Package 'r2mlm'

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Type Package

Title R-Squared Measures for Multilevel Models

Version 0.1.0

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Description Generates both total- and level-specific R-squared measures from Rights and Sterba's (2019) <doi:10.1037/met0000184> framework of R-squared measures for multilevel
models with random intercepts and/or slopes, which is based on a completely full decomposition of variance. Additionally generates graphical representations of these R-squared measures to allow visualizing and interpreting all measures in the framework together as an integrated set. This framework subsumes 10 previously-developed R-squared measures for multilevel models as special cases of 5 measures from the framework, and it also includes several newly-developed measures. Measures in the framework can be used to compute R-squared differences when comparing multilevel models (following proce-
dures in Rights & Sterba (2020) <doi:10.1080/00273171.2019.1660605>).

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Encoding UTF-8

LazyData true

Imports dplyr (>= 0.8.5), magrittr (>= 1.5), rlang (>= 0.4.6), stringr (>= 1.4.0), tidyselect (>= 1.0.0)

Depends lme4 (>= 1.1.23), nlme (>= 3.1.14), R (>= 3.2.0)

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Suggests testthat, Matrix

URL https://github.com/mkshaw/r2mlm

BugReports https://github.com/mkshaw/r2mlm/issues

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R topics documented:

`r2mlm` *Compute R-squared values for multilevel models, automatically inputting parameter estimates.*

Description

`r2mlm` reads in a multilevel model (MLM) object generated using `lmer` or `nlme`, and outputs all relevant R-squared measures from the Rights and Sterba (2019) framework of multilevel model R-squared measures, which can be visualized together as a set using the outputted bar chart decompositions of outcome variance. That is, when predictors are cluster-mean-centered, all R-squared measures from Rights & Sterba (2019) Table 1 and decompositions from Rights & Sterba (2019) Figure 1 are outputted. When predictors are not cluster-mean-centered, the total R-squared measures from Rights & Sterba (2019) Table 5, as well as bar chart decompositions are outputted. Any number of level-1 and/or level-2 predictors is supported. Any of the level-1 predictors can have random slopes.

Usage

```
r2mlm(model)
```

Arguments

`model`	A model generated using `lmer` or `nlme`.

Details

`r2mlm` first determines whether a given model was generated using `lmer` or `nlme`, then passes the model to helper functions that pull the raw data and parameter estimates from the model, and pass that information to `r2mlm_manual`.

Value

If the input is a valid model, then the output will be a list and associated graphical representation of R-squared decompositions. If the model is not valid, it will return an error prompting the user to input a valid model.

See Also

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. Psychological Methods, 24(3), 309–338.

Other r2mlm single model functions: `r2mlm_manual()`

Examples

```
# Using lme4 for your model

# The "bobyqa" optimizer is required for this particular model to converge

model_lme4 <- lmer(satisfaction ~ 1 + salary_c + control_c + salary_m + control_m +
s_t_ratio + (1 + salary_c + control_c| schoolID), data = teachsat, REML =
TRUE, control = lmerControl(optimizer = "bobyqa"))

r2mlm(model_lme4)

# Using nlme for your model

model_nlme <- lme(satisfaction ~ 1 + salary_c + control_c + salary_m +
                  control_m + s_t_ratio,
                  random = ~ 1 + salary_c + control_c | schoolID,
                  data = teachsat,
                  method = "REML",
                  control = lmeControl(opt = "optim"))

r2mlm(model_nlme)
```

`r2mlm_comp` *Compute R-squared differences between two multilevel models, automatically inputting parameter estimates.*

Description

`r2mlm_comp` reads in two multilevel models (MLMs) (generated using `lmer` or `nlme`) under comparison (designated Model A and Model B), and outputs all R-squared measures in the Rights and Sterba (2019) framework for both models, as well as R-squared differences between the two models. Definitions of these R-squared difference measures are provided in Rights & Sterba (2020) Table 1; importantly, to detect the impact of a specific kind of term (e.g., the kind of term added to Model A to form Model B), a particular target single-source R-squared difference measure from this framework is used. For instructions on how to identify which target single-source R-squared difference measure to interpret to detect the impact of which kind of term that distinguishes Model A from B, see Rights and Sterba (2020) Table 2. Additionally, this function produces side-by-side graphical comparisons of the R-squared measures for Model A vs. Model B that can be used to visualize changes in each measure across models. This function assumes all level-1 predictors are cluster-mean-centered, for reasons described in Rights & Sterba (2020). Any number of level-1 and/or level-2 predictors is supported and any of the level-1 predictors can have random slopes.

