Package ‘zebu’

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Description Implements the estimation of local (and global) association measures: Lewontin's D, Ducher's Z, pointwise mutual information, normalized pointwise mutual information and chi-squared residuals. The significance of local (and global) association is accessed using p-values estimated by permutations.
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**Description**

Maximum-likelihood estimation of marginal and multivariate observed and expected independence probabilities. Marginal probability refers to probability of each factor per individual column. Multivariate probability refer to cross-classifying factors for all columns.

**Usage**

```r
estimate_prob(x)
```

**Arguments**

- `x` data.frame or matrix.

**Value**

List containing the following values:

- `margins`: a list of marginal probabilities. Names correspond to `colnames(x)`.
- `observed`: observed multivariate probability array.
- `expected`: expected multivariate probability array.
Examples

# This is what happens behind the curtains in the 'lassie' function
# Here we compute the association between the 'Girth' and 'Height' variables
# of the 'trees' dataset

# 'select' and 'continuous' take column numbers or names
select <- c('Girth', 'Height') # select subset of trees
continuous <- c(1, 2) # both 'Girth' and 'Height' are continuous

# equal-width discretization with 3 bins
breaks <- 3

# Preprocess data: subset, discretize and remove missing data
pre <- preprocess(trees, select, continuous, breaks)

# Estimates marginal and multivariate probabilities from preprocessed data.frame
prob <- estimate_prob(pre$pp)

# Computes local and global association using Ducher's Z
lam <- local_association(prob, measure = 'z')

---

format.lassie

Format a lassie object

Description

Formats a lassie object for printing to console (see print.lassie) and for writing to a file (see write.lassie). Melts probability or local association measure arrays into a data.frame.

Usage

## S3 method for class 'lassie'
format(x, what_x, range, what_range, what_sort, decreasing, na.rm, ...)

Arguments

x lassie S3 object.
what_x vector specifying values to be returned:
  • 'local': local association measure values (default).
  • 'obs': observed probabilities.
  • 'exp': expected probabilities.
  • 'local_p': p-value of local association (after running permtest).
range range of values to be retained (vector of two numeric values).
what_range character specifying what value range refers to (same options as what_x). By default, takes the first value in what_x.
what_sort character specifying according to which values should x be sorted (same options as what_x). By default, takes the first value in what_x.
lassie

**Description**

Estimates local (and global) association measures: Ducher’s Z and pointwise mutual information, normalized pointwise mutual information and chi-squared residuals.

**Usage**

```r
lassie(x, select, continuous, breaks, measure = "chisq", default_breaks = 4)
```

**Arguments**

- `x` data.frame or matrix.
- `select` optional vector of column numbers or column names specifying a subset of data to be used. By default, uses all columns.
- `continuous` optional vector of column numbers or column names specifying continuous variables that should be discretized. By default, assumes that every variable is categorical.
- `breaks` numeric vector or list passed on to `cut` to discretize continuous variables. When a numeric vector is specified, break points are applied to all continuous variables. In order to specify variable-specific breaks, lists are used. List names identify variables and list values identify breaks. List names are column names (not numbers). If a continuous variable has no specified breaks, then `default_breaks` will be applied.
- `measure` name of measure to be used:
  - 'chisq': Chi-squared residuals.
  - 'd': Lewontin’s D.
  - 'z': Ducher’s 'z'.
  - 'pmi': Pointwise mutual information (in bits).
  - 'npmi': Normalized pointwise mutual information (Bouma).
  - 'npmi2': Normalized pointwise mutual information (Multivariate).
- `default_breaks` default break points for discretizations. Same syntax as in `cut`. 

---

**See Also**

lassie Lassie Local Association Measures
**Value**

An instance of S3 class `lassie` with the following objects:

- data: raw and preprocessed data.frames (see `preprocess`).
- prob probability arrays (see `estimate_prob`).
- global global association (see `local_association`).
- local local association arrays (see `local_association`).
- lassie_params parameters used in `lassie`.

**See Also**

Results can be visualized using `plot.lassie` and `print.lassie` methods. `plot.lassie` is only available in the bivariate case and returns a tile plot representing the probability or local association measure matrix. `print.lassie` shows an array or a data.frame.

Results can be saved using `write.lassie`.

The `permtest` function accesses the significance of local and global association values using p-values estimated by permutations.

