# Package ‘simr’

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**Type**  Package 
**Title**  Power Analysis for Generalised Linear Mixed Models by Simulation 
**Description**  Calculate power for generalised linear mixed models, using simulation. Designed to work with models fit using the 'lme4' package. Described in Green and MacLeod, 2016 <doi:10.1111/2041-210X.12504>. 
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doFit

Description

This is normally an internal function, but it can be overloaded to extend simr to other packages.

Usage

doFit(y, fit, subset, ...)

Arguments

y
  new values for the response variable (vector or matrix depending on the model).
fit
  a previously fitted model object.
subset
  boolean vector specifying how much of the data to use. If missing, the model is fit to all the data. This argument needs to be implemented for powerCurve to work.
...
  additional options.

Value

  a fitted model object.
doSim

Generate simulated response variables.

Description

This is normally an internal function, but it can be overloaded to extend simr to other packages.

Usage

doSIm(object, ...)  

Arguments

object  an object to simulate from, usually a fitted model.
...  additional options.

Value

a vector containing simulated response values (or, for models with a multivariate response such as binomial glm’s, a matrix of simulated response values). Suitable as input for doFit.

doTest

Apply a hypothesis test to a fitted model.

Description

This is normally an internal function, but it can be overloaded to extend simr to other packages.

Usage

doTest(object, test, ...)  

Arguments

object  an object to apply a statistical test to, usually a fitted model.
test  a test function, see tests.
...  additional options.

Value

a p-value with attributes describing the test.
extend

Extend a longitudinal model.

Description

This method increases the sample size for a model.

Usage

extend(object, along, within, n, values)

Arguments

object  a fitted model object to extend.
along the name of an explanatory variable. This variable will have its number of levels extended.
within names of grouping variables, separated by "+" or ",". Each combination of groups will be extended to n rows.
n number of levels: the levels of the explanatory variable will be replaced by 1, 2, 3, ..., n for a continuous variable or a, b, c, ..., n for a factor.
values alternatively, you can specify a new set of levels for the explanatory variable.

Details

extend takes "slices" through the data for each unique value of the extended variable. An extended dataset is built from n slices, with slices duplicated if necessary.

Value

A copy of object suitable for doSim with an extended dataset attached as an attribute named newData.

Examples

fm <- lmer(y ~ x + (1|g), data=simdata)
nrow(example)
fmx1 <- extend(fm, along="x", n=20)
nrow(getData(fmx1))
fmx2 <- extend(fm, along="x", values=c(1,2,4,8,16))
nrow(getData(fmx2))
getData

Description
Get an object's data.

Usage
getData(object)
getData(object) <- value

Arguments
object a fitted model object (e.g. an object of class merMod or lm).
value a new data.frame to replace the old one. The new data will be stored in the
newData attribute.

Details
Looks for data in the following order:

1. The object's newData attribute, if it has been set by simr.
2. The data argument of getCall(object), in the environment of formula(object).

Value
A data.frame with the required data.

Examples

lm1 <- lmer(y ~ x + (1|g), data=simdata)
X <- getData(lm1)
**lastResult**

*Recover an unsaved simulation*

**Description**

Simulations can take a non-trivial time to run. If the user forgets to assign the result to a variable this method can recover it.

**Usage**

`lastResult()`

**See Also**

`.Last.value`

**Examples**

```r
fm1 <- lmer(y ~ x + (1|g), data=simdata) 
powerSim(fm1, nsim=10) 
ps1 <- lastResult()
```

---

**makeGlmer**

*Create an artificial mixed model object*

**Description**

Make a `merMod` object with the specified structure and parameters.

**Usage**

```r
makeGlmer(formula, family, fixef, VarCorr, data)
```

```r
makeLmer(formula, fixef, VarCorr, sigma, data)
```

**Arguments**

- `formula`: a formula describing the model (see `glmer`).
- `family`: type of response variable (see `family`).
- `fixef`: vector of fixed effects.
- `VarCorr`: variance and covariances for random effects. If there are multiple random effects, supply their parameters as a list.
- `data`: data.frame of explanatory variables.
- `sigma`: residual variance.
**Description**

These functions can be used to change the size of a model’s fixed effects, its random effect variance/covariance matrices, or its residual variance. This gives you more control over simulations from the model.

