Package ‘pbkrtest’

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Version 0.5.3

Title Parametric Bootstrap, Kenward-Roger and Satterthwaite Based
Methods for Test in Mixed Models

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Description Computes p-values based on (a) Satterthwaite or
Kenward-Rogers degree of freedom methods and (b) parametric bootstrap
for mixed effects models as implemented in the 'lme4'
package. Implements parametric bootstrap test for generalized linear
mixed models as implemented in 'lme4' and generalized linear
models. The package is documented in the paper by Halekoh and
‘citation("pbkrtest")’ for citation details.

URL https://people.math.aau.dk/~sorenh/software/pbkrtest/

Depends R (>= 4.2.0), lme4 (>= 1.1.31)

Imports broom, dplyr, MASS, methods, numDeriv, Matrix (>= 1.2.3), doBy

Suggests markdown, knitr

Encoding UTF-8

VignetteBuilder knitr

License GPL (>= 2)

ByteCompile Yes

RoxygenNote 7.3.1

LazyData true

NeedsCompilation no

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Repository CRAN

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**compare_column_space**

**Description**

Compare column spaces of two matrices

**Usage**

```r
compare_column_space(X1, X2)
```

**Arguments**

- `X1, X2`: matrices with the same number of rows

**Value**

- `-1`: Either \(\text{C}(X1) = \text{C}(X2)\), or the spaces are not nested.
- `0`: \(\text{C}(X1)\) is contained in \(\text{C}(X2)\)
- `1`: \(\text{C}(X2)\) is contained in \(\text{C}(X1)\)

**Examples**

```r
A1 <- matrix(c(1,1,1,1,2,3), nrow=3)
A2 <- A1[, 1, drop=FALSE]

compare_column_space(A1, A2)
compare_column_space(A2, A1)
compare_column_space(A1, A1)
```
**Description**

Yield and sugar percentage in sugar beets from a split plot experiment. The experimental layout was as follows: There were three blocks. In each block, the harvest time defines the "whole plot" and the sowing time defines the "split plot". Each plot was $25m^2$ and the yield is recorded in kg. See 'details' for the experimental layout. The data originates from a study carried out at The Danish Institute for Agricultural Sciences (the institute does not exist any longer; it became integrated in a Danish university).

**Usage**

beets

**Format**

A dataframe with 5 columns and 30 rows.

**Details**

Experimental plan

<table>
<thead>
<tr>
<th>Sowing times</th>
<th>1 4. april</th>
<th>2 12. april</th>
<th>3 21. april</th>
<th>4 29. april</th>
<th>5 18. may</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest times</td>
<td>1 2. october</td>
<td>2 21. october</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot allocation:</td>
<td>Block 1</td>
<td>Block 2</td>
<td>Block 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot</td>
<td>1 1 1 1 1</td>
<td>2 2 2 2 2</td>
<td>1 1 1 1 1</td>
<td>Harvest time</td>
<td></td>
</tr>
<tr>
<td>1-15</td>
<td>3 4 5 2 1</td>
<td>3 2 4 5 1</td>
<td>5 2 3 4 1</td>
<td>Sowing time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot</td>
<td>2 2 2 2 2</td>
<td>1 1 1 1 1</td>
<td>2 2 2 2 2</td>
<td>Harvest time</td>
<td></td>
</tr>
<tr>
<td>16-30</td>
<td>2 1 5 4 3</td>
<td>4 1 3 2 5</td>
<td>1 4 3 2 5</td>
<td>Sowing time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**References**

Examples

```r
data(beets)

beets$bh <- with(beets, interaction(block, harvest))
summary(aov(yield ~ block + sow + harvest + Error(bh), beets))
summary(aov(sugpct ~ block + sow + harvest + Error(bh), beets))
```

---

**data-budworm**

### Budworm data

**Description**

Experiment on the toxicity to the tobacco budworm *Heliothis virescens* of doses of the pyrethroid trans-cypermethrin to which the moths were beginning to show resistance. Batches of 20 moths of each sex were exposed for three days to the pyrethroid and the number in each batch that were dead or knocked down was recorded. Data is reported in Collett (1991, p. 75).

