Package ‘cat2cat’

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**Title**  Unify a Categorical Variable in a Panel Dataset

**Version**  0.3.3

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**Description**  There are offered automatic methods to map a categorical variable according to a specific encoding across different time points. The main rule is to replicate the observation if it could be assign to a few categories. Then using simple frequencies or statistical methods to approximate probabilities of being assign to each of them. This algorithm was invented and implemented in the paper by (Nasinski, Majchrowska and Broniatowska (2020) <doi:10.24425/cejeme.2020.134747>).

**Depends**  R (>= 3.6)

**License**  GPL (>= 2)


**BugReports**  https://github.com/Polkas/cat2cat/issues

**Encoding**  UTF-8

**Imports**  MASS, assertthat

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  **Automatic mapping of a categorical variable in a panel dataset according to a new encoding**

**Description**

This function is built to work for two time points at once. Thus for more periods some recursion will be needed. The prune_c2c might be needed when we have many interactions to limit growing number of replications. This function might seems to be a complex at the first glance though it is built to offer a wide range of applications for complex tasks.

**Usage**

```r
cat2cat(
  data = list(old = NULL, new = NULL, cat_var = NULL, id_var = NULL, time_var = NULL,
              multiplier_var = NULL, freqs_df = NULL),
  mappings = list(trans = NULL, direction = NULL),
  ml = list(method = NULL, features = NULL, args = NULL)
)
```

**Arguments**

- `data` list with 4, 5, 6 or 7 named fields ‘old’ ‘new’ ‘cat_var’ ‘time_var’ and optional ‘id_var’, ‘multiplier_var’, ‘freq_df’
- `mappings` list with 2 named fields ‘trans’ ‘direction’
- `ml` list with 3 named fields ‘method’ ‘features’ ‘args’
Details

data args

• "old" data.frame older time point in a panel
• "new" data.frame more recent time point in a panel
• "cat_var" character name of the categorical variable. NA values are automatically converted to "NA" strings.
• "time_var" character name of the time variable
• "id_var" optional character name of the unique identifier variable - if this is specified then for subjects observe in both periods the direct mapping is applied.
• "multiplier_var" optional character name of the multiplier variable - number of replication needed to reproduce the population
• "freqs_df" optional only for advanced users - data.frame with 2 columns where first one is category name and second counts which will be used to assess the probabilities.

mappings args

• "trans" data.frame with 2 columns - transition table - all categories for cat_var in old and new datasets have to be included. First column contains an old encoding and second a new one. The transition table should to have a candidate for each category from the targeted for an update period.
• "direction" character direction - "backward" or "forward"

optional ml args

• "method" character vector - one or a few from "knn", "rf" and "lda" methods - "knn" k-NearestNeighbors, "lda" Linear Discrimination Analysis, "rf" Random Forest
• "features" character vector of features names where all have to be numeric or logical
• "args" list parameters: knn: k ; rf: ntree

Without ml section only simple frequencies are assessed. When ml model is broken then weights from simple frequencies are taken. Method knn is recommended for smaller datasets.

Value

named list with 2 fields old and new - 2 data.frames. There will be added additional columns like index_c2c, g_new_c2c, wei_freq_c2c, rep_c2c, wei_(ml method name)_c2c. Additional columns will be informative only for a one data.frame as we always make a changes to one direction.

Note

The transition table should to have a candidate for each category from the targeted for an update period. The observation from targeted for an updated period without a matched category from base period is removed. If you want to leave NA values add ‘c(NA, NA)’ row to the ‘trans’ table.
Examples

```r
## Not run:
data(occup_small)
data(occup)
data(trans)

occup_old <- occup_small[occup_small$year == 2008, ]
occup_new <- occup_small[occup_small$year == 2010, ]

# default only simple frequencies
occup_simple <- cat2cat(
data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
mappings = list(trans = trans, direction = "forward")
)

# additionally add probabilities from knn
occup_ml <- cat2cat(
data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
mappings = list(trans = trans, direction = "forward"),
ml = list(
  method = "knn",
  features = c("age", "sex", "edu", "exp", "parttime", "salary"),
  args = list(k = 10)
)
)

## End(Not run)
```

---

**cat2cat_agg**

*Manual mapping of a categorical variable according to a new encoding for aggregated panel dataset*

### Description

Aggregate panel dataset - Manual mapping of a categorical variable according to a new encoding where user providing transitions with equations.

