Package: partR2 (via r-universe)

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Title Partitioning R2 in GLMMs

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Description Partitioning the R2 of GLMMs into variation explained by each predictor and combination of predictors using semi-partial (part) R2 and inclusive R2. Methods are based on the R2 for GLMMs described in Nakagawa & Schielzeth (2013) and Nakagawa, Johnson & Schielzeth (2017).

License GPL (>= 2)

URL https://github.com/mastoffel/partR2

BugReports https://github.com/mastoffel/partR2/issues

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`partR2-package` *partR2: Partitioning R2 in generalized linear mixed models*

Description

The partR2 package provides a simple way to estimate R2 in mixed models fitted with lme4 as well as part (semi-partial) R2 for specific predictors and combinations of predictors, among other several other statistics. Here is an overview:

Details

- Marginal and conditional R2 for LMMs and GLMMs.
- Part (semi-partial) R2 which estimate the explained variance for specific predictors and combinations of predictors.
- Structure coefficients (SC). SC are the correlation between a predictor and the predicted response (called the linear predictor), independent of the other predictors.
- Inclusive R2 (IR2), which estimate the the total variance explained by a predictor independent of other predictors. IR2 is estimated with SC^2 * R2_full_model.
- Beta weights, which are standardised regression coefficients. If beta is a model estimate for variable x, and y is the response,then the beta weight is beta * (sd(x)/sd(y).
- Confidence intervals for all estimates using parametric bootstrapping.

The package has one main function `partR2` which takes a fitted model from lme4. At the moment, Gaussian, Poisson and binomial models are supported. For Poisson and non-binary binomial models, `partR2` adds an observational level random effect to model additive overdispersion (if an olre is not fitted already).

The `summary.partR2` function provides an extended summary with R2s, semi-partial R2s, model estimates and structure coefficients. The `forestplot` function provides a means of plotting the results.

References

Nakagawa, S., & Schielzeth, H. (2013). *A general and simple method for obtaining R2 from generalized linear mixed-effects models*. Methods in Ecology and Evolution, 4(2), 133-142.

Nakagawa, S., Johnson, P. C., & Schielzeth, H. (2017). *The coefficient of determination R2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded*. Journal of the Royal Society Interface, 14(134), 20170213.

`biomass` *biomass dataset*

Description

biomass dataset

Details

This is an simulated dataset about grassland biodiversity and biomass.

In brief the imaginary sampling design of the simulated dataset is as follows. Invertebrates were sampled once every year over 10 successive years (‘Year‘) from 20 different populations (‘Population‘). For each sample, the temperature (‘Temperature‘) and (‘Precipitation‘) were measured and overall species diversity (‘SpeciesDiversity‘) and biomass were recorded (‘Biomass‘).

`forestplot` *Plot a partR2 object*

Description

Forestplot of the partR2 results

Usage

```
forestplot(
  x,
  type = c("R2", "BW", "SC", "IR2", "Ests"),
  line_size = 0.5,
  text_size = 12,
  point_size = 3
)
```

Arguments

x	A partR2 object.
type	Plot either "R2" or "SC" or "Ests" for R2s, structure coefficients or model estimates.
line_size	Controls size of all lines in the forestplot. Defaults to 0.5 which usually looks good.
text_size	Base text size, default is 12.
point_size	Point size, default is 3.

Grasshoppers *Grasshoppers dataset*

Description

Grasshoppers dataset

Details

This is a real dataset from grasshoppers.

This dataset contains data on spatial variation in color morph ratios in a color-polymorphic species of grasshopper (Dieker et al 2018). Individuals of this species occur either in green or a brown color variant and the dataset contains counts of brown and green individuals (seprarated for females and males) from 42 sites sampled in the field. All 'Bio' variables describe various aspects of ecologically relevant climatic conditions (see Karger et al. 2017).

References

Dieker, P., L. Beckmann, J. Teckentrup, and H. Schielzeth (2018) *Spatial analyses of two colour polymorphisms in an alpine grasshopper reveal a role of small-scale heterogeneity*. Ecology and Evolution, 8, 7273-7284.

Karger, D. N., O. Conrad, J. Bohner, T. Kawohl, H. Kreft, R. W. Soria-Auza, N. E. Zimmermann, H. P. Linder, and M. Kessler (2017) *Data descriptor: Climatologies at high resolution for the earth's land surface areas*. Scientific Data, 4, 170122.

GuineaPigs *GuineaPigs dataset*

Description

GuineaPigs dataset

Details

This is a real dataset from guinea pigs.

