Package ‘representr’

September 5, 2023

Type Package
Title Create Representative Records After Entity Resolution
Version 0.1.5
Description An implementation of Kaplan, Betancourt, Steorts (2022) <doi:10.1080/00031305.2022.2041482> that creates representative records for use in downstream tasks after entity resolution is performed. Multiple methods for creating the representative records (data sets) are provided.
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\textbf{R} topics documented:

\begin{verbatim}
clust_composite ........................................... 2
clust_proto_random ......................................... 3
dist_binary ................................................ 4
dist_col_type ............................................... 5
emp_kl_div .................................................. 6
\end{verbatim}
clust_composite

Composite record from a cluster using a weighted average of each column values.

Description

Composite record from a cluster using a weighted average of each column values.

Usage

```r
clust_composite(
  cluster,
  col_type,
  weights = rep(1/nrow(cluster), nrow(cluster))
)
```

Arguments

- `cluster`: A data frame of the clustered records
- `col_type`: A vector encoding the column type for each column in the dataset. Can take values in "categorical", "ordinal", "string", or "numeric"
- `weights`: A vector of length equal to the number of records in the cluster indicating the weight for each. Defaults to equal weight.

Value

Returns the composite record from an individual cluster.

```r
# @examples data("rl_reg1")
clusters <- split(rl_reg1, identity.rl_reg1) type <- c("string", "string", "numeric", "numeric", "numeric", "categorical", "ordinal", "numeric", "numeric")
clust_composite(clusters[[1]], type)
```
**clust_proto_random**

Prototype record from a cluster.

---

**Description**

Prototype record from a cluster.

**Usage**

```r
clust_proto_random(
    cluster,
    prob = rep(1/nrow(cluster), nrow(cluster)),
    id = TRUE
)

clust_proto_minimax(cluster, not_cluster, distance, id = TRUE, ...)

maxmin_compare(ties, not_cluster, distance, ...)

within_category_compare(ties, not_cluster, distance, ...)

random_compare(ties, not_cluster, distance, ...)
```

**Arguments**

- `cluster` A data frame of the clustered records.
- `prob` A vector of length `nrow(cluster)` that sums to 1, giving the probability of selection.
- `id` Logical indicator to return id of record selected (TRUE) or actual record (FALSE). Note, if returning id, must have original row numbers as rownames in each cluster.
- `not_cluster` A data frame of the records outside the cluster
- `distance` A distance function for comparing records
- `...` Additional arguments passed to the comparison function
- `ties` A data frame of the records that are tied

**Value**

If `id = FALSE`, returns the prototype record from an individual cluster. Otherwise, returns the record id of the prototype record for that cluster. If there is a tie in the minimax prototype method, then random selection is used to break the tie.
Examples

data("rl_reg1")

clusters <- split(rl_reg1, identity.rl_reg1)
clust_proto_random(clusters[[1]])

not_clusters <- lapply(seq_along(clusters), function(x){
  if(nrow(clusters[[x]]) > 1)
    do.call(rbind, clusters[-x])
})
clust_proto_minimax(clusters[[1]], not_clusters[[1]], dist_binary)

---

**dist_binary**

*The distance between two records*

Description

The distance between two records

Usage

`dist_binary(a, b)`

```
dist_col_type_slow(
  a, 
  b, 
  col_type, 
  string_dist = utils::adist, 
  weights = rep(1/length(a), length(a)), 
  orders = NULL, 
  ...
)
```

Arguments

- `a`: Record a
- `b`: Record b
- `col_type`: A vector encoding the column type for each column in the dataset. Can take values in "categorical", "ordinal", "string", or "numeric"
- `string_dist`: String distance function. Default is edit distance. Function must take at least two arguments (strings)
- `weights`: A vector of weights for each column for making some column distances more important. Must sum to 1. Defaults to equal weights.
- `orders`: A named list containing the order of the levels in each ordinal column. Defaults to NULL, which corresponds to no ordinal variables.
- `...`: Additional parameters passed to string distance function.
Value

binary_dist returns a numeric value indicating how many discrepancies there are between two records.

col_type_dist return a numeric value of the weighted column type specific distance between two records.