**Usage**

`budworm`

**Format**

This data frame contains 12 rows and 4 columns:

- **sex**: sex of the budworm.
- **dose**: dose of the insecticide trans-cypermethrin (in micro grams).
- **ndead**: budworms killed in a trial.
- **ntotal**: total number of budworms exposed per trial.

**Source**


**References**

Examples

```r
data(budworm)

## function to calculate the empirical logits
empirical.logit <- function(nevent, ntotal) {
  y <- log((nevent + 0.5) / (ntotal - nevent + 0.5))
  y
}

# plot the empirical logits against log-dose
log.dose <- log(budworm$dose)
emp.logit <- empirical.logit(budworm$ndead, budworm$ntotal)
plot(log.dose, emp.logit, type='n', xlab='log-dose', ylab='empirical logit')
title('budworm: empirical logits of probability to die ')
male <- budworm$sex == 'male'
female <- budworm$sex == 'female'
lines(log.dose[male], emp.logit[male], type='b', lty=1, col=1)
lines(log.dose[female], emp.logit[female], type='b', lty=2, col=2)
legend(0.5, 2, legend=c('male', 'female'), lty=c(1,2), col=c(1,2))
```

## Not run:
* SAS example:
```r
data budworm;
infile 'budworm.txt' firstobs=2;
input sex dose ndead ntotal;
run;
```

## End(Not run)

---

**get_ddf_Lb**

*Adjusted denominator degrees of freedom for linear estimate for linear mixed model.*

**Description**

Get adjusted denominator degrees freedom for testing Lb=0 in a linear mixed model where L is a restriction matrix.

**Usage**

```r
get_Lb_ddf(object, L)
```

## S3 method for class 'lmerMod'
```r
get_Lb_ddf(object, L)
```
get_ddf_Lb(object, Lcoef)

## S3 method for class 'lmerMod'
get_ddf_Lb(object, Lcoef)

Lb_ddf(L, V0, Vadj)

ddf_Lb(VVa, Lcoef, VV0 = VVa)

**Arguments**

- **object**: A linear mixed model object.
- **L**: A vector with the same length as `fixef(object)` or a matrix with the same number of columns as the length of `fixef(object)`.
- **Lcoef**: Linear contrast matrix.
- **V0, Vadj**: The unadjusted and the adjusted covariance matrices for the fixed effects parameters. The unadjusted covariance matrix is obtained with `vcov()` and adjusted with `vcovAdj()`.
- **VVa**: Adjusted covariance matrix.
- **VV0**: Unadjusted covariance matrix.

**Value**

Adjusted degrees of freedom (adjustment made by a Kenward-Roger approximation).

**Author(s)**

Søren Højsgaard, <sorenh@math.aau.dk>

**References**


**See Also**

`KRmodcomp, vcovAdj, model2restriction_matrix, restriction_matrix2model`

**Examples**

```r
(fmLarge <- lmer(Reaction ~ Days + (Days|Subject), sleepstudy))
## removing Days
(fmSmall <- lmer(Reaction ~ 1 + (Days|Subject), sleepstudy))
anova(fmLarge, fmSmall)
KRmodcomp(fmLarge, fmSmall) ## 17 denominator df's
get_Lb_ddf(fmLarge, c(0, 1)) ## 17 denominator df's
```
get_modcomp

# Notice: The restriction matrix L corresponding to the test above
# can be found with
L <- model2restriction_matrix(fmLarge, fmSmall)
L

get_modcomp  Extract (or "get") components from a KRmodcomp object.

Description

Extract (or get") components from a KRmodcomp object, which is the result of the KRmodcomp function.