**Usage**

```r
fixef(object) <- value
coef(object) <- value
VarCorr(object) <- value
sigma(object) <- value
scale(object) <- value
```

**Arguments**

- **object** a fitted model object.
- **value** new parameter values.

**Details**

New values for `VarCorr` are interpreted as variances and covariances, not standard deviations and correlations. New values for `sigma` and `scale` are interpreted on the standard deviation scale. This means that both `VarCorr(object) <- VarCorr(object)` and `sigma(object) <- sigma(object)` leave object unchanged, as you would expect.

`sigma <-` will only change the residual standard deviation, whereas `scale <-` will affect both `sigma` and `VarCorr`.

These function can be used to change the value of individual parameters, such as a single fixed effect coefficient, using standard R subsetting commands.

**See Also**

- `getData` if you want to modify the model’s data.

**Examples**

```r
fm <- lmer(y ~ x + (1|g), data=simdata)
fixef(fm)
fixef(fm)["x"] <- -0.1
fixef(fm)
```
powerCurve

Estimate power at a range of sample sizes.

Description

This function runs \texttt{powerSim} over a range of sample sizes.

Usage

\begin{verbatim}
powerCurve(fit, test = fixed(getDefaultXname(fit)), sim = fit, 
  along = getDefaultXname(fit), within, breaks, seed, fitOpts = list(),
  testOpts = list(), simOpts = list(), ...)
\end{verbatim}

Arguments

- \textit{fit}: a fitted model object (see \texttt{doFit}).
- \textit{test}: specify the test to perform. By default, the first fixed effect in \textit{fit} will be tested. (see: \texttt{tests}).
- \textit{sim}: an object to simulate from. By default this is the same as \textit{fit} (see \texttt{doSim}).
- \textit{along}: the name of an explanatory variable. This variable will have its number of levels varied.
- \textit{within}: names of grouping variables, separated by ",+" or ",.". Each combination of groups will be extended to \(n\) rows.
- \textit{breaks}: number of levels of the variable specified by \textit{along} at each point on the power curve.
- \textit{seed}: specify a random number generator seed, for reproducible results.
- \textit{fitOpts}: extra arguments for \texttt{doFit}.
- \textit{testOpts}: extra arguments for \texttt{doTest}.
- \textit{simOpts}: extra arguments for \texttt{doSim}.
- \ldots: any additional arguments are passed on to \texttt{simOptions}. Common options include:
  - \textit{nsim}: the number of simulations to run (default is 1000).
  - \textit{alpha}: the significance level for the statistical test (default is 0.05).
  - \textit{progress}: use progress bars during calculations (default is TRUE).

See Also

\texttt{print.powerCurve, summary.powerCurve, confint.powerCurve}
Examples

```r
## Not run:
fm <- lmer(y ~ x + (1|g), data=simdata)
pcl <- powerCurve(fm)
pcl2 <- powerCurve(fm, breaks=c(4,6,8,10))
print(pcl2)
plot(pcl2)

## End(Not run)
```

**powerSim**

*Estimate power by simulation.*

Description

Perform a power analysis for a mixed model.

Usage

```r
powerSim(fit, test = fixed(getDefaultXname(fit)), sim = fit,
          fit0pts = list(), test0pts = list(), sim0pts = list(), seed, ...)
```

Arguments

- **fit**: a fitted model object (see `doFit`).
- **test**: specify the test to perform. By default, the first fixed effect in `fit` will be tested. (see: `tests`).
- **sim**: an object to simulate from. By default this is the same as `fit` (see `doSim`).
- **fit0pts**: extra arguments for `doFit`.
- **test0pts**: extra arguments for `doTest`.
- **sim0pts**: extra arguments for `doSim`.
- **seed**: specify a random number generator seed, for reproducible results.
- **...**: any additional arguments are passed on to `simrOptions`. Common options include:
  - `nsim`: the number of simulations to run (default is 1000).
  - `alpha`: the significance level for the statistical test (default is 0.05).
  - `progress`: use progress bars during calculations (default is TRUE).