Examples

data("rl_reg1")
dist_binary(rl_reg1[,1], rl_reg1[,2])

type <- c("string", "string", "numeric", "numeric",
"numeric", "categorical", "ordinal", "numeric", "numeric")
order <- list(education = c("Less than a high school diploma",
"High school graduates, no college", "Some college or associate degree",
"Bachelor's degree only", "Advanced degree"))

dist_col_type_slow(rl_reg1[,1], rl_reg1[,2], col_type = type, order = order)

dist_col_type

Description

dist_col_type Inner column type record distance function

Usage

dist_col_type(a, b, col_type, weights, orders)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>record a</td>
</tr>
<tr>
<td>b</td>
<td>record b</td>
</tr>
<tr>
<td>col_type</td>
<td>A vector encoding the column type for each column in the dataset. Can take values in &quot;categorical&quot;, &quot;ordinal&quot;, &quot;string&quot;, or &quot;numeric&quot;</td>
</tr>
<tr>
<td>weights</td>
<td>A vector of weights for each column for making some column distances more important. Must sum to 1. Defaults to equal weights.</td>
</tr>
<tr>
<td>orders</td>
<td>A named list containing the order of the levels in each ordinal column. Defaults to NULL, which corresponds to no ordinal variables.</td>
</tr>
</tbody>
</table>
emp_kl_div

Calculate the empirical KL divergence for a representative dataset as compared to the true dataset

Description
Calculate the empirical KL divergence for a representative dataset as compared to the true dataset

Usage

```r
emp_kl_div(
  true_dat, 
  rep_dat, 
  categoric_vars, 
  numeric_vars, 
  l_m = 10, 
  weights = rep(1, nrow(rep_dat))
)
```

Arguments

- `true_dat` The true dataset
- `rep_dat` A representative dataset
- `categoric_vars` A vector of column positions or column names for the categoric variables.
- `numeric_vars` A vector of column positions or column names for the numeric variables.
- `l_m` Approximate number of true data points to be in each bin for numeric variables. Default is 10.
- `weights` If weighted frequencies are desired, pass a vector weights of the same length as representative data points.

Details
This function computes the estimated the KL divergence of two samples of data using the empirical distribution functions for the representative data set and true data set with continuous variables transformed to categorical using a histogram approach with statistically equivalent data-dependent bins, as detailed in


Examples

```r
data("rl_reg1")
## random prototyping
```
```r
rep_dat_random <- represent(rl_reg1, identity.rl_reg1, "proto_random", id = FALSE, parallel = FALSE)

## empirical KL divergence
cat_vars <- c("sex")
num_vars <- c("income", "bp")
emp_kl_div(rl_reg1[unique(identity.rl_reg1), c(cat_vars, num_vars)],
          rep_dat_random[, c(cat_vars, num_vars)],
          cat_vars, num_vars)
```

### Description

Get posterior weights for each record post record-linkage using posterior prototyping.

### Usage

```r
pp_weights(
  data,
  posterior_linkage,
  rep_method,
  parallel = TRUE,
  cores = NULL,
  ...,  # Additional parameters sent to cluster representation function. See minimax or random methods. If passing a probability to the random method, must be list of the same length as the number of iterations in lambda and within each must
  scale = FALSE,
  save_loc = NULL,
  verbose = FALSE
)
```

### Arguments

- **data**: A data frame of records to be represented.
- **posterior_linkage**: A matrix of size m x n, indicating the posterior cluster ids post-record linkage, each row represents the cluster assignment for each record in data for 1 iteration of the sampler.
- **rep_method**: Which method to use for representation. Valid options include "proto_minimax" and "proto_random".
- **parallel**: Logical flag if to use parallel computation or not (via foreach).
- **cores**: If specified, the number of cores to use with foreach.
- **...**: Additional parameters sent to cluster representation function. See minimax or random methods. If passing a probability to the random method, must be list of the same length as the number of iterations in lambda and within each must
be a list of the same length as the number of clusters. Within each should be a vector of probabilities, the same length as the number of rows in the cluster 
prob[[iteration]][[cluster]].

scale If "proto_minimax" method is specified, logical flag to indicate if the column-
type distance function should be scaled so that each distance takes value in [0, 
1]. Defaults to FALSE.

save_loc Location to save intermediate progress. If NULL, no intermediate progress is 
saved.

verbose Flag for progress messages.

