Package ‘LMMELSM’

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Title  Fit Latent Multivariate Mixed Effects Location Scale Models

Version  0.1.0

Description  In addition to modeling the expectation (location) of an outcome, mixed effects location scale models (MELSMs) include submodels on the variance components (scales) directly. This allows models on the within-group variance with mixed effects, and between-group variances with fixed effects. The MELSM can be used to model volatility, intraindividual variance, uncertainty, measurement error variance, and more. Multivariate MELSMs (MMELSMs) extend the model to include multiple correlated outcomes, and therefore multiple locations and scales. The latent multivariate MELSM (LMMELSM) further includes multiple correlated latent variables as outcomes. This package implements two-level mixed effects location scale models on multiple observed or latent outcomes, and between-group variance modeling. Williams, Martin, Liu, and Rast (2020) <doi:10.1027/1015-5759/a000624>. Hedeker, Mermelstein, and Demirtas (2008) <doi:10.1111/j.1541-0420.2007.00924.x>.

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LazyData  true

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BugReports  https://github.com/stephenSRMMartin/LMMELSM

Depends  R (>= 3.4.0)

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LinkingTo  BH (>= 1.66.0), Rcpp (>= 0.12.0), RcppEigen (>= 0.3.3.3.0), rstan (>= 2.18.1), StanHeaders (>= 2.18.0)

SystemRequirements  GNU make

Suggests  testthat

NeedsCompilation  yes

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LMMELSM-package  The 'LMMELSM' package.

Description

A DESCRIPTION OF THE PACKAGE

References

https://mc-stan.org

coef.lmmelsm  Extract group-specific coefficients.

Description

Coef method for lmmelsm objects.

Usage

## S3 method for class 'lmmelsm'
coef(object, prob = 0.95, summarize = TRUE, ...)
Arguments

- **object**: lmmelsm object.
- **prob**: Numeric (Default: .95). Amount of probability mass contained in the credible interval.
- **summarize**: Logical (Default: TRUE). Whether to return posterior summaries (TRUE) or MCMC samples (FALSE).
- **...** Not used.

Details

Extracts all group-specific coefficients from lmmelsm object. Note that this is different from `ranef`. Whereas `ranef` extracts the zero-centered random effects, `coef` extracts the group-specific effects, defined as the sum of the fixed effect and random effect.

Value

List of summaries (if `summarize` is TRUE), or list of MCMC samples.

Author(s)

Stephen R Martin

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**lmmelsm**

*Specify and fit the (latent) (multivariate) melsm.*

Description

Fits a mixed effects location scale model on one or more observed or latent variables. Currently supports multiple endogenous latent factors or observed outcomes, and exogenous observed variables. Data are assumed to be two-level data. I.e., multiple indicators, repeatedly measured within group. Currently assumes measurement invariance (i.e., the measurement model params are equivalent across groups) and a unit-variance identification for latent variables. Excludes rows with missing data (and warns the user).

Usage

`lmmelsm(formula, group, data, ...)`

Arguments

- **formula**: Formula or list of formulas. See section on model specification.
- **group**: Raw grouping variable name (not character).
- **data**: Data frame.
- **...**: Options passed onto `sampling`
Value

Immelsm object.

Model specification

The model is specified as a list of formulas. LMMELSM supports the specification of latent measurement models, location models, scale models, between-group scale models, and (if latent variables are undesired) observed outcome models. The covariates do not need to be the same across the location, scale, and between-group models. The specified covariates will be used to predict the location and scale of all latent factors via multivariate regression.

The latent factor model is specified as follows. In the simplest case, only one formula is required, and a single-factor model is estimated. The left-hand side (LHS) contains the user-specified latent variable name, and the right-hand side (RHS) contains the indicators. Let "latent1" and "latent2" be user-chosen names of two latent variables with three indicators each. Then the formula syntax would be: list(latent1 ~ y1 + y2 + y3, latent2 ~ y4 + y5 + y6)

The location model is specified as either a one or two-part formula. The LHS must be "location" and the RHS contains the covariates. Random slopes are specified in the optional second part, separated by "|". Because LMMELSM fits MELSMs, random intercepts are always included. For example, if x1 and x2 are two location predictors, then:

location ~ x1 + x2

specifies a location model with a random intercept per factor, and no random slopes.

location ~ x1 + x2 | x1

specifies a location model with a random intercept per factor, a random x1 coefficient per factor, and no random x2 coefficient.

The within-group scale model is specified similarly. The LHS must be "scale" and the RHS contains the covariates. Random slopes are always included, and random slopes are specified in the optional second part of the RHS. For example, if x2 and x3 are two scale predictors, then:

scale ~ x2 + x3

specifies a scale model with a random intercept per factor, and no random slopes.

scale ~ x2 + x3 | x3

specifies a scale model with a random intercept per factor, a random x3 coefficient per factor, and no random x2 coefficient.

