Package 'hardhat'

January 24, 2022

Title Construct Modeling Packages

Version 0.2.0

Maintainer Davis Vaughan <davis@rstudio.com>

Description Building modeling packages is hard. A large amount of effort generally goes into providing an implementation for a new method that is efficient, fast, and correct, but often less emphasis is put on the user interface. A good interface requires specialized knowledge about S3 methods and formulas, which the average package developer might not have. The goal of 'hardhat' is to reduce the burden around building new modeling packages by providing functionality for preprocessing, predicting, and validating input.

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URL https://github.com/tidymodels/hardhat

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

Depends R (¿= 2.10)

Imports glue,
rlang (¿= 0.4.2),
tibble,
vctrs (¿= 0.3.0)

Suggests covr,
crayon,
devtools,
knitr,
Matrix,
modeldata (¿= 0.0.2),
recipes (¿= 0.1.8),
rmarkdown (¿= 2.3),
roxygen2,
testthat (¿= 2.1.0),
usethis

Config/Needs/website tidyverse/tidytemplate

VignetteBuilder knitr

Encoding UTF-8

LazyData true

Roxygen list(markdown = TRUE)

RoxygenNote 7.1.2

R topics documented:

`modeling-package` *Create a modeling package*

Description

`create_modeling_package()` will:

- Call `usethis::create_package()` to set up a new R package.
- Call `use_modeling_deps()`.
- Call `use_modeling_files()`.

`use_modeling_deps()` will:

- Add hardhat, rlang, and stats to Imports
- Add recipes to Suggests
- If roxygen2 is available, use roxygen markdown

`use_modeling_files()` will:

- Add a package documentation file
- Generate and populate 3 files in R/:
  - {{model}}-constructor.R
  - {{model}}-fit.R
  - {{model}}-predict.R

Usage

```
create_modeling_package(path, model, fields = NULL, open = interactive())

use_modeling_deps()

use_modeling_files(model)
```

Arguments

`path`	A path. If it exists, it is used. If it does not exist, it is created, provided that the parent path exists.
`model`	A string. The name of the high level modeling function that users will call. For example, `"linear_regression"`. This will be used to populate the skeleton. Spaces are not allowed.
`fields`	A named list of fields to add to DESCRIPTION, potentially overriding default values. See `usethis::use_description()` for how you can set personalized defaults using package options.
`open`	If TRUE, activates the new project: • If RStudio desktop, the package is opened in a new session. • If on RStudio server, the current RStudio project is activated. • Otherwise, the working directory and active project is changed.

Value

`create_modeling_package()` returns the project path invisibly.

`use_modeling_deps()` returns invisibly.

`use_modeling_files()` return `model` invisibly.

add_intercept_column *Add an intercept column to* data

Description

This function adds an integer column of 1's to data.

Usage

```
add_intercept_column(data, name = "(Intercept)")
```

Arguments

data	A data frame or matrix.
name	The name for the intercept column. Defaults to "(Intercept)", which is the same name that stats::lm() uses.

Details

If a column named name already exists in data, then data is returned unchanged and a warning is issued.

Value

data with an intercept column.

Examples

```
add_intercept_column(mtcars)

add_intercept_column(mtcars, "intercept")

add_intercept_column(as.matrix(mtcars))
```

default_formula_blueprint *Default formula blueprint*

Description

This pages holds the details for the formula preprocessing blueprint. This is the blueprint used by default from mold() if x is a formula.

Usage

```
default_formula_blueprint(
  intercept = FALSE,
  allow_novel_levels = FALSE,
  indicators = "traditional",
  composition = "tibble"
)

## S3 method for class 'formula'
mold(formula, data, ..., blueprint = NULL)
```

Arguments

`intercept`	A logical. Should an intercept be included in the processed data? This information is used by the `process` function in the `mold` and `forge` function list.
`allow_novel_levels`	A logical. Should novel factor levels be allowed at prediction time? This information is used by the `clean` function in the `forge` function list, and is passed on to `scream()`.
`indicators`	A single character string. Control how factors are expanded into dummy variable indicator columns. One of: • `"traditional"` - The default. Create dummy variables using the traditional `model.matrix()` infrastructure. Generally this creates `K -1` indicator columns for each factor, where `K` is the number of levels in that factor. • `"none"` - Leave factor variables alone. No expansion is done. • `"one_hot"` - Create dummy variables using a one-hot encoding approach that expands unordered factors into all `K` indicator columns, rather than `K -1`.
`composition`	Either "tibble", "matrix", or "dgCMatrix" for the format of the processed predictors. If "matrix" or "dgCMatrix" are chosen, all of the predictors must be numeric after the preprocessing method has been applied; otherwise an error is thrown.
`formula`	A formula specifying the predictors and the outcomes.
`data`	A data frame or matrix containing the outcomes and predictors.
`...`	Not used.
`blueprint`	A preprocessing `blueprint`. If left as `NULL`, then a `default_formula_blueprint()` is used.

Details

While not different from base R, the behavior of expanding factors into dummy variables when `indicators = "traditional"` and an intercept is *not* present is not always intuitive and should be documented.

- When an intercept is present, factors are expanded into `K-1` new columns, where `K` is the number of levels in the factor.

- When an intercept is *not* present, the first factor is expanded into all `K` columns (one-hot encoding), and the remaining factors are expanded into `K-1` columns. This behavior ensures that meaningful predictions can be made for the reference level of the first factor, but is not the exact "no intercept" model that was requested. Without this behavior, predictions for the reference level of the first factor would always be forced to `0` when there is no intercept.

Offsets can be included in the formula method through the use of the inline function `stats::offset()`. These are returned as a tibble with 1 column named `".offset"` in the $extras$offset slot of the return value.

Value

For `default_formula_blueprint()`, a formula blueprint.

Mold

When `mold()` is used with the default formula blueprint:

- Predictors
  - The RHS of the `formula` is isolated, and converted to its own 1 sided formula: `~ RHS`.
  - Runs `stats::model.frame()` on the RHS formula and uses `data`.
  - If `indicators = "traditional"`, it then runs `stats::model.matrix()` on the result.
  - If `indicators = "none"`, factors are removed before `model.matrix()` is run, and then added back afterwards. No interactions or inline functions involving factors are allowed.
  - If `indicators = "one_hot"`, it then runs `stats::model.matrix()` on the result using a contrast function that creates indicator columns for all levels of all factors.
  - If any offsets are present from using `offset()`, then they are extracted with `model_offset()`.
  - If `intercept = TRUE`, adds an intercept column.
  - Coerces the result of the above steps to a tibble.
- Outcomes
  - The LHS of the `formula` is isolated, and converted to its own 1 sided formula: `~ LHS`.
  - Runs `stats::model.frame()` on the LHS formula and uses `data`.
  - Coerces the result of the above steps to a tibble.

Forge

When `forge()` is used with the default formula blueprint:

- It calls `shrink()` to trim `new_data` to only the required columns and coerce `new_data` to a tibble.
- It calls `scream()` to perform validation on the structure of the columns of `new_data`.
- Predictors
  - It runs `stats::model.frame()` on `new_data` using the stored terms object corresponding to the *predictors*.

  - If, in the original `mold()` call, `indicators = "traditional"` was set, it then runs `stats::model.matrix()` on the result.
  - If, in the original `mold()` call, `indicators = "none"` was set, it runs `stats::model.matrix()` on the result without the factor columns, and then adds them on afterwards.
  - If, in the original `mold()` call, `indicators = "one_hot"` was set, it runs `stats::model.matrix()` on the result with a contrast function that includes indicators for all levels of all factor columns.
  - If any offsets are present from using `offset()` in the original call to `mold()`, then they are extracted with `model_offset()`.
  - If `intercept = TRUE` in the original call to `mold()`, then an intercept column is added.
  - It coerces the result of the above steps to a tibble.

- Outcomes
  - It runs `stats::model.frame()` on `new_data` using the stored terms object corresponding to the *outcomes*.
  - Coerces the result to a tibble.

Differences From Base R

There are a number of differences from base R regarding how formulas are processed by `mold()` that require some explanation.

Multivariate outcomes can be specified on the LHS using syntax that is similar to the RHS (i.e. `outcome_1 + outcome_2 ~ predictors`). If any complex calculations are done on the LHS and they return matrices (like `stats::poly()`), then those matrices are flattened into multiple columns of the tibble after the call to `model.frame()`. While this is possible, it is not recommended, and if a large amount of preprocessing is required on the outcomes, then you are better off using a `recipes::recipe()`.

Global variables are *not* allowed in the formula. An error will be thrown if they are included. All terms in the formula should come from `data`. If you need to use inline functions in the formula, the safest way to do so is to prefix them with their package name, like `pkg::fn()`. This ensures that the function will always be available at `mold()` (fit) and `forge()` (prediction) time. That said, if the package is *attached* (i.e. with `library()`), then you should be able to use the inline function without the prefix.

