Package ‘varTestnlme’

July 7, 2020

Type Package

Title Variance Components Testing for Linear and Nonlinear Mixed Effects Models

Version 0.2.0

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>.

Encoding UTF-8

LazyData true

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

RoxygenNote 7.1.0

Suggests knitr, rmarkdown, ggplot2

VignetteBuilder knitr

NeedsCompilation no

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Repository CRAN

Date/Publication 2020-07-07 21:10:02 UTC

R topics documented:

`approxWeights` *Monte Carlo approximation of chi-bar-square weights*

Description

Approximation of the chi-bar-square weigths 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 $c_1, \ldots, c_{p-2}$ (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 $c_1, \ldots, c_{p-2}$, 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)

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

`bootinvFIM` *Approximation of the (inverse of the) Fisher Information Matrix*

Description

Approximation of the inverse of the Fisher Information Matix via parametric bootstrap

Usage

```
bootinvFIM(m, B = 1000)
```

Arguments

`m`	a fitted model that will be used as the basis of the parametric bootstrap (providing the initial maximum likelihood estimate of the parameters and the modelling framework)
`B`	the size of the bootstrap sample

Details

When the FIM is not available, this function provides an approximation of the FIM based on an estimate of the covariancole matrix of the model's parameters obtained via parametric bootstrap.

Value

the empirical covariancole matrix of the parameter estimates obtained on the bootstrap sample

Author(s)

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

`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 R^r

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`dfchisqbar` *dfchisqbar Computes the degrees of freedom of the chi-square involved in the mixture*

Description

dfchisqbar Computes the degrees of freedom of the chi-square involved in the mixture

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 Matix 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 of `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>`>

funcStruct — *Extracting models structures*

Description

Functions extracting the structure of the models for each package `nlme`, `lme4` and `saemix`.

Usage

```
modelStructnlme(m1, m0, randm0)

modelStructlme4(m1, m0, linmodel, randm0)

modelStructsaemix(m1, m0, randm0)
```

Arguments

`m1`	the model under H1
`m0`	the model under H0
`randm0`	a boolean stating whether the model under H0 contains any random effect
`linmodel`	(only for `modelStructlme4`) a boolean to specify whether the model is linear or not

Value

A list with the following components:

`detailStruct`	a data frame containing 8 variables: `name` with the name of the model parameters, `var1` and `var2` with the names of the two variances associated with each covariance parameter, `type` giving the type of parameter (`beta` for fixed effects, `sd` for variances and `co` for covariances), `tested` equal to `TRUE` if the parameter is tested and `FALSE` otherwise, `block` giving the block number to which the variance component parameter belongs (equal 0 for fixed effects), `covTested` indicating whether a covariance is tested without the associated variances being tested, and `covInBlock` indicating whether a covariance is tested within a block of the complete covariance matrix
`dims`	a list with the dimensions of the models (`nbFE1` and `nbFE0` the number of fixed effects in m1 and m0, `nbRE1` and `nbRE0` the number of random effects in m1 and m0 and `dimSigma` the number of residual error parameters)
`structGamma`	the structure of the covariance matrix of the random effects as a list of three logical elements: `diag`, `full` and `blockDiag`, equal to `TRUE` if the matrix is diagonal, full or block-diagonal respectively.

`getVarCovlme4` *Extract covariance matrix*

Description

Extract covariance matrix of the random effects for a model fitted with lme4.

Usage

```
getVarCovlme4(m)
```

Arguments

`m`	a fit from lme4 package (either linear or nonlinear)

getVarCovnlme — *Extract covariance matrix*

Description

Extract covariance matrix of the random effects for a model fitted with nlme.

Usage

```
getVarCovnlme(m)
```

Arguments

`m`	a fit from nlme package (either linear or nonlinear)

pchisqbar — *pchisqbar Cumulative distribution function of the chi-bar-square distribution*

Description

pchisqbar Cumulative distribution function of the chi-bar-square distribution

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

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`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, parallel = T, nbcores = 1, B = 1000),
  pval.comp = "bounds",
  fim = "extract"
)
```

Arguments

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

When `pval.comp="approx"` or `pval.comp="both"`, the weights of th chi-bar-square distribution are computed and thus

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:

`lrt`	the likelihood ratio test statistics
`ddl`	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
`pval`	the p-value of the test

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.

Examples

```
# load nlme package and example dataset
library(lme4)
data(Orthodont, package = "nlme")

# fit the two models under H1 and H0
lm1.h1.lme4 <- lmer(distance ~ 1 + Sex + age + age*Sex +
```

```
(0 + age | Subject), data = Orthodont, REML = FALSE)
lm1.h0.lme4 <- lm(distance ~ 1 + Sex + age + age*Sex, data = Orthodont)

# compare them (order is important: m1 comes first)
varTest(lm1.h1.lme4,lm1.h0.lme4,pval.comp="bounds")
```

`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 weigths.

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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