Package 'flps'

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Type Package

Title Fully-Latent Principal Stratification

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`flps-package` *Fully latent principal stratification*

Description

The FLPS package conducts Bayesian analysis for fully latent principal stratification via rstan.

_PACKAGE

Details

The 'flps' package.

Author(s)

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References

Sales, A. C., & Pane, J. F. (2019). The role of mastery learning in an intelligent tutoring system: Principal stratification on a latent variable. The Annals of Applied Statistics, 13(1), 420-443. Lee, S., Adam, S., Kang, H.-A., & Whittaker, T. A. (2022). Fully latent principal stratification: Combining ps with model-based measurement models. In The annual meeting of the psychometric society (pp. 287–298).

`binary` *binary.rda*

Description

A data set containing binary items information. Example data regenerated from CTA1

Usage

```
binary
```

Format

A data frame with variables:

schid School ID

id Student ID

sex 0 = boys; 1 = girls

race 0 = White; 1 = Others

pretest Pre test scores

stdscore Standardized scores

cm_sex Cluster-mean of sex

cm_race Cluster-mean of race

cm_pretest Cluster-mean of Pre test scores

cm_stdscore Cluster-mean of of Standardized scores

trt Treatment assignment; 0 = control, 1 = treatment

Y Outcome

q1 Binary item

q2 Binary item

q3 Binary item

q4 Binary item

q5 Binary item

q6 Binary item

q7 Binary item

q8 Binary item

q9 Binary item

q10 Binary item

q11 Binary item

q12 Binary item

q13 Binary item

q14 Binary item

q15 Binary item

q16 Binary item

q17 Binary item

q18 Binary item

q19 Binary item

q20 Binary item

Source

CTA1

Examples

```
data(binary)
summary(binary)
```

`continuous` *continuous.rda*

Description

A data set containing continuous items information. Example data regenerated from CTA1

Usage

```
continuous
```

Format

A data frame with variables:

schid School ID

id Student ID

sex 0 = boys; 1 = girls

race 0 = White; 1 = Others

pretest Pre test scores

stdscore Standardized scores

cm_sex Cluster-mean of sex

cm_race Cluster-mean of race

cm_pretest Cluster-mean of Pre test scores

cm_stdscore Cluster-mean of of Standardized scores

trt Treatment assignment; 0 = control, 1 = treatment

Y Outcome

q1 Continuous item

q2 Continuous item

q3 Continuous item

q4 Continuous item

q5 Continuous item

q6 Continuous item

q7 Continuous item

q8 Continuous item

q9 Continuous item

q10 Continuous item

q11 Continuous item

q12 Continuous item

q13 Continuous item

q14 Continuous item

q15 Continuous item

q16 Continuous item

q17 Continuous item

q18 Continuous item

q19 Continuous item

q20 Continuous item

Source

CTA1

Examples

```
data(continuous)
summary(continuous)
```

`example0` *example0.rda*

Description

A generated data set for rasch FLPS to mimic CTA1 data.

Usage

```
example0
```

Format

A data frame with variables:

Y Outcome

trt Treatment assignment; 0 = control, 1 = treatment

sex 0 = boys; 1 = girls

race 0 = White; 1 = Others

pretest Pre test scores

stdscore Standardized scores

V1 Binary item

V2 Binary item

V3 Binary item

V4 Binary item

V5 Binary item

V6 Binary item

V7 Binary item

V8 Binary item

V9 Binary item

V10 Binary item

V11 Binary item

V12 Binary item

---

example1 *example1.rda*

Description

A generated data set containing binary items information.

Usage

```
example1
```

Format

A data frame with variables:

Y Outcome

trt Treatment assignment; 0 = control, 1 = treatment

X1 Continuous covariate 1

X2 Continuous covariate 2

q1 Binary item
q2 Binary item
q3 Binary item
q4 Binary item
q5 Binary item
q6 Binary item
q7 Binary item
q8 Binary item
q9 Binary item
q10 Binary item

`example2` *example2.rda*

Description

A generated data set containing continuous items information.

