Package 'RLRsim'

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Type Package

Title Exact (Restricted) Likelihood Ratio tests for mixed and additive models.

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Description Rapid, simulation-based exact (restricted) likelihood ratio tests for testing the presence of variance components/nonparametric terms for models fit with nlme::lme(),lme4::lmer(), mgcv::gamm() and SemiPar:spm()

License GPL

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RLRsim-package *(Restricted) likelihood ratio tests in linear mixed models*

Description

Rapid, simulation-based exact (restricted) likelihood ratio tests for testing the presence of variance components/nonparametric terms with a convenient interface for models fit with nlme::lme(), lme4::lmer(), mgcv::gamm() and SemiPar:spm().

Details

Package:	RLRsim
Type:	Package
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Author(s)

Maintainer: Fabian Scheipl <fabian.scheipl@stat.uni-muenchen.de>

exactLRT *Likelihood Ratio Tests for simple linear mixed models*

Description

This function provides an exact likelihood ratio test based on simulated values from the finite sample distribution for simultaneous testing of the presence of the variance component and some restrictions of the fixed effects in a simple linear mixed model with known correlation structure of the random effect and i.i.d. errors.

Usage

```
exactLRT(m, m0, seed = NA, nsim = 10000, log.grid.hi = 8,
    log.grid.lo = -10, gridlength = 200)
```

Arguments

m	The fitted model under the alternative; of class lme, lmer or spm
m0	The fitted model under the null hypothesis; of class lm
seed	Specify a seed for set.seed

nsim	Number of values to simulate
log.grid.hi	Lower value of the grid on the log scale. See exactLRT.
log.grid.lo	Lower value of the grid on the log scale. See exactLRT.
gridlength	Length of the grid. See LRTSim.

Details

The model under the alternative must be a linear mixed model $y = X\beta + Zb + \varepsilon$ with a *single* random effect b with known correlation structure and error terms that are i.i.d. The hypothesis to be tested must be of the form

$$H_0 : \beta_{p+1-q} = \beta^0_{p+1-q}, \ldots, \beta_p = \beta^0_p; \quad Var(b) = 0$$

versus

$$H_A : \ \beta_{p+1-q} \neq \beta^0_{p+1-q} \text{ or} \ldots \text{or } \beta_p \neq \beta^0_p \ \text{ or } Var(b) > 0$$

We use the exact finite sample distribution of the likelihood ratio test statistic as derived by Crainiceanu & Ruppert (2004).

Value

A list of class htest containing the following components:

statistic	the observed likelihood ratio
p	p-value for the observed test statistic
method	a character string indicating what type of test was performed and how many values were simulated to determine the critical value
sample	the samples from the null distribution returned by RLRTSim

Author(s)

Fabian Scheipl, updates for **lme4.0**-compatibility by Ben Bolker

References

Crainiceanu, C. and Ruppert, D. (2004) Likelihood ratio tests in linear mixed models with one variance component, *Journal of the Royal Statistical Society: Series B*,**66**,165–185.

See Also

LRTSim for the underlying simulation algorithm; RLRTSim and exactRLRT for restricted likelihood based tests

Examples

```
library(nlme);
data(Orthodont);

##test for Sex:Age interaction and Subject-Intercept
mA<-lme(distance ~ Sex * I(age - 11), random = ~ 1| Subject,
    data = Orthodont, method = "ML")
m0<-lm(distance ~ Sex + I(age - 11), data = Orthodont)
summary(mA)
summary(m0)
exactLRT(m = mA, m0 = m0)
```

`exactRLRT` *Restricted Likelihood Ratio Tests for additive and linear mixed models*

Description

This function provides an (exact) restricted likelihood ratio test based on simulated values from the finite sample distribution for testing whether the variance of a random effect is 0 in a linear mixed model with known correlation structure of the tested random effect and i.i.d. errors.

