Package ‘embed’

November 24, 2021

Title Extra Recipes for Encoding Predictors

Version 0.1.5

Description Predictors can be converted to one or more numeric representations using a variety of methods. Effect encodings using simple generalized linear models <arXiv:1611.09477> or nonlinear models <arXiv:1604.06737> can be used. There are also functions for dimension reduction and other approaches.

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URL https://embed.tidymodels.org, https://github.com/tidymodels/embed

BugReports https://github.com/tidymodels/embed/issues

Depends R (>= 3.1), recipes (>= 0.1.17)

Imports dplyr, generics (>= 0.1.0), keras, lifecycle, purrr, rlang (>= 0.4.10), rsample, stats, tensorflow, tibble, tidyr, utils, uwot, withr

Suggests covr, ggplot2, irlba, knitr, lme4, modeldata, rmarkdown, rpart, rstanarm, testthat (>= 3.0.0), VBsparsePCA, xgboost

ByteCompile true

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Encoding UTF-8

RoxygenNote 7.1.2

NeedsCompilation no

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R topics documented:

`add_woe` *Add WoE in a data frame*

Description

A tidyverse friendly way to plug WoE versions of a set of predictor variables against a given binary outcome.

Usage

```
add_woe(.data, outcome, ..., dictionary = NULL, prefix = "woe")
```

Arguments

`.data`	A tbl. The data.frame to plug the new woe version columns.
`outcome`	The bare name of the outcome variable.
`...`	Bare names of predictor variables, passed as you would pass variables to `dplyr::select()`. This means that you can use all the helpers like `starts_with()` and `matches()`.
`dictionary`	A tbl. If NULL the function will build a dictionary with those variables passed to `...`. You can pass a custom dictionary too, see `dictionary()` for details.
`prefix`	A character string that will be the prefix to the resulting new variables.

Details

You can pass a custom dictionary to `add_woe()`. It must have the exactly the same structure of the output of `dictionary()`. One easy way to do this is to tweak a output returned from it.

Value

A tibble with the original columns of .data plus the woe columns wanted.

Examples

```
mtcars %>% add_woe("am", cyl, gear:carb)
```

`dictionary` *Weight of evidence dictionary*

Description

Builds the woe dictionary of a set of predictor variables upon a given binary outcome. Convenient to make a woe version of the given set of predictor variables and also to allow one to tweak some woe values by hand.

Usage

```
dictionary(.data, outcome, ..., Laplace = 1e-06)
```

Arguments

`.data`	A tbl. The data.frame where the variables come from.
`outcome`	The bare name of the outcome variable with exactly 2 distinct values.
`...`	bare names of predictor variables or selectors accepted by `dplyr::select()`.
`Laplace`	Default to 1e-6. The `pseudocount` parameter of the Laplace Smoothing estimator. Value to avoid -Inf/Inf from predictor category with only one outcome class. Set to 0 to allow Inf/-Inf.

Details

You can pass a custom dictionary to `step_woe()`. It must have the exactly the same structure of the output of `dictionary()`. One easy way to do this is by tweaking an output returned from it.

Value

a tibble with summaries and woe for every given predictor variable stacked up.

References

Kullback, S. (1959). *Information Theory and Statistics.* Wiley, New York.

Hastie, T., Tibshirani, R. and Friedman, J. (1986). *Elements of Statistical Learning*, Second Edition, Springer, 2009.

Good, I. J. (1985), "Weight of evidence: A brief survey", *Bayesian Statistics*, 2, pp.249-270.

Examples

```
mtcars %>% dictionary("am", cyl, gear:carb)
```

---

is_tf_available — *Test to see if tensorflow is available*

Description

Test to see if tensorflow is available

Usage

```
is_tf_available()
```

Value

A logical

Examples

```
is_tf_available()
```

---

solubility — *Compound solubility data*

Description

Compound solubility data

Details

Tetko et al. (2001) and Huuskonen (2000) investigated a set of compounds with corresponding experimental solubility values using complex sets of descriptors. They used linear regression and neural network models to estimate the relationship between chemical structure and solubility. For our analyses, we will use 1267 compounds and a set of more understandable descriptors that fall into one of three groups: 208 binary "fingerprints" that indicate the presence or absence of a particular chemical sub-structure, 16 count descriptors (such as the number of bonds or the number of Bromine atoms) and 4 continuous descriptors (such as molecular weight or surface area).

Value

`solubility` a data frame

Source

Tetko, I., Tanchuk, V., Kasheva, T., and Villa, A. (2001). Estimation of aqueous solubility of chemical compounds using E-state indices. *Journal of Chemical Information and Computer Sciences*, 41(6), 1488-1493.

Huuskonen, J. (2000). Estimation of aqueous solubility for a diverse set of organic compounds based on molecular topology. *Journal of Chemical Information and Computer Sciences*, 40(3), 773-777.

Examples

```
data(solubility)
str(solubility)
```

---

step_discretize_cart *Discretize numeric variables with CART*

Description

step_discretize_cart creates a *specification* of a recipe step that will discretize numeric data (e.g. integers or doubles) into bins in a supervised way using a CART model.