#### Usage

```r
cat2cat_agg(
data = list(old = NULL, new = NULL, cat_var = NULL, time_var = NULL, freq_var = NULL),
...
)
```

#### Arguments

- **data**
- **...**
  - equations where direction is set with any of ‘>’, ‘<’, ‘%>%’, ‘%<%’. 

Details

data argument - list with fields

- "old" data.frame older time point in the panel
- "new" data.frame more recent time point in the panel
- "cat_var" character name of the categorical variable
- "time_var" character name of time variable
- "freq_var" character name of frequency variable

Value

list of two data.frame objects.

Examples

data(verticals)
agg_old <- verticals[verticals$v_date == "2020-04-01", ]
agg_new <- verticals[verticals$v_date == "2020-05-01", ]

## cat2cat_agg - could map in both directions at once although
## usually we want to have old or new representation

agg <- cat2cat_agg(
data = list(
  old = agg_old,
  new = agg_new,
  cat_var = "vertical",
  time_var = "v_date",
  freq_var = "counts"
),
  Automotive %<% c(Automotive1, Automotive2),
  c(Kids1, Kids2) %>% c(Kids),
  Home %>% c(Home, Supermarket)
)

Description

applying frequencies to the object returned by get_mappings. We will get a symmetric object to
returned one by get_mappings function, nevertheless categories are replaced with frequencies. Fre-
quencies for each category/key are sum to 1, so could be interpreted as probabilities.

Usage

cat_apply_freq(to_x, freqs)
**Arguments**

- `to_x` list object returned by `get_mappings`.
- `freqs` vector object returned by `get_freqs`.

**Value**

a list with 2 named lists ‘to_old’ and ‘to_new’.

**Examples**

```r
data(trans)
data(occup)
mappings <- get_mappings(trans)
mappings$to_old[1:4]
mappings$to_new[1:4]
mapp_p <- cat_apply_freq(
mappings$to_old,
get_freqs(
  occup$code[occup$year == "2008"],
  occup$multiplier[occup$year == "2008"]
)
)
head(data.frame(I(mappings$to_old), I(mapp_p)))
mapp_p <- cat_apply_freq(
mappings$to_new,
get_freqs(
  occup$code[occup$year == "2010"],
  occup$multiplier[occup$year == "2010"]
)
)
head(data.frame(I(mappings$to_new), I(mapp_p)))
```

---

cross_c2c

*a function to make a combination of weights from different methods by each row*

**Description**

adding additional column which is a mix of weights columns by each row

**Usage**

```r
cross_c2c(
  df,
  cols = colnames(df)[grep("^weι_.+_c2c$", colnames(df))],
  weis = rep(1/length(cols), length(cols)),
```
cross_c2c

    na.rm = TRUE
  }

Arguments

df     data.frame
cols   character vector default all columns follow regex like "wei_.+_c2c"
weis   numeric vector Default vector the same length as cols and with equally spaced values summing to 1.
na.rm  logical if NA should be skipped, default TRUE

Value
data.frame with an additional column wei_cross_c2c

Examples

## Not run:
data(occup_small)
data(occup)
data(trans)

occup_old <- occup_small[occup_small$year == 2008, ]
occup_new <- occup_small[occup_small$year == 2010, ]

# mix of methods - forward direction, try out backward too
occup_mix <- cat2cat(    data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
  mappings = list(trans = trans, direction = "backward"),
  ml = list(
    method = c("knn"),
    features = c("age", "sex", "edu", "exp", "parttime", "salary"),
    args = list(k = 10, ntree = 20)
  )
)