Examples

data(r1_reg1)

# make a fake posterior distribution for the linkage
m <- 10
n <- nrow(r1_reg1)
post_link <- matrix(sample(seq_len(n), n*m, replace = TRUE), nrow = m)

# get the posterior prototyping weights
col_type <- c("string", "string", "numeric", "numeric", "categorical", "ordinal", 
"numeric", "numeric")
orders <- list(education = c("Less than a high school diploma", "High school graduates, no college", 
"Some college or associate degree", "Bachelor's degree only", "Advanced degree"))
weights <- c(.25, .25, .05, .05, .1, .15, .05, .05, .05)

pp_weight <- pp_weights(r1_reg1, post_link, "proto_minimax", distance = dist_col_type, 
col_type = col_type, weights = weights, orders = orders, scale = TRUE, parallel = FALSE)

# threshold by posterior prototyping weights
head(r1_reg1[pp_weight > 0.5, ])

represent Create a representative dataset post record-linkage.

Description

Create a representative dataset post record-linkage.

Usage

represent(
  data,
  linkage,
represent

rep_method,
parallel = TRUE,
cores = NULL,
..., 
scale = FALSE
)

Arguments

data A data frame of records to be represented.
linkage A numeric vector indicating the cluster ids post-record linkage for each record in data.
rep_method Which method to use for representation. Valid options include "proto_minimax", "proto_random", and "composite".
parallel Logical flag if to use parallel computation or not (via foreach).
cores If specified, the number of cores to use with foreach.
... Additional parameters sent to cluster representation function. See prototyping or composite methods.
scale If "proto_minimax" method is specified, logical flag to indicate if the column-type distance function should be scaled so that each distance takes value in [0, 1]. Defaults to FALSE.

Examples

data("rl_reg1")

## random prototyping
rep_dat_random <- represent(rl_reg1, identity.rl_reg1, "proto_random", id = FALSE, parallel = FALSE)
head(rep_dat_random)

## minimax prototyping
col_type <- c("string", "string", "numeric", "numeric", "numeric", "categorical", "ordinal",
\ "numeric", "numeric")
orders <- list(education = c("Less than a high school diploma", "High school graduates, no college",
\ "Some college or associate degree", "Bachelor’s degree only", "Advanced degree"))
weights <- c(.25, .25, .05, .05, .1, .15, .05, .05, .05)
rep_dat_minimax <- represent(rl_reg1, identity.rl_reg1, "proto_minimax", id = FALSE,
\ distance = dist_col_type, col_type = col_type, weights = weights, orders = orders,
\ scale = TRUE, parallel = FALSE)
head(rep_dat_minimax)

## Not run:
## with alternative tie breaker
rep_dat_minimax <- represent(rl_reg1, identity.rl_reg1, "proto_minimax", id = FALSE,
\ distance = dist_col_type, col_type = col_type, weights = weights, orders = orders,
\ ties_fn = "maxmin_compare", scale = TRUE, parallel = FALSE)
head(rep_dat_minimax)
rep_dat_minimax <- represent(rl_reg1, identity.rl_reg1, "proto_minimax", id = FALSE, distance = dist_col_type, col_type = col_type, weights = weights, orders = orders, ties_fn = "within_category_compare_cpp", scale = TRUE, parallel = FALSE)
head(rep_dat_minimax)

## composite prototyping
rep_dat_composite <- represent(rl_reg1, identity.rl_reg1, "composite", col_type = col_type, parallel = FALSE)
head(rep_dat_composite)

## End(Not run)

**Description**

The representr package provides two types of representative record generation: point prototyping and posterior prototyping.

**Point Prototyping**

To bridge the gap between record linkage and a downstream task, there are three methods to choose or create the representative records from linked data: random prototyping, minimax prototyping, and composite. These are all based on a point estimate of the linkage structure post-record linkage (rather than a posterior distribution).

**Random prototyping** chooses a record from each cluster at random, either uniformly or according to a supplied distribution. **Minimax prototyping** selects the record whose farthest neighbors within the cluster is closest, based on some notion of closeness that is measured by a record distance function. There are two distance functions included in this package (binary and column-based), or the user can specify their own. **Composite** record creation constructs the representative record by aggregating the records (in each cluster) to form a composite record that includes information from each linked record.

Each of these three types of prototyping can be used from the function `represent`.