Usage

```
step_discretize_cart(
  recipe,
  ...,
  role = NA,
  trained = FALSE,
  outcome = NULL,
  cost_complexity = 0.01,
  tree_depth = 10,
  min_n = 20,
  rules = NULL,
  skip = FALSE,
  id = rand_id("discretize_cart")
)

## S3 method for class 'step_discretize_cart'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose which variables are affected by the step. See selections() for more details.

`role`	Defaults to `"predictor"`.
`trained`	A logical to indicate if the quantities for preprocessing have been estimated.
`outcome`	A call to `vars` to specify which variable is used as the outcome to train CART models in order to discretize explanatory variables.
`cost_complexity`	The regularization parameter. Any split that does not decrease the overall lack of fit by a factor of `cost_complexity` is not attempted. Corresponds to `cp` in `rpart::rpart()`. Defaults to 0.01.
`tree_depth`	The *maximum* depth in the final tree. Corresponds to `maxdepth` in `rpart::rpart()`. Defaults to 10.
`min_n`	The number of data points in a node required to continue splitting. Corresponds to `minsplit` in `rpart::rpart()`. Defaults to 20.
`rules`	The splitting rules of the best CART tree to retain for each variable. If length zero, splitting could not be used on that column.
`skip`	A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations
`id`	A character string that is unique to this step to identify it.
`x`	A `step_discretize_cart` object.

Details

`step_discretize_cart()` creates non-uniform bins from numerical variables by utilizing the information about the outcome variable and applying a CART model.

The best selection of buckets for each variable is selected using the standard cost-complexity pruning of CART, which makes this discretization method resistant to overfitting.

This step requires the **rpart** package. If not installed, the step will stop with a note about installing the package.

Note that the original data will be replaced with the new bins.

Value

An updated version of `recipe` with the new step added to the sequence of any existing operations.

See Also

`step_discretize_xgb()`, `recipes::recipe()`, `recipes::prep.recipe()`, `recipes::bake.recipe()`

Examples

```
library(modeldata)
data(ad_data)
library(rsample)
```

```
split <- initial_split(ad_data, strata = "Class")

ad_data_tr <- training(split)
ad_data_te <- testing(split)

cart_rec <-
  recipe(Class ~ ., data = ad_data_tr) %>%
  step_discretize_cart(tau, age, p_tau, Ab_42, outcome = "Class", id = "cart splits")

cart_rec <- prep(cart_rec, training = ad_data_tr)

# The splits:
tidy(cart_rec, id = "cart splits")

bake(cart_rec, ad_data_te, tau)
```

---

step_discretize_xgb *Discretize numeric variables with XgBoost*

Description

step_discretize_xgb creates a *specification* of a recipe step that will discretize numeric data (e.g. integers or doubles) into bins in a supervised way using an XgBoost model.

Usage

```
step_discretize_xgb(
  recipe,
  ...,
  role = NA,
  trained = FALSE,
  outcome = NULL,
  sample_val = 0.2,
  learn_rate = 0.3,
  num_breaks = 10,
  tree_depth = 1,
  min_n = 5,
  rules = NULL,
  skip = FALSE,
  id = rand_id("discretize_xgb")
)

## S3 method for class 'step_discretize_xgb'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.

...	One or more selector functions to choose which variables are affected by the step. See selections() for more details.
role	Defaults to "predictor".
trained	A logical to indicate if the quantities for preprocessing have been estimated.
outcome	A call to vars to specify which variable is used as the outcome to train XgBoost models in order to discretize explanatory variables.
sample_val	Share of data used for validation (with early stopping) of the learned splits (the rest is used for training). Defaults to 0.20.
learn_rate	The rate at which the boosting algorithm adapts from iteration-to-iteration. Corresponds to eta in the **xgboost** package. Defaults to 0.3.
num_breaks	The *maximum* number of discrete bins to bucket continuous features. Corresponds to max_bin in the **xgboost** package. Defaults to 10.
tree_depth	The maximum depth of the tree (i.e. number of splits). Corresponds to max_depth in the **xgboost** package. Defaults to 1.
min_n	The minimum number of instances needed to be in each node. Corresponds to min_child_weight in the **xgboost** package. Defaults to 5.
rules	The splitting rules of the best XgBoost tree to retain for each variable.
skip	A logical. Should the step be skipped when the recipe is baked by recipes::bake.recipe()? While all operations are baked when recipes::prep.recipe() is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using skip = TRUE as it may affect the computations for subsequent operations
id	A character string that is unique to this step to identify it.
x	A step_discretize_xgb object.

Details

step_discretize_xgb() creates non-uniform bins from numerical variables by utilizing the information about the outcome variable and applying the xgboost model. It is advised to impute missing values before this step. This step is intended to be used particularly with linear models because thanks to creating non-uniform bins it becomes easier to learn non-linear patterns from the data.

The best selection of buckets for each variable is selected using an internal early stopping scheme implemented in the **xgboost** package, which makes this discretization method prone to overfitting.

The pre-defined values of the underlying xgboost learns good and reasonably complex results. However, if one wishes to tune them the recommended path would be to first start with changing the value of num_breaks to e.g.: 20 or 30. If that doesn't give satisfactory results one could experiment with modifying the tree_depth or min_n parameters. Note that it is not recommended to tune learn_rate simultaneously with other parameters.

This step requires the **xgboost** package. If not installed, the step will stop with a note about installing the package.

Note that the original data will be replaced with the new bins.

Value

An updated version of recipe with the new step added to the sequence of any existing operations.

See Also

step_discretize_cart(), recipes::recipe(), recipes::prep.recipe(), recipes::bake.recipe()

Examples

```
library(modeldata)
data(credit_data)
library(rsample)
library(recipes)

split <- initial_split(credit_data, strata = "Status")

credit_data_tr <- training(split)
credit_data_te <- testing(split)

xgb_rec <-
  recipe(Status ~ ., data = credit_data_tr) %>%
  step_impute_median(all_numeric()) %>%
  step_discretize_xgb(all_numeric(), outcome = "Status")

if (rlang::is_installed("xgboost")) {
  xgb_rec <- prep(xgb_rec, training = credit_data_tr)

   bake(xgb_rec, credit_data_te, Price)
}
```

---

step_embed — *Encoding Factors into Multiple Columns*

Description

step_embed creates a *specification* of a recipe step that will convert a nominal (i.e. factor) predictor into a set of scores derived from a tensorflow model via a word-embedding model. embed_control is a simple wrapper for setting default options.