By default, intercepts are *not* included in the predictor output from the formula. To include an intercept, set `blueprint = default_formula_blueprint(intercept = TRUE)`. The rationale for this is that many packages either always require or never allow an intercept (for example, the `earth` package), and they do a large amount of extra work to keep the user from supplying one or removing it. This interface standardizes all of that flexibility in one place.

Examples

```
# ------------------------------------------------------------------------------

data("hardhat-example-data")

# ------------------------------------------------------------------------------
# Formula Example

# Call mold() with the training data
processed <- mold(
```

```
  log(num_1) ~ num_2 + fac_1,
  example_train,
  blueprint = default_formula_blueprint(intercept = TRUE)
)

# Then, call forge() with the blueprint and the test data
# to have it preprocess the test data in the same way
forge(example_test, processed$blueprint)

# Use `outcomes = TRUE` to also extract the preprocessed outcome
forge(example_test, processed$blueprint, outcomes = TRUE)

# ------------------------------------------------------------------------------
# Factors without an intercept

# No intercept is added by default
processed <- mold(num_1 ~ fac_1 + fac_2, example_train)

# So, for factor columns, the first factor is completely expanded into all
# `K` columns (the number of levels), and the subsequent factors are expanded
# into `K - 1` columns.
processed$predictors

# In the above example, `fac_1` is expanded into all three columns,
# `fac_2` is not. This behavior comes from `model.matrix()`, and is somewhat
# known in the R community, but can lead to a model that is difficult to
# interpret since the corresponding p-values are testing wildly different
# hypotheses.

# To get all indicators for all columns (irrespective of the intercept),
# use the `indicators = "one_hot"` option
processed <- mold(
  num_1 ~ fac_1 + fac_2,
  example_train,
  blueprint = default_formula_blueprint(indicators = "one_hot")
)

processed$predictors

# It is not possible to construct a no-intercept model that expands all
# factors into `K - 1` columns using the formula method. If required, a
# recipe could be used to construct this model.

# ------------------------------------------------------------------------------
# Global variables

y <- rep(1, times = nrow(example_train))

# In base R, global variables are allowed in a model formula
frame <- model.frame(fac_1 ~ y + num_2, example_train)
head(frame)

# mold() does not allow them, and throws an error
try(mold(fac_1 ~ y + num_2, example_train))

# ------------------------------------------------------------------------------
# Dummy variables and interactions
```

```
# By default, factor columns are expanded
# and interactions are created, both by
# calling `model.matrix()`. Some models (like
# tree based models) can take factors directly
# but still might want to use the formula method.
# In those cases, set `indicators = "none"` to not
# run `model.matrix()` on factor columns. Interactions
# are still allowed and are run on numeric columns.

bp_no_indicators <- default_formula_blueprint(indicators = "none")

processed <- mold(
  ~ fac_1 + num_1:num_2,
  example_train,
  blueprint = bp_no_indicators
)

processed$predictors

# An informative error is thrown when `indicators = "none"` and
# factors are present in interaction terms or in inline functions
try(mold(num_1 ~ num_2:fac_1, example_train, blueprint = bp_no_indicators))
try(mold(num_1 ~ paste0(fac_1), example_train, blueprint = bp_no_indicators))

# ------------------------------------------------------------------------------
# Multivariate outcomes

# Multivariate formulas can be specified easily
processed <- mold(num_1 + log(num_2) ~ fac_1, example_train)
processed$outcomes

# Inline functions on the LHS are run, but any matrix
# output is flattened (like what happens in `model.matrix()`)
# (essentially this means you don't wind up with columns
# in the tibble that are matrices)
processed <- mold(poly(num_2, degree = 2) ~ fac_1, example_train)
processed$outcomes

# TRUE
ncol(processed$outcomes) == 2

# Multivariate formulas specified in mold()
# carry over into forge()
forge(example_test, processed$blueprint, outcomes = TRUE)

# ------------------------------------------------------------------------------
# Offsets

# Offsets are handled specially in base R, so they deserve special
# treatment here as well. You can add offsets using the inline function
# `offset()`
processed <- mold(num_1 ~ offset(num_2) + fac_1, example_train)

processed$extras$offset

# Multiple offsets can be included, and they get added together
```

```
processed <- mold(
  num_1 ~ offset(num_2) + offset(num_3),
  example_train
)

identical(
  processed$extras$offset$.offset,
  example_train$num_2 + example_train$num_3
)

# Forging test data will also require
# and include the offset
forge(example_test, processed$blueprint)

# ------------------------------------------------------------------------------
# Intercept only

# Because `1` and `0` are intercept modifying terms, they are
# not allowed in the formula and are instead controlled by the
# `intercept` argument of the blueprint. To use an intercept
# only formula, you should supply `NULL` on the RHS of the formula.
mold(
  ~ NULL,
  example_train,
  blueprint = default_formula_blueprint(intercept = TRUE)
)

# ------------------------------------------------------------------------------
# Matrix output for predictors

# You can change the `composition` of the predictor data set
bp <- default_formula_blueprint(composition = "dgCMatrix")
processed <- mold(log(num_1) ~ num_2 + fac_1, example_train, blueprint = bp)
class(processed$predictors)
```

`default_recipe_blueprint` *Default recipe blueprint*

Description

This pages holds the details for the recipe preprocessing blueprint. This is the blueprint used by default from `mold()` if `x` is a recipe.

Usage

```
default_recipe_blueprint(
  intercept = FALSE,
  allow_novel_levels = FALSE,
  fresh = TRUE,
  composition = "tibble"
)
```

```
## S3 method for class 'recipe'
mold(x, data, ..., blueprint = NULL)
```

Arguments

intercept	A logical. Should an intercept be included in the processed data? This information is used by the process function in the mold and forge function list.
allow_novel_levels	A logical. Should novel factor levels be allowed at prediction time? This information is used by the clean function in the forge function list, and is passed on to scream().
fresh	Should already trained operations be re-trained when prep() is called?
composition	Either "tibble", "matrix", or "dgCMatrix" for the format of the processed predictors. If "matrix" or "dgCMatrix" are chosen, all of the predictors must be numeric after the preprocessing method has been applied; otherwise an error is thrown.
x	An unprepped recipe created from recipes::recipe().
data	A data frame or matrix containing the outcomes and predictors.
...	Not used.
blueprint	A preprocessing blueprint. If left as NULL, then a default_recipe_blueprint() is used.

Value

For default_recipe_blueprint(), a recipe blueprint.

Mold

When mold() is used with the default recipe blueprint:

- It calls recipes::prep() to prep the recipe.
- It calls recipes::juice() to extract the outcomes and predictors. These are returned as tibbles.
- If intercept = TRUE, adds an intercept column to the predictors.

Forge

When forge() is used with the default recipe blueprint:

- It calls shrink() to trim new_data to only the required columns and coerce new_data to a tibble.
- It calls scream() to perform validation on the structure of the columns of new_data.
- It calls recipes::bake() on the new_data using the prepped recipe used during training.
- It adds an intercept column onto new_data if intercept = TRUE.

Examples

```
library(recipes)

# ------------------------------------------------------------------------------
# Setup

train <- iris[1:100,]
test <- iris[101:150,]

# ------------------------------------------------------------------------------
# Recipes example

# Create a recipe that logs a predictor
rec <- recipe(Species ~ Sepal.Length + Sepal.Width, train) %>%
   step_log(Sepal.Length)

processed <- mold(rec, train)

# Sepal.Length has been logged
processed$predictors

processed$outcomes

# The underlying blueprint is a prepped recipe
processed$blueprint$recipe

# Call forge() with the blueprint and the test data
# to have it preprocess the test data in the same way
forge(test, processed$blueprint)

# Use `outcomes = TRUE` to also extract the preprocessed outcome!
# This logged the Sepal.Length column of `new_data`
forge(test, processed$blueprint, outcomes = TRUE)

# ------------------------------------------------------------------------------
# With an intercept

# You can add an intercept with `intercept = TRUE`
processed <- mold(rec, train, blueprint = default_recipe_blueprint(intercept = TRUE))

processed$predictors

# But you also could have used a recipe step
rec2 <- step_intercept(rec)

mold(rec2, iris)$predictors

# ------------------------------------------------------------------------------
# Non standard roles

# If you have custom recipe roles, they are processed and returned in
# the `$extras$roles` slot of the return value of `mold()` and `forge()`.

rec_roles <- recipe(train) %>%
  update_role(Sepal.Width, new_role = "predictor") %>%
  update_role(Species, new_role = "outcome") %>%
```

```
  update_role(Sepal.Length, new_role = "custom_role") %>%
  update_role(Petal.Length, new_role = "custom_role2")

processed_roles <- mold(rec_roles, train)

processed_roles$extras

forge(test, processed_roles$blueprint)

# ------------------------------------------------------------------------
# Matrix output for predictors

# You can change the `composition` of the predictor data set
bp <- default_recipe_blueprint(composition = "dgCMatrix")
processed <- mold(rec, train, blueprint = bp)
class(processed$predictors)
```

`default_xy_blueprint` *Default XY blueprint*

Description

This pages holds the details for the XY preprocessing blueprint. This is the blueprint used by default from `mold()` if `x` and `y` are provided separately (i.e. the XY interface is used).