Usage

```
exactRLRT(m, mA = NULL, m0 = NULL, seed = NA, nsim = 10000,
         log.grid.hi = 8, log.grid.lo = -10, gridlength = 200)
```

Arguments

`m`	The fitted model under the alternative or, for testing in models with multiple variance components, the reduced model containing only the random effect to be tested (see Details), an `lme`, `lmer` or `spm` object
`mA`	The full model under the alternative for testing in models with multiple variance components
`m0`	The model under the null for testing in models with multiple variance components
`seed`	input for `set.seed`
`nsim`	Number of values to simulate
`log.grid.hi`	Lower value of the grid on the log scale. See `exactRLRT`.
`log.grid.lo`	Lower value of the grid on the log scale. See `exactRLRT`.
`gridlength`	Length of the grid. See `exactLRT`.

Details

Testing in models with only a single variance component require only the first argument `m`. For testing in models with multiple variance components, the fitted model `m` must contain **only** the random effect set to zero under the null hypothesis, while `mA` and `m0` are the models under the alternative and the null, respectively. For models with a single variance component, the simulated distribution is exact if the number of parameters (fixed and random) is smaller than the number of observations. Extensive simulation studies (see second reference below) confirm that the application of the test to models with multiple variance components is safe and the simulated distribution is correct as long as the number of parameters (fixed and random) is smaller than the number of observations and the nuisance variance components are not superfluous or very small. We use the finite sample distribution of the restricted likelihood ratio test statistic as derived by Crainiceanu & Ruppert (2004).

Value

A list of class `htest` containing the following components:

`statistic`	the observed restricted likelihood ratio
`p`	p-value for the observed test statistic
`method`	a character string indicating what type of test was performed and how many values were simulated to determine the critical value
`sample`	the samples from the null distribution returned by `RLRTSim`

Author(s)

Fabian Scheipl, bug fixes by Andrzej Galecki, updates for **lme4.0**-compatibility by Ben Bolker

References

Crainiceanu, C. and Ruppert, D. (2004) Likelihood ratio tests in linear mixed models with one variance component, *Journal of the Royal Statistical Society: Series B*,**66**,165–185.

Greven, S., Crainiceanu, C., Kuechenhoff, H., and Peters, A. (2008) Restricted Likelihood Ratio Testing for Zero Variance Components in Linear Mixed Models, *Journal of Computational and Graphical Statistics*, **17** (4): 870–891.

Scheipl, F., Greven, S. and Kuechenhoff, H. (2008) Size and power of tests for a zero random effect variance or polynomial regression in additive and linear mixed models. *Computational Statistics & Data Analysis*, **52**(7):3283–3299.

See Also

`RLRTSim` for the underlying simulation algorithm; `exactLRT` for likelihood based tests

Examples

```
library(lme4)
data(sleepstudy)
mA <- lmer(Reaction ~ I(Days-4.5) + (1|Subject) + (0 + I(Days-4.5)|Subject), sleepstudy)
m0 <- update(mA, . ~ . - (0 + I(Days-4.5)|Subject))
```

```
m.slope  <- update(mA, . ~ . - (1|Subject))
#test for subject specific slopes:
exactRLRT(m.slope, mA, m0)

library(mgcv)
data(trees)
#test quadratic trend vs. smooth alternative
m.q<-gamm(I(log(Volume)) ~ Height + s(Girth, m = 3), data = trees, method = "REML")$lme
exactRLRT(m.q)
#test linear trend vs. smooth alternative
m.l<-gamm(I(log(Volume)) ~ Height + s(Girth, m = 2), data = trees, method = "REML")$lme
exactRLRT(m.l)
```

`extract.lmeDesign` *Extract the Design of a linear mixed model*

Description

These functions extract various elements of the design of a fitted `lme`-, `mer` or `lmerMod`-Object. They are called by `exactRLRT` and `exactLRT`.