**Examples**

```r
# In this example, we will use the 'mtcars' dataset
# Selecting a subset of mtcars.
# Takes column names or numbers.
# If nothing was specified, all variables would have been used.
select <- c('mpg', 'cyl') # or select <- c(1, 2)

# Specifying 'mpg' as a continuous variables using column numbers
# Takes column names or numbers.
# If nothing was specified, all variables would have been used.
continuous <- 'mpg' # or continuous <- 1

# How should breaks be specified?
# Specifying equal-width discretization with 5 bins for all continuous variables ('mpg')
# breaks <- 5

# Specifying user-defined breakpoints for all continuous variables.
# breaks <- c(10, 15, 25, 30)

# Same thing but only for 'mpg'.
# Here both notations are equivalent because 'mpg' is the only continuous variable.
# This notation is useful if you wish to specify different break points for different variables
# breaks <- list('mpg' = 5)
# breaks <- list('mpg' = c(10, 15, 25, 30))

# Calling lassie
# Not specifying breaks means that the value in default_breaks (4) will be used.
las <- lassie(mtcars, select = c(1, 2), continuous = 1)
```
# Print local association to console as an array
print(las)

# Print local association and probabilities
# Here only rows having a positive local association are printed
# The data.frame is also sorted by observed probability
print(las, type = 'df', range = c(0, 1), what_sort = 'obs')

# Plot results as heatmap
plot(las)

# Plot observed probabilities using different colors
plot(las, what_x = 'obs', low = 'white', mid = 'grey', high = 'black', text_colour = 'red')

## lassie_get

_Return the value of 'lassie' object_

**Description**

Subroutine for _lassie_ methods. Tries to retrieve a value from a _lassie_ object and gives an error if value does not exist.

**Usage**

`lassie_get(x, what_x)`

**Arguments**

- `x` _lassie_ S3 object.
- `what_x` vector specifying values to be returned:
  - 'local': local association measure values (default).
  - 'obs': observed probabilities.
  - 'exp': expected probabilities.
  - 'local_p': p-value of local association (after running _permtest_).

**Value**

Corresponding array contained in _lassie_ object.

**Examples**

```r
las <- lassie(trees)
las_array <- lassie_get(las, 'local')
```
**Description**

Subroutines called by `lassie` to compute local and global association measures from a list of probabilities.

**Usage**

```r
local_association(x, measure = "chisq", nr = 1)
lewontin_d(x)
duchers_z(x)

pmi(x, normalize)

chisq(x, nr)
```

**Arguments**

- `x`: list of probabilities as outputted by `estimate_prob`.
- `measure`: name of measure to be used:
  - 'chisq': Chi-squared residuals.
  - 'd': Lewontin’s D.
  - 'z': Ducher’s ‘z’.
  - 'pmi': Pointwise mutual information (in bits).
  - 'npmi': Normalized pointwise mutual information (Bouma).
  - 'npmi2': Normalized pointwise mutual information (Multivariate).
- `nr`: number of rows/samples. Only used to estimate chi-squared residuals.
- `normalize`: 0 for pmi, 1 for npmi, 2 for npmi2

**Value**

List containing the following values:

- `local`: local association array (may contain NA, NaN and Inf values).
- `global`: global association numeric value.

**See Also**

`lassie`
Examples

# This is what happens behind the curtains in the 'lassie' function
# Here we compute the association between the 'Girth' and 'Height' variables
# of the 'trees' dataset

# 'select' and 'continuous' take column numbers or names
select <- c('Girth', 'Height') # select subset of trees
continuous <- c(1, 2) # both 'Girth' and 'Height' are continuous

# equal-width discretization with 3 bins
breaks <- 3

# Preprocess data: subset, discretize and remove missing data
pre <- preprocess(trees, select, continuous, breaks)

# Estimates marginal and multivariate probabilities from preprocessed data.frame
prob <- estimate_prob(pre$pp)

# Computes local and global association using Ducher's Z
lam <- local_association(prob, measure = 'z')

permtest

permtest S3 object.

Arguments

x lassie S3 object.

nb number of resampling iterations.

group list of column names specifying which columns should be permuted together. This is useful for the multivariate case, for example, when there is many dependent variables and one independent variable. By default, permutes all columns separately.

p_adjust multiple testing correction method. (see p.adjust.methods for a list of methods).
Value

`permtest` returns an S3 object of class `lassie` and `permtest`. Adds the following to the lassie object `x`:

- `global_p`: global association p-value.
- `local_p`: array of local association p-values.
- `global_perm`: numeric global association values obtained with permutations.
- `local_perm`: matrix local association values obtained with permutations. Column number correspond to positions in local association array after converting to numeric (e.g. `local_perm[,1]` corresponds to `local[1]`).
- `perm_params`: parameters used when calling `permtest` (nb and p_adjust).

See Also

`lassie`

Examples

```r
# Calling lassie on cars dataset
las <- lassie(cars)

# Permutation test using default settings
permtest(las, nb = 30) # keep resampling low for example
```

plot.lassie

Plot a lassie object

Description

Plots a `lassie` object as a tile plot using the ggplot2 package. Only available for bivariate association.