Usage

```
default_xy_blueprint(
  intercept = FALSE,
  allow_novel_levels = FALSE,
  composition = "tibble"
)

## S3 method for class 'data.frame'
mold(x, y, ..., blueprint = NULL)

## S3 method for class 'matrix'
mold(x, y, ..., blueprint = NULL)
```

Arguments

`intercept`	A logical. Should an intercept be included in the processed data? This information is used by the `process` function in the `mold` and `forge` function list.
`allow_novel_levels`	A logical. Should novel factor levels be allowed at prediction time? This information is used by the `clean` function in the `forge` function list, and is passed on to `scream()`.
`composition`	Either "tibble", "matrix", or "dgCMatrix" for the format of the processed predictors. If "matrix" or "dgCMatrix" are chosen, all of the predictors must be numeric after the preprocessing method has been applied; otherwise an error is thrown.

x	A data frame or matrix containing the predictors.
y	A data frame, matrix, or vector containing the outcomes.
...	Not used.
blueprint	A preprocessing blueprint. If left as NULL, then a default_xy_blueprint() is used.

Details

As documented in standardize(), if y is a *vector*, then the returned outcomes tibble has 1 column with a standardized name of ".outcome".

The one special thing about the XY method's forge function is the behavior of outcomes = TRUE when a *vector* y value was provided to the original call to mold(). In that case, mold() converts y into a tibble, with a default name of .outcome. This is the column that forge() will look for in new_data to preprocess. See the examples section for a demonstration of this.

Value

For default_xy_blueprint(), an XY blueprint.

Mold

When mold() is used with the default xy blueprint:

- It converts x to a tibble.
- It adds an intercept column to x if intercept = TRUE.
- It runs standardize() on y.

Forge

When forge() is used with the default xy blueprint:

- It calls shrink() to trim new_data to only the required columns and coerce new_data to a tibble.
- It calls scream() to perform validation on the structure of the columns of new_data.
- It adds an intercept column onto new_data if intercept = TRUE.

Examples

```
# ------------------------------------------------------------------------------
# Setup

train <- iris[1:100,]
test <- iris[101:150,]

train_x <- train[, "Sepal.Length", drop = FALSE]
train_y <- train[, "Species", drop = FALSE]

test_x <- test[, "Sepal.Length", drop = FALSE]
test_y <- test[, "Species", drop = FALSE]

# ------------------------------------------------------------------------------
# XY Example
```

```
# First, call mold() with the training data
processed <- mold(train_x, train_y)

# Then, call forge() with the blueprint and the test data
# to have it preprocess the test data in the same way
forge(test_x, processed$blueprint)

# ------------------------------------------------------------------------
# Intercept

processed <- mold(train_x, train_y, blueprint = default_xy_blueprint(intercept = TRUE))

forge(test_x, processed$blueprint)

# ------------------------------------------------------------------------
# XY Method and forge(outcomes = TRUE)

# You can request that the new outcome columns are preprocessed as well, but
# they have to be present in `new_data`!

processed <- mold(train_x, train_y)

# Can't do this!
try(forge(test_x, processed$blueprint, outcomes = TRUE))

# Need to use the full test set, including `y`
forge(test, processed$blueprint, outcomes = TRUE)

# With the XY method, if the Y value used in `mold()` is a vector,
# then a column name of `.outcome` is automatically generated.
# This name is what forge() looks for in `new_data`.

# Y is a vector!
y_vec <- train_y$Species

processed_vec <- mold(train_x, y_vec)

# This throws an informative error that tell you
# to include an `".outcome"` column in `new_data`.
try(forge(iris, processed_vec$blueprint, outcomes = TRUE))

test2 <- test
test2$.outcome <- test2$Species
test2$Species <- NULL

# This works, and returns a tibble in the $outcomes slot
forge(test2, processed_vec$blueprint, outcomes = TRUE)

# ------------------------------------------------------------------------
# Matrix output for predictors

# You can change the `composition` of the predictor data set
bp <- default_xy_blueprint(composition = "dgCMatrix")
processed <- mold(train_x, train_y, blueprint = bp)
class(processed$predictors)
```

delete_response *Delete the response from a terms object*

Description

`delete_response()` is exactly the same as `delete.response()`, except that it fixes a long standing bug by also removing the part of the `"dataClasses"` attribute corresponding to the response, if it exists.

Usage

```
delete_response(terms)
```

Arguments

`terms`	A terms object.

Details

The bug is described here:

https://stat.ethz.ch/pipermail/r-devel/2012-January/062942.html

Value

`terms` with the response sections removed.

Examples

```
framed <- model_frame(Species ~ Sepal.Width, iris)

attr(delete.response(framed$terms), "dataClasses")

attr(delete_response(framed$terms), "dataClasses")
```

forge *Forge prediction-ready data*

Description

`forge()` applies the transformations requested by the specific `blueprint` on a set of `new_data`. This `new_data` contains new predictors (and potentially outcomes) that will be used to generate predictions.

All blueprints have consistent return values with the others, but each is unique enough to have its own help page. Click through below to learn how to use each one in conjunction with `forge()`.

- XY Method - `default_xy_blueprint()`
- Formula Method - `default_formula_blueprint()`
- Recipes Method - `default_recipe_blueprint()`

Usage

```
forge(new_data, blueprint, ..., outcomes = FALSE)
```

Arguments

new_data	A data frame or matrix of predictors to process. If outcomes = TRUE, this should also contain the outcomes to process.
blueprint	A preprocessing blueprint.
...	Not used.
outcomes	A logical. Should the outcomes be processed and returned as well?

Details

If the outcomes are present in new_data, they can optionally be processed and returned in the outcomes slot of the returned list by setting outcomes = TRUE. This is very useful when doing cross validation where you need to preprocess the outcomes of a test set before computing performance.

Value

A named list with 3 elements:

- predictors: A tibble containing the preprocessed new_data predictors.
- outcomes: If outcomes = TRUE, a tibble containing the preprocessed outcomes found in new_data. Otherwise, NULL.
- extras: Either NULL if the blueprint returns no extra information, or a named list containing the extra information.

Examples

```
# See the blueprint specific documentation linked above
# for various ways to call forge with different
# blueprints.

train <- iris[1:100,]
test <- iris[101:150,]

# Formula
processed <- mold(
  log(Sepal.Width) ~ Species,
  train,
  blueprint = default_formula_blueprint(indicators = "none")
)

forge(test, processed$blueprint, outcomes = TRUE)
```

get_data_classes *Extract data classes from a data frame or matrix*

Description

When predicting from a model, it is often important for the `new_data` to have the same classes as the original data used to fit the model. `get_data_classes()` extracts the classes from the original training data.

Usage

```
get_data_classes(data)
```

Arguments

`data`	A data frame or matrix.

Value

A named list. The names are the column names of `data` and the values are character vectors containing the class of that column.

Examples

```
get_data_classes(iris)

get_data_classes(as.matrix(mtcars))

# Unlike .MFclass(), the full class
# vector is returned
data <- data.frame(col = ordered(c("a", "b")))

.MFclass(data$col)

get_data_classes(data)
```

get_levels *Extract factor levels from a data frame*

Description

`get_levels()` extracts the levels from any factor columns in `data`. It is mainly useful for extracting the original factor levels from the predictors in the training set. `get_outcome_levels()` is a small wrapper around `get_levels()` for extracting levels from a factor outcome that first calls `standardize()` on `y`.

Usage

```
get_levels(data)

get_outcome_levels(y)
```

Arguments

`data`	A data.frame to extract levels from.
`y`	The outcome. This can be: • A factor vector • A numeric vector • A 1D numeric array • A numeric matrix with column names • A 2D numeric array with column names • A data frame with numeric or factor columns

Value

A named list with as many elements as there are factor columns in `data` or `y`. The names are the names of the factor columns, and the values are character vectors of the levels.

If there are no factor columns, `NULL` is returned.

See Also

`stats::.getXlevels()`

Examples

```
# Factor columns are returned with their levels
get_levels(iris)

# No factor columns
get_levels(mtcars)

# standardize() is first run on `y`
# which converts the input to a data frame
# with an automatically named column, `".outcome"`
get_outcome_levels(y = factor(letters[1:5]))
```

`hardhat-example-data` *Example data for hardhat*

Description

Example data for hardhat

Details

Data objects for a training and test set with the same variables: three numeric and two factor columns.