See Also

- `print.powerSim`, `summary.powerSim`, `confint.powerSim`

Examples

```r
fm1 <- lmer(y ~ x + (1|g), data=simdata)
powerSim(fm1, nsim=10)
```
print.powerSim  Report simulation results

Description

Describe and extract power simulation results

Usage

```r
## S3 method for class 'powerSim'
print(x, alpha = x$alpha, level = 0.95, ...)

## S3 method for class 'powerCurve'
print(x, ...)

## S3 method for class 'powerSim'
summary(object, alpha = object$alpha, level = 0.95,
         method = getSimrOption("binom"), ...)

## S3 method for class 'powerCurve'
summary(object, alpha = object$alpha, level = 0.95,
         method = getSimrOption("binom"), ...)

## S3 method for class 'powerSim'
confint(object, parm, level = 0.95,
         method = getSimrOption("binom"), alpha = object$alpha, ...)

## S3 method for class 'powerCurve'
confint(object, parm, level = 0.95,
         method = getSimrOption("binom"), ...)
```

Arguments

- `x` a `powerSim` or `powerCurve` object
- `alpha` the significance level for the statistical test (default is that used in the call to `powerSim`).
- `level` confidence level for power estimate
- `...` additional arguments to pass to `binom::binom.confint()`
  - `alpha` refers to the threshold for an effect being significant and thus directly determines the point estimate for the power calculation. `level` is the confidence level that is calculated for this point evidence and determines the width/coverage of the confidence interval for power.
- `object` a `powerSim` or `powerCurve` object
- `method` method to use for computing binomial confidence intervals (see `binom::binom.confint()`)
- `parm` currently ignored, included for S3 compatibility with `stats::confint`
See Also

`binom::binom.confint, powerSim, powerCurve`

---

**simdata**  
*Example dataset.*

**Description**

A simple artificial data set used in the tutorial. There are two response variables, a Poisson count \( z \) and a Gaussian response \( y \). There is a continuous predictor \( x \) with ten values \( \{1, 2, \ldots, 10\} \) and a categorical predictor \( g \) with three levels \( \{a, b, c\} \).

---

**simrOptions**  
*Options Settings for simr*

**Description**

Control the default behaviour of simr analyses.

**Usage**

```r
simrOptions(...)  
getSimrOption(opt)
```

**Arguments**

```r
...  
opt  
```

- \( ... \) a list of names to get options, or a named list of new values to set options.
- \( opt \) option name (character string).

**Value**

- \( getSimrOption \) returns the current value for the option \( x \).
- \( simrOptions \) returns
  1. a named list of all options, if no arguments are given.
  2. a named list of specified options, if a list of option names is given.
  3. (invisibly) a named list of changed options with their previous values, if options are set.
**Options in simr**

Options that can be set with this method (and their default values).

- `nsim` default number of simulations (1000).
- `alpha` default confidence level (0.05).
- `progress` use progress bars during calculations (TRUE).
- `binom` method for calculating confidence intervals ("exact").
- `pbnsim` number of simulations for parametric bootstrap tests using pbkrtest (100).
- `pcmin` minimum number of levels for the smallest point on a `powerCurve` (3).
- `pcmax` maximum number of points on the default `powerCurve` (10).
- `observedPowerWarning` warn if an unmodified fitted model is used (TRUE).
- `carTestType` type of test, i.e. type of sum of squares, for tests performed with `car::anova` ("II").
- `lmerTestDdf` approximation to use for denominator degrees of freedom for tests performed with `lmerTest` ("Satterthwaite"). Note that setting this option to "lme4" will reduce the `lmerTest` model to an `lme4` model and break functionality based on `lmerTest`.
- `lmerTestType` type of test, i.e. type of sum of squares, for F-tests performed with `lmerTest::anova` (2). Note that unlike the tests performed with `car::anova`, the test type must be given as a number and not a character.

