyp-method
(transform-extract-methods), 50
transform-extract-methods, 50
transform.ghyp
(transform-extract-methods), 50
transformation, *19*

uniroot, *18, 19*, *31*, *39*, *45*

vcov, *4*, *22*, *24*, *29*, *46*, *49*
vcov,ghyp-method
(mean-vcov-skew-kurt-methods), 37
vcov-methods
(mean-vcov-skew-kurt-methods), 37
vcov.ghyp
(mean-vcov-skew-kurt-methods), 37
VG, *3*, *19*, *23, 24*
VG (ghyp-constructors), 14

weights, *8*
weights,ghyp.attribution-method
(ghyp.attribution-class), 27

xxx.ad, *24*