Package ‘ghyp’

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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.
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ghyp-package

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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
Type: Package
Version: 1.5.6
Date: 2013-02-04
License: GPL (GNU Public Licence), Version 2 or later

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 http://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 `plotHdistributionNobjectI`. Additionally, one can take advantage of generic programming since R provides virtual classes and some forms of polymorphism.

Acknowledgement

This package has been partially developed in the framework of the COST-P10 “Physics of Risk” project. Financial support by the Swiss State Secretariat for Education and Research (SBF) is gratefully acknowledged.

Author(s)

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Maintainer: Marc Weibel <marc.weibel@zhaw.ch>

References

Princeton Press, 2005
 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

```r
## 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.
coef-method

If type is “alpha.bar” a list with components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lambda</td>
<td>Shape parameter.</td>
</tr>
<tr>
<td>alpha.bar</td>
<td>Shape parameter.</td>
</tr>
<tr>
<td>mu</td>
<td>Location parameter.</td>
</tr>
<tr>
<td>sigma</td>
<td>Dispersion parameter.</td>
</tr>
<tr>
<td>gamma</td>
<td>Skewness parameter.</td>
</tr>
</tbody>
</table>

If type is “alpha.delta” a list with components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lambda</td>
<td>Shape parameter.</td>
</tr>
<tr>
<td>alpha</td>
<td>Shape parameter.</td>
</tr>
<tr>
<td>delta</td>
<td>Shape parameter.</td>
</tr>
<tr>
<td>mu</td>
<td>Location parameter.</td>
</tr>
<tr>
<td>Delta</td>
<td>Dispersion matrix with a determinant of 1 (only returned in the multivariate case).</td>
</tr>
<tr>
<td>beta</td>
<td>Shape and skewness parameter.</td>
</tr>
</tbody>
</table>

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
coeff(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
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

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

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

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

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

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

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

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 vector gamma.
A named logical vector which states which parameters should be fitted.

If TRUE the skewness parameter gamma keeps zero.

If TRUE the sample will be standardized before fitting. Afterwards, the parameters and log-likelihood et cetera will be back-transformed.

If TRUE data will be stored within the mle.ghyp object (cf. ghyp.data).

If TRUE the evolution of the parameter values during the fitting procedure will be traced and stored (cf. ghyp.fit.info).

If TRUE missing values will be removed from data.

If TRUE no prompts will appear in the console.

Maximal number of iterations of the expectation maximization algorithm.

Relative convergence tolerance.

Absolute convergence tolerance.

Arguments passed to optim and to fit.ghypmv when fitting special cases of the generalized hyperbolic distribution.

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.

An object of class mle.ghyp.

The variance gamma distribution becomes singular when \( x - \mu = 0 \). This singularity is caught 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.

Wolfgang Breymann, David Luethi
References


ghyp-package vignette in the doc folder or on [http://cran.r-project.org/package=ghyp](http://cran.r-project.org/package=ghyp).


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

```r
data(smi.stocks)

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

**Description**

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

**Usage**

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

```r
fit.hypuv(data,
opt.pars = c(alpha.bar = T, mu = T, sigma = T, gamma = !symmetric),
symmetric = F, ...)
```

```r
fit.NIGuv(data,
opt.pars = c(alpha.bar = T, mu = T, sigma = T, gamma = !symmetric),
symmetric = F, ...)
```

```r
fit.VGuv(data, lambda = 1,
```
opt.pars = c(lambda = T, mu = T, sigma = T, gamma = !symmetric),
symmetric = F, ...)

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

fit.gaussuv(data, na.rm = T, save.data = T)

Arguments

data          An object coercible to a vector.
lambda        Starting value for the shape parameter lambda.
alp.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 log-likelihood 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.
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)

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

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.
u           Location parameter. Either a scalar or a vector. Common for all parametriza-
            tions.
sigma       Dispersion parameter of the “chi/psi” parametrization. Either a scalar or a ma-
            trix.
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 ve-
            ctor.
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.

<table>
<thead>
<tr>
<th>Parametrization</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>“chi/psi”</td>
<td>“alpha.bar”</td>
</tr>
<tr>
<td>ghyp(...)</td>
<td>ghyp(..., alpha.bar=x)</td>
</tr>
<tr>
<td>hyp(...)</td>
<td>hyp(..., alpha.bar=x)</td>
</tr>
<tr>
<td>NIG(...)</td>
<td>NIG(..., alpha.bar=x)</td>
</tr>
<tr>
<td>Student-t(...)</td>
<td>Student-t(...)</td>
</tr>
<tr>
<td>VG(...)</td>
<td>VG(...)</td>
</tr>
</tbody>
</table>

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 implementation 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 [http://cran.r-project.org/package=ghyp](http://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/ghyp` for density, distribution function et cetera, `fit.ghypuv` and `fit.ghypmv` for fitting routines.