**Examples**

```r
getSimOption("nsim")
oldopts <- simrOptions(nsim=5)
getSimOption("nsim")
simrOptions(oldopts)
getSimOption("nsim")
```

**Description**

Specify a statistical test to apply

**Usage**

```r
fixed(xname, method = c("z", "t", "f", "chisq", "anova", "lr", "sa", "kr", "pb"))

compare(model, method = c("lr", "pb"))

fcompare(model, method = c("lr", "kr", "pb"))
```
rcompare(model, method = c("lr", "pb"))

Arguments

- **xname**: an explanatory variable to test (character).
- **method**: the type of test to apply (see Details).
- **model**: a null model for comparison (formula).

Details

- **fixed**: Test a single fixed effect, specified by xname.
- **compare**: Compare the current model to a smaller one specified by the formula model.
- **fcompare, rcompare**: Similar to compare, but only the fixed/random part of the formula needs to be supplied.
- **random**: Test the significance of a single random effect.

Value

A function which takes a fitted model as an argument and returns a single p-value.

Methods

The **method** argument can be used to specify one of the following tests. Note that "z" is an asymptotic approximation for models not fitted with **glmer** and "kr" will only work with models fitted with **lmer**.

- **z**: Z-test for models fitted with **glmer** (or **glm**), using the p-value from **summary**. For models fitted with **lmer**, this test can be used to treat the t-values from **summary** as z-values, which is equivalent to assuming infinite degrees of freedom. This asymptotic approximation seems to perform well for even medium-sized data sets, as the denominator degrees of freedom are already quite large (cf. Baayen et al. 2008) even if calculating their exact value is analytically unsolved and computationally difficult (e.g. with Satterthwaite or Kenward-Roger approximations). Setting **alpha**=0.045 is roughly equal to the t=2 threshold suggested by Baayen et al. (2008) and helps compensate for the slightly anti-conservative approximation.

- **t**: T-test for models fitted with **lm**. Also available for mixed models when **lmerTest** is installed, using the p-value calculated using the Satterthwaite approximation for the denominator degrees of freedom by default. This can be changed by setting **lmerTestDf**, see **simrOptions**.

- **lr**: Likelihood ratio test, using **anova**.

- **f**: Wald F-test, using **car::Anova**. Useful for examining categorical terms. For to models fitted with **lmer**, this should yield equivalent results to **method=’kr’**. Uses Type-II tests by default, this can be changed by setting **carTestType**, see **simrOptions**.

- **chisq**: Wald Chi-Square test, using **car::Anova**. Please note that while this is much faster than the F-test computed with Kenward-Roger, it is also known to be anti-conservative, especially for small samples. Uses Type-II tests by default, this can be changed by setting **carTestType**, see **simrOptions**.
anova: ANOVA-style F-test, using `anova` and `lmerTest::anova`. For ‘lm’, this yields a Type-I (sequential) test (see `anova`); to use other test types, use the F-tests provided by `car::Anova()` (see above). For `lmer`, this generates Type-II tests with Satterthwaite denominator degrees of freedom by default, this can be changed by setting `lmerTestDf` and `lmerTestType`, see `simrOptions`.

kr: Kenward-Roger test, using `KRmodcomp`. This only applies to models fitted with `lmer`, and compares models with different fixed effect specifications but equivalent random effects.

pb: Parametric bootstrap test, using `PBmodcomp`. This test will be very accurate, but is also very computationally expensive.

Tests using `random` for a single random effect call `exactRLRT`.

References


Examples

```R
lm1 <- lmer(y ~ x + (x|g), data=simdata)
lm0 <- lmer(y ~ x + (1|g), data=simdata)
anova(lm1, lm0)
compare(~ x + (1|g))(lm1)
rcmpare(~ (1|g))(lm1)
## Not run: powersim(fm1, compare(~ x + (1|g)))
```
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