Usage

```
extract.lmeDesign(m)
extract.lmerDesign(m)
extract.lmerModDesign(m)
```

Arguments

`m`	fitted `lme`- or `mer`-Object

Value

a list with components

`Vr`	estimated covariance of the random effects divided by the estimated variance of the residuals
`X`	design of the fixed effects
`Z`	design of the random effects
`sigmasq`	variance of the residuals
`lambda`	ratios of the variances of the random effects and the variance of the residuals
`y`	response variable

Note

`extract.lmeDesign` is based on `mgcv::extract.lme.cov` by Simon Wood

Author(s)

Fabian Scheipl, `extract.lmerModDesign` supplied by Ben Bolker

Examples

```
library(nlme)
d <- extract.lmeDesign(lme(distance ~ age + Sex, data = Orthodont, random = ~ 1))
```

`LRTSim` *Simulation of the (Restricted) Likelihood Ratio Statistic*

Description

These functions simulate values from the (exact) finite sample distribution of the (restricted) likelihood ratio statistic for testing the presence of the variance component (and restrictions of the fixed effects) in a simple linear mixed model with known correlation structure of the random effect and i.i.d. errors. They are usually called by `exactLRT` or `exactRLRT`.

Usage

```
LRTSim(X, Z, q, sqrt.Sigma, seed = NA, nsim = 10000, log.grid.hi = 8,
       log.grid.lo=-10, gridlength=200)
RLRTSim(X, Z, qrX, sqrt.Sigma, lambda0 = NA, seed = NA, nsim = 10000, use.approx=0,
       log.grid.hi=8, log.grid.lo=-10, gridlength=200)
```

Arguments

`X`	The fixed effects design matrix of the model under the alternative
`Z`	The random effects design matrix of the model under the alternative
`qrX`	The QR-decomposition of the fixed effects design matrix
`q`	The number of parameters restrictions on the fixed effects (see Details)
`sqrt.Sigma`	The upper triangular cholesky factor of the correlation matrix of the random effect
`lambda0`	The value of the ratio of the variance of the random effect and the errors under the null
`seed`	Specify a seed for `set.seed`
`nsim`	Number of values to simulate
`use.approx`	If 0, the exact distribution is simulated. If between 0 and 1, only the largest eigenvalues whose sum represents at least `use.approx`*(sum of all eigenvalues) are used.
`log.grid.hi`	Lower value of the grid on the log scale. See **Details**
`log.grid.lo`	Lower value of the grid on the log scale. See **Details**
`gridlength`	Length of the grid for the grid search over lambda. See **Details**

Details

The model under the alternative must be a linear mixed model $y = X\beta+Zb+\varepsilon$ with a single random effect b with known correlation structure $Sigma$ and i.i.d errors. The simulated distribution of the likelihood ratio statistic was derived by Crainiceanu & Ruppert (2004). The simulation algorithm uses a gridsearch over a log-regular grid of values of $\lambda = \frac{Var(b)}{Var(\varepsilon)}$ to maximize the likelihood under the alternative for `nsim` realizations of y drawn under the null hypothesis. `log.grid.hi` and `log.grid.lo` are the lower and upper limits of this grid on the log scale. `gridlength` is the number of points on the grid.\ These are just wrapper functions for the underlying C code.

Value

A vector containig the the simulated values of the (R)LRT under the null, with attribute 'lambda' giving $\arg\min(f(\lambda))$ (see Crainiceanu, Ruppert (2004)) for the simulations.

Author(s)

Fabian Scheipl

References

Crainiceanu, C. and Ruppert, D. (2004) Likelihood ratio tests in linear mixed models with one variance component, *Journal of the Royal Statistical Society: Series B*,**66**,165–185.

Scheipl, F. (2007) Testing for nonparametric terms and random effects in structured additive regression. Diploma thesis.\ http://www.statistik.lmu.de/~scheipl/downloads/DIPLOM.zip.

Scheipl, F., Greven, S. and Kuechenhoff, H (2008) Size and power of tests for a zero random effect variance or polynomial regression in additive and linear mixed models, *Computational Statistics & Data Analysis*, **52**(7):3283-3299

See Also

`exactLRT`, `exactRLRT` for tests

Examples

```
library(lme4)
g <- rep(1:10, e = 10)
x <- rnorm(100)
y <- 0.1 * x + rnorm(100)
m <- lmer(y ~ x + (1|g), REML=FALSE)
m0 <- lm(y ~ 1)

(obs.LRT <- 2*(logLik(m)-logLik(m0)))
X <- m@X
Z <- t(as.matrix(m@Zt))
sim.LRT <- LRTSim(X, Z, 1, diag(10))
(pval <- mean(sim.LRT > obs.LRT))
```

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