**Examples**

```r
## 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)
```
### 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**

```r
dghyp(x, object = ghyp(), logvalue = FALSE)
pghyp(q, object = ghyp(), n.sim = 10000, subdivisions = 200,
    rel.tol = .Machine$double.eps^0.5, abs.tol = rel.tol,
    lower.tail = TRUE)
```
```r
qghyp(p, object = ghyp(), method = c("integration", "splines"),
  spline.points = 200, subdivisions = 200,
  root.tol = .Machine$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 http://cran.r-project.org/package=ghyp and references therein.

See Also

ghyp-class definition, ghyp constructors, fitting routines fit.ghypuv and fit.ghympmv, risk and performance measurement EShyp and ghyp.omega, transformation and subsetting of ghyp objects, integrate, spline.

Examples

```r
## 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)

## Multivariate 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 ghyp object. ghyp.dim returns the dimension of a ghyp object. ghyp.name returns the name of the distribution of a ghyp 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.

<table>
<thead>
<tr>
<th>abbr</th>
<th>skew.attr</th>
<th>ghyp</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALSE</td>
<td>TRUE</td>
<td>ghyp</td>
</tr>
<tr>
<td>TRUE</td>
<td>FALSE</td>
<td>ghyp</td>
</tr>
</tbody>
</table>

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**

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

**Examples**

```r
## 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))
```
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 etcetera.

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 class 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 generalized 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 univariate 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 $\alpha$ is defined as $ES_{\alpha} := E(X|X \leq F_{X}^{-1}(\alpha))$ while in case of a loss distribution it is defined on a confidence level $\alpha$ as $ES_{\alpha} := E(X|X > F_{X}^{-1}(\alpha))$.

$Omega$ 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)
**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 univariate 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, Ewig

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)
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

gig 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 \texttt{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 \texttt{rel.tol}, \texttt{abs.tol}, \texttt{root.tol} and \texttt{spline.points}.

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

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

Value

d\texttt{gig} gives the density,
p\texttt{gig} gives the distribution function,
q\texttt{gig} gives the quantile function,
E\texttt{sgig} gives the expected shortfall,
\texttt{rgig} generates random deviates and
\texttt{Egig} gives the expected value of either x, 1/x, log(x) or the variance if \texttt{func} equals \texttt{var}.

Author(s)

David Luethi and Ester Pantaleo

References


See Also

\texttt{fit.ghypuv}, \texttt{fit.ghypmv}, \texttt{integrate}, \texttt{uniroot}, \texttt{spline}

Examples

d\texttt{gig}(1:40, \texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1)
q\texttt{gig}(1e-5, \texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1)

E\texttt{sgig}(c(0.19,0.3), \texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1, \texttt{distr} = "loss")
E\texttt{sgig}(\texttt{alpha}=c(0.19,0.3), \texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1, \texttt{distr} = "re")

\texttt{Egig} (\texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1, \texttt{func} = "x")
\texttt{Egig} (\texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1, \texttt{func} = "var")
\texttt{Egig} (\texttt{lambda} = 10, \texttt{chi} = 1, \texttt{psi} = 1, \texttt{func} = "1/x")
Description

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

Usage

```r
## 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 histogram 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 histogram.
- `nclass`: A single number giving the number of cells for the histogram.
- `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)
**Description**

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

**Usage**

```r
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

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

Where $L$ denotes the likelihood function with respect to the parameter $\theta$ and data $X$, and $\Theta_0$ is a subset of the parameter space $\Theta$. The null hypothesis $H_0$ states that $\theta \in \Theta_0$. Under the null hypothesis and under certain regularity conditions it can be shown that $-2\log(\Lambda)$ is asymptotically chi-squared distributed with $\nu$ degrees of freedom. $\nu$ is the number of free parameters specified by $\Theta$ minus the number of free parameters specified by $\Theta_0$.

The null hypothesis is rejected if $-2\log(\Lambda)$ exceeds the `conf.level`-quantile of the chi-squared distribution with $\nu$ 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
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 $-2 \cdot \text{log-likelihood} + k \cdot n_{\text{par}}$, where $n_{\text{par}}$ represents the number of parameters in the fitted model, and $k = 2$ for the usual AIC.
Usage

```r
## 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

```r
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

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

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

```r
ghyp.skewness(object)
```

```r
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

```r
## 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)
```

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 histograms.

Usage

```r
## 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(40)),
     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.
plot-lines-methods

The number of bins passed to `hist2d`.

If TRUE qq-plots are drawn.

If TRUE qq-plots with the normal distribution are plotted.

A vector of colors passed to `hist2d`.

The number of support points when computing the quantiles used by the qq-plot. Passed to `qqhyp`.

The tolerance of the quantiles. Passed to `uniroot` via `qqhyp`.

The tolerance of the quantiles. Passed to `integrate` via `qqhyp`.

The tolerance of the quantiles. Passed to `integrate` via `qqhyp`.

Arguments passed to `plot` and `axis`.

Author(s)

David Luethi

See Also

`pairs, fit.ghypmv, qqhyp, hist2d`

Examples

data(smi.stocks)

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

Description

These functions plot probability densities of generalized hyperbolic distribution objects.

Usage

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

Examples

```r
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")
```
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 type 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")

---

### 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

```r
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.
scale-methods

scale(x, center = TRUE, scale = TRUE)

Usage

scale centers and/or scales a generalized hyperbolic distribution to zero expectation and/or unit variance.
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.gaussianmv(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.
summary-method

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

```r
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]])
```

Description
Produces a formatted output of a fitted generalized hyperbolic distribution.
transform-extract-methods

Usage

```r
## 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

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

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

```r
## 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.
...  Arguments passed to transform.

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, information 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

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

Examples

```r
## 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)]
```
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