**Posterior prototyping**

The posterior distribution of the linkage can be used in two ways in this package. The first, is as weights or in a distance function for the above point prototyping methods. The second, is through the posterior prototyping (PP) weights presented in Kaplan, Betancourt, and Steorts (2018+). The PP weights are accessible through the `pp_weights` function.

**References**

**Description**

Simulated datasets containing the name, birthdate, and additional attributes of 500 records, of which there are 350 unique individuals.

**Usage**

- `rl_reg1`
- `rl_reg2`
- `rl_reg5`
- `identity.rl_reg1`
- `identity.rl_reg2`
- `identity.rl_reg5`
- `linkage.rl`

**Format**

`rl_reg1` and `rl_reg5` are data frames with 500 rows and 9 columns. Each row represents 1 records with the following columns:

- **fname** First name
- **lname** Last name
- **bm** Birth month (numeric)
- **bd** Birth day
- **by** Birth year
- **sex** Sex ("M" or "F")
- **education** Education level ("Less than a high school diploma", "High school graduates, no college", "Some college or associate degree", "Bachelor's degree only", or "Advanced degree")
- **income** Yearly income (in 1000s)
- **bp** Systolic blood pressure

`identity.rl_reg1` and `identity.rl_reg5` are integer vectors indicating the true record ids of the two datasets. Two records represent the same individual if and only if their corresponding identity values are equal.
Within linkage.r1 contains the result of running 100,000 iterations of a record linkage model using the package dblinkR.

An object of class data.frame with 500 rows and 9 columns.
An object of class data.frame with 500 rows and 9 columns.
An object of class integer of length 500.
An object of class integer of length 500.
An object of class integer of length 500.
An object of class matrix (inherits from array) with 100000 rows and 500 columns.

Details

There is a known relationship between three of the variables in the dataset, blood pressure (bp), income, and sex.

\[ bp = 160 + 10I(\text{sex} = "M") - \text{income} + 0.5\text{income} \times I(\text{sex} = "M") + \epsilon \]

where \(\epsilon \sim \text{Normal}(0, \sigma^2)\) and \(\sigma = 1, 2, 5\).

The 150 duplicated records have randomly generated errors.

Source

Names and birthdates generated with the ANU Online Personal Data Generator and Corruptor (GeCO) version 0.1 https://dmm.anu.edu.au/geco/.

within_category_compare_cpp

within_category_compare_cpp Inner column type record distance function

Description

within_category_compare_cpp Inner column type record distance function

Usage

within_category_compare_cpp(
  ties,
  not_cluster,
  col_type,
  weights,
  orders,
  distance
)
Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ties</td>
<td>A data frame of the records that are tied</td>
</tr>
<tr>
<td>not_cluster</td>
<td>A data frame of the records outside the cluster</td>
</tr>
<tr>
<td>col_type</td>
<td>A vector encoding the column type for each column in the dataset. Can take values in &quot;categorical&quot;, &quot;ordinal&quot;, &quot;string&quot;, or &quot;numeric&quot;</td>
</tr>
<tr>
<td>weights</td>
<td>A vector of weights for each column for making some column distances more important. Must sum to 1. Defaults to equal weights.</td>
</tr>
<tr>
<td>orders</td>
<td>A named list containing the order of the levels in each ordinal column. Defaults to NULL, which corresponds to no ordinal variables.</td>
</tr>
<tr>
<td>distance</td>
<td>function that does nothing right now, but must be supplied to not break other code.</td>
</tr>
</tbody>
</table>
Index

* datasets
  rl_reg1, 11

binary, 10

clust_composite, 2
clust_proto_minimax
  (clust_proto_random), 3
clust_proto_random, 3
column-based, 10
composite, 9
dist_binary, 4
dist_col_type, 5
dist_col_type_slow (dist_binary), 4

emp_kl_div, 6

identity.rl_reg1 (rl_reg1), 11
identity.rl_reg2 (rl_reg1), 11
identity.rl_reg5 (rl_reg1), 11

linkage.rl (rl_reg1), 11

maxmin_compare (clust_proto_random), 3
minimax, 7

pp_weights, 7, 10
prototyping, 9

random, 7
random_compare (clust_proto_random), 3
represent, 8, 10
representr, 10
rl_reg1, 11
rl_reg2 (rl_reg1), 11
rl_reg5 (rl_reg1), 11

within_category_compare
  (clust_proto_random), 3
within_category_compare_cpp, 12