Package: edina (via r-universe)

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Title Bayesian Estimation of an Exploratory Deterministic Input, Noisy and Gate Model

Version 0.1.2

Description Perform a Bayesian estimation of the exploratory deterministic input, noisy and gate (EDINA) cognitive diagnostic model described by Chen et al. (2018) <doi:10.1007/s11336-017-9579-4>.

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`as_q_matrix` *Coerce* `data.frame` *and* `matrix` *classes to Q Matrix.*

Description

`as.q_matrix` acts as an aliases.

Usage

```
as_q_matrix(x, ...)

## S3 method for class 'data.frame'
as_q_matrix(x, ...)

## S3 method for class 'matrix'
as_q_matrix(x, ...)

## Default S3 method:
as_q_matrix(x, ...)
```

Arguments

`x`	Either a `data.frame` or `matrix`.
`...`	Not used

Value

A q_matrix object.‘

See Also

q_matrix()

Examples

```
# Q matrix values
x = matrix(c(1, 0, 0, 1), nrow = 2)

# Construct class
q_mat = as_q_matrix(x)
```

---

auto_edina *Auto EDINA model selection routine*

Description

Automatically select an appropriate K dimension for a Q matrix under the Exploratory Deterministic Input, Noise And gate (EDINA) Model.

Usage

```
auto_edina(data, k = 2:4, burnin = 10000, chain_length = 20000)
```

Arguments

data	Binary responses to assessments in matrix form with dimensions $N \times J$.
k	Number of Attribute Levels as a positive integer.
burnin	Number of Observations to discard on the chain.
chain_length	Length of the MCMC chain

Value

An auto_edina object that contains:

- edina_models: A list containing all estimated edina model objects.
- criterions: Information criterions calculated for each model
- k_checked: Varying k dimensions checked.
- j: Number of Items

See Also

autoplot.auto_edina(), best_model(), model_selection_graph(), parameter_evolution_graph()

Examples

```
if(requireNamespace("simcdm", quietly = TRUE)) {

# Set a seed for reproducibility
set.seed(1512)

# Setup data simulation parameters
N = 15   # Number of Examinees / Subjects
J = 10   # Number of Items
K = 2    # Number of Skills / Attributes

# Note:
# Sample size and attributes have been reduced to create a minimally
# viable example that can be run during CRAN's automatic check.
# Please make sure to have a larger sample size...

# Assign slipping and guessing values for each item
ss = gs = rep(.2, J)

# Simulate an identifiable Q matrix
Q = simcdm::sim_q_matrix(J, K)

# Simulate subject attributes
subject_alphas = simcdm::sim_subject_attributes(N, K)

# Simulate items under the DINA model
items_dina = simcdm::sim_dina_items(subject_alphas, Q, ss, gs)


# Requires at least 15 seconds of execution time.
# Three EDINA models will be fit with increasing number of attributes.
model_set_edina = auto_edina(items_dina, k = 2:4)

# Display results
model_set_edina

# Retrieve criterion table
table = summary(model_set_edina)

# Extract "best model"
best_model(model_set_edina)

}
```

`autoplot.auto_edina` *Graph the Auto EDINA Object*

Description

Presents either the fitting of model heuristics or the evolution of parameters on a graph

Usage

```
## S3 method for class 'auto_edina'
autoplot(
  object,
  type = c("selection", "guessing", "slipping", "evolution"),
  ...
)
```

Arguments

object	An auto_edina object.
type	Kind of graph to display. Valid types: "selection" or "evolution".
...	Not used.

Value

A ggplot2 object.

See Also

auto_edina(), best_model(), model_selection_graph(), parameter_evolution_graph()