The dataset contains testosterone measurements ('Testo') of 31 male guinea pigs, each measured at 5 time points. (age between 120 and 240 days at 30-day intervals). As covariates the dataset contains the time point of measurement ('Time') and a rank index derived from behavioral observations ('Rank') around the time of measurement (see Mutwill et al. in prep. for details).

mergeR2 *Merge partR2 objects to combine R2s for main effects and interactions*

Description

The function merges partR2 object based on a full model with interactions with a partR2 object based on a reduced model without interaction. The reduced model is used to infer main effect semi-partial R2s. This function essentially takes over the complete partR2 object for the full model and adds semi-partial R2s which have been calculated based on the reduced model and are not already present in the full model partR2 object (which can be main effects). The function also combines the bootstrap estimates, accessible with partR2_obj$R2_boot.

Usage

```
mergeR2(R2_full, ...)
```

Arguments

R2_full	partR2 object for the full model, with the interaction (but not the main effects) in partvars.
...	other partR2 objects, which do not contain the interaction so that the semi-partial R2s for the main effects could be calculated.

Details

This function is experimental and should be used with caution. See vignette or paper on how to use it to obtain semi-partial R2s for main effects which are also involved in interactions.

Value

Returns an object of class partR2, which takes most components from the full model except for semi-partial R2s.

Examples

```
data(biomass)
library(lme4)

# scale data
biomass[] <- lapply(biomass, function(x) if (is.double(x)) scale(x) else x)

# Full model
mod_full <- lmer(Biomass ~ Year + Temperature * Precipitation + SpeciesDiversity + (1|Population),
            data = biomass)
# Semi-partial R2 for interaction and all other predictors of interest
(R2_full <- partR2(mod_full, partvars = c("Temperature:Precipitation", "SpeciesDiversity", "Year"),
data = biomass))

# model without interaction to get main effect semi-partial R2s
mod_noIA <- lmer(Biomass ~ Year + Temperature + Precipitation + SpeciesDiversity + (1|Population),
            data = biomass)
(R2_noIA <- partR2(mod_noIA, partvars = c("Temperature", "Precipitation"), data = biomass))

# combine both
(R2_comb <- mergeR2(R2_full, R2_noIA))
```

---

partR2 *Partitioning R2 (R-square) in mixed models*

Description

R2, semi-partial (part) R2 for predictors and their combinations as well as inclusive R2, structure coefficients and beta weights for Gaussian, Poisson and binomial mixed models.

Usage

```
partR2(
  mod,
  partvars = NULL,
  data = NULL,
  R2_type = "marginal",
  max_level = NULL,
  nboot = NULL,
  CI = 0.95,
  parallel = FALSE,
  expct = "meanobs",
```

```
  olre = TRUE,
  partbatch = NULL,
  allow_neg_r2 = FALSE
)
```

Arguments

mod	Fitted lme4 model (a merMod object).
partvars	Character vector specifying the predictors (fixed effects) for which to partition the R2. Can be main effects like c("Var1", "Var2") and interactions ("Var1:Var2"). Predictors specified in partvars have to be named precisely like the terms in the formula to fit the model.
data	The data.frame used to fit the lme4 model. If not provided, partR2 will try to fetch it.
R2_type	"marginal" or "conditional" R2. With "marginal", the variance explained by fixed effects is calculated. With "conditional", the variance explained by both fixed and random effects is calculated.
max_level	Level up to which shared semi-partial R2s are calculated. The number of sets for which to calculate R2 increases exponentially, i.e. for 10 variables 2^10 - 1 R2s can be calculated. If you are only interested in the unique but not the shared effects, use max_level = 1. If interested in unique effects and combinations of two terms, use max_level = 2 etc.
nboot	Number of parametric bootstrap iterations for confidence interval estimation (defaults to NULL, i.e. no bootstrapping). Larger numbers of bootstraps give a better asymptotic CI, but may be time-consuming. Bootstrapping can be switched on by setting `nboot = 1000`.
CI	Width of the required confidence interval between 0 and 1 (defaults to 0.95).
parallel	If TRUE, computation uses `future` within `furrr::map` which allows parallelisation. However, it is necessary to specify a plan before running `partR2()`. To see which options you have, check `?future::plan` and have a look at our vignette for details. When running RStudio, usually `plan(multisession, workers = 4)` is a good choice, when you want to use 4 cores. To detect how many cores you have, use `parallel::detectCores()`. If no plan is specified, `partR2` will simply run sequentially.
expct	A string specifying the method for estimating the expectation in Poisson models with log link and in Binomial models with logit link (in all other cases the argument is ignored). The only valid terms are 'meanobs', 'latent', 'none' (and 'liability for binary and proportion data). With the default 'meanobs', the expectation is estimated as the mean of the observations in the sample. With 'latent', the expectation is estimated from estimates of the intercept and variances on the link scale. While this is a preferred solution, it is susceptible to the distribution of fixed effect covariates and gives appropriate results typically only when all covariances are centered to zero. With 'liability' estimates follow formulae as presented in Nakagawa & Schielzeth (2010). With 'none', R2 is calculated without distribution specific variance in the denominator.