Usage

```
example2
```

Format

A data frame with variables:

Y Outcome
trt Treatment assignment; 0 = control, 1 = treatment
X1 Continuous covariate 1
X2 Continuous covariate 2
q1 Continuous item
q2 Continuous item
q3 Continuous item
q4 Continuous item
q5 Continuous item
q6 Continuous item
q7 Continuous item
q8 Continuous item
q9 Continuous item
q10 Continuous item

`example3` *example3.rda*

Description

A generated data set for multidimensional FLPS.

Usage

```
example3
```

Format

A data frame with variables:

Y Outcome

Z Treatment assignment; 0 = control, 1 = treatment

X1 Continuous covariate 1

X2 Continuous covariate 2

X3 Continuous covariate 2

X4 Continuous covariate 2

V1 Continuous item

V2 Continuous item

V3 Continuous item

V4 Continuous item

V5 Continuous item

V6 Continuous item

V7 Continuous item

V8 Continuous item

V9 Continuous item

V10 Continuous item

V11 Continuous item

V12 Continuous item

flps_plot *Make plots related to FLPS models*

Description

Make plots related to FLPS models

Usage

```
flps_plot(object, type = "causal", ...)
```

Arguments

object	a flps object
type	a character indicating the type of plots
...	Additional features related to plots

Value

A ggplot object that can be further customized using the **ggplot2** package.

graded *graded.rda*

Description

A data set containing graded response items information. Example data regenerated from CTA1

Usage

```
graded
```

Format

A data frame with variables:

schid School ID

id Student ID

sex 0 = boys; 1 = girls

race 0 = White; 1 = Others

pretest Pre test scores

stdscore Standardized scores

cm_sex Cluster-mean of sex

cm_race Cluster-mean of race

cm_pretest Cluster-mean of Pre test scores

cm_stdscore Cluster-mean of of Standardized scores

trt Treatment assignment; 0 = control, 1 = treatment

Y Outcome

q1 Graded response item

q2 Graded response item

q3 Graded response item

q4 Graded response item

q5 Graded response item

q6 Graded response item

q7 Graded response item

q8 Graded response item

q9 Graded response item

q10 Graded response item

q11 Graded response item

q12 Graded response item

q13 Graded response item

q14 Graded response item

q15 Graded response item

q16 Graded response item

q17 Graded response item

q18 Graded response item

q19 Graded response item

q20 Graded response item

Source

CTA1

Examples

```
data(graded)
summary(graded)
```

importModel *Import compiled Stan object*

Description

Import compiled Stan object

Usage

```
importModel(lv_type, multilevel = FALSE, lv_randomeffect = FALSE)
```

Arguments

lv_type	a character indicating the type of FLPS model.
multilevel	a logical indicating multilevel Stan model.
lv_randomeffect	A logical indicating whether to estimate random effects for latent variables.

Value

a Stan compiled stanmodel object generated by modelBuilder

makeInpData *Generate a matrix style data for simulation*

Description

makeInpData is a function for generating a data based on the given information.

Usage

```
makeInpData(
  N,
  R2Y,
  R2eta,
  omega,
  tau0,
  tau1,
  betaL,
  betaY,
  linear = TRUE,
  ydist = "n",
  lambda,
  nitem,
  nfac = 1,
```

```
  lvmodel,
  fcovmat,
  item.missing = TRUE,
  misspec = FALSE,
  cov.res = 0,
  relsize = 0.6
)
```

Arguments

N	a numeric indicating sample size.
R2Y	a numeric indicating predictive power of covariates.
R2eta	a numeric indicating Predictive power of latent variable
omega	a numeric indicating the size of effect of latent factor on the outcome.
tau0	a numeric indicating the size of difference in the outcome between the treatment and the control.
tau1	a numeric indicating the principal effect
betaL	a numeric vector indicating the effects of covariates on the latent factor
betaY	a numeric vector indicating the effects of covariates on the outcome
linear	a logical whether the relationship between the outcome and covariates is linear (default is TRUE).
ydist	a character indicating the outcome distribution (default is n).
lambda	a numeric indicating the mean of Worked problems/person. (extent to which covariates predict eta).
nitem	a numeric indicating the number of maximum measurement items given to students.
nfac	a numeric indicating the number of latent factors
lvmodel	a character specifying a type of latent variable model.
fcovmat	a matrix indicating the variance-covariance matrix of latent factors when nfac > 1
item.missing	a logical to make the measurement item data missing for the control group (default is TRUE).
misspec	a logical to allow cross-loadings across latent factors when nfac > 1 (default is FALSE).
cov.res	a logical to allow for residual correlations (only for CFA model) (default is 0).
relsize	a numeric indicating the degree to which the latent factor explain the variances of continuous items (only for CFA model) (default is 0.6).