Value

`example_train`, `example_test`
: tibbles

Examples

```
data("hardhat-example-data")
```

`hardhat-extract` *Generics for object extraction*

Description

These generics are used to extract elements from various model objects. Methods are defined in other packages, such as tune, workflows, and workflowsets, but the returned object is always the same.

- `extract_fit_engine()` returns the engine specific fit embedded within a parsnip model fit. For example, when using `parsnip::linear_reg()` with the `"lm"` engine, this returns the underlying `lm` object.
- `extract_fit_parsnip()` returns a parsnip model fit.
- `extract_mold()` returns the preprocessed "mold" object returned from `mold()`. It contains information about the preprocessing, including either the prepped recipe, the formula terms object, or variable selectors.
- `extract_spec_parsnip()` returns a parsnip model specification.
- `extract_preprocessor()` returns the formula, recipe, or variable expressions used for preprocessing.
- `extract_recipe()` returns a recipe, possibly estimated.
- `extract_workflow()` returns a workflow, possibly fit.
- `extract_parameter_dials()` returns a single dials parameter object.
- `extract_parameter_set_dials()` returns a set of dials parameter objects.

Usage

```
extract_workflow(x, ...)

extract_recipe(x, ...)

extract_spec_parsnip(x, ...)

extract_fit_parsnip(x, ...)

extract_fit_engine(x, ...)

extract_mold(x, ...)

extract_preprocessor(x, ...)

extract_parameter_dials(x, ...)

extract_parameter_set_dials(x, ...)
```

Arguments

x	An object.
...	Extra arguments passed on to methods.

Examples

```
# See packages where methods are defined for examples, such as `parsnip` or
# `workflows`.
```

---

is_blueprint *Is* x *a preprocessing blueprint?*

Description

`is_blueprint()` checks if `x` inherits from `"hardhat_blueprint"`.

Usage

```
is_blueprint(x)
```

Arguments

x	An object.

Examples

```
is_blueprint(default_xy_blueprint())
```

---

model_frame *Construct a model frame*

Description

`model_frame()` is a stricter version of `stats::model.frame()`. There are a number of differences, with the main being that rows are *never* dropped and the return value is a list with the frame and terms separated into two distinct objects.

Usage

```
model_frame(formula, data)
```

Arguments

formula	A formula or terms object representing the terms of the model frame.
data	A data frame or matrix containing the terms of `formula`.

Details

The following explains the rationale for some of the difference in arguments compared to `stats::model.frame()`:

- `subset`: Not allowed because the number of rows before and after `model_frame()` has been run should always be the same.
- `na.action`: Not allowed and is forced to `"na.pass"` because the number of rows before and after `model_frame()` has been run should always be the same.
- `drop.unused.levels`: Not allowed because it seems inconsistent for `data` and the result of `model_frame()` to ever have the same factor column but with different levels, unless specified though `original_levels`. If this is required, it should be done through a recipe step explicitly.
- `xlev`: Not allowed because this check should have been done ahead of time. Use `scream()` to check the integrity of `data` against a training set if that is required.
- `...`: Not exposed because offsets are handled separately, and it is not necessary to pass weights here any more because rows are never dropped (so weights don't have to be subset alongside the rest of the design matrix). If other non-predictor columns are required, use the "roles" features of recipes.

It is important to always use the results of `model_frame()` with `model_matrix()` rather than `stats::model.matrix()` because the tibble in the result of `model_frame()` does *not* have a terms object attached. If model.matrix(¡terms¿, ¡tibble¿) is called directly, then a call to `model.frame()` will be made automatically, which can give faulty results.

Value

A named list with two elements:

- `"data"`: A tibble containing the model frame.
- `"terms"`: A terms object containing the terms for the model frame.

Examples

```
# ------------------------------------------------------------------------------
# Example usage

framed <- model_frame(Species ~ Sepal.Width, iris)

framed$data

framed$terms

# ------------------------------------------------------------------------------
# Missing values never result in dropped rows

iris2 <- iris
iris2$Sepal.Width[1] <- NA

framed2 <- model_frame(Species ~ Sepal.Width, iris2)

head(framed2$data)

nrow(framed2$data) == nrow(iris2)
```

model_matrix *Construct a design matrix*

Description

`model_matrix()` is a stricter version of `stats::model.matrix()`. Notably, `model_matrix()` will *never* drop rows, and the result will be a tibble.

Usage

```
model_matrix(terms, data)
```

Arguments

`terms`	A terms object to construct a model matrix with. This is typically the terms object returned from the corresponding call to `model_frame()`.
`data`	A tibble to construct the design matrix with. This is typically the tibble returned from the corresponding call to `model_frame()`.

Details

The following explains the rationale for some of the difference in arguments compared to `stats::model.matrix()`:

- `contrasts.arg`: Set the contrasts argument, `options("contrasts")` globally, or assign a contrast to the factor of interest directly using `stats::contrasts()`. See the examples section.
- `xlev`: Not allowed because `model.frame()` is never called, so it is unnecessary.
- `...`: Not allowed because the default method of `model.matrix()` does not use it, and the `lm` method uses it to pass potential offsets and weights through, which are handled differently in hardhat.

Value

A tibble containing the design matrix.

Examples

```
# ------------------------------------------------------------------------------
# Example usage

framed <- model_frame(Sepal.Width ~ Species, iris)

model_matrix(framed$terms, framed$data)

# ------------------------------------------------------------------------------
# Missing values never result in dropped rows

iris2 <- iris
iris2$Species[1] <- NA

framed2 <- model_frame(Sepal.Width ~ Species, iris2)
```

```
model_matrix(framed2$terms, framed2$data)

# ------------------------------------------------------------------------------
# Contrasts

# Default contrasts
y <- factor(c("a", "b"))
x <- data.frame(y = y)
framed <- model_frame(~y, x)

# Setting contrasts directly
y_with_contrast <- y
contrasts(y_with_contrast) <- contr.sum(2)
x2 <- data.frame(y = y_with_contrast)
framed2 <- model_frame(~y, x2)

# Compare!
model_matrix(framed$terms, framed$data)
model_matrix(framed2$terms, framed2$data)

# Also, can set the contrasts globally
global_override <- c(unordered = "contr.sum", ordered = "contr.poly")

rlang::with_options(
  .expr = {
    model_matrix(framed$terms, framed$data)
  },
  contrasts = global_override
)
```

`model_offset` *Extract a model offset*

Description

`model_offset()` extracts a numeric offset from a model frame. It is inspired by `stats::model.offset()`, but has nicer error messages and is slightly stricter.

Usage

```
model_offset(terms, data)
```

Arguments

`terms`	A `"terms"` object corresponding to `data`, returned from a call to `model_frame()`.
`data`	A data frame returned from a call to `model_frame()`.

Details

If a column that has been tagged as an offset is not numeric, a nice error message is thrown telling you exactly which column was problematic.

`stats::model.offset()` also allows for a column named `"(offset)"` to be considered an offset along with any others that have been tagged by `stats::offset()`. However, `stats::model.matrix()`

does not recognize these columns as offsets (so it doesn't remove them as it should). Because of this inconsistency, columns named `"(offset)"` are *not* treated specially by `model_offset()`.

Value

A numeric vector representing the offset.

Examples

```
x <- model.frame(Species ~ offset(Sepal.Width), iris)

model_offset(terms(x), x)

xx <- model.frame(Species ~ offset(Sepal.Width) + offset(Sepal.Length), iris)

model_offset(terms(xx), xx)

# Problematic columns are caught with intuitive errors
tryCatch(
  expr = {
    x <- model.frame(~ offset(Species), iris)
    model_offset(terms(x), x)
  },
  error = function(e) {
    print(e$message)
  }
)
```

`mold` *Mold data for modeling*

Description

`mold()` applies the appropriate processing steps required to get training data ready to be fed into a model. It does this through the use of various *blueprints* that understand how to preprocess data that come in various forms, such as a formula or a recipe.

All blueprints have consistent return values with the others, but each is unique enough to have its own help page. Click through below to learn how to use each one in conjunction with `mold()`.

- XY Method - `default_xy_blueprint()`
- Formula Method - `default_formula_blueprint()`
- Recipes Method - `default_recipe_blueprint()`

Usage

```
mold(x, ...)
```

Arguments

x	An object. See the method specific implementations linked in the Description for more information.
...	Not used.

Value

A named list containing 4 elements:

- `predictors`: A tibble containing the molded predictors to be used in the model.
- `outcome`: A tibble containing the molded outcomes to be used in the model.
- `blueprint`: A method specific `"hardhat_blueprint"` object for use when making predictions.
- `extras`: Either `NULL` if the blueprint returns no extra information, or a named list containing the extra information.