# correlation between ml model
occup_mix_old <- occup_mix$old
cor(occup_mix_old[occup_mix_old$rep_c2c != 1, c("wei_knn_c2c", "wei_freq_c2c")])

# cross all methods and subset one highest probability category for each subject
occup_old_highest1_mix <- prune_c2c(cross_c2c(occup_mix$old),
  column = "wei_cross_c2c", method = "highest1"
)

## End(Not run)
### get_freqs

**Description**

Getting frequencies from a 'character' vector with an optional multiplier argument

**Usage**

```r
get_freqs(x, multiplier = NULL)
```

**Arguments**

- `x`: character vector categorical variable to summarize.
- `multiplier`: numeric vector how many times to repeat certain value, additional weights.

**Value**

data.frame with two columns 'input' 'Freq'

**Note**

without multiplier variable it is a basic 'table' function wrapped with the 'as.data.frame' function. The 'table' function is used with the 'useNA = "ifany"' argument.

**Examples**

```r
data(occup)
head(get_freqs(occup$code[occup$year == "2008"]))
head(get_freqs(occup$code[occup$year == "2010"]))
head(get_freqs(occup$code[occup$year == "2008"], occup$multiplier[occup$year == "2008"]))
head(get_freqs(occup$code[occup$year == "2010"], occup$multiplier[occup$year == "2010"]))
```

### get_mappings

**Description**

Transforming a transition table with mappings to two associative lists

**Description**

to rearrange the one classification encoding into another, an associative list that maps keys to values is used. More precisely, an association list is used which is a linked list in which each list element consists of a key and value or values. An association list where unique categories codes are keys and matching categories from next or previous time point are values. A transition table is used to build such associative lists.
get_mappings(x = data.frame())

Arguments

x  data.frame or matrix - transition table with 2 columns where first column is assumed to be the older encoding.

Details

the named list will be a more efficient solution than hash map as we are not expecting more than a few thousand keys.

Value

a list with 2 named lists 'to_old' and 'to_new'.

Examples

data(trans)

mappings <- get_mappings(trans)
mappings$to_old[1:4]
mappings$to_new[1:4]

occup

Occupational dataset

Description

Occupational dataset

Usage

occup

Format

A data frame with around 20000 observations and 12 variables.

id  integer id
age  numeric age of a subject
sex  numeric sex of a subject
edu  integer edu level of education of a subject where lower means higher - 1 for at least master degree
exp  numeric exp number of experience years for a subject
district  integer district
Details

occup dataset is an example of unbalance panel dataset. This is a simulated data although there are applied a real world characteristics from national statistical office survey. The original survey is anonymous and take place every two years. It is presenting a characteristics from randomly selected company and then using k step procedure employees are chosen.

occupational dataset

---

occup_small  Occupational dataset - small one

Description

Occupational dataset - small one

Usage

occup_small

Format

A data frame with around 5000 observations and 12 variables.

id  integer id
age  numeric age of a subject
sex  numeric sex of a subject
edu  integer edu level of education of a subject where lower means higher - 1 for at least master degree
exp  numeric exp number of experience years for a subject
district  integer district
parttime  numeric contract type regards time where 1 mean full-time (work a whole week)
salary  numeric salary per year
code  character code - occupational code
multiplier  numeric multiplier for the subject to reproduce a population - how many of such subjects in population
year  integer year
code4  character code - occupational code - first 4 digits
Details
occup dataset is an example of unbalance panel dataset. This is a simulated data although there are applied real world characteristics from national statistical office survey. The original survey is anonymous and take place every two years. It is presenting a characteristics from randomly selected company and then using k step procedure employees are chosen.

occupational dataset

Examples
```r
set.seed(1234)
data(occup)
occup_small <- occup[sort(sample(nrow(occup), 5000)), ]
```

plot_c2c

Summary plots for cat2cat results

Description
This function help to understand properties of cat2cat results. It is recommended to run it before further processing, like next iterations.