Examples

```
if(requireNamespace("simcdm", quietly = TRUE)) {

# Set a seed for reproducibility
set.seed(1512)

# Setup data simulation parameters
N = 2    # Number of Examinees / Subjects
J = 10   # Number of Items
K = 2    # Number of Skills / Attributes

# Note:
# Sample size and attributes have been reduced to create a minimally
# viable example that can be run during CRAN's automatic check.
# Please make sure to have a larger sample size...

# Assign slipping and guessing values for each item
ss = gs = rep(.2, J)

# Simulate an identifiable Q matrix
Q = simcdm::sim_q_matrix(J, K)

# Simulate subject attributes
subject_alphas = simcdm::sim_subject_attributes(N, K)

# Simulate items under the DINA model
items_dina = simcdm::sim_dina_items(subject_alphas, Q, ss, gs)
```

```
# Requires at least 15 seconds of execution time.
# Three EDINA models will be fit with increasing number of attributes.
model_set_edina = auto_edina(items_dina, k = 2:4)

# Visualize results results
autoplot(model_set_edina, type = "selection")

# Equivalent to:
model_selection_graph(model_set_edina)

# View model parameters
autoplot(model_set_edina, type = "guessing")

# Or directly call with:
parameter_evolution_graph(model_set_edina, type = "guessing")

}
```

`best_model` *Extract the Best Model*

Description

Extracts the best model from the `auto_*()` search procedure.

Usage

```
best_model(x, ...)

## S3 method for class 'auto_edina'
best_model(x, ic = c("ppp", "bic", "dic"), ...)
```

Arguments

`x`	An `auto_edina` object
`...`	Not used.
`ic`	Information criterion name. Default `"ppp"`.

Value

An `edina` model object corresponding to the smallest value of requested information criterion.

See Also

`DIC.edina()`, `BIC.edina()`, `PPP.edina()`

BIC.edina *Bayesian Information Criterion (BIC)*

Description

Calculate BIC for EDINA models.

Usage

```
## S3 method for class 'edina'
BIC(object, ...)
```

Arguments

object	An edina object
...	Not used.

Value

The BIC value of the given model.

BIC Computation Procedure

$$BIC = -2 \log p\left(\mathbf{y}|\hat{\theta}\right) + ((k+2) * j + 2^k) \log(n)$$

See Also

PPP.edina(), DIC.edina()

PPP.edina(), DIC.edina()

DIC *Deviance Information Criterion (DIC)*

Description

Calculate DIC for EDINA models.

Usage

```
DIC(object, ...)

## S3 method for class 'edina'
DIC(object, ...)
```

Arguments

`object`	An `edina` object
`...`	Not used.

Value

The DIC value of the given model.

DIC Computation Procedure

$$DIC = -2\left(\log p\left(\mathbf{y}|\hat{\theta}\right) - 2\left(\log p\left(\mathbf{y}|\hat{\theta}\right) - \frac{1}{N}\sum_{n=1}^{N}\log p\left(\mathbf{y}|\theta_s\right)\right)\right)$$

See Also

`PPP.edina()`, `BIC.edina()`

`edina` *EDINA Estimation Routine*

Description

Performs the Exploratory Deterministic Input, Noise and Gate Model (EDINA) estimation on a given data set with a prespecified `k` value.

Usage

```
edina(data, k = 3, burnin = 10000, chain_length = 20000)
```

Arguments

`data`	Binary responses to assessments in `matrix` form with dimensions $N \times J$.
`k`	Number of Attribute Levels as a positive `integer`.
`burnin`	Number of Observations to discard on the chain.
`chain_length`	Length of the MCMC chain

Value

An `edina` object that contains:

- `coefficients`: Estimated coefficients of the model fit
- `loglike_summed`: Summed log-likelihood
- `loglike_pmean`: Mean of log-likelihood
- `pi_classes`: Latent classes
- `avg_q`: Estimated Averaged Q Matrix

- `est_q`: Estimated Dichotomous Q Matrix
- `or_tested`: Odds Ratio used in the model selection.
- `sample_or`: Odds Ratio for the sample.
- `n`: Number of Observations
- `j`: Number of Items
- `k`: Number of Traits
- `burnin`: Amount of iterations to discard
- `chain_length`: Amount of iterations to retain.
- `timing`: Duration of the run
- `dataset_name`: Name of the data set used in estimation.