Usage

getKR(
  object,
  name = c("ndf", "ddf", "Fstat", "p.value", "F.scaling", "FstatU", "p.valueU", "aux")
)

gSAT(object, name = c("ndf", "ddf", "Fstat", "p.value"))

Arguments

object A KRmodcomp object, which is the result of the KRmodcomp function
name The available slots. If name is missing or NULL then everything is returned.

Author(s)

Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

KRmodcomp, PBmodcomp, vcovAdj
Examples

data(beets, package='pbkrtest')
lg <- lmer(sugpct ~ block + sow + harvest + (1|block:harvest),
  data=beets, REML=FALSE)
sm <- update(lg, .~- harvest)
modcomp <- KRmodcomp(lg, sm)
getKR(modcomp, "ddf") # get denominator degrees of freedom.

kr-vcovAdj

Adjusted covariance matrix for linear mixed models according to Kenward and Roger

Description

Kenward and Roger (1997) describe an improved small sample approximation to the covariance matrix estimate of the fixed parameters in a linear mixed model.

Usage

vcovAdj(object, details = 0)

## S3 method for class 'lmerMod'
vcovAdj(object, details = 0)

Arguments

object         An lmer model
details        If larger than 0 some timing details are printed.
kr-vcovAdj

Value

- **phiA**: the estimated covariance matrix, this has attributed P, a list of matrices used in KR_adjust and the estimated matrix W of the variances of the covariance parameters of the random effects.
- **SigmaG**: list: Sigma: the covariance matrix of Y; G: the G matrices that sum up to Sigma; n.ggamma: the number (called M in the article) of G matrices.

Note

If $N$ is the number of observations, then the vcovAdj() function involves inversion of an $N \times N$ matrix, so the computations can be relatively slow.

Author(s)

Ulrich Halekoh <uhalekoh@health.sdu.dk>, Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

getKR, KRmodcomp, lmer, PBmodcomp, vcovAdj

Examples

```r
fm1 <- lmer(Reaction ~ Days + (Days|Subject), sleepstudy)
class(fm1)

## Here the adjusted and unadjusted covariance matrices are identical,  
## but that is not generally the case:

v1 <- vcov(fm1)
v2 <- vcovAdj(fm1, details=0)
v2 / v1

## For comparison, an alternative estimate of the variance-covariance  
## matrix is based on parametric bootstrap (and this is easily  
## parallelized):

## Not run:
nsim <- 100
sim <- simulate(fm.ml, nsim)
B <- lapply(sim, function(newy) try(fixef(refit(fm.ml, newresp=newy))))
B <- do.call(rbind, B)
v3 <- cov.wt(B)$cov
```
kr_modcomp

F-test and degrees of freedom based on Kenward-Roger approximation

Description

An approximate F-test based on the Kenward-Roger approach.

Usage

KRmodcomp(largeModel, smallModel, betaH = 0, details = 0)

## S3 method for class 'lmerMod'
KRmodcomp(largeModel, smallModel, betaH = 0, details = 0)

Arguments

largeModel An lmer model
smallModel An lmer model or a restriction matrix
betaH A number or a vector of the beta of the hypothesis, e.g. L beta=L betaH. If smallModel is a model object then betaH=0.
details If larger than 0 some timing details are printed.

Details

An F test is calculated according to the approach of Kenward and Roger (1997). The function works for linear mixed models fitted with the lmer() function of the lme4 package. Only models where the covariance structure is a linear combination (a weighted sum) of known matrices can be compared. The smallModel is the model to be tested against the largeModel.

The largeModel is a model fitted with lmer(). A technical detail: The model must be fitted with REML=TRUE. If the model is fitted with REML=FALSE then the model is refitted with REML=TRUE before the p-values are calculated. Put differently, the user needs not worry about this issue.

