

Package ‘varTestnlme’

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Type Package

Title Variance Components Testing for Linear and Nonlinear Mixed Effects Models

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URL <http://github.com/baeyc/varTestnlme/>

BugReports <http://github.com/baeyc/varTestnlme/issues>

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Description An implementation of the Likelihood ratio Test (LRT) for testing that, in a (non)linear mixed effects model, the variances of a subset of the random effects are equal to zero. There is no restriction on the subset of variances that can be tested: for example, it is possible to test that all the variances are equal to zero. Note that the implemented test is asymptotic. This package should be used on model fits from packages 'nlme', 'lmer', and 'saemix'.
Charlotte Baey, Paul-Henry Cournède and Estelle Kuhn (2019) <doi:10.1016/j.csda.2019.01.014>.

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LazyData true

Imports mvtnorm, alabama, Matrix, merDeriv, matrixcalc, anocva, corpcor, quadprog, lme4, nlme, saemix, msm, foreach, methods, doParallel, parallel

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Suggests knitr, rmarkdown, ggplot2

VignetteBuilder knitr

NeedsCompilation no

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approxWeights	<i>Monte Carlo approximation of chi-bar-square weights</i>
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Description

Approximation of the chi-bar-square weights via Monte Carlo approximation.

Usage

```
approxWeights(x, df, q)
```

Arguments

x	a vector of i.i.d. random realizations of the target chi-bar-square distribution
df	a vector containing the degrees of freedom of the chi-squared components
q	the empirical quantile of x used to choose the $p - 2$ values c_1, \dots, c_{p-2} (see Details)

Details

The chi-bar-square distribution $\bar{\chi}^2(I, C)$ is a mixture of chi-square distributions. The function provides a method to approximate the weights of the mixture components, when the number of components is known as well as the degrees of freedom of each chi-square distribution in the mixture, and given a vector of simulated values from the target $\bar{\chi}^2(I, C)$ distribution. Let us assume that there are p components in the mixture, with degrees of freedom between n_1 and n_p . By definition of a mixture distribution, we have :

$$P(\bar{\chi}^2(I, C) \leq c) = \sum_{i=n_1}^{n_p} w_i P(\chi_i^2 \leq c)$$

Choosing $p-2$ values c_1, \dots, c_{p-2} , the function will generate a system of $p-2$ equations according to the above relationship, and add two additional relationships stating that the sum of all the weights is equal to 1, and that the sum of odd weights and of even weights is equal to $1/2$, so that we end up with a system a p equations with p variables.

Value

A vector containing the estimated weights, as well as their covariance matrix.

Author(s)

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chiBarSquareObject-class

Class "chiBarSquareObject"

Description

An object of the chiBarSquareObject class, storing the parameters of the chi-bar-square distribution.

Slots

V a positive-definite matrix

dims the set of dimensions defining the cone

orthant logical, equals TRUE is the cone is the nonnegative orthant of \mathbb{R}^r

dfchisqbar

dfchisqbar

Description

dfchisqbar

Usage

```
## S4 method for signature 'chiBarSquareObject'
dfchisqbar(object)
```

Arguments

object a chiBarSquareObject

 extractFIMnlme

Extraction of the Fisher Information Matrix for nlme package

Description

Extraction of the Fisher Information Matrix for variance components fitted with nlme using Delta method

Usage

```
extractFIMnlme(m, struct)
```

Arguments

m	a model fitted using nlme
struct	a string giving the structure of the covariance matrix: either diag for a diagonal matrix, blockDiag for a block diagonal matrix or full for a matrix with non-zero components

Details

This function extract the FIM computed by the nlme for the transformed variance components, and uses the Delta method to compute the FIM for the natural variance components (i.e. variances and covariances)

Value

the FIM matrix for the variance components

Author(s)

Charlotte Baey <<charlotte.baey@univ-lille.fr>>

pchisqbar

pchisqbar

Description

pchisqbar

Usage

```
## S4 method for signature 'numeric,chiBarSquareObject,logical'
pchisqbar(q, object, lower.tail = T)
```

Arguments

q the quantile
object a `chiBarSquareObject`
lower.tail logical, default to TRUE

`plot.varTestObject` *Diagnostic plot for the approximation of the chi-bar-square distribution*

Description

Plot the empirical cumulative distribution function (cdf) of the simulated chi-bar-square distributed variable, along with the exact cdf of all the chi-square distributions involved in the mixture, and with the cdf based on the approximated weights. This function can only be used when the weights were approximated by simulation.

Arguments

x a object of class `varTestObject` obtained from a call to function `varTest`

`print.varTestObject` *Print basic information about the variance components test*

Description

Displays the likelihood ratio test statistics and the p-value of the test

Arguments

x a object of class `varTestObject` obtained from a call to function `varTest`

summary.varTestObject *Summary information for the variance components test*

Description

Displays the likelihood ratio test statistics, the limiting distribution and the p-value of the test

Arguments

x a object of class `varTestObject` obtained from a call to function `varTest`

Value

a list containing the following elements:

lrt	the likelihood ratio test statistics
df	the degrees of freedom of the chi-bar distributions involved in the chi-bar-square distribution
weights	the weights of the limiting chi-bar-square distribution
pvalWeights	the p-value of the test calculated using the cdf of the chi-bar-square based on (approximated) weights
pvalMC	the Monte-Carlo estimate of the p-value of the test based on the simulated chi-bar-square distribution

varTest *Variance component testing*

Description

Perform a likelihood ratio test to test whether a subset of the variances of the random effects are equal to zero. The test is defined by two hypotheses, H0 and H1, and the model under H0 is assumed to be nested within the model under H1.