See Also

`auto_edina()`, `summary.edina()`, `print.edina()`

Examples

```
if(requireNamespace("simcdm", quietly = TRUE)) {

# Set a seed for reproducibility
set.seed(1512)

# Setup data simulation parameters
N = 1    # Number of Examinees / Subjects
J = 10   # Number of Items
K = 2    # Number of Skills / Attributes

# Note:
# Sample size and attributes have been reduced to create a minimally
# viable example that can be run during CRAN's automatic check.
# Please make sure to have a larger sample size...

# Assign slipping and guessing values for each item
ss = gs = rep(.2, J)

# Simulate an identifiable Q matrix
Q = simcdm::sim_q_matrix(J, K)

# Simulate subject attributes
subject_alphas = simcdm::sim_subject_attributes(N, K)

# Simulate items under the DINA model
items_dina = simcdm::sim_dina_items(subject_alphas, Q, ss, gs)

# Compute the edina model
edina_model = edina(items_dina, k = K)

# Display results
edina_model
```

```
# Provide a summary overview
summary(edina_model)
}
```

`extract_q_matrix` *Extract Q Matrix*

Description

Given a modeling object, extract the Q Matrix

Usage

```
extract_q_matrix(x, ...)

## S3 method for class 'q_matrix'
extract_q_matrix(x, ...)

## S3 method for class 'edina'
extract_q_matrix(x, binary = TRUE, ...)

## Default S3 method:
extract_q_matrix(x, ...)
```

Arguments

`x`	An `edina` or `q_matrix` object
`...`	Additional parameters
`binary`	Boolean to indicate whether the Q matrix is shown in dichotomous form or in an estimated form.

Value

A `matrix` that is either dichotomous or estimated depending on the value of the `binary` parameter.

See Also

`q_matrix()`, `as_q_matrix()`, `edina()`, `auto_edina()`

Examples

```
# Q matrix values
x = matrix(c(1, 0, 0, 1), nrow = 2)

# Show Q matrix structure
Q = q_matrix(x)
```

```
# Retrieve Q matrix
extract_q_matrix(Q)
```

`model_selection_graph` *View Model Selection Statistics Across Models*

Description

Displays information about the value of each model information criterion for a given model across the dimensions the Q matrix is estimated.

Usage

```
model_selection_graph(x, ...)
```

Arguments

`x`	An `auto_edina` or `auto_errum` object.
`...`	Not used

Value

A `ggplot2` object

See Also

`autoplot.auto_edina()`

`parameter_evolution_graph`
View Slipping and Guessing Parameter Changes Across Models

Description

Displays the slipping and guessing parameter changes for each model across the dimensions the Q matrix is estimated.

Usage

```
parameter_evolution_graph(x, ...)
```

Arguments

`x`	An `auto_edina` or `auto_errum` object.
`...`	Not used

Value

A ggplot2 object

See Also

autoplot.auto_edina()

PPP *Posterior Predictive Probabilities (PPPs)*

Description

Computes posterior predictive probabilities (PPPs) based on the odds ratios for each pair of items.

Usage

```
PPP(object, ...)

## S3 method for class 'edina'
PPP(object, alpha = 0.05, ...)
```

Arguments

object	An edina object
...	Not used.
alpha	Defining region to indicate the level of extremeness the data must before the model is problematic.

Details

PPPs that smaller than 0.05 or greater than 0.95 tend to be extreme and evidence of misfit. As a result, this is more of a heuristic metric.

Value

The PPP value given the specified alpha value.

PPP Computation Procedure

1. simulate observed responses $\mathbf{Y}^{(r)}$ using model parameters from iteration r of the MCMC sampler
2. computing the odds ratio for each pair of items at iteration r as

$$OR^{(r)} = n_{11}^{(r)} n_{00}^{(r)} / \left(n_{10}^{(r)} n_{01}^{(r)} \right)$$

, where $n_{11}^{(r)}$ is the frequency of ones on both variables at iteration r, $n_{10}^{(r)}$ is the frequency of ones on the first item and zeros on the second at iteration r, etc.; and

3. computing PPPs for each item pair as the proportion of generated $OR^{(r)}$'s that exceeded elements of the observed odds ratios.

`print.auto_edina` *Print method for* `auto_edina`

Description

Custom print method for displaying the results of the Auto EDINA method.

Usage

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

Arguments

`x`	An `auto_edina` object
`...`	Additional values passed onto the `print.data.frame` method.

Value

None.

The function provides a side-effect of displaying the overview of computed results across all models estimated.

`print.edina` *Printing out the EDINA Object*

Description

Custom print method for computing the EDINA.