This function can be used with either the hierarchical or the simultaneous model-building approach described in Rights and Sterba (2020). This function can be used with either nested or non-nested model comparisons (in which R-squared estimates for Model A are subtracted from those for Model B).

Usage

```
r2mlm_comp(modelA, modelB)
```

Arguments

`modelA, modelB`	Models generated using `lmer` or `nlme`.

Details

Assumes that both models are fit with lmer or both models are fit with nlme.

Value

If the inputs are valid models, then the output will be a list and associated graphical representation of R-squared decompositions. If the models are not valid, the function will return an error prompting the user to input valid models.

See Also

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. Psychological Methods, 24(3), 309–338.

Rights, J. D., & Sterba, S. K. (2020). New recommendations on the use of R-squared differences in multilevel model comparisons. Multivariate Behavioral Research.

Other r2mlm model comparison functions: `r2mlm_comp_manual()`

Examples

```
# Using lme4 for your model
# The "bobyqa" optimizer is required for these particular models to converge

# Model A, no "salary" components included

modelA_lme4 <- lmer(satisfaction ~ 1 + control_c + control_m + s_t_ratio + (1
+ control_c | schoolID), data = teachsat, REML = TRUE, control =
lmerControl(optimizer = "bobyqa"))

# Model B, full model with "salary" components included

modelB_lme4 <- lmer(satisfaction ~ 1 + salary_c + control_c + salary_m +
control_m + s_t_ratio + (1 + salary_c + control_c | schoolID), data =
teachsat, REML = TRUE, control = lmerControl(optimizer = "bobyqa"))

r2mlm_comp(modelA_lme4, modelB_lme4)

# Using nlme for your model
```

```
# Model A, no "salary" components included

modelA_nlme <- lme(satisfaction ~ 1 + control_c + control_m + s_t_ratio,
                   random = ~ 1 + control_c | schoolID,
                   data = teachsat,
                   method = "REML",
                   control = lmeControl(opt = "optim"))

# Model B, full model with "salary" components included

modelB_nlme <- lme(satisfaction ~ 1 + salary_c + control_c + salary_m +
                   control_m + s_t_ratio,
                   random = ~ 1 + salary_c + control_c | schoolID,
                   data = teachsat,
                   method = "REML",
                   control = lmeControl(opt = "optim"))

r2mlm_comp(modelA_nlme, modelB_nlme)
```

`r2mlm_comp_manual` *Compute R-squared differences between two multilevel models, manually inputting parameter estimates.*

Description

`r2mlm_comp_manual` reads in raw data and multilevel model (MLM) parameter estimates from two separate models under comparison (designated Model A and Model B), and outputs all R-squared measures in the Rights and Sterba (2019) framework for both models, as well as R-squared differences between the two models. Definitions of these R-squared difference measures are provided in Rights & Sterba (2020) Table 1; importantly, to detect the impact of a specific kind of term (e.g., the kind of term added to Model A to form Model B), a particular target single-source R-squared difference measure from this framework is used. For instructions on how to identify which target single-source R-squared difference measure to interpret to detect the impact of which kind of term that distinguishes Model A from B, see Rights and Sterba (2020) Table 2. Additionally, this function produces side-by-side graphical comparisons of the R-squared measures for Model A vs. Model B that can be used to visualize changes in each measure across models. This function assumes all level-1 predictors are cluster-mean-centered for reasons described in Rights & Sterba (2020). Any number of level-1 and/or level-2 predictors is supported and any of the level-1 predictors can have random slopes. This function can be used with either the hierarchical or the simultaneous model-building approach described in Rights and Sterba (2020). This function can also be used with either nested or non-nested model comparisons (in which R-squared estimates for Model A are subtracted from those for Model B).