The smallModel can be one of several things:

1. a model fitted with lmer(). It must have the same covariance structure as largeModel. Furthermore, its linear space of expectation must be a subspace of the space for largeModel.
2. a restriction matrix $L$ specifying the hypothesis

$$L\beta = L\beta_H$$

where $L$ is a $k \times p$ matrix (there are $k$ restrictions and $p$ is the number of fixed effect parameters (the length of $\text{fixef(largeModel)}$) and $\beta_H$ is a $p$ column vector.

3. A formula or a text string specifying what is to be removed from the larger model to form the smaller model.

Notice: if you want to test a hypothesis

$$L\beta = c$$

with a $k$ vector $c$, a suitable $\beta_H$ is obtained via $\beta_H = Lc$ where $L_n$ is a g-inverse of $L$.

Notice: It cannot be guaranteed that the results agree with other implementations of the Kenward-Roger approach!

Author(s)

Ulrich Halekoh <uhalekoh@health.sdu.dk>, Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

getKR, lmer, vcovAdj, PBmodcomp, SATmodcomp

Examples

```r
(fm0 <- lmer(Reaction ~ (Days|Subject), sleepstudy))
(fm1 <- lmer(Reaction ~ Days + (Days|Subject), sleepstudy))
(fm2 <- lmer(Reaction ~ Days + I(Days^2) + (Days|Subject), sleepstudy))

## Test for no effect of Days in fm1, i.e. test fm0 under fm1
KRmodcomp(fm1, "Days")
KRmodcomp(fm1, ~.-Days)
L1 <- cbind(0, 1)
KRmodcomp(fm1, L1)
KRmodcomp(fm1, fm0)
anova(fm1, fm0)

## Test for no effect of Days and Days-squared in fm2, i.e. test fm0 under fm2
KRmodcomp(fm2, "(Days+I(Days^2))")
KRmodcomp(fm2, ~.- Days - I(Days^2))
```
L2 <- rbind(c(0, 1, 0), c(0, 0, 1))
KRmodcomp(fm2, L2)
KRmodcomp(fm2, fm0)
anova(fm2, fm0)

## Test for no effect of Days-squared in fm2, i.e. test fm1 under fm2
KRmodcomp(fm2, "I(Days^2)"")
KRmodcomp(fm2, ~. - I(Days^2))
L3 <- rbind(c(0, 0, 1))
KRmodcomp(fm2, L3)
KRmodcomp(fm2, fm1)
anova(fm2, fm1)

### model-coerce

**Conversion between a model object and a restriction matrix**

**Description**

Testing a small model under a large model corresponds imposing restrictions on the model matrix of the larger model and these restrictions come in the form of a restriction matrix. These functions converts a model to a restriction matrix and vice versa.

**Usage**

```r
model2restriction_matrix(largeModel, smallModel, sparse = FALSE)
```

```r
restriction_matrix2model(largeModel, L, REML = TRUE, ...)
```

```r
make_model_matrix(X, L)
```

```r
make_restriction_matrix(X, X2)
```

**Arguments**

- `largeModel, smallModel` Model objects of the same "type". Possible types are linear mixed effects models and linear models (including generalized linear models)
- `sparse` Should the restriction matrix be sparse or dense?
- `L` A restriction matrix; a full rank matrix with as many columns as `X` has.
- `REML` Controls if new model object should be fitted with REML or ML.
- `...` Additional arguments; not used.
- `X, X2` Model matrices. Must have same number of rows.

**Details**

`make_restriction_matrix` Make a restriction matrix. If `span(X2)` is in `span(X)` then the corresponding restriction matrix `L` is returned.
Value


Note

That these functions are visible is a recent addition; minor changes may occur.