Usage

```
step_embed(
  recipe,
  ...,
  role = "predictor",
  trained = FALSE,
  outcome = NULL,
  predictors = NULL,
  num_terms = 2,
  hidden_units = 0,
  options = embed_control(),
  mapping = NULL,
```

```
  history = NULL,
  skip = FALSE,
  id = rand_id("lencode_bayes")
)

## S3 method for class 'step_embed'
tidy(x, ...)

embed_control(
  loss = "mse",
  metrics = NULL,
  optimizer = "sgd",
  epochs = 20,
  validation_split = 0,
  batch_size = 32,
  verbose = 0,
  callbacks = NULL
)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables. For `step_embed`, this indicates the variables to be encoded into a numeric format. See `recipes::selections()` for more details. For the `tidy` method, these are not currently used.
role	For model terms created by this step, what analysis role should they be assigned?. By default, the function assumes that the embedding variables created will be used as predictors in a model.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
outcome	A call to `vars` to specify which variable is used as the outcome in the neural network.
predictors	An optional call to `vars` to specify any variables to be added as additional predictors in the neural network. These variables should be numeric and perhaps centered and scaled.
num_terms	An integer for the number of resulting variables.
hidden_units	An integer for the number of hidden units in a dense ReLu layer between the embedding and output later. Use a value of zero for no intermediate layer (see Details below).
options	A list of options for the model fitting process.
mapping	A list of tibble results that define the encoding. This is `NULL` until the step is trained by `recipes::prep.recipe()`.
history	A tibble with the convergence statistics for each term. This is `NULL` until the step is trained by `recipes::prep.recipe()`.

skip
: A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations.

id
: A character string that is unique to this step to identify it.

x
: A `step_embed` object.

optimizer, loss, metrics
: Arguments to pass to `keras::compile()`

epochs, validation_split, batch_size, verbose, callbacks
: Arguments to pass to `keras::fit()`

Details

Factor levels are initially assigned at random to the new variables and these variables are used in a neural network to optimize both the allocation of levels to new columns as well as estimating a model to predict the outcome. See Section 6.1.2 of Francois and Allaire (2018) for more details.

The new variables are mapped to the specific levels seen at the time of model training and an extra instance of the variables are used for new levels of the factor.

One model is created for each call to `step_embed`. All terms given to the step are estimated and encoded in the same model which would also contain predictors give in `predictors` (if any).

When the outcome is numeric, a linear activation function is used in the last layer while softmax is used for factor outcomes (with any number of levels).

For example, the `keras` code for a numeric outcome, one categorical predictor, and no hidden units used here would be

```
keras_model_sequential() %>%
layer_embedding(
  input_dim = num_factor_levels_x + 1,
  output_dim = num_terms,
  input_length = 1
) %>%
layer_flatten() %>%
layer_dense(units = 1, activation = 'linear')
```

If a factor outcome is used and hidden units were requested, the code would be

```
keras_model_sequential() %>%
layer_embedding(
  input_dim = num_factor_levels_x + 1,
  output_dim = num_terms,
  input_length = 1
 ) %>%
layer_flatten() %>%
layer_dense(units = hidden_units, activation = "relu") %>%
layer_dense(units = num_factor_levels_y, activation = 'softmax')
```

Other variables specified by `predictors` are added as an additional dense layer after `layer_flatten` and before the hidden layer.

Also note that it may be difficult to obtain reproducible results using this step due to the nature of Tensorflow (see link in References).

tensorflow models cannot be run in parallel within the same session (via `foreach` or `futures`) or the `parallel` package. If using a recipes with this step with `caret`, avoid parallel processing.

Value

An updated version of `recipe` with the new step added to the sequence of existing steps (if any). For the `tidy` method, a tibble with columns `terms` (the selectors or variables for encoding), `level` (the factor levels), and several columns containing `embed` in the name.

References

Francois C and Allaire JJ (2018) *Deep Learning with R*, Manning

"How can I obtain reproducible results using Keras during development?" https://tinyurl.com/keras-repro

"Concatenate Embeddings for Categorical Variables with Keras" https://flovv.github.io/Embeddings_with_keras_part2/

Examples

```
library(modeldata)

data(grants)

set.seed(1)
grants_other <- sample_n(grants_other, 500)

if (is_tf_available()) {
  rec <- recipe(class ~ num_ci + sponsor_code, data = grants_other) %>%
    step_embed(sponsor_code, outcome = vars(class),
               options = embed_control(epochs = 10))
}
```

`step_feature_hash` *Dummy Variables Creation via Feature Hashing*

Description

`step_feature_hash` creates a a *specification* of a recipe step that will convert nominal data (e.g. character or factors) into one or more numeric binary columns using the levels of the original data.

Usage

```
step_feature_hash(
  recipe,
  ...,
  role = "predictor",
  trained = FALSE,
  num_hash = 2^6,
  preserve = deprecated(),
  columns = NULL,
  keep_original_cols = FALSE,
  skip = FALSE,
  id = rand_id("feature_hash")
)

## S3 method for class 'step_feature_hash'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables for this step. See `selections()` for more details.
role	For model terms created by this step, what analysis role should they be assigned? By default, the new columns created by this step from the original variables will be used as *predictors* in a model.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
num_hash	The number of resulting dummy variable columns.
preserve	Use `keep_original_cols` instead to specify whether the selected column(s) should be retained in addition to the new dummy variables.
columns	A character vector for the selected columns. This is `NULL` until the step is trained by `recipes::prep.recipe()`.
keep_original_cols	A logical to keep the original variables in the output. Defaults to `FALSE`.
skip	A logical. Should the step be skipped when the recipe is baked by `bake.recipe()`? While all operations are baked when `prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations.
id	A character string that is unique to this step to identify it.
x	A `step_feature_hash` object.