The between-group scale model is specified by a LHS of "between" and RHS containing covariates. There are no random coefficients permitted in the between-group scale model. The between-group scale model is responsible for modeling the random effect standard deviations. Note: The between-group model only models the SDs of the random location and scale intercepts.

between ~ x2

specifies a between-group scale model on the SDs of the location and scale intercepts for each factor.

If you want to fit a non-latent multivariate MELSM, use "observed" as the LHS:

For example, if y1, y2, and y3 are three observed outcome variables, then

observed ~ y1 + y2 + y3
would fit an M-MELSM. Location, scale, and between-group models can still be specified, but they will model the observed variables, rather than latent variables. You cannot currently have both observed and latent outcomes in the same model.

*Note:* Because location, scale, between, and observed represent special formulas, latent factors cannot be named location, scale, between, nor observed. It is assumed that any formula with location, scale, or between on the left-hand side (LHS) is a predictive formula, not a latent variable specification.

**Author(s)**

Stephen R. Martin

**Examples**

data(sim_data)

# Fit LMMEGLSM with two latent factors (A and B),
# Location model with one random coefficient
# Scale model with one random coefficient
# Between-group scale model with one covariate
fit <- lmmelsm(list(A ~ A_1 + A_2 + A_3 + A_4 + A_5 + A_6,
                  B ~ N_1 + N_2 + N_3 + N_4 + N_5 + N_6,
                  location ~ x1 + baseline | x1,
                  scale ~ x2 + baseline | x2,
                  between ~ baseline),
                  subject, sim_data, cores = 2)

# Summarize fit
summary(fit)

# Get random effects
ranef(fit)

# Get group-specific parameter values
coef(fit)

# Get approximate leave-one-out
loo(fit)
Usage

```r
## S3 method for class 'lmmelsm'
loo(x, type = c("observation", "group"), ...)
```

Arguments

- `x` Immelsm object.
- `type` String (Default: "observation"). If "observation", then loo is leave-row-out. If "group", then loo is leave-group-out.
- `...` Not used.

Value

loo object.

Author(s)

Stephen R. Martin

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Description

Print method for lmmelsm objects.

Usage

```r
## S3 method for class 'lmmelsm'
print(x, ...)
```

Arguments

- `x` Immelsm object.
- `...` Not used.

Value

x (Invisibly).

Author(s)

Stephen R. Martin
print.summary.lmmelsm

Print method for summary.lmmelsm objects.

Description

Print method for summary.lmmelsm objects.

Usage

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

Arguments

  x          summary.lmmelsm object.
  ...        Not used.

Value

  x (Invisibly).

Author(s)

Stephen R. Martin

ranef.lmmelsm

Extract random effects.

Description

Ranef method for lmmelsm objects.

Usage

## S3 method for class 'lmmelsm'
ranef(object, prob = 0.95, summarize = TRUE, ...)

Arguments

  object      lmmelsm object.
  prob        Numeric (Default: .95). Amount of probability mass contained in the credible interval.
  summarize   Logical (Default: TRUE). Whether to return posterior summaries (TRUE) or MCMC samples (FALSE).
  ...         Not used.
Details

Extracts the random effects from the lmmelsm object. Note that this is different from the random coefficients. E.g., if $\beta_{0i} = \beta_0 + u_{0i}$, then coef extracts $\beta_{0i}$ and ranef extracts $u_{0i}$.

Value

List of ranef summaries (random_mu_intercept, random_logsd_intercept, random_mu_coef, and random_logsd_coef), or samples (if summarize = FALSE).

Author(s)

Stephen R. Martin

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**sim_data**

*Simulated data for fitting the LMMELSM*

**Description**

Dataset containing 50 observations of 12 items for 100 persons. The data are generated from an LMMELSM.

**Usage**

sim_data

**Format**

Data frame with 5000 rows and 16 variables.

- subject  The subject ID
- baseline  A subject-level covariate
- x1  A time-varying covariate
- x2  A time-varying covariate
- A_1 · A_6 Six indicators for "Agreeableness"
- N_1 · N_6 Six indicators for "Neuroticism"
Summary method for lmmelsm objects.

Description

Summary method for lmmelsm objects.

Usage

```r
## S3 method for class 'lmmelsm'
summary(object, prob = 0.95, ...)
```

Arguments

- `object`: Immelsm object.
- `prob`: Numeric (Default: .95). Amount of probability mass contained in the credible interval.
- `...`: Not used.

Value

summary.lmmelsm object. A list containing `meta` (metadata) and `summary` (summary tables).

Author(s)

Stephen R. Martin
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