Author(s)

Ulrich Halekoh <uhalekoh@health.sdu.dk>, Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

`PBmodcomp`, `PBrefdist`, `KRmodcomp`

Examples

```r
library(pbkrtest)
data("beets", package = "pbkrtest")
sug <- lm(sugpct ~ block + sow + harvest, data=beets)
sug.h <- update(sug, .~. - harvest)
sug.s <- update(sug, .~. - sow)

## Construct restriction matrices from models
L.h <- model2restriction_matrix(sug, sug.h); L.h
L.s <- model2restriction_matrix(sug, sug.s); L.s

## Construct submodels from restriction matrices
mod.h <- restriction_matrix2model(sug, L.h); mod.h
mod.s <- restriction_matrix2model(sug, L.s); mod.s

## Sanity check: The models have the same fitted values and log likelihood
plot(fitted(mod.h), fitted(sug.h))
plot(fitted(mod.s), fitted(sug.s))
logLik(mod.h)
logLik(sug.h)
logLik(mod.s)
logLik(sug.s)
```
Calculate reference distribution using parametric bootstrap

### Description

Calculate reference distribution of likelihood ratio statistic in mixed effects models using parametric bootstrap

### Usage

```r
PBrefdist(
  largeModel,
  smallModel,
  nsim = 1000,
  seed = NULL,
  cl = NULL,
  details = 0
)
```

```r
## S3 method for class 'lm'
PBrefdist(
  largeModel,
  smallModel,
  nsim = 1000,
  seed = NULL,
  cl = NULL,
  details = 0
)
```

```r
## S3 method for class 'merMod'
PBrefdist(
  largeModel,
  smallModel,
  nsim = 1000,
  seed = NULL,
  cl = NULL,
  details = 0
)
```

### Arguments

- **largeModel**: A linear mixed effects model as fitted with the `lmer()` function in the `lme4` package. This model must be larger than `smallModel` (see below).
- **smallModel**: A linear mixed effects model as fitted with the `lmer()` function in the `lme4` package. This model must be smaller than `largeModel` (see above).
- **nsim**: The number of simulations to form the reference distribution.
seed

Seed for the random number generation.

c1

Used for controlling parallel computations. See sections 'details' and 'examples' below.

details

The amount of output produced. Mainly relevant for debugging purposes.

Details

The model object must be fitted with maximum likelihood (i.e. with REML=FALSE). If the object is fitted with restricted maximum likelihood (i.e. with REML=TRUE) then the model is refitted with REML=FALSE before the p-values are calculated. Put differently, the user needs not worry about this issue.

The argument 'c1' (originally short for 'cluster') is used for controlling parallel computations. 'c1' can be NULL (default), positive integer or a list of clusters.

Special care must be taken on Windows platforms (described below) but the general picture is this:

The recommended way of controlling c1 is to specify the component \code{pbcl} in options() with e.g. \code{options("pbcl"=4)}.

If c1 is NULL, the function will look at if the pbcl has been set in the options list with \code{getOption("pbcl")}

If c1=N then N cores will be used in the computations. If c1 is NULL then the function will look for

Value

A numeric vector

Author(s)

Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

PBmodcomp, KRmodcomp
Examples

data(beets)
head(beets)
beet0 <- lmer(sugpct ~ block + sow + harvest + (1|block:harvest), data=beets, REML=FALSE)
beet_no.harv <- update(beet0, . ~ . - harvest)
rd <- PBrefdist(beet0, beet_no.harv, nsim=20, cl=1)
rd

## Not run:
## Note: Many more simulations must be made in practice.

# Computations can be made in parallel using several processors:

# 1: On OSs that fork processes (that is, not on windows):
# -------------------------------------------------------------

if ( Sys.info()["sysname"] != "Windows"){
  N <- 2  ## Or N <- parallel::detectCores()

  # N cores used in all calls to function in a session
  options("mc.cores"=N)
  rd <- PBrefdist(beet0, beet_no.harv, nsim=20)

  # N cores used just in one specific call (when cl is set, #
  # options("mc.cores") is ignored):
  rd <- PBrefdist(beet0, beet_no.harv, nsim=20, cl=N)
}