Details

`step_feature_hash()` will create a set of binary dummy variables from a factor or character variable. The values themselves are used to determine which row that the dummy variable should be assigned (as opposed to having a specific column that the value will map to).

Since this method does not rely on a pre-determined assignment of levels to columns, new factor levels can be added to the selected columns without issue. Missing values result in missing values for all of the hashed columns.

Note that the assignment of the levels to the hashing columns does not try to maximize the allocation. It is likely that multiple levels of the column will map to the same hashed columns (even with small data sets). Similarly, it is likely that some columns will have all zeros. A zero-variance filter (via `recipes::step_zv()`) is recommended for any recipe that uses hashed columns.

Value

An updated version of `recipe` with the new step added to the sequence of any existing operations.

References

Weinberger, K, A Dasgupta, J Langford, A Smola, and J Attenberg. 2009. "Feature Hashing for Large Scale Multitask Learning." In Proceedings of the 26th Annual International Conference on Machine Learning, 1113–20. ACM.

Kuhn and Johnson (2020) *Feature Engineering and Selection: A Practical Approach for Predictive Models*. CRC/Chapman Hall https://bookdown.org/max/FES/encoding-predictors-with-many-categories.html

See Also

`recipes::step_dummy()`, `recipes::step_zv()`

Examples

```
data(grants, package = "modeldata")

if (is_tf_available()) {
  # This may take a while:
  rec <-
    recipe(class ~ sponsor_code, data = grants_other) %>%
    step_feature_hash(sponsor_code, num_hash = 2^6, keep_original_cols = TRUE) %>%
    prep()

  # How many of the 298 locations ended up in each hash column?
  results <-
    bake(rec, new_data = NULL, starts_with("sponsor_code")) %>%
    distinct()

  apply(results %>% select(-sponsor_code), 2, sum) %>% table()
}
```

step_lencode_bayes *Supervised Factor Conversions into Linear Functions using Bayesian Likelihood Encodings*

Description

step_lencode_bayes creates a *specification* of a recipe step that will convert a nominal (i.e. factor) predictor into a single set of scores derived from a generalized linear model estimated using Bayesian analysis.

Usage

```
step_lencode_bayes(
  recipe,
  ...,
  role = NA,
  trained = FALSE,
  outcome = NULL,
  options = list(seed = sample.int(10^5, 1)),
  verbose = FALSE,
  mapping = NULL,
  skip = FALSE,
  id = rand_id("lencode_bayes")
)

## S3 method for class 'step_lencode_bayes'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables. For step_lencode_bayes, this indicates the variables to be encoded into a numeric format. See recipes::selections() for more details. For the tidy method, these are not currently used.
role	Not used by this step since no new variables are created.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
outcome	A call to vars to specify which variable is used as the outcome in the generalized linear model. Only numeric and two-level factors are currently supported.
options	A list of options to pass to rstanarm::stan_glmer().
verbose	A logical to control the default printing by rstanarm::stan_glmer().
mapping	A list of tibble results that define the encoding. This is NULL until the step is trained by recipes::prep.recipe().

skip	A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations
id	A character string that is unique to this step to identify it.
x	A `step_lencode_bayes` object.

Details

For each factor predictor, a generalized linear model is fit to the outcome and the coefficients are returned as the encoding. These coefficients are on the linear predictor scale so, for factor outcomes, they are in log-odds units. The coefficients are created using a no intercept model and, when two factor outcomes are used, the log-odds reflect the event of interest being the *first* level of the factor.

For novel levels, a slightly timmed average of the coefficients is returned.

A hierarchical generalized linear model is fit using `rstanarm::stan_glmer()` and no intercept via

```
stan_glmer(outcome ~ (1 | predictor), data = data, ...)
```

where the `...` include the `family` argument (automatically set by the step) as well as any arguments given to the `options` argument to the step. Relevant options include `chains`, `iter`, `cores`, and arguments for the priors (see the links in the References below). `prior_intercept` is the argument that has the most effect on the amount of shrinkage.

Value

An updated version of `recipe` with the new step added to the sequence of existing steps (if any). For the `tidy` method, a tibble with columns `terms` (the selectors or variables for encoding), `level` (the factor levels), and `value` (the encodings).

References

Micci-Barreca D (2001) "A preprocessing scheme for high-cardinality categorical attributes in classification and prediction problems," ACM SIGKDD Explorations Newsletter, 3(1), 27-32.

Zumel N and Mount J (2017) "vtreat: a data.frame Processor for Predictive Modeling," arXiv:1611.09477

"Hierarchical Partial Pooling for Repeated Binary Trials" https://tinyurl.com/stan-pooling

"Prior Distributions for ‘rstanarm“ Models" https://tinyurl.com/stan-priors

"Estimating Generalized (Non-)Linear Models with Group-Specific Terms with `rstanarm`" https://tinyurl.com/stan-glm-grouped

Examples

```
library(recipes)
library(dplyr)
library(modeldata)

data(grants)
```

```
set.seed(1)
grants_other <- sample_n(grants_other, 500)

reencoded <- recipe(class ~ sponsor_code, data = grants_other) %>%
  step_lencode_bayes(sponsor_code, outcome = vars(class))
```

---

step_lencode_glm *Supervised Factor Conversions into Linear Functions using Likelihood Encodings*

Description

`step_lencode_glm` creates a *specification* of a recipe step that will convert a nominal (i.e. factor) predictor into a single set of scores derived from a generalized linear model.

Usage