Usage

```
r2mlm_comp_manual(
  data,
```

```
  within_covs_modA,
  between_covs_modA,
  random_covs_modA,
  gamma_w_modA,
  gamma_b_modA,
  Tau_modA,
  sigma2_modA,
  within_covs_modB,
  between_covs_modB,
  random_covs_modB,
  gamma_w_modB,
  gamma_b_modB,
  Tau_modB,
  sigma2_modB
)
```

Arguments

`data` Dataset with rows denoting observations and columns denoting variables.

`within_covs_modA, within_covs_modB`
List of numbers corresponding to the columns in the dataset of the level-1 predictors used in the MLM (if none used, set to NULL).

`between_covs_modA, between_covs_modB`
List of numbers corresponding to the columns in the dataset of the level-2 predictors used in the MLM (if none used, set to NULL).

`random_covs_modA, random_covs_modB`
List of numbers corresponding to the columns in the dataset of the level-1 predictors that have random slopes in the MLM (if no random slopes, set to NULL).

`gamma_w_modA, gamma_w_modB`
Vector of fixed slope estimates for all level-1 predictors, to be entered in the order of the predictors listed by within_covs (if none, set to NULL).

`gamma_b_modA, gamma_b_modB`
Vector of fixed intercept estimate (if applicable; see has_intercept below) and fixed slope estimates for all level-2 predictors, to be entered intercept first (if applicable) followed by level-2 slopes in the order listed by between_covs (if none, set to NULL).

`Tau_modA, Tau_modB`
Random effect covariance matrix; note that the first row/column denotes the intercept variance and covariances (if intercept is fixed, set all to 0) and each subsequent row/column denotes a given random slope's variance and covariances (to be entered in the order listed by random_covs).

`sigma2_modA, sigma2_modB`
Level-1 residual variance.

Value

If the inputs are valid models, then the output will be a list and associated graphical representation of R-squared decompositions.

See Also

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. Psychological Methods, 24(3), 309–338.

Rights, J. D., & Sterba, S. K. (2020). New recommendations on the use of R-squared differences in multilevel model comparisons. Multivariate Behavioral Research.

Other r2mlm model comparison functions: `r2mlm_comp()`

Examples

```
# Model A: no "salary" components included

modelA <- lmer(satisfaction ~ 1 + control_c + control_m + s_t_ratio + (1 +
control_c | schoolID), data = teachsat, REML = TRUE, control =
lmerControl(optimizer = "bobyqa"))

# Model B: full model with "salary" components included

modelB <- lmer(satisfaction ~ 1 + salary_c + control_c + salary_m + control_m
+ s_t_ratio + (1 + salary_c + control_c | schoolID), data = teachsat, REML =
TRUE, control = lmerControl(optimizer = "bobyqa"))

r2mlm_comp_manual(data = teachsat, within_covs_modA = c(4), between_covs_modA
= c(6, 8), random_covs_modA = c(4), gamma_w_modA = c(2.68263), gamma_b_modA =
c(19.6868596, 3.61309, -0.42385), Tau_modA = matrix(c(26.882, -0.298, -0.298,
3.536), 2, 2), sigma2_modA = 53.522, within_covs_modB = c(5, 4),
between_covs_modB = c(7, 6, 8), random_covs_modB = c(5, 4), gamma_w_modB =
c(1.55160, 2.69277), gamma_b_modB = c(19.68596, 1.45138, 3.68630, -0.37230),
Tau_modB = matrix(c(18.548, -0.676, -0.396, -0.676, 1.065, -0.143, -0.396,
-0.143, 3.612), 3, 3), sigma2_modB = 39.821)
```

`r2mlm_manual` *Compute R-squared values for multilevel models, manually inputting parameter estimates.*

Description

`r2mlm_manual` takes as input raw data and parameter estimates from a multilevel model, and outputs all relevant R-squared measures from the Rights and Sterba (2019) framework of R-squared measures for multilevel models, which can be visualized together as a set using the outputted bar chart decompositions of outcome variance. That is, when predictors are cluster-mean-centered, all R-squared measures from Rights & Sterba (2019) Table 1 and decompositions from Rights & Sterba (2019) Figure 1 are outputted. When predictors are not cluster-mean-centered, the total R-squareds from Rights & Sterba (2019) Table 5, as well as bar chart decompositions are outputted. Any number of level-1 and/or level-2 predictors is supported. Any of the level-1 predictors can have random slopes.