Value

a list containing all the data related to population values and running FLPS.

Examples

```
sdat <- makeInpData(
N       = 200,  # sample size
R2Y     = 0.2,  # r^2 of outcome
R2eta   = 0.5,  # r^2 of eta by one covariates
omega   = 0.2,  # the effect of eta
tau0    = 0.13, # direct effect
tau1    = -0.06,# interaction effect between Z and eta
betaL   = 0.2,
betaY   = 0.4,
lambda  = 0.8,  # the proportion of administered items
nitem    = 10,   # the total number of items
nfac    = 1,    # the number of latent factors
lvmodel = '2pl' )
```

---

makeSimData *Generate Fully Latent Principal Stratification data for simulation*

Description

makeInpData is a function for generating a data based on the given information.

Usage

```
makeSimData(
  N,
  R2Y,
  R2eta,
  omega,
  tau0,
  tau1,
  betaL,
  betaY,
  linear = TRUE,
  ydist = "n",
  lambda,
  nitem,
  nfac,
  lvmodel,
  fcovmat,
  item.missing = TRUE,
  misspec = FALSE,
  cov.res = 0,
  relsize = 0.6
)
```

Arguments

N	a numeric indicating sample size.
R2Y	a numeric indicating predictive power of covariates.
R2eta	a numeric indicating Predictive power of latent variable
omega	a numeric indicating the size of effect of latent factor on the outcome.
tau0	a numeric indicating the size of difference in the outcome between the treatment and the control.
tau1	a numeric indicating the principal effect
betaL	a numeric vector indicating the effects of covariates on the latent factor
betaY	a numeric vector indicating the effects of covariates on the outcome
linear	a logical whether the relationship between the outcome and covariates is linear (default is TRUE).
ydist	a character indicating the outcome distribution (default is n).
lambda	a numeric indicating the mean of Worked problems/person. (extent to which covariates predict eta).
nitem	a numeric indicating the number of maximum measurement items given to students.
nfac	a numeric indicating the number of latent factors
lvmodel	a character specifying a type of latent variable model.
fcovmat	a matrix indicating the variance-covariance matrix of latent factors when nfac > 1
item.missing	a logical to make the measurement item data missing for the control group (default is TRUE).
misspec	a logical to allow cross-loadings across latent factors when nfac > 1 (default is FALSE).
cov.res	a logical to allow for residual correlations (only for CFA model) (default is 0).
relsize	a numeric indicating the degree to which the latent factor explain the variances of continuous items (only for CFA model) (default is 0.6).

Value

a list containing all the data related to population values and running FLPS.

Examples

```
sdat <- makeSimData(
N       = 200,  # sample size
R2Y     = 0.2,  # r^2 of outcome
R2eta   = 0.5,  # r^2 of eta by one covariates
omega   = 0.2,  # the effect of eta
tau0    = 0.13, # direct effect
tau1    = -0.06,# interaction effect between Z and eta
betaL   = 0.2,
betaY   = 0.4,
```

```
lambda  = 0.8,  # the proportion of administered items
nitem    = 10,   # the total number of items
nfac    = 1,    # the number of latent factors
lvmodel = '2pl' )
```

`modelBuilder` *Generate compiled Stan object to facilitate the analysis*

Description

Generate compiled Stan object to facilitate the analysis

Usage

```
modelBuilder(lv_type, multilevel = FALSE, lv_randomeffect = FALSE)
```

Arguments

`lv_type`	A character string specifying the type of FLPS model
`multilevel`	a logical indicating multilevel Stan model.
`lv_randomeffect`	A logical indicating whether to estimate random effects for latent variables.

Value

There's no return, but the compiled objects are saved in the package root directory.

`plot.flps` *Plot*

Description

Plot

Usage

```
## S3 method for class 'flps'
plot(x, type = NULL, pars = c("tau0", "tau1"), ...)
```

Arguments

`x`	an object of class `flps`
`type`	a string for the type of plot
`pars`	a character vector indicating the target parameters
`...`	additional options for `stan_plot`

Value

A ggplot object that can be further customized using the **ggplot2** package.