Usage

```r
## S3 method for class 'lassie'
plot(
x,  
what_x = "local",  
digits = 3,  
low = "royalblue",  
mid = "gainsboro",  
high = "firebrick",  
na = "purple",  
text_colour = "black",
```
Arguments

- **x**: lassie S3 object.
- **what_x**: vector specifying values to be returned:
  - 'local': local association measure values (default).
  - 'obs': observed probabilities.
  - 'exp': expected probabilities.
  - 'local_p': p-value of local association (after running permtest).
- **digits**: integer indicating the number of decimal places.
- **low**: colour for low end of the gradient.
- **mid**: colour for midpoint of the gradient.
- **high**: colour for high end of the gradient.
- **na**: colour for NA values.
- **text_colour**: colour of text inside cells.
- **text_size**: integer indicating text size inside cells.
- **limits**: limits of gradient.
- **midpoint**: midpoint of gradient.
- **...**: other arguments passed on to methods. Not currently used.

See Also

- lassie

---

**preprocess**  
Preprocess data

Description

Subroutine called by lassie. Discretizes, subsets and remove missing data from a data.frame.

Usage

preprocess(x, select, continuous, breaks, default_breaks = 4)
Arguments

- **x**: data.frame or matrix.
- **select**: optional vector of column numbers or column names specifying a subset of data to be used. By default, uses all columns.
- **continuous**: optional vector of column numbers or column names specifying continuous variables that should be discretized. By default, assumes that every variable is categorical.
- **breaks**: numeric vector or list passed on to `cut` to discretize continuous variables. When a numeric vector is specified, break points are applied to all continuous variables. In order to specify variable-specific breaks, lists are used. List names identify variables and list values identify breaks. List names are column names (not numbers). If a continuous variable has no specified breaks, then `default_breaks` will be applied.
- **default_breaks**: default break points for discretizations. Same syntax as in `cut`.

Value

List containing the following values:

- `raw`: raw subsetted data.frame
- `pp`: discretized, subsetted and complete data.frame
- `select`
- `continuous`
- `breaks`
- `default_breaks`

Examples

```
# This is what happens behind the curtains in the 'lassie' function
# Here we compute the association between the 'Girth' and 'Height' variables
# of the 'trees' dataset

# 'select' and 'continuous' take column numbers or names
select <- c('Girth', 'Height')  # select subset of trees
continuous <- c(1, 2)          # both 'Girth' and 'Height' are continuous

# equal-width discretization with 3 bins
breaks <- 3

# Preprocess data: subset, discretize and remove missing data
pre <- preprocess(trees, select, continuous, breaks)

# Estimates marginal and multivariate probabilities from preprocessed data.frame
prob <- estimate_prob(pre$pp)

# Computes local and global association using Ducher's Z
lam <- local_association(prob, measure = 'z')
```
**print.lassie**

*Print a lassie object*

## Description

Print a lassie object as an array or a data.frame.

## Usage

```r
## S3 method for class 'lassie'
print(x, type, what_x, range, what_range, what_sort, decreasing, na.rm, ...)
```

## Arguments

- **x**
  - lassie S3 object.
- **type**
  - print style: 'array' for array or 'df' for data.frame.
- **what_x**
  - vector specifying values to be returned:
    - 'local': local association measure values (default).
    - 'obs': observed probabilities.
    - 'exp': expected probabilities.
    - 'local_p': p-value of local association (after running permtest).
- **range**
  - range of values to be retained (vector of two numeric values).
- **what_range**
  - character specifying what value range refers to (same options as what_x). By default, takes the first value in what_x.
- **what_sort**
  - character specifying according to which values should x be sorted (same options as what_x). By default, takes the first value in what_x.
- **decreasing**
  - logical value specifying sort order.
- **na.rm**
  - logical value indicating whether NA values should be stripped.
- **...**
  - other arguments passed on to methods. Not currently used.

## See Also

lassie, permtest
write.lassie

Write a lassie object

Description

Writes lassie object to a file in a table structured format.

Usage

write.lassie(
  x,
  file,
  sep = ",",
  dec = ".",
  col.names = TRUE,
  row.names = FALSE,
  quote = TRUE,
  ...
)

Arguments

  x  lassie S3 object.
  file  character string naming a file.
  sep  the field separator string. Values within each row of x are separated by this string.
  dec  the string to use for decimal points in numeric or complex columns: must be a single character.
  col.names  either a logical value indicating whether the column names of x are to be written along with x, or a character vector of column names to be written. See the section on ‘CSV files’ for the meaning of col.names = NA.
  row.names  either a logical value indicating whether the row names of x are to be written along with x, or a character vector of row names to be written.
  quote  a logical value (TRUE or FALSE) or a numeric vector. If TRUE, any character or factor columns will be surrounded by double quotes. If a numeric vector, its elements are taken as the indices of columns to quote. In both cases, row and column names are quoted if they are written. If FALSE, nothing is quoted.
  ...  other arguments passed on to write.table.

See Also

  lassie, permtest
**Description**

The *zebu* package implements the estimation of local (and global) association measures: Ducher’s Z, pointwise mutual information and normalized pointwise mutual information. The significance of local (and global) association is accessed using p-values estimated by permutations.

**Functions**

- `lassie` estimates local (and global) association measures: Ducher’s Z, pointwise mutual information and normalized pointwise mutual information.
- `permtest` accesses the significance of local (and global) association values using p-values estimated by permutations.
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