Examples

```
# See the method specific documentation linked in Description
# for the details of each blueprint, and more examples.

# XY
mold(iris[, "Sepal.Width", drop = FALSE], iris$Species)

# Formula
mold(Species ~ Sepal.Width, iris)

# Recipe
library(recipes)
mold(recipe(Species ~ Sepal.Width, iris), iris)
```

---

new_default_formula_blueprint

Create a new default blueprint

Description

This page contains the constructors for the default blueprints. They can be extended if you want to add extra behavior on top of what the default blueprints already do, but generally you will extend the non-default versions of the constructors found in the documentation for `new_blueprint()`.

Usage

```
new_default_formula_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  ptypes = NULL,
```

```
  formula = NULL,
  indicators = "traditional",
  composition = "tibble",
  terms = list(predictors = NULL, outcomes = NULL),
  ...,
  subclass = character()
)

new_default_recipe_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  fresh = TRUE,
  composition = "tibble",
  ptypes = NULL,
  recipe = NULL,
  extra_role_ptypes = NULL,
  ...,
  subclass = character()
)

new_default_xy_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  composition = "tibble",
  ptypes = NULL,
  ...,
  subclass = character()
)
```

Arguments

mold	A named list with two elements, `clean` and `process`, see the new_blueprint() section, Mold Functions, for details.
forge	A named list with two elements, `clean` and `process`, see the new_blueprint() section, Forge Functions, for details.
intercept	A logical. Should an intercept be included in the processed data? This information is used by the `process` function in the `mold` and `forge` function list.
allow_novel_levels	A logical. Should novel factor levels be allowed at prediction time? This information is used by the `clean` function in the `forge` function list, and is passed on to scream().
ptypes	Either `NULL`, or a named list with 2 elements, `predictors` and `outcomes`, both of which are 0-row tibbles. `ptypes` is generated automatically at mold() time and is used to validate `new_data` at prediction time. At mold() time, the information found in `blueprint$mold$process()$ptype` is used to set `ptypes` for the `blueprint`.

`formula` Either `NULL`, or a formula that specifies how the predictors and outcomes should be preprocessed. This argument is set automatically at `mold()` time.

`indicators` A single character string. Control how factors are expanded into dummy variable indicator columns. One of:

- `"traditional"` - The default. Create dummy variables using the traditional `model.matrix()` infrastructure. Generally this creates `K -1` indicator columns for each factor, where `K` is the number of levels in that factor.
- `"none"` - Leave factor variables alone. No expansion is done.
- `"one_hot"` - Create dummy variables using a one-hot encoding approach that expands unordered factors into all `K` indicator columns, rather than `K -1`.

`composition` Either "tibble", "matrix", or "dgCMatrix" for the format of the processed predictors. If "matrix" or "dgCMatrix" are chosen, all of the predictors must be numeric after the preprocessing method has been applied; otherwise an error is thrown.

`terms` A named list of two elements, `predictors` and `outcomes`. Both elements are `terms` objects that describe the terms for the outcomes and predictors separately. This argument is set automatically at `mold()` time.

`...` Name-value pairs for additional elements of blueprints that subclass this blueprint.

`subclass` A character vector. The subclasses of this blueprint.

`fresh` Should already trained operations be re-trained when `prep()` is called?

`recipe` Either `NULL`, or an unprepped recipe. This argument is set automatically at `mold()` time.

`extra_role_ptypes` A named list. The names are the unique non-standard recipe roles (i.e. everything except `"predictors"` and `"outcomes"`). The values are prototypes of the original columns with that role. These are used for validation in `forge()`.

`new_formula_blueprint` *Create a new preprocessing blueprint*

Description

These are the base classes for creating new preprocessing blueprints. All blueprints inherit from the one created by `new_blueprint()`, and the default method specific blueprints inherit from the other three here.

If you want to create your own processing blueprint for a specific method, generally you will subclass one of the method specific blueprints here. If you want to create a completely new preprocessing blueprint for a totally new preprocessing method (i.e. not the formula, xy, or recipe method) then you should subclass `new_blueprint()`.

Usage

```
new_formula_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  ptypes = NULL,
  formula = NULL,
  indicators = "traditional",
  composition = "tibble",
  ...,
  subclass = character()
)

new_recipe_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  fresh = TRUE,
  composition = "tibble",
  ptypes = NULL,
  recipe = NULL,
  ...,
  subclass = character()
)

new_xy_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  composition = "tibble",
  ptypes = NULL,
  ...,
  subclass = character()
)

new_blueprint(
  mold,
  forge,
  intercept = FALSE,
  allow_novel_levels = FALSE,
  composition = "tibble",
  ptypes = NULL,
  ...,
  subclass = character()
)
```

Arguments

mold	A named list with two elements, clean and process, see the new_blueprint() section, Mold Functions, for details.
forge	A named list with two elements, clean and process, see the new_blueprint() section, Forge Functions, for details.
intercept	A logical. Should an intercept be included in the processed data? This information is used by the process function in the mold and forge function list.
allow_novel_levels	A logical. Should novel factor levels be allowed at prediction time? This information is used by the clean function in the forge function list, and is passed on to scream().
ptypes	Either NULL, or a named list with 2 elements, predictors and outcomes, both of which are 0-row tibbles. ptypes is generated automatically at mold() time and is used to validate new_data at prediction time. At mold() time, the information found in blueprint$mold$process()$ptype is used to set ptypes for the blueprint.
formula	Either NULL, or a formula that specifies how the predictors and outcomes should be preprocessed. This argument is set automatically at mold() time.
indicators	A single character string. Control how factors are expanded into dummy variable indicator columns. One of: • "traditional" - The default. Create dummy variables using the traditional model.matrix() infrastructure. Generally this creates K -1 indicator columns for each factor, where K is the number of levels in that factor. • "none" - Leave factor variables alone. No expansion is done. • "one_hot" - Create dummy variables using a one-hot encoding approach that expands unordered factors into all K indicator columns, rather than K -1.
composition	Either "tibble", "matrix", or "dgCMatrix" for the format of the processed predictors. If "matrix" or "dgCMatrix" are chosen, all of the predictors must be numeric after the preprocessing method has been applied; otherwise an error is thrown.
...	Name-value pairs for additional elements of blueprints that subclass this blueprint.
subclass	A character vector. The subclasses of this blueprint.
fresh	Should already trained operations be re-trained when prep() is called?
recipe	Either NULL, or an unprepped recipe. This argument is set automatically at mold() time.

Value

A preprocessing blueprint, which is a list containing the inputs used as arguments to the function, along with a class specific to the type of blueprint being created.

Mold Functions

`blueprint$mold` should be a named list with two elements, both of which are functions:

- `clean`: A function that performs initial cleaning of the user's input data to be used in the model.
  - *Arguments*:
    - If this is an xy blueprint, `blueprint`, `x` and `y`.
    - Otherwise, `blueprint` and `data`.
  - *Output*: A named list of three elements:
    - `blueprint`: The blueprint, returned and potentially updated.
    - If using an xy blueprint:
      - `x`: The cleaned predictor data.
      - `y`: The cleaned outcome data.
    - If not using an xy blueprint:
      - `data`: The cleaned data.
- `process`: A function that performs the actual preprocessing of the data.
  - *Arguments*:
    - If this is an xy blueprint, `blueprint`, `x` and `y`.
    - Otherwise, `blueprint` and `data`.
  - *Output*: A named list of 5 elements:
    - `blueprint`: The blueprint, returned and potentially updated.
    - `predictors`: A tibble of predictors.
    - `outcomes`: A tibble of outcomes.
    - `ptypes`: A named list with 2 elements, `predictors` and `outcomes`, where both elements are 0-row tibbles.
    - `extras`: Varies based on the blueprint. If the blueprint has no extra information, `NULL`. Otherwise a named list of the extra elements returned by the blueprint.

Both `blueprint$mold$clean()` and `blueprint$mold$process()` will be called, in order, from `mold()`.

Forge Functions

`blueprint$forge` should be a named list with two elements, both of which are functions:

- `clean`: A function that performs initial cleaning of `new_data`:
  - *Arguments*:
    - `blueprint`, `new_data`, and `outcomes`.
  - *Output*: A named list of the following elements:
    - `blueprint`: The blueprint, returned and potentially updated.
    - `predictors`: A tibble containing the cleaned predictors.
    - `outcomes`: A tibble containing the cleaned outcomes.
    - `extras`: A named list of any extras obtained while cleaning. These are passed on to the `process()` function for further use.
- `process`: A function that performs the actual preprocessing of the data using the known information in the `blueprint`.
  - *Arguments*:

    * `blueprint`, `new_data`, `outcomes`, `extras`.
  - *Output*: A named list of the following elements:
    * `blueprint`: The blueprint, returned and potentially updated.
    * `predictors`: A tibble of the predictors.
    * `outcomes`: A tibble of the outcomes, or `NULL`.
    * `extras`: Varies based on the blueprint. If the blueprint has no extra information, `NULL`. Otherwise a named list of the extra elements returned by the blueprint.