---

print.flps *Print results*

Description

Print results

Usage

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

Arguments

x	an object of class flps
...	additional options for future development

Value

Summary of FLPS model are printed.

---

print.summary.flps *Print summary of results*

Description

Print summary of results

Usage

```
## S3 method for class 'summary.flps'
print(x, type = "structures", ...)
```

Arguments

x	an object of class flps
type	a string for the part of FLPS model • structures : prints the results of structural parts. • measurement : prints the results of measurement parts. • latent : prints the information of individual latent scores • raw : prints the results via the summary function of **rstan** package..
...	additional options for future development

Value

Summary of FLPS model are printed.

---

runFLPS *Conduct fully latent principal stratification*

Description

Conduct fully latent principal stratification

Usage

```
runFLPS(
  inp_data = NULL,
  compiled_stan = NULL,
  outcome = NULL,
  trt = NULL,
  covariate = NULL,
  lv_model = NULL,
  lv_type = NULL,
  priors_input = NULL,
  stan_options = list(),
  ...
)
```

Arguments

inp_data	A matrix or data frame containing the input data.
compiled_stan	An object of S4 class stanmodel produced by the modelBuilder function.
outcome	A character string specifying the outcome variable's name.
trt	A character string specifying the treatment or control group variable's name.
covariate	A character string specifying the covariate variable names.
lv_model	A description of the latent variable model using syntax akin to the **lavaan** package. Key operators include: • =~ : Denotes associations between factors and indicators (e.g., F1 =~ v1 + v2 + v3). All indicators associated with the corresponding factor should be written in the same line with +. • + : Specifies a series of indicators.
lv_type	A character string indicating the type of latent variable models.
priors_input	A list specifying the priors or defaults to N(0, 5) if not provided. Relevant parameters: tau0 (group difference), tau1 (principal effects), and omega (effect of latent factors on outcome). Ensure that the lengths of tau1 and omega match the number of factors. Examples:

- `list(tau0 = c(0, 1), tau1 = c(0.5, 1))` : Mean and variance for normal priors.
- `list(tau1 = list(c(0.5, 1), c(-0.4, 1)))` : For two factors.

`stan_options` A list of options for [rstan::stan()], specified as 'name = value'.

`...` Additional parameters for the latent variable models

- `nclass` A number specifying the number of latent classes.
- `multilevel` A logical indicating if a multilevel structure is present.
- `lv_randomeffect` A logical indicating whether to estimate random effects for latent variables.
- `group_id` A string for grouping variable for multilevel structure.

Value

An object of class `flps` encompassing a `stanfit` object. Components include:

`call`	Function call with arguments.
`inp_data`	The input data frame provided.
`flps_model`	The Stan syntax used in [rstan::stan()].
`flps_data`	Data list used for [rstan::stan()].
`flps_fit`	Resulting `stanfit` object.
`time`	A numeric; Time taken for computation

See Also

[rstan::stan()]

Examples

```
inp_data <- flps::makeInpData(
  N       = 200,
  R2Y     = 0.2,
  R2eta   = 0.5,
  omega   = 0.2,
  tau0    = 0.23,
  tau1    = -0.16,
  betaL   = 0.1,
  betaY   = 0.2,
  lambda  = 0.8,
  nitem    = 10,
  nfac    = 1,
  lvmodel = 'rasch' )

res <- runFLPS(
   inp_data = inp_data,
   outcome = "Y",
   trt = "Z",
   covariate = c("X1"),
```

```
lv_type = "rasch",
lv_model = "F =~ v1 + v2 + v3 + v4 + v5 + v6 + v7 + v8 + v9 + v10",
stan_options = list(iter = 1000, warmup = 500, cores = 1, chains = 2)
)
```

`summary.flps` *Summarize the results*

Description

Summarize the results

Usage

```
## S3 method for class 'flps'
summary(object, type = "structures", ...)
```

Arguments

`object`	an object of class `flps`
`type`	a string for the part of FLPS model • `structures` : prints the results of structural parts. • `measurement` : prints the results of measurement parts. • `latent` : prints the information of individual latent scores • `raw` : prints the results via the `summary` function of **rstan** package..
`...`	additional options for future development

Value

Summary of FLPS model are printed.

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