```
step_lencode_glm(
  recipe,
  ...,
  role = NA,
  trained = FALSE,
  outcome = NULL,
  mapping = NULL,
  skip = FALSE,
  id = rand_id("lencode_glm")
)

## S3 method for class 'step_lencode_glm'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables. For `step_lencode_glm`, this indicates the variables to be encoded into a numeric format. See `recipes::selections()` for more details. For the `tidy` method, these are not currently used.
role	Not used by this step since no new variables are created.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
outcome	A call to `vars` to specify which variable is used as the outcome in the generalized linear model. Only numeric and two-level factors are currently supported.
mapping	A list of tibble results that define the encoding. This is `NULL` until the step is trained by `recipes::prep.recipe()`.

skip — A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations

id — A character string that is unique to this step to identify it.

x — A `step_lencode_glm` object.

Details

For each factor predictor, a generalized linear model is fit to the outcome and the coefficients are returned as the encoding. These coefficients are on the linear predictor scale so, for factor outcomes, they are in log-odds units. The coefficients are created using a no intercept model and, when two factor outcomes are used, the log-odds reflect the event of interest being the *first* level of the factor.

For novel levels, a slightly timmed average of the coefficients is returned.

Value

An updated version of `recipe` with the new step added to the sequence of existing steps (if any). For the `tidy` method, a tibble with columns `terms` (the selectors or variables for encoding), `level` (the factor levels), and `value` (the encodings).

References

Micci-Barreca D (2001) "A preprocessing scheme for high-cardinality categorical attributes in classification and prediction problems," ACM SIGKDD Explorations Newsletter, 3(1), 27-32.

Zumel N and Mount J (2017) "vtreat: a data.frame Processor for Predictive Modeling," arXiv:1611.09477

Examples

```
library(recipes)
library(dplyr)
library(modeldata)

data(grants)

set.seed(1)
grants_other <- sample_n(grants_other, 500)


reencoded <- recipe(class ~ sponsor_code, data = grants_other) %>%
  step_lencode_glm(sponsor_code, outcome = vars(class))
```

step_lencode_mixed — *Supervised Factor Conversions into Linear Functions using Bayesian Likelihood Encodings*

Description

step_lencode_mixed creates a *specification* of a recipe step that will convert a nominal (i.e. factor) predictor into a single set of scores derived from a generalized linear mixed model.

Usage

```
step_lencode_mixed(
  recipe,
  ...,
  role = NA,
  trained = FALSE,
  outcome = NULL,
  options = list(verbose = 0),
  mapping = NULL,
  skip = FALSE,
  id = rand_id("lencode_mixed")
)

## S3 method for class 'step_lencode_mixed'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables. For step_lencode_mixed, this indicates the variables to be encoded into a numeric format. See recipes::selections() for more details. For the tidy method, these are not currently used.
role	Not used by this step since no new variables are created.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
outcome	A call to vars to specify which variable is used as the outcome in the generalized linear model. Only numeric and two-level factors are currently supported.
options	A list of options to pass to lme4::lmer() or lme4::glmer().
mapping	A list of tibble results that define the encoding. This is NULL until the step is trained by recipes::prep.recipe().
skip	A logical. Should the step be skipped when the recipe is baked by recipes::bake.recipe()? While all operations are baked when recipes::prep.recipe() is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using skip = TRUE as it may affect the computations for subsequent operations

id	A character string that is unique to this step to identify it.
x	A step_lencode_mixed object.

Details

For each factor predictor, a generalized linear model is fit to the outcome and the coefficients are returned as the encoding. These coefficients are on the linear predictor scale so, for factor outcomes, they are in log-odds units. The coefficients are created using a no intercept model and, when two factor outcomes are used, the log-odds reflect the event of interest being the *first* level of the factor.

For novel levels, a slightly timmed average of the coefficients is returned.

A hierarchical generalized linear model is fit using `lme4::lmer()` or `lme4::glmer()`, depending on the nature of the outcome, and no intercept via

```
lmer(outcome ~ 1 + (1 | predictor), data = data, ...)
```

where the `...` include the `family` argument (automatically set by the step) as well as any arguments given to the `options` argument to the step. Relevant options include `control` and others.

Value

An updated version of `recipe` with the new step added to the sequence of existing steps (if any). For the `tidy` method, a tibble with columns `terms` (the selectors or variables for encoding), `level` (the factor levels), and `value` (the encodings).

References

Micci-Barreca D (2001) "A preprocessing scheme for high-cardinality categorical attributes in classification and prediction problems," ACM SIGKDD Explorations Newsletter, 3(1), 27-32.

Zumel N and Mount J (2017) "vtreat: a data.frame Processor for Predictive Modeling," arXiv:1611.09477

Examples

```
library(recipes)
library(dplyr)
library(modeldata)

data(grants)

set.seed(1)
grants_other <- sample_n(grants_other, 500)


reencoded <- recipe(class ~ sponsor_code, data = grants_other) %>%
  step_lencode_mixed(sponsor_code, outcome = vars(class))
```

step_pca_sparse *Sparse PCA Signal Extraction*

Description

step_pca_sparse() creates a *specification* of a recipe step that will convert numeric data into one or more principal components that can have some zero coefficients.

Usage

```
step_pca_sparse(
  recipe,
  ...,
  role = "predictor",
  trained = FALSE,
  num_comp = 5,
  predictor_prop = 1,
  options = list(),
  res = NULL,
  prefix = "PC",
  keep_original_cols = FALSE,
  skip = FALSE,
  id = rand_id("pca_sparse")
)