olre	Logical, defaults to TRUE. This argument allows the user to prevent the automatic fitting of an observation level random effect (by setting it to FALSE) in Poisson and binomial models. The OLRE is used to account for overdispersion.
partbatch	List of character vectors with predictors that should be fitted and removed together. For example, partbatch = list(batch1 = c("V1", "V2", "V3"), batch2 = c("V4", "V5", "V6")) would calculate part R2 only for combinations of predictors which contain the variables V1, V2, V3 together or/and V4,V5,V6 together. This is useful when the number of potential subsets gets too large to be computationally practical, for example when dummy coding is used. See our vignette for details. This feature is still experimental and should be used with caution.
allow_neg_r2	Calculating part R2 involves fitting two models, one with and one without the predictor of interest. In cases where the predictor has little association with the response, the resulting part R2 value can become negative. By default we set negative values to 0, but by setting this parameter to TRUE, R2 values can become negative.

Value

Returns an object of class partR2 that is a a list with the following elements:

call	model call
R2_type	Marginal or conditional R2
R2	R2 and confidence intervals for full model and semi-partial R2 for predictors and their combinations
SC	Structure coefficients and confidence intervals. SC are the correlation between a predictor and the predicted response.
IR2	Inclusive R2. This is SC^2 * R2_full.
BW	Standardised model estimates (beta weights) for fixed effects. Beta weights for Gaussian models are calculated as beta * sd(x)/sd(y), with beta being the estimated slope of a fixed effect for predictor x and response y. Beta weight for Non-Gaussian models are calculated as beta * sd(x). Beta weights for interactions or polynomial terms are not informative at the moment and we recommend users to standardise variables themselves before fitting the model and to look at the model estimates (Ests) instead of beta weights (BW) in the partR2 output. See vignette for details.
Ests	Model estimates and confidence intervals.
R2_boot	Parametric bootstrap samples for R2 for full model and partitions
SC_boot	Parametric bootstrap samples for structure coefficients
IR2_boot	Parametric bootstrap samples for inclusive R2 values
BW_boot	Parametric bootstrap samples for beta weights
Ests_boot	Parametric bootstrap samples for model estimates
partvars	Predictors to partition
CI	Coverage of the confidence interval as specified by the CI argument.
boot_warnings	Potential warnings from estimating partial R2s during parametric bootstrapping
boot_message	Potential messages from estimating partial R2s during parametric bootstrapping. Common are for example singularity messages in lme4.

References

Nakagawa, S., & Schielzeth, H. (2013). *A general and simple method for obtaining R2 from generalized linear mixed-effects models*. Methods in Ecology and Evolution, 4(2), 133-142.

Nakagawa, S., Johnson, P. C., & Schielzeth, H. (2017). *The coefficient of determination R2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded*. Journal of the Royal Society Interface, 14(134), 20170213.

Examples

```
data(biomass)
library(lme4)

# scale data
biomass[] <- lapply(biomass, function(x) if (is.double(x)) scale(x) else x)

# Gaussian data
mod <- lmer(Biomass ~ Year + Temperature + Precipitation + SpeciesDiversity + (1 | Population),
  data = biomass)

# R2
(R2_1 <- partR2(mod))

# R2 with CI
(R2_2 <- partR2(mod, R2_type = "marginal", nboot = 15, CI = 0.95))

# Part (semi-partial) R2s with CIs
(R2_3 <- partR2(mod,
  partvars = c("SpeciesDiversity", "Temperature", "Precipitation"),
  R2_type = "marginal", nboot = 10, CI = 0.95
))
```

---

print.partR2 *Print a partR2 object*

Description

Displays the results a partR2object (i.e. the result of a partR2 function call) in a nice form.

Usage

```
## S3 method for class 'partR2'
print(x, round_to = 4, ...)
```

Arguments

x	partR2 object returned from one of the partR2 functions
round_to	defaults to 4 (decimals)
...	Additional arguments; none are used in this method.

Value

No return value, prints concise results of partR2 calculation.

`summary.partR2` *Complete summary of a partR2 object*

Description

Displays extended results of partR2, including R2, part (semi-partial) R2, inclusive R2, structure coefficients and beta weights.

Usage

```
## S3 method for class 'partR2'
summary(object, round_to = 4, ests = FALSE, ...)
```

Arguments

`object`	partR2 object returned from one of the partR2 functions
`round_to`	Defaults to 4 (decimals)
`ests`	Defaults to FALSE, if TRUE, also prints raw model estimates.
`...`	Additional arguments; not used at the moment

Value

No return value, prints extended summary of partR2 calculation.

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