Both `blueprint$forge$clean()` and `blueprint$forge$process()` will be called, in order, from `forge()`.

`new_model` *Constructor for a base model*

Description

A **model** is a *scalar object*, as classified in Advanced R. As such, it takes uniquely named elements in `...` and combines them into a list with a class of `class`. This entire object represent a single model.

Usage

```
new_model(..., blueprint = default_xy_blueprint(), class = character())
```

Arguments

`...`	Name-value pairs for elements specific to the model defined by `class`.
`blueprint`	A preprocessing `blueprint` returned from a call to `mold()`.
`class`	A character vector representing the class of the model.

Details

Because every model should have multiple interfaces, including formula and `recipes` interfaces, all models should have a `blueprint` that can process new data when `predict()` is called. The easiest way to generate an blueprint with all of the information required at prediction time is to use the one that is returned from a call to `mold()`.

Value

A new scalar model object, represented as a classed list with named elements specified in `....`

Examples

```
new_model(
  custom_element= "my-elem",
  blueprint = default_xy_blueprint(),
  class = "custom_model"
)
```

`refresh_blueprint` *Refresh a preprocessing blueprint*

Description

`refresh_blueprint()` is a developer facing generic function that is called at the end of `update_blueprint()`. It simply is a wrapper around the method specific new_*_blueprint() function that runs the updated blueprint through the constructor again to ensure that all of the elements of the blueprint are still valid after the update.

Usage

```
refresh_blueprint(blueprint)
```

Arguments

`blueprint`	A preprocessing blueprint.

Details

If you implement your own custom `blueprint`, you should export a `refresh_blueprint()` method that just calls the constructor for your blueprint and passes through all of the elements of the blueprint to the constructor.

Value

`blueprint` is returned after a call to the corresponding constructor.

Examples

```
blueprint <- default_xy_blueprint()

# This should never be done manually, but is essentially
# what `update_blueprint(blueprint, intercept = TRUE)` does for you
blueprint$intercept <- TRUE

# Then update_blueprint() will call refresh_blueprint()
# to ensure that the structure is correct
refresh_blueprint(blueprint)

# So you can't do something like...
blueprint_bad <- blueprint
blueprint_bad$intercept <- 1

# ...because the constructor will catch it
try(refresh_blueprint(blueprint_bad))

# And update_blueprint() catches this automatically
try(update_blueprint(blueprint, intercept = 1))
```

run_mold *Call* mold$clean() *and* mold$process()

Description

This is a purely developer facing function, that is *only* used if you are creating a completely new blueprint inheriting only from new_blueprint(), and not from one of the more common: new_xy_blueprint(), new_recipe_blueprint(), new_formula_blueprint().

Usage

```
run_mold(blueprint, ...)
```

Arguments

blueprint	A preprocessing blueprint.
...	Not used. Required for extensibility.

Details

Because mold() has different interfaces (like XY and formula), which require different arguments (x and y vs data), their corresponding blueprints also have different arguments for the blueprint$mold$clean() and blueprint$mold$process() functions. The sole job of run_mold() is simply to call these two functions with the right arguments.

The only time you need to implement a method for run_mold() is if you are creating a new_blueprint() that does not follow one of the three core blueprint types. In that special case, create a method for run_mold() with your blueprint type, and pass through whatever arguments are necessary to call your blueprint specific clean() and process() functions.

If you go this route, you will also need to create a mold() method if x is not a data frame / matrix, recipe, or formula. If x is one of those types, then run_mold() will be called for you by the existing mold() method, you just have to supply the run_mold() method for your blueprint.

Value

The preprocessed result, as a named list.

scream *Scream.*

Description

scream() ensures that the structure of data is the same as prototype, ptype. Under the hood, vctrs::vec_cast() is used, which casts each column of data to the same type as the corresponding column in ptype.

This casting enforces a number of important structural checks, including but not limited to:

- *Data Classes* - Checks that the class of each column in data is the same as the corresponding column in ptype.

- *Novel Levels* - Checks that the factor columns in `data` don't have any *new* levels when compared with the `ptype` columns. If there are new levels, a warning is issued and they are coerced to `NA`. This check is optional, and can be turned off with `allow_novel_levels = TRUE`.
- *Level Recovery* - Checks that the factor columns in `data` aren't missing any factor levels when compared with the `ptype` columns. If there are missing levels, then they are restored.

Usage

```
scream(data, ptype, allow_novel_levels = FALSE)
```

Arguments

`data`	A data frame containing the new data to check the structure of.
`ptype`	A data frame prototype to cast `data` to. This is commonly a 0-row slice of the training set.
`allow_novel_levels`	Should novel factor levels in `data` be allowed? The safest approach is the default, which throws a warning when novel levels are found, and coerces them to `NA` values. Setting this argument to `TRUE` will ignore all novel levels. This argument does not apply to ordered factors. Novel levels are not allowed in ordered factors because the level ordering is a critical part of the type.

Details

`scream()` is called by `forge()` after `shrink()` but before the actual processing is done. Generally, you don't need to call `scream()` directly, as `forge()` will do it for you.

If `scream()` is used as a standalone function, it is good practice to call `shrink()` right before it as there are no checks in `scream()` that ensure that all of the required column names actually exist in `data`. Those checks exist in `shrink()`.

Value

A tibble containing the required columns after any required structural modifications have been made.

Factor Levels

`scream()` tries to be helpful by recovering missing factor levels and warning about novel levels. The following graphic outlines how `scream()` handles factor levels when coercing *from* a column in `data` *to* a column in `ptype`.

To	Factor				Ordered			
From	Same levels	New levels (allowed)	New levels (prohibited)	Missing levels	Same levels	New levels (allowed)	New levels (prohibited)	Missing levels
Factor	No change	No change	Warning: New levels coerced to NA	Levels recovered	Error	Error	Error	Error
Ordered	Error	Error	Error	Error	No change	Error	Error	Error
Character	Coerce to factor	Coerce to factor	Coerce to factor + Warning: New levels coerced to NA	Coerce to factor + Levels recovered	Coerce to ordered	Error	Error	Coerce to ordered + Levels recovered

Note that ordered factor handing is much stricter than factor handling. Ordered factors in `data` must have *exactly* the same levels as ordered factors in `ptype`.

Examples

```
# ------------------------------------------------------------------------------
# Setup

train <- iris[1:100,]
test <- iris[101:150,]

# mold() is run at model fit time
# and a formula preprocessing blueprint is recorded
x <- mold(log(Sepal.Width) ~ Species, train)

# Inside the result of mold() are the prototype tibbles
# for the predictors and the outcomes
ptype_pred <- x$blueprint$ptypes$predictors
ptype_out <- x$blueprint$ptypes$outcomes

# ------------------------------------------------------------------------------
# shrink() / scream()

# Pass the test data, along with a prototype, to
# shrink() to extract the prototype columns
test_shrunk <- shrink(test, ptype_pred)

# Now pass that to scream() to perform validation checks
# If no warnings / errors are thrown, the checks were
# successful!
scream(test_shrunk, ptype_pred)

# ------------------------------------------------------------------------------
# Outcomes

# To also extract the outcomes, use the outcome prototype
test_outcome <- shrink(test, ptype_out)
scream(test_outcome, ptype_out)

# ------------------------------------------------------------------------------
# Casting

# scream() uses vctrs::vec_cast() to intelligently convert
# new data to the prototype automatically. This means
# it can automatically perform certain conversions, like
# coercing character columns to factors.
test2 <- test
test2$Species <- as.character(test2$Species)

test2_shrunk <- shrink(test2, ptype_pred)
scream(test2_shrunk, ptype_pred)

# It can also recover missing factor levels.
# For example, it is plausible that the test data only had the
# "virginica" level
test3 <- test
test3$Species <- factor(test3$Species, levels = "virginica")
```

```
test3_shrunk <- shrink(test3, ptype_pred)
test3_fixed <- scream(test3_shrunk, ptype_pred)

# scream() recovered the missing levels
levels(test3_fixed$Species)

# ------------------------------------------------------------------------------
# Novel levels

# When novel levels with any data are present in `data`, the default
# is to coerce them to `NA` values with a warning.
test4 <- test
test4$Species <- as.character(test4$Species)
test4$Species[1] <- "new_level"

test4$Species <- factor(
  test4$Species,
  levels = c(levels(test$Species), "new_level")
)

test4 <- shrink(test4, ptype_pred)

# Warning is thrown
test4_removed <- scream(test4, ptype_pred)

# Novel level is removed
levels(test4_removed$Species)

# No warning is thrown
test4_kept <- scream(test4, ptype_pred, allow_novel_levels = TRUE)

# Novel level is kept
levels(test4_kept$Species)
```

`shrink` *Subset only required columns*

Description

`shrink()` subsets `data` to only contain the required columns specified by the prototype, `ptype`.