## S3 method for class 'step_pca_sparse'
tidy(x, ...)

## S3 method for class 'step_pca_sparse'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose which variables will be used to compute the components. See selections() for more details. For the tidy method, these are not currently used.
role	For model terms created by this step, what analysis role should they be assigned? By default, the function assumes that the new principal component columns created by the original variables will be used as predictors in a model.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
num_comp	The number of PCA components to retain as new predictors. If num_comp is greater than the number of columns or the number of possible components, a smaller value will be used.

predictor_prop	The maximum number of original predictors that can have non-zero coefficients for each PCA component (via regularization).
options	A list of options to the default method for irlba::ssvd().
res	The rotation matrix once this preprocessing step has be trained by prep.recipe().
prefix	A character string that will be the prefix to the resulting new variables. See notes below.
keep_original_cols	A logical to keep the original variables in the output. Defaults to FALSE.
skip	A logical. Should the step be skipped when the recipe is baked by recipes::bake.recipe()? While all operations are baked when recipes::prep.recipe() is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using skip = TRUE as it may affect the computations for subsequent operations
id	A character string that is unique to this step to identify it.
x	A step_pca_sparse object.

Details

The irlba package is required for this step. If it is not installed, the user will be prompted to do so when the step is defined. The irlba::ssvd() function is used to encourage sparsity; that documentation has details about this method.

The argument num_comp controls the number of components that will be retained (per default the original variables that are used to derive the components are removed from the data). The new components will have names that begin with prefix and a sequence of numbers. The variable names are padded with zeros. For example, if num_comp < 10, their names will be PC1 - PC9. If num_comp = 101, the names would be PC001 - PC101.

Value

An updated version of recipe with the new step added to the sequence of existing steps (if any). For the tidy method, a tibble with columns terms (the selectors or variables selected), value (the loading), and component.

See Also

step_pca_sparse_bayes()

Examples

```
library(recipes)
library(ggplot2)

data(ad_data, package = "modeldata")

ad_rec <-
  recipe(Class ~ ., data = ad_data) %>%
  step_zv(all_predictors()) %>%
  step_YeoJohnson(all_numeric_predictors()) %>%
```

```
  step_normalize(all_numeric_predictors()) %>%
  step_pca_sparse(all_numeric_predictors(),
                  predictor_prop = 0.75,
                  num_comp = 3,
                  id = "sparse pca") %>%
  prep()

tidy(ad_rec, id = "sparse pca") %>%
  mutate(value = ifelse(value == 0, NA, value)) %>%
  ggplot(aes(x = component, y = terms, fill = value)) +
  geom_tile() +
  scale_fill_gradient2() +
  theme(axis.text.y = element_blank())
```

`step_pca_sparse_bayes` *Sparse Bayesian PCA Signal Extraction*

Description

`step_pca_sparse_bayes()` creates a *specification* of a recipe step that will convert numeric data into one or more principal components that can have some zero coefficients.

Usage

```
step_pca_sparse_bayes(
  recipe,
  ...,
  role = "predictor",
  trained = FALSE,
  num_comp = 5,
  prior_slab_dispersion = 1,
  prior_mixture_threshold = 0.1,
  options = list(),
  res = NULL,
  prefix = "PC",
  keep_original_cols = FALSE,
  skip = FALSE,
  id = rand_id("pca_sparse_bayes")
)

## S3 method for class 'step_pca_sparse_bayes'
tidy(x, ...)
```

Arguments

`recipe`	A recipe object. The step will be added to the sequence of operations for this recipe.

`...`	One or more selector functions to choose which variables will be used to compute the components. See `selections()` for more details. For the `tidy` method, these are not currently used.
`role`	For model terms created by this step, what analysis role should they be assigned? By default, the function assumes that the new principal component columns created by the original variables will be used as predictors in a model.
`trained`	A logical to indicate if the quantities for preprocessing have been estimated.
`num_comp`	The number of PCA components to retain as new predictors. If `num_comp` is greater than the number of columns or the number of possible components, a smaller value will be used. A value of zero indicates that PCA will *not* be used on the data.
`prior_slab_dispersion`	This value is proportional to the dispersion (or scale) parameter for the slab portion of the prior. Smaller values result in an increase in zero coefficients.
`prior_mixture_threshold`	The parameter that defines the trade-off between the spike and slab components of the prior. Increasing this parameter increases the number of zero coefficients.
`options`	A list of options to the default method for `VBsparsePCA::VBsparsePCA()`.
`res`	The rotation matrix once this preprocessing step has been trained by `prep.recipe()`.
`prefix`	A character string that will be the prefix to the resulting new variables. See notes below.
`keep_original_cols`	A logical to keep the original variables in the output. Defaults to `FALSE`.
`skip`	A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations
`id`	A character string that is unique to this step to identify it.
`x`	A `step_pca_sparse_bayes` object.

Details

The `VBsparsePCA` package is required for this step. If it is not installed, the user will be prompted to do so when the step is defined.

A spike-and-slab prior is a mixture of two priors. One (the "spike") has all of its mass at zero and represents a variable that has no contribution to the PCA coefficients. The other prior is a broader distribution that reflects the coefficient distribution of variables that do affect the PCA analysis. This is the "slab". The narrower the slab, the more likely that a coefficient will be zero (or are regularized to be closer to zero). The mixture of these two priors is governed by a mixing parameter, which itself has a prior distribution and a hyper-parameter prior.

PCA coefficients and their resulting scores are unique only up to the sign. This step will attempt to make the sign of the components more consistent from run-to-run. However, the sparsity constraint may interfere with this goal.