Usage

```
varTest(
  m1,
  m0,
  control = list(M = 5000),
  pval.comp = "bounds",
  fim = "extract"
)
```

Arguments

<code>m1</code>	a fit of the model under H1, obtained from <code>nlme</code> , <code>lme4</code> or <code>saemix</code>
<code>m0</code>	a fit of the model under H0, obtained from the same package as <code>m0</code>
<code>control</code>	(optional) a list of control options for the computation of the chi-bar-weights
<code>pval.comp</code>	(optional) the method to be used to compute the p-value, one of: "bounds" (the default), "approx" or "both" (see Details section)
<code>fim</code>	(optional) the method to compute the Fisher Information Matrix. Currently, only <code>fim="extract"</code> is supported.

Details

It is possible to tests if any subset of the variances are equal to zero. However, the function does not currently support nested random effects, and assumes that the random effects are Gaussian.

The asymptotic distribution of the likelihood ratio test is a chi-bar-square, with weights that need to be approximated by Monte Carlo methods, apart from some specific cases where they are available explicitly. Therefore, the p-value of the test is not exact but approximated. This computation can be time-consuming, so the default behaviour of the function is to provide bounds on the exact p-value, which can be enough in practice to decide whether to reject or not the null hypothesis. This is triggered by the option `pval.comp="bounds"`. To compute an approximation of the exact p-value, one should use the option `pval.comp="approx"` or `pval.comp="both"`.

The control argument controls the options for chi-bar-square weights computation. It is a list with the following elements: `M` the size of the Monte Carlo simulation, `parallel` a boolean for parallel computing and `nbcores` the number of cores to be used in case of parallel computing. Default is `M=5000`, `parallel=FALSE` and `nbcores=1`.

Value

A list with the following components:

<code>lrt</code>	the likelihood ratio test statistics
<code>ddl</code>	the degrees of freedom of the chi-bar distributions involved in the chi-bar-square distribution
<code>weights</code>	the weights of the limiting chi-bar-square distribution
<code>pval</code>	the p-value of the test

Author(s)

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References

Baey C, Cournède P-H, Kuhn E, 2019. Asymptotic distribution of likelihood ratio test statistics for variance components in nonlinear mixed effects models. *Computational Statistics and Data Analysis* 135:107-122.

Silvapulle MJ, Sen PK, 2011. Constrained statistical inference: order, inequality and shape constraints.

Examples

```
# load nlme package and example dataset
library(nlme)
data(Orthodont)

# fit the two models under H1 and H0
lm1.h1.nlme <- lme(distance ~ 1 + Sex + age + age*Sex, random = ~ 1 + age | Subject,
data = Orthodont, method = "ML")
lm1.h0.nlme <- lme(distance ~ 1 + Sex + age + age*Sex, random = ~ 1 | Subject,
data = Orthodont, method = "ML")

# compare them (order is important: m1 comes first)
varTest(lm1.h1.nlme, lm1.h0.nlme)
```

varTestnlme-internal *Internal varTestnlme Functions*

Description

Internal varTestnlme functions

varTestObject-class *Class "varTestObject"*

Description

An object of the varTestObject class, storing the results of the LRT

Slots

lrt the likelihood ratio test statistics
df the degrees of freedom of the chi-square distributions involved in the mixture
weights the weights associated to the chi-square distributions involved in the mixture
pvalue the p-value of the LRT

Objects from the Class

An object of the varTestObject contains the following slots:

weightsChiBarSquare *Chi-bar-square weights computation*

Description

Computation of the chi-bar-square weights.

Usage

```
weightsChiBarSquare(cbs, control)
```

Arguments

`cbs` an object of class `chiBarSquareObject`, containing the parameters of the chi-bar-square distribution

`control` (optional) a list of control options for the computation of the chi-bar-weights

Details

The function computes an approximation of the weights of the chi-bar-square distribution $\bar{\chi}^2(I, C)$ arising as the limiting distribution of the likelihood ratio test statistics under the null hypothesis. More details can be found in the references listed below

Value

A list containing the degrees of freedom of the chi-bar distributions involved in the chi-bar-square, along with the associated weights.

Author(s)

Charlotte Baey <<charlotte.baey@univ-lille.fr>>

References

Baey C, Cournède P-H, Kuhn E, 2019. Asymptotic distribution of likelihood ratio test statistics for variance components in nonlinear mixed effects models. *Computational Statistics and Data Analysis* 135:107-122.

Silvapulle MJ, Sen PK, 2011. Constrained statistical inference: order, inequality and shape constraints.

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