Usage

```
shrink(data, ptype)
```

Arguments

`data`	A data frame containing the data to subset.
`ptype`	A data frame prototype containing the required columns.

Details

`shrink()` is called by `forge()` before `scream()` and before the actual processing is done.

Value

A tibble containing the required columns.

Examples

```
# ------------------------------------------------------------------------------
# Setup

train <- iris[1:100,]
test <- iris[101:150,]

# ------------------------------------------------------------------------------
# shrink()

# mold() is run at model fit time
# and a formula preprocessing blueprint is recorded
x <- mold(log(Sepal.Width) ~ Species, train)

# Inside the result of mold() are the prototype tibbles
# for the predictors and the outcomes
ptype_pred <- x$blueprint$ptypes$predictors
ptype_out <- x$blueprint$ptypes$outcomes

# Pass the test data, along with a prototype, to
# shrink() to extract the prototype columns
shrink(test, ptype_pred)

# To extract the outcomes, just use the
# outcome prototype
shrink(test, ptype_out)

# shrink() makes sure that the columns
# required by `ptype` actually exist in the data
# and errors nicely when they don't
test2 <- subset(test, select = -Species)
try(shrink(test2, ptype_pred))
```

---

spruce *Spruce up predictions*

Description

The family of spruce_*() functions convert predictions into a standardized format. They are generally called from a prediction implementation function for the specific `type` of prediction to return.

Usage

```
spruce_numeric(pred)

spruce_class(pred_class)

spruce_prob(pred_levels, prob_matrix)
```

Arguments

`pred`	(`type = "numeric"`) A numeric vector of predictions.
`pred_class`	(`type = "class"`) A factor of "hard" class predictions.
`pred_levels, prob_matrix`	(`type = "prob"`) • `pred_levels` should be a character vector of the original levels of the outcome used in training. • `prob_matrix` should be a numeric matrix of class probabilities with as many columns as levels in `pred_levels`, and in the same order.

Details

After running a spruce_*() function, you should *always* use the validation function `validate_prediction_size()` to ensure that the number of rows being returned is the same as the number of rows in the input (`new_data`).

Value

A tibble, ideally with the same number of rows as the `new_data` passed to `predict()`. The column names and number of columns vary based on the function used, but are standardized.

`standardize` *Standardize the outcome*

Description

Most of the time, the input to a model should be flexible enough to capture a number of different input types from the user. `standardize()` focuses on capturing the flexibility in the *outcome*.

Usage

```
standardize(y)
```

Arguments

`y`	The outcome. This can be: • A factor vector • A numeric vector • A 1D numeric array • A numeric matrix with column names • A 2D numeric array with column names • A data frame with numeric or factor columns

Details

`standardize()` is called from `mold()` when using an XY interface (i.e. a `y` argument was supplied).

Value

All possible values of `y` are transformed into a `tibble` for standardization. Vectors are transformed into a `tibble` with a single column named `".outcome"`.

Examples

```
standardize(1:5)

standardize(factor(letters[1:5]))

mat <- matrix(1:10, ncol = 2)
colnames(mat) <- c("a", "b")
standardize(mat)

df <- data.frame(x = 1:5, y = 6:10)
standardize(df)
```

---

tune *Mark arguments for tuning*

Description

`tune()` is an argument placeholder to be used with the recipes, parsnip, and tune packages. It marks recipes step and parsnip model arguments for tuning.

Usage

```
tune(id = "")
```

Arguments

`id`	A single character value that can be used to differentiate parameters that are used in multiple places but have the same name, or if the user wants to add a note to the specified parameter.

Value

A call object that echos the user's input.

See Also

`tune::tune_grid()`, `tune::tune_bayes()`

Examples

```
tune()
tune("your name here")

# In practice, `tune()` is used alongside recipes or parsnip to mark
# specific arguments for tuning
library(recipes)

recipe(mpg ~ ., data = mtcars) %>%
  step_normalize(all_numeric_predictors()) %>%
  step_pca(all_numeric_predictors, num_comp = tune())
```

---

update_blueprint *Update a preprocessing blueprint*

Description

`update_blueprint()` is the correct way to alter elements of an existing `blueprint` object. It has two benefits over just doing `blueprint$elem <-new_elem`.

- The name you are updating *must* already exist in the blueprint. This prevents you from accidentally updating non-existent elements.
- The constructor for the blueprint is automatically run after the update by `refresh_blueprint()` to ensure that the blueprint is still valid.

Usage

```
update_blueprint(blueprint, ...)
```

Arguments

`blueprint`	A preprocessing blueprint.
`...`	Name-value pairs of *existing* elements in `blueprint` that should be updated.

Examples

```
blueprint <- default_xy_blueprint()

# `intercept` defaults to FALSE
blueprint

update_blueprint(blueprint, intercept = TRUE)

# Can't update non-existent elements
try(update_blueprint(blueprint, intercpt = TRUE))

# Can't add non-valid elements
try(update_blueprint(blueprint, intercept = 1))
```

validate_column_names *Ensure that* data *contains required column names*

Description

validate - asserts the following:

- The column names of `data` must contain all `original_names`.

check - returns the following:

- `ok` A logical. Does the check pass?
- `missing_names` A character vector. The missing column names.

Usage

```
validate_column_names(data, original_names)

check_column_names(data, original_names)
```

Arguments

`data`	A data frame to check.
`original_names`	A character vector. The original column names.

Details

A special error is thrown if the missing column is named `".outcome"`. This only happens in the case where `mold()` is called using the xy-method, and a *vector* `y` value is supplied rather than a data frame or matrix. In that case, `y` is coerced to a data frame, and the automatic name `".outcome"` is added, and this is what is looked for in `forge()`. If this happens, and the user tries to request outcomes using `forge(...,outcomes = TRUE)` but the supplied `new_data` does not contain the required `".outcome"` column, a special error is thrown telling them what to do. See the examples!

Value

`validate_column_names()` returns `data` invisibly.

`check_column_names()` returns a named list of two components, `ok`, and `missing_names`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: validate_no_formula_duplication(), validate_outcomes_are_binary(), validate_outcomes_are_factors(), validate_outcomes_are_numeric(), validate_outcomes_are_univariate(), validate_prediction_size(), validate_predictors_are_numeric()

Examples

```
# ------------------------------------------------------------------------

original_names <- colnames(mtcars)

test <- mtcars
bad_test <- test[, -c(3, 4)]

# All good
check_column_names(test, original_names)

# Missing 2 columns
check_column_names(bad_test, original_names)

# Will error
try(validate_column_names(bad_test, original_names))

# ------------------------------------------------------------------------
# Special error when `.outcome` is missing

train <- iris[1:100,]
test <- iris[101:150,]

train_x <- subset(train, select = -Species)
train_y <- train$Species

# Here, y is a vector
processed <- mold(train_x, train_y)

# So the default column name is `".outcome"`
processed$outcomes

# It doesn't affect forge() normally
forge(test, processed$blueprint)

# But if the outcome is requested, and `".outcome"`
# is not present in `new_data`, an error is thrown
# with very specific instructions
try(forge(test, processed$blueprint, outcomes = TRUE))

# To get this to work, just create an .outcome column in new_data
test$.outcome <- test$Species

forge(test, processed$blueprint, outcomes = TRUE)
```

`validate_no_formula_duplication`

Ensure no duplicate terms appear in `formula`

Description

validate - asserts the following:

- `formula` must not have duplicates terms on the left and right hand side of the formula.

check - returns the following:

- `ok` A logical. Does the check pass?
- `duplicates` A character vector. The duplicate terms.

Usage

```
validate_no_formula_duplication(formula, original = FALSE)

check_no_formula_duplication(formula, original = FALSE)
```

Arguments

`formula`	A formula to check.
`original`	A logical. Should the original names be checked, or should the names after processing be used? If `FALSE`, `y ~ log(y)` is allowed because the names are `"y"` and `"log(y)"`, if `TRUE`, `y ~ log(y)` is not allowed because the original names are both `"y"`.

Value

`validate_no_formula_duplication()` returns `formula` invisibly.