The argument num_comp controls the number of components that will be retained (per default the original variables that are used to derive the components are removed from the data). The new components will have names that begin with prefix and a sequence of numbers. The variable names are padded with zeros. For example, if num_comp < 10, their names will be PC1 - PC9. If num_comp = 101, the names would be PC001 - PC101.

Value

An updated version of recipe with the new step added to the sequence of existing steps (if any). For the tidy method, a tibble with columns terms (the selectors or variables selected), value (the loading), and component.

References

Ning, B. (2021). Spike and slab Bayesian sparse principal component analysis. arXiv:2102.00305.

See Also

step_pca_sparse()

Examples

```
library(recipes)
library(ggplot2)

data(ad_data, package = "modeldata")

ad_rec <-
  recipe(Class ~ ., data = ad_data) %>%
  step_zv(all_predictors()) %>%
  step_YeoJohnson(all_numeric_predictors()) %>%
  step_normalize(all_numeric_predictors()) %>%
  step_pca_sparse_bayes(all_numeric_predictors(),
                        prior_mixture_threshold = 0.95,
                        prior_slab_dispersion = 0.05,
                        num_comp = 3,
                        id = "sparse bayesian pca") %>%
  prep()

tidy(ad_rec, id = "sparse bayesian pca") %>%
  mutate(value = ifelse(value == 0, NA, value)) %>%
  ggplot(aes(x = component, y = terms, fill = value)) +
  geom_tile() +
  scale_fill_gradient2() +
  theme(axis.text.y = element_blank())
```

step_umap *Supervised and unsupervised uniform manifold approximation and projection (UMAP)*

Description

step_umap creates a *specification* of a recipe step that will project a set of features into a smaller space.

Usage

```
step_umap(
  recipe,
  ...,
  role = "predictor",
  trained = FALSE,
  outcome = NULL,
  neighbors = 15,
  num_comp = 2,
  min_dist = 0.01,
  learn_rate = 1,
  epochs = NULL,
  options = list(verbose = FALSE, n_threads = 1),
  seed = sample(10^5, 2),
  prefix = "UMAP",
  keep_original_cols = FALSE,
  retain = deprecated(),
  object = NULL,
  skip = FALSE,
  id = rand_id("umap")
)

## S3 method for class 'step_umap'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose variables for this step. See selections() for more details.
role	For model terms created by this step, what analysis role should they be assigned? By default, the new columns created by this step from the original variables will be used as *predictors* in a model.
trained	A logical to indicate if the quantities for preprocessing have been estimated.

outcome — A call to vars to specify which variable is used as the outcome in the encoding process (if any).

neighbors — An integer for the number of nearest neighbors used to construct the target simplicial set. If neighbors is greater than the number of data points, the smaller value is used.

num_comp — An integer for the number of UMAP components. If num_comp is greater than the number of selected columns minus one, the smaller value is used.

min_dist — The effective minimum distance between embedded points.

learn_rate — Positive number of the learning rate for the optimization process.

epochs — Number of iterations for the neighbor optimization. See uwot::umap() for more details.

options — A list of options to pass to uwot::umap(). The arguments X, n_neighbors, n_components, min_dist, n_epochs, ret_model, and learning_rate should not be passed here. By default, verbose and n_threads are set.

seed — Two integers to control the random numbers used by the numerical methods. The default pulls from the main session's stream of numbers and will give reproducible results if the seed is set prior to calling prep.recipe() or bake.recipe().

prefix — A character string for the prefix of the resulting new variables. See notes below.

keep_original_cols — A logical to keep the original variables in the output. Defaults to FALSE.

retain — Use keep_original_cols instead to specify whether the original predictors should be retained along with the new embedding variables.

object — An object that defines the encoding. This is NULL until the step is trained by recipes::prep.recipe().

skip — A logical. Should the step be skipped when the recipe is baked by bake.recipe()? While all operations are baked when prep.recipe() is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using skip = TRUE as it may affect the computations for subsequent operations.

id — A character string that is unique to this step to identify it.

x — A step_umap object.

Details

UMAP, short for Uniform Manifold Approximation and Projection, is a nonlinear dimension reduction technique that finds local, low-dimensional representations of the data. It can be run unsupervised or supervised with different types of outcome data (e.g. numeric, factor, etc).

The new components will have names that begin with prefix and a sequence of numbers. The variable names are padded with zeros. For example, if num_comp < 10, their names will be UMAP1 - UMAP9. If num_comp = 101, the names would be UMAP001 - UMAP101.

Value

An updated version of recipe with the new step added to the sequence of any existing operations.

References

McInnes, L., & Healy, J. (2018). UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction. https://arxiv.org/abs/1802.03426.

"How UMAP Works" https://umap-learn.readthedocs.io/en/latest/how_umap_works.html

Examples

```
library(recipes)
library(ggplot2)

split <- seq.int(1, 150, by = 9)
tr <- iris[-split, ]
te <- iris[ split, ]

set.seed(11)
supervised <-
  recipe(Species ~ ., data = tr) %>%
  step_center(all_predictors()) %>%
  step_scale(all_predictors()) %>%
  step_umap(all_predictors(), outcome = vars(Species), num_comp = 2) %>%
  prep(training = tr)

theme_set(theme_bw())

bake(supervised, new_data = te, Species, starts_with("umap")) %>%
  ggplot(aes(x = UMAP1, y = UMAP2, col = Species)) +
  geom_point(alpha = .5)
```

---

step_woe *Weight of evidence transformation*

Description

step_woe creates a *specification* of a recipe step that will transform nominal data into its numerical transformation based on weights of evidence against a binary outcome.

Usage