# In fact, on Windows, the approach above also work but only when setting the #
# number of cores to 1 (so there is to parallel computing)

# In all calls:
# options("mc.cores"=1)
# rd <- PBrefdist(beet0, beet_no.harv, nsim=20)
# Just once
# rd <- PBrefdist(beet0, beet_no.harv, nsim=20, cl=1)

# 2. On all platforms (also on Windows) one can do
# ----------------------------------------------

library(parallel)
N <- 2      ## Or N <- detectCores()
clus <- makeCluster(rep("localhost", N))

# In all calls in a session
options("pb.cl"=clus)
rd <- PBrefdist(beet0, beet_no.harv, nsim=20)

# Just once:
rd <- PBrefdist(beet0, beet_no.harv, nsim=20, cl=clus)
stopCluster(clus)

## End(Not run)
Model comparison using parametric bootstrap methods.

Description

Model comparison of nested models using parametric bootstrap methods. Implemented for some commonly applied model types.

Usage

PBmodcomp(
  largeModel, smallModel, nsim = 1000, ref = NULL, seed = NULL, cl = NULL, details = 0
)

## S3 method for class 'merMod'
PBmodcomp(
  largeModel, smallModel, nsim = 1000, ref = NULL, seed = NULL, cl = NULL, details = 0
)

## S3 method for class 'lm'
PBmodcomp(
  largeModel, smallModel, nsim = 1000, ref = NULL, seed = NULL, cl = NULL, details = 0
)

seqPBmodcomp(largeModel, smallModel, h = 20, nsim = 1000, cl = 1)

Arguments

largeModel An lmer model
smallModel An lmer model or a restriction matrix
nsim The number of simulations to form the reference distribution.
ref Vector containing samples from the reference distribution. If NULL, this vector will be generated using PBrefdist().
seed A seed that will be passed to the simulation of new datasets.
c1 A vector identifying a cluster; used for calculating the reference distribution using several cores. See examples below.
details The amount of output produced. Mainly relevant for debugging purposes.
h For sequential computing for bootstrap p-values: The number of extreme cases needed to generate before the sampling process stops.

Details

The model object must be fitted with maximum likelihood (i.e. with REML=FALSE). If the object is fitted with restricted maximum likelihood (i.e. with REML=TRUE) then the model is refitted with REML=FALSE before the p-values are calculated. Put differently, the user needs not worry about this issue.

Under the fitted hypothesis (i.e. under the fitted small model) nsim samples of the likelihood ratio test statistic (LRT) are generated. Then p-values are calculated as follows:

LRT: Assuming that LRT has a chi-square distribution.
PBltest: The fraction of simulated LRT-values that are larger or equal to the observed LRT value.
Bartlett: A Bartlett correction is of LRT is calculated from the mean of the simulated LRT-values
Gamma: The reference distribution of LRT is assumed to be a gamma distribution with mean and variance determined as the sample mean and sample variance of the simulated LRT-values.
F: The LRT divided by the number of degrees of freedom is assumed to be F-distributed, where the denominator degrees of freedom are determined by matching the first moment of the reference distribution.

Note

It can happen that some values of the LRT statistic in the reference distribution are negative. When this happens one will see that the number of used samples (those where the LRT is positive) are reported (this number is smaller than the requested number of samples).

In theory one can not have a negative value of the LRT statistic but in practice one can: We speculate that the reason is as follows: We simulate data under the small model and fit both the small and the large model to the simulated data. Therefore the large model represents - by definition - an over fit; the model has superfluous parameters in it. Therefore the fit of the two models will for some simulated datasets be very similar resulting in similar values of the log-likelihood. There is no guarantee that the log-likelihood for the large model in practice always will be larger than for the small (convergence problems and other numerical issues can play a role here).