Usage
```r
plot_c2c(data, weis = "wei_freq_c2c", type = c("both", "hist", "bar"))
```

Arguments
data
data.frame - one of the data.frames returned by the `cat2cat` function.
weis
character - name of a certain wei_*_c2c column, added by cat2cat function. Default wei_freq_c2c
type
character - one of 3 types "both", "hist", "bar".

Value
base plot graphics

Note
It will work only for data.frame produced by cat2cat function.
prune_c2c

A set of prune methods which will be useful after transition process

Description

user could specify one from four methods to prune replications

Usage

```r
prune_c2c(
  df, 
  index = "index_c2c", 
  column = "wei_freq_c2c", 
  method = "nonzero", 
  percent = 50
)
```

Arguments

df data.frame

index character default wei_freq_c2c

column character default index_c2c

method character one of four available methods: default "nonzero", "highest", "highest1", "morethan"

percent integer from 0 to 99

Details

method - specify method to reduce number of replications

- "nonzero" remove nonzero probabilities
- "highest" leave only highest probabilities for each subject- accepting ties
- "highest1" leave only highest probabilities for each subject- not accepting ties so always one is returned
- "morethan" leave rows where a probability is higher than value specify by percent argument

Examples

```r
data(occup_small)
occup_old <- occup_small[occup_small$year == 2008, ]
occup_new <- occup_small[occup_small$year == 2010, ]

occup_2 <- cat2cat(
  data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
  mappings = list(trans = trans, direction = "backward")
)

plot_c2c(occup_2$old, type = c("both"))
plot_c2c(occup_2$old, type = c("hist"))
plot_c2c(occup_2$old, type = c("bar"))
```
summary_c2c

Value

data.frame

Examples

```r
## Not run:
data(occup_small)
data(occup)
data(trans)

occup_old <- occup_small[occup_small$year == 2008, ]
occup_new <- occup_small[occup_small$year == 2010, ]

occup_ml <- cat2cat(
  data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
  mappings = list(trans = trans, direction = "backward"),
  ml = list(
    method = "knn",
    features = c("age", "sex", "edu", "exp", "parttime", "salary"),
    args = list(k = 10)
  )
)

prune_c2c(occup_ml$old, method = "nonzero")
prune_c2c(occup_ml$old, method = "highest")
prune_c2c(occup_ml$old, method = "highest1")
prune_c2c(occup_ml$old, method = "morethan", percent = 90)
prune_c2c(occup_ml$old, column = "wei_knn_c2c", method = "nonzero")

## End(Not run)
```

---

### summary_c2c

*Adjusted summary for linear regression when based on replicated dataset*

#### Description

Adjusting lm object results according to original number of degree of freedom. The standard errors, t statistics and p values have to be adjusted because of replicated rows.

#### Usage

```r
summary_c2c(x, df_old, df_new = x$df.residual)
```
Arguments

- x: lm object
- df_old: integer number of d.f in original dataset. For bigger datasets 'nrow' should be sufficient.
- df_new: integer number of d.f in dataset with replicated rows, Default: x$df.residual

Details

The size of the correction is equal to \sqrt{df\_new / df\_old}. Where standard errors are multiplied and t statistics divided by it. In most cases the default df\_new value should be used.

Value

data.frame with additional columns over a regular summary.lm output, like correct and statistics adjusted by it.

Examples

data(occup_small)
data(trans)

occup_old <- occup_small[occup_small$year == 2008, ]
occup_new <- occup_small[occup_small$year == 2010, ]

occup_2 <- cat2cat(
  data = list(old = occup_old, new = occup_new, cat_var = "code", time_var = "year"),
  mappings = list(trans = trans, direction = "backward"),
  ml = list(
    method = "knn",
    features = c("age", "sex", "edu", "exp", "parttime", "salary"),
    args = list(k = 10)
  )
)

# Regression
# we have to adjust size of std as we artificially enlarge degrees of freedom
lms <- lm(I(log(salary)) ~ age + sex + factor(edu) + parttime + exp, occup_2$old,
  weights = multiplier * wei_freq_c2c
)

summary_c2c(lms, df_old = nrow(occup_old))

---

trans

trans dataset containing transitions between old (2008) and new (2010) occupational codes. This table could be used to map encodings in both directions.
Description

trans dataset containing transitions between old (2008) and new (2010) occupational codes. This table could be used to map encodings in both directions.