```
step_woe(
  recipe,
  ...,
  role = "predictor",
  outcome,
  trained = FALSE,
  dictionary = NULL,
  Laplace = 1e-06,
  prefix = "woe",
  skip = FALSE,
```

```
  id = rand_id("woe")
)

## S3 method for class 'step_woe'
tidy(x, ...)
```

Arguments

recipe	A recipe object. The step will be added to the sequence of operations for this recipe.
...	One or more selector functions to choose which variables will be used to compute the components. See `selections()` for more details. For the `tidy` method, these are not currently used.
role	For model terms created by this step, what analysis role should they be assigned?. By default, the function assumes that the new woe components columns created by the original variables will be used as predictors in a model.
outcome	The bare name of the binary outcome encased in `vars()`.
trained	A logical to indicate if the quantities for preprocessing have been estimated.
dictionary	A tbl. A map of levels and woe values. It must have the same layout than the output returned from `dictionary()`. If 'NULL" the function will build a dictionary with those variables passed to `...`. See `dictionary()` for details.
Laplace	The Laplace smoothing parameter. A value usually applied to avoid -Inf/Inf from predictor category with only one outcome class. Set to 0 to allow Inf/-Inf. The default is 1e-6. Also known as 'pseudocount' parameter of the Laplace smoothing technique.
prefix	A character string that will be the prefix to the resulting new variables. See notes below.
skip	A logical. Should the step be skipped when the recipe is baked by `recipes::bake.recipe()`? While all operations are baked when `recipes::prep.recipe()` is run, some operations may not be able to be conducted on new data (e.g. processing the outcome variable(s)). Care should be taken when using `skip = TRUE` as it may affect the computations for subsequent operations
id	A character string that is unique to this step to identify it.
x	A `step_woe` object.

Details

WoE is a transformation of a group of variables that produces a new set of features. The formula is

$$woe_c = log((P(X = c|Y = 1))/(P(X = c|Y = 0)))$$

where c goes from 1 to C levels of a given nominal predictor variable X.

These components are designed to transform nominal variables into numerical ones with the property that the order and magnitude reflects the association with a binary outcome. To apply it on numerical predictors, it is advisable to discretize the variables prior to running WoE. Here, each variable will be binarized to have woe associated later. This can achieved by using `step_discretize()`.

The argument Laplace is an small quantity added to the proportions of 1's and 0's with the goal to avoid log(p/0) or log(0/p) results. The numerical woe versions will have names that begin with woe_ followed by the respective original name of the variables. See Good (1985).

One can pass a custom dictionary tibble to step_woe(). It must have the same structure of the output from dictionary() (see examples). If not provided it will be created automatically. The role of this tibble is to store the map between the levels of nominal predictor to its woe values. You may want to tweak this object with the goal to fix the orders between the levels of one given predictor. One easy way to do this is by tweaking an output returned from dictionary().

Value

An updated version of recipe with the new step added to the sequence of existing steps (if any). For the tidy method, a tibble with the woe dictionary used to map categories with woe values.

References

Kullback, S. (1959). *Information Theory and Statistics.* Wiley, New York.

Hastie, T., Tibshirani, R. and Friedman, J. (1986). *Elements of Statistical Learning*, Second Edition, Springer, 2009.

Good, I. J. (1985), "Weight of evidence: A brief survey", *Bayesian Statistics*, 2, pp.249-270.

Examples

```
library(modeldata)
data("credit_data")

set.seed(111)
in_training <- sample(1:nrow(credit_data), 2000)

credit_tr <- credit_data[ in_training, ]
credit_te <- credit_data[-in_training, ]

rec <- recipe(Status ~ ., data = credit_tr) %>%
  step_woe(Job, Home, outcome = vars(Status))

woe_models <- prep(rec, training = credit_tr)

# the encoding:
bake(woe_models, new_data = credit_te %>% slice(1:5), starts_with("woe"))
# the original data
credit_te %>% slice(1:5) %>% dplyr::select(Job, Home)
# the details:
tidy(woe_models, number = 1)

# Example of custom dictionary + tweaking
# custom dictionary
woe_dict_custom <- credit_tr %>% dictionary(Job, Home, outcome = "Status")
woe_dict_custom[4, "woe"] <- 1.23 #tweak

#passing custom dict to step_woe()
```

```
rec_custom <- recipe(Status ~ ., data = credit_tr) %>%
  step_woe(Job, Home, outcome = vars(Status), dictionary = woe_dict_custom) %>%
  prep

rec_custom_baked <- bake(rec_custom, new_data = credit_te)
rec_custom_baked %>% dplyr::filter(woe_Job == 1.23) %>% head
```

`woe_table` *Crosstable with woe between a binary outcome and a predictor variable.*

Description

Calculates some summaries and the WoE (Weight of Evidence) between a binary outcome and a given predictor variable. Used to biuld the dictionary.

Usage

```
woe_table(predictor, outcome, Laplace = 1e-06)
```

Arguments

`predictor`	A atomic vector, usualy with few distinct values.
`outcome`	The dependent variable. A atomic vector with exactly 2 distinct values.
`Laplace`	The `pseudocount` parameter of the Laplace Smoothing estimator. Default to 1e-6. Value to avoid -Inf/Inf from predictor category with only one outcome class. Set to 0 to allow Inf/-Inf.

Value

a tibble with counts, proportions and woe. Warning: woe can possibly be -Inf. Use 'Laplace' arg to avoid that.

References

Kullback, S. (1959). *Information Theory and Statistics.* Wiley, New York.

Hastie, T., Tibshirani, R. and Friedman, J. (1986). *Elements of Statistical Learning*, Second Edition, Springer, 2009.

Good, I. J. (1985), "Weight of evidence: A brief survey", *Bayesian Statistics*, 2, pp.249-270.

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