Usage

```
## S3 method for class 'edina'
print(x, binary = FALSE, ...)
```

Arguments

`x`	An `edina` object
`binary`	Boolean to indicate whether the Q matrix is shown in dichotomous form or in an estimated form.
`...`	Additional methods passed onto the `print.matrix` method.

Value

None.

The function provides a side-effect of displaying the overview of the model estimated.

`print.q_matrix` *Printing out a Q Matrix Object*

Description

Custom print method for the Q Matrix Object.

Usage

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

Arguments

`x`	An `q_matrix` object
`...`	Additional methods passed onto the `print.matrix` method.

Value

An invisible `matrix` without the `q_matrix` class displayed as a part of the output displayed.

See Also

`q_matrix()`, `as_q_matrix()`

Examples

```
# Q matrix values
x = matrix(c(1, 0, 0, 1), nrow = 2)

# Show Q matrix structure
q_matrix(x)
```

print.summary_auto_edina *Print the* auto_edina *model summary*

Description

Custom method for displaying the results of the summary(auto_edina).

Usage

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

Arguments

x	A summay_auto_edina object
...	Additional values passed onto the print.data.frame method.

Value

None.

The function provides a side-effect of displaying the overview of computed results across all models estimated.

print.summary_edina *Printing out the Summary EDINA Object*

Description

Custom print method for displaying the EDINA model summary information.

Usage

```
## S3 method for class 'summary_edina'
print(x, binary = FALSE, ...)
```

Arguments

x	A summary_edina object
binary	Boolean to indicate whether the Q matrix is shown in dichotomous form or in an estimated form.
...	Past onto the print.data.frame method.

Value

None.

The function provides a side-effect of displaying the overview of the model estimated.

q_graph *Graph Q Matrix*

Description

Provides a heatmap approach to showing the estimated binary or averaged values of the Q Matrix.

Usage

```
q_graph(x, ...)

## S3 method for class 'auto_edina'
q_graph(x, binary = TRUE, ic = c("ppp", "bic", "dic"), ...)

## S3 method for class 'edina'
q_graph(x, binary = TRUE, ...)

## S3 method for class 'matrix'
q_graph(x, ...)

## S3 method for class 'q_matrix'
q_graph(x, ...)
```

Arguments

x	Either an edina, auto_edina, or q_matrix object.
...	Additional parameters not used
binary	Boolean to indicate if a classified Q (dichotomous by decision rule) or an estimate Q (non-dichotomous) or should be shown. Default: TRUE.
ic	Information criterion name. Default "ppp".

Value

A ggplot2 object with a heatmap overview of the estimated Q matrix.

Examples

```
q = q_matrix(matrix(c(1, 0, 1, 1, 0, 1), ncol = 3))
q_graph(q)
```

`q_matrix` *Create a Q Matrix Object*

Description

Provides a way to create an object as a "`q_matrix`".

Usage

```
q_matrix(x)
```

Arguments

`x`	Either a `data.frame` or `matrix`.

Value

A `q_matrix` object.

See Also

`as_q_matrix()`

Examples

```
# Q matrix values
x = matrix(c(1, 0, 0, 1), nrow = 2)

# Q matrix wrapper
q_mat = q_matrix(x)

# Data Frame encoding of Q
q_df = data.frame(
   k1 = c(1, 0),
   k2 = c(0, 1)
)

# Create a Q matrix
q_mat = q_matrix(q_df)
```

summary.auto_edina *Summarize* auto_edina *model data*

Description

Custom method for displaying the results of the auto_edina.

Usage

```
## S3 method for class 'auto_edina'
summary(object, ...)
```

Arguments

object	An auto_edina object
...	Not used.

Value

The original auto_edina object with an added class of summary.auto_edina.

summary.edina *Summarize the EDINA Object*

Description

Provide a more detailed view inside of edina model object.

Usage

```
## S3 method for class 'edina'
summary(object, alpha = 0.05, ...)
```

Arguments

object	An edina object
alpha	Defining region to indicate the level of extremeness the data must before the model is problematic.
...	Not used.

Value

A summary object that includes everything in the original edina() object and:

- model_fit: Matrix of model fit summary statistics.
- alpha: Alpha-value used to compute PPP()s.

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