Usage

```
r2mlm_manual(
  data,
  within_covs,
  between_covs,
  random_covs,
  gamma_w,
  gamma_b,
  Tau,
  sigma2,
  has_intercept = TRUE,
  clustermeancentered = TRUE
)
```

Arguments

data	Dataset with rows denoting observations and columns denoting variables.
within_covs	List of numbers corresponding to the columns in the dataset of the level-1 predictors used in the MLM (if none used, set to NULL).
between_covs	List of numbers corresponding to the columns in the dataset of the level-2 predictors used in the MLM (if none used, set to NULL).
random_covs	List of numbers corresponding to the columns in the dataset of the level-1 predictors that have random slopes in the MLM (if no random slopes, set to NULL).
gamma_w	Vector of fixed slope estimates for all level-1 predictors, to be entered in the order of the predictors listed by within_covs (if none, set to NULL).
gamma_b	Vector of fixed intercept estimate (if applicable; see has_intercept below) and fixed slope estimates for all level-2 predictors, to be entered intercept first (if applicable) followed by level-2 slopes in the order listed by between_covs (if none, set to NULL).
Tau	Random effect covariance matrix; note that the first row/column denotes the intercept variance and covariances (if intercept is fixed, set all to 0) and each subsequent row/column denotes a given random slope's variance and covariances (to be entered in the order listed by random_covs).
sigma2	Level-1 residual variance.
has_intercept	If set to TRUE, the first element of gamma_b is assumed to be the fixed intercept estimate; if set to FALSE, the first element of gamma_b is assumed to be the first fixed level- 2 predictor slope; set to TRUE by default.
clustermeancentered	If set to TRUE, all level-1 predictors (indicated by the within_covs list) are assumed to be cluster-mean-centered and function will output all decompositions; if set to FALSE, function will output only total decompositions (see Description above); set to TRUE by default.

Value

If the input is valid, then the output will be a list and associated graphical representation of R-squared decompositions. If the input is not valid, it will return an error.

See Also

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. Psychological Methods, 24(3), 309–338.

Other r2mlm single model functions: `r2mlm()`

Examples

```
# The bobyqa optimizer is required for this model to converge in lme4

model <- lmer(satisfaction ~ 1 + salary_c + control_c + salary_m + control_m
+ s_t_ratio + (1 + salary_c + control_c | schoolID), data = teachsat, REML =
TRUE, control = lmerControl(optimizer = "bobyqa"))

r2mlm_manual(data = teachsat, within_covs = c(5, 4), between_covs = c(7, 6,
8), random_covs =  c(5, 4), gamma_w = c(1.55160, 2.69277), gamma_b =
c(19.68596,1.45138 , 3.68630, -0.37230), Tau = matrix(c(18.548, -0.676,
-0.396, -0.676, 1.064, -0.143, -0.039, -0.143, 3.612), 3, 3), sigma2 =
39.821, has_intercept = TRUE, clustermeancentered = TRUE)
```

---

teachsat *Teacher job satisfaction.*

Description

A simulated dataset containing information about teacher job satisfaction. Teachers clustered within schools.

Usage

```
teachsat
```

Format

A data frame with 9000 rows and 8 columns:

schoolID school identification number

teacherID teacher identification number

satisfaction numerical rating of teacher job satisfaction

control_c school-mean-centered rating of teacher's reported control over curriculum

salary_c school-mean-centered teacher's salary (in thousands of dollars)

control_m grand-mean-centered school-mean rating of teacher's reported control over curriculum

salary_m grand-mean-centered school-mean teacher's salary (in thousands of dollars)

s_t_ratio grand-mean-centered student to teacher ratio for the school (total number of students/ total number of teachers)

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