To look further into the problem, one can use the PBrefdist() function for simulating the reference distribution (this reference distribution can be provided as input to PBmodcomp()). Inspection sometimes reveals that while many values are negative, they are numerically very small. In this case
one may try to replace the negative values by a small positive value and then invoke PBmodcomp() to get some idea about how strong influence there is on the resulting p-values. (The p-values get smaller this way compared to the case when only the originally positive values are used).

Author(s)

Søren Højsgaard <sorenh@math.aau.dk>

References


See Also

KRmodcomp, PBrefdist

Examples

## Not run:
(fm0 <- lmer(Reaction ~ (Days|Subject), sleepstudy))
(fm1 <- lmer(Reaction ~ Days + (Days|Subject), sleepstudy))
(fm2 <- lmer(Reaction ~ Days + I(Days^2) + (Days|Subject), sleepstudy))

NSIM <- 50 ## Simulations in parametric bootstrap; default is 1000.

## Test for no effect of Days in fm1, i.e. test fm0 under fm1
PBmodcomp(fm1, "Days", cl=1, nsim=NSIM)
PBmodcomp(fm1, ~.-Days, cl=1, nsim=NSIM)
L1 <- cbind(0, 1)
## PBmodcomp(fm1, L1, cl=1, nsim=NSIM) ## FIXME
PBmodcomp(fm1, fm0, cl=1, nsim=NSIM)
anova(fm1, fm0)

## Test for no effect of Days and Days-squared in fm2, i.e. test fm0 under fm2
PBmodcomp(fm2, "(Days+I(Days^2))", cl=1, nsim=NSIM)
PBmodcomp(fm2, ~.- Days - I(Days^2), cl=1, nsim=NSIM)
L2 <- rbind(c(0, 1, 0), c(0, 0, 1))
## PBmodcomp(fm2, L2, cl=1, nsim=NSIM) ## FIXME
PBmodcomp(fm2, fm0, cl=1, nsim=NSIM)
anova(fm2, fm0)

## Test for no effect of Days-squared in fm2, i.e. test fm1 under fm2
PBmodcomp(fm2, "I(Days^2)", cl=1, nsim=NSIM)
PBmodcomp(fm2, ~.- I(Days^2), cl=1, nsim=NSIM)
L3 <- rbind(c(0, 0, 1))
## PBmodcomp(fm2, L3, cl=1, nsim=NSIM) ## FIXME
PBmodcomp(fm2, fm1, cl=1, nsim=NSIM)
anova(fm2, fm1)
## Linear normal model:

```r
sug <- lm(sugpct ~ block + sow + harvest, data=beets)
sug.h <- update(sug, .~. -harvest)
sug.s <- update(sug, .~. -sow)

PBmodcomp(sug, "harvest", nsim=NSIM, cl=1)
PBmodcomp(sug, ~. - harvest, nsim=NSIM, cl=1)
PBmodcomp(sug, sug.h, nsim=NSIM, cl=1)
anova(sug, sug.h)
```

## Generalized linear model

```r
mm <- glm(ndead/ntotal ~ sex + log(dose), family=binomial, weight=ntotal, data=budworm)
mm0 <- update(mm, .~. -sex)

### Test for no effect of sex

PBmodcomp(mm, "sex", cl=1, nsim=NSIM)
PBmodcomp(mm, ~.-sex, cl=1, nsim=NSIM)

## PBmodcomp(mm, cbind(0, 1, 0), nsim=NSIM): FIXME

PBmodcomp(mm, mm0, cl=1, nsim=NSIM)
anova(mm, mm0, test="Chisq")
```

## Generalized linear mixed model (it takes a while to fit these)

## Not run:

```r
(gm1 <- glmer(cbind(incidence, size - incidence) ~ period + (1 | herd),
data = cbpp, family = binomial))
(gm2 <- update(gm1, .~.-period))

PBmodcomp(gm1, "period", nsim=NSIM)
PBmodcomp(gm1, ~.-period, nsim=NSIM)
PBmodcomp(gm1, gm2, nsim=NSIM)
anova(gm1, gm2)
```