`check_no_formula_duplication()` returns a named list of two components, `ok` and `duplicates`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: `validate_column_names()`, `validate_outcomes_are_binary()`, `validate_outcomes_are_factors()`, `validate_outcomes_are_numeric()`, `validate_outcomes_are_univariate()`, `validate_prediction_size()`, `validate_predictors_are_numeric()`

Examples

```
# All good
check_no_formula_duplication(y ~ x)

# Not good!
check_no_formula_duplication(y ~ y)

# This is generally okay
check_no_formula_duplication(y ~ log(y))

# But you can be more strict
check_no_formula_duplication(y ~ log(y), original = TRUE)

# This would throw an error
try(validate_no_formula_duplication(log(y) ~ log(y)))
```

---

validate_outcomes_are_binary

Ensure that the outcome has binary factors

Description

validate - asserts the following:

- `outcomes` must have binary factor columns.

check - returns the following:

- `ok` A logical. Does the check pass?
- `bad_cols` A character vector. The names of the columns with problems.
- `num_levels` An integer vector. The actual number of levels of the columns with problems.

Usage

```
validate_outcomes_are_binary(outcomes)

check_outcomes_are_binary(outcomes)
```

Arguments

`outcomes`	An object to check.

Details

The expected way to use this validation function is to supply it the $outcomes element of the result of a call to `mold()`.

Value

`validate_outcomes_are_binary()` returns `outcomes` invisibly.

`check_outcomes_are_binary()` returns a named list of three components, `ok`, `bad_cols`, and `num_levels`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: `validate_column_names()`, `validate_no_formula_duplication()`, `validate_outcomes_are_factors()`, `validate_outcomes_are_numeric()`, `validate_outcomes_are_univariate()`, `validate_prediction_size()`, `validate_predictors_are_numeric()`

Examples

```
# Not a binary factor. 0 levels
check_outcomes_are_binary(data.frame(x = 1))

# Not a binary factor. 1 level
check_outcomes_are_binary(data.frame(x = factor("A")))

# All good
check_outcomes_are_binary(data.frame(x = factor(c("A", "B"))))
```

---

validate_outcomes_are_factors

Ensure that the outcome has only factor columns

Description

validate - asserts the following:

- `outcomes` must have factor columns.

check - returns the following:

- `ok` A logical. Does the check pass?
- `bad_classes` A named list. The names are the names of problematic columns, and the values are the classes of the matching column.

Usage

```
validate_outcomes_are_factors(outcomes)

check_outcomes_are_factors(outcomes)
```

Arguments

outcomes	An object to check.

Details

The expected way to use this validation function is to supply it the $outcomes element of the result of a call to mold().

Value

validate_outcomes_are_factors() returns outcomes invisibly.

check_outcomes_are_factors() returns a named list of two components, ok and bad_classes.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, ok, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: validate_column_names(), validate_no_formula_duplication(), validate_outcomes_are_binary(), validate_outcomes_are_numeric(), validate_outcomes_are_univariate(), validate_prediction_size(), validate_predictors_are_numeric()

Examples

```
# Not a factor column.
check_outcomes_are_factors(data.frame(x = 1))

# All good
check_outcomes_are_factors(data.frame(x = factor(c("A", "B"))))
```

---

validate_outcomes_are_numeric

Ensure outcomes are all numeric

Description

validate - asserts the following:

- outcomes must have numeric columns.

check - returns the following:

- ok A logical. Does the check pass?

- `bad_classes` A named list. The names are the names of problematic columns, and the values are the classes of the matching column.

Usage

```
validate_outcomes_are_numeric(outcomes)

check_outcomes_are_numeric(outcomes)
```

Arguments

`outcomes`	An object to check.

Details

The expected way to use this validation function is to supply it the $outcomes element of the result of a call to `mold()`.

Value

`validate_outcomes_are_numeric()` returns `outcomes` invisibly.

`check_outcomes_are_numeric()` returns a named list of two components, `ok` and `bad_classes`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: `validate_column_names()`, `validate_no_formula_duplication()`, `validate_outcomes_are_binary()`, `validate_outcomes_are_factors()`, `validate_outcomes_are_univariate()`, `validate_prediction_size()`, `validate_predictors_are_numeric()`

Examples

```
# All good
check_outcomes_are_numeric(mtcars)

# Species is not numeric
check_outcomes_are_numeric(iris)

# This gives an intelligent error message
try(validate_outcomes_are_numeric(iris))
```

`validate_outcomes_are_univariate` *Ensure that the outcome is univariate*

Description

validate - asserts the following:

- `outcomes` must have 1 column. Atomic vectors are treated as 1 column matrices.

check - returns the following:

- `ok` A logical. Does the check pass?
- `n_cols` A single numeric. The actual number of columns.

Usage

```
validate_outcomes_are_univariate(outcomes)

check_outcomes_are_univariate(outcomes)
```

Arguments

`outcomes`	An object to check.

Details

The expected way to use this validation function is to supply it the $outcomes element of the result of a call to `mold()`.

Value

`validate_outcomes_are_univariate()` returns `outcomes` invisibly.

`check_outcomes_are_univariate()` returns a named list of two components, `ok` and `n_cols`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: `validate_column_names()`, `validate_no_formula_duplication()`, `validate_outcomes_are_binary()`, `validate_outcomes_are_factors()`, `validate_outcomes_are_numeric()`, `validate_prediction_size()`, `validate_predictors_are_numeric()`

Examples

```
validate_outcomes_are_univariate(data.frame(x = 1))

try(validate_outcomes_are_univariate(mtcars))
```

`validate_prediction_size` *Ensure that predictions have the correct number of rows*

Description

validate - asserts the following:

- The size of `pred` must be the same as the size of `new_data`.

check - returns the following:

- `ok` A logical. Does the check pass?
- `size_new_data` A single numeric. The size of `new_data`.
- `size_pred` A single numeric. The size of `pred`.

Usage

```
validate_prediction_size(pred, new_data)

check_prediction_size(pred, new_data)
```

Arguments

`pred`	A tibble. The predictions to return from any prediction `type`. This is often created using one of the spruce functions, like `spruce_numeric()`.
`new_data`	A data frame of new predictors and possibly outcomes.

Details

This validation function is one that is more developer focused rather than user focused. It is a final check to be used right before a value is returned from your specific `predict()` method, and is mainly a "good practice" sanity check to ensure that your prediction blueprint always returns the same number of rows as `new_data`, which is one of the modeling conventions this package tries to promote.

Value

`validate_prediction_size()` returns `pred` invisibly.

`check_prediction_size()` returns a named list of three components, `ok`, `size_new_data`, and `size_pred`.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, `ok`, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: `validate_column_names()`, `validate_no_formula_duplication()`, `validate_outcomes_are_binary()`, `validate_outcomes_are_factors()`, `validate_outcomes_are_numeric()`, `validate_outcomes_are_univariate()`, `validate_predictors_are_numeric()`

Examples

```
# Say new_data has 5 rows
new_data <- mtcars[1:5,]

# And somehow you generate predictions
# for those 5 rows
pred_vec <- 1:5

# Then you use `spruce_numeric()` to clean
# up these numeric predictions
pred <- spruce_numeric(pred_vec)

pred

# Use this check to ensure that
# the number of rows or pred match new_data
check_prediction_size(pred, new_data)

# An informative error message is thrown
# if the rows are different
try(validate_prediction_size(spruce_numeric(1:4), new_data))
```

---

validate_predictors_are_numeric

Ensure predictors are all numeric

Description

validate - asserts the following:

- `predictors` must have numeric columns.

check - returns the following:

- ok A logical. Does the check pass?
- bad_classes A named list. The names are the names of problematic columns, and the values are the classes of the matching column.

Usage

```
validate_predictors_are_numeric(predictors)

check_predictors_are_numeric(predictors)
```

Arguments

predictors	An object to check.

Details

The expected way to use this validation function is to supply it the $predictors element of the result of a call to mold().

Value

validate_predictors_are_numeric() returns predictors invisibly.

check_predictors_are_numeric() returns a named list of two components, ok, and bad_classes.

Validation

hardhat provides validation functions at two levels.

- check_*(): *check a condition, and return a list.* The list always contains at least one element, ok, a logical that specifies if the check passed. Each check also has check specific elements in the returned list that can be used to construct meaningful error messages.
- validate_*(): *check a condition, and error if it does not pass.* These functions call their corresponding check function, and then provide a default error message. If you, as a developer, want a different error message, then call the check_*() function yourself, and provide your own validation function.

See Also

Other validation functions: validate_column_names(), validate_no_formula_duplication(), validate_outcomes_are_binary(), validate_outcomes_are_factors(), validate_outcomes_are_numeric(), validate_outcomes_are_univariate(), validate_prediction_size()

Examples

```
# All good
check_predictors_are_numeric(mtcars)

# Species is not numeric
check_predictors_are_numeric(iris)

# This gives an intelligent error message
try(validate_predictors_are_numeric(iris))
```

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