Usage

trans

Format

A data frame with 2693 observations and 2 variables.

old character an old encoding of a certain occupation
new character a new encoding of a certain occupation

Details

Transition table for occupations where first column contains old encodings and second one a new encoding

---

verticals

Description

verticals dataset

Usage

verticals

Format

A data frame with 21 observations and 4 variables.

vertical character an certain sales vertical
sales numeric a size of sale
counts integer counts size
v_date character Date

Details

Random data - aggregate sales across e-commerce verticals
Examples

```r
set.seed(1234)
agg_old <- data.frame(
  vertical = c(
    "Clothes", "Home", "Fashion", "Health", "Sport"
  ),
  sales = rnorm(10, 100, 10),
  counts = rgeom(10, 0.0001),
  v_date = rep("2020-04-01", 10), stringsAsFactors = FALSE
)
agg_new <- data.frame(
  vertical = c(
    "Electronics", "Supermarket", "Kids", "Automotive1",
  ),
  sales = rnorm(11, 100, 10),
  counts = rgeom(11, 0.0001),
  v_date = rep("2020-05-01", 11), stringsAsFactors = FALSE
)
verticals <- rbind(agg_old, agg_new)
```

### verticals2

**Description**
verticals2 dataset

**Usage**
verticals2

**Format**
A data frame with 202 observations and 4 variables.

- **ean** product ean
- **vertical** character an certain sales vertical
- **sales** numeric a size of sale
- **v_date** character Date

**Details**
random data - single products sales across e-commerce verticals
Examples

```r
set.seed(1234)
vert_old <- data.frame(
  ean = 90000001:90000020,
  vertical = sample(c(
    "Clothes", "Home", "Fashion", "Health", "Sport"
  ), 20, replace = TRUE),
  sales = rnorm(20, 100, 10),
  v_date = rep("2020-04-01", 20), stringsAsFactors = FALSE
)
vert_old2 <- data.frame(
  ean = 90000021:90000100,
  vertical = sample(c(
    "Clothes", "Home", "Fashion", "Health", "Sport"
  ), 80, replace = TRUE),
  sales = rnorm(80, 100, 10),
  v_date = rep("2020-04-01", 80), stringsAsFactors = FALSE
)
vert_new <- vert_old2
vert_new$sales <- rnorm(nrow(vert_new), 80, 10)
vert_new$v_date <- "2020-05-01"
vert_new$vertical[vert_new$vertical %in% c("Kids1", "Kids2")] <- "Kids"
vert_new$vertical[vert_new$vertical %in% c("Automotive")] <-
  sample(c("Automotive1", "Automotive2"), sum(vert_new$vertical %in% c("Automotive")),
         replace = TRUE)
vert_new$vertical[vert_new$vertical %in% c("Home")] <-
  sample(c("Home", "Supermarket"), sum(vert_new$vertical %in% c("Home")), replace = TRUE)
vert_new2 <- data.frame(
  ean = 90000101:90000120,
  vertical = sample(c(
    "Electronics", "Supermarket", "Kids", "Automotive1",
    "Automotive2", "Books", "Clothes", "Home",
    "Fashion", "Health", "Sport"
  ), 20, replace = TRUE),
  sales = rnorm(20, 100, 10),
  v_date = rep("2020-05-01", 20), stringsAsFactors = FALSE
)
verticals2 <- rbind(
  rbind(vert_old, vert_old2),
  rbind(vert_new, vert_new2)
)
verticals2$vertical <- as.character(verticals2$vertical)
```
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