## Not run:

## Linear mixed effects model:

```r
sug <- lmer(sugpct ~ block + sow + harvest + (1|block:harvest),
data=beets, REML=FALSE)
sug.h <- update(sug, .~. -harvest)
sug.s <- update(sug, .~. -sow)

anova(sug, sug.h)
PBmodcomp(sug, sug.h, nsim=NSIM, cl=1)
PBmodcomp(sug, "harvest", nsim=NSIM, cl=1)

anova(sug, sug.s)
PBmodcomp(sug, sug.s, nsim=NSIM, cl=1)
PBmodcomp(sug, "sow", nsim=NSIM, cl=1)
```
## Simulate reference distribution separately:
refdist <- PBrefdist(sug, sug.h, nsim=1000, cl=1)
refdist <- PBrefdist(sug, "harvest", nsim=1000, cl=1)
refdist <- PBrefdist(sug, ~.-harvest, nsim=1000, cl=1)

## Do computations with multiple processors:
## Number of cores:
(nc <- detectCores())
## Create clusters
c1 <- makeCluster(rep("localhost", nc))

## Then do:
refdist <- PBrefdist(sug, sug.h, nsim=1000, cl=c1)

## It is recommended to stop the clusters before quitting R:
stopCluster(c1)

## End(Not run)

---

**sat_modcomp**

*F-test and degrees of freedom based on Satterthwaite approximation*

### Description

An approximate F-test based on the Satterthwaite approach.

### Usage

```r
SATmodcomp(
  largeModel,  # Large model
  smallModel,   # Small model
  betaH = 0,    # Hypothesis parameter
  details = 0,  # Print details
  eps = sqrt(.Machine$double.eps)
)

## S3 method for class 'lmerMod'
SATmodcomp(
  largeModel,  # Large model
  smallModel,   # Small model
  betaH = 0,    # Hypothesis parameter
  details = 0,  # Print details
  eps = sqrt(.Machine$double.eps)
)
```
Arguments

largeModel  An lmer model
smallModel  An lmer model or a restriction matrix
betaH      A number or a vector of the beta of the hypothesis, e.g. L beta=L betaH. If
           smallModel is a model object then betaH=0.
details    If larger than 0 some timing details are printed.
eps         A small number.

Details

Notice: It cannot be guaranteed that the results agree with other implementations of the Satterthwaite approach!

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References


See Also

getKR, lmer, vcovAdj, PBmodcomp, KRmodcomp

Examples

(fm0 <- lmer(Reaction ~ (Days|Subject), sleepstudy))
(fm1 <- lmer(Reaction ~ Days + (Days|Subject), sleepstudy))
(fm2 <- lmer(Reaction ~ Days + I(Days^2) + (Days|Subject), sleepstudy))

## Test for no effect of Days in fm1, i.e. test fm0 under fm1
SATmodcomp(fm1, "Days")
SATmodcomp(fm1, ~.-.Days)
L1 <- cbind(0, 1)
SATmodcomp(fm1, L1)
SATmodcomp(fm1, fm0)
anova(fm1, fm0)

## Test for no effect of Days and Days-squared in fm2, i.e. test fm0 under fm2
SATmodcomp(fm2, "(Days+I(Days^2))")
SATmodcomp(fm2, ~.- Days - I(Days^2))
L2 <- rbind(c(0, 1, 0), c(0, 0, 1))
SATmodcomp(fm2, L2)
SATmodcomp(fm2, fm0)
anova(fm2, fm0)

## Test for no effect of Days-squared in fm2, i.e. test fm1 under fm2
SATmodcomp(fm2, "I(Days^2)")
SATmodcomp(fm2, ~ - I(Days^2))
L3 <- rbind(c(0, 0, 1))
SATmodcomp(fm2, L3)
SATmodcomp(fm2, fm1)
anova(fm2, fm1)
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