Package ‘modeltime’

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Title The Tidymodels Extension for Time Series Modeling

Version 0.0.2

Description The time series forecasting framework for use with the 'tidymodels' ecosystem. Models include ARIMA, Exponential Smoothing, and additional time series models from the 'forecast' and 'prophet' packages. Refer to ``Forecasting Principles & Practice, Second edition''
(<https://otexts.com/fpp2/>).
Refer to ``Prophet: forecasting at scale''
(<https://research.fb.com/blog/2017/02/prophet-forecasting-at-scale/>.).

URL https://github.com/business-science/modeltime

BugReports https://github.com/business-science/modeltime/issues

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`arima_boost` *General Interface for "Boosted" ARIMA Regression Models*

Description

`arima_boost()` is a way to generate a *specification* of a time series model that uses boosting to improve modeling errors (residuals) on Exogenous Regressors. It works with both "automated" ARIMA (`auto.arima`) and standard ARIMA (`arima`). The main algorithms are:

- Auto ARIMA + XGBoost Errors (engine = `auto_arima_xgboost`, default)
- ARIMA + XGBoost Errors (engine = `arima_xgboost`)

Usage

```
arima_boost(
  mode = "regression",
  seasonal_period = NULL,
  non_seasonal_ar = NULL,
  non_seasonal_differences = NULL,
  non_seasonal_ma = NULL,
  seasonal_ar = NULL,
  seasonal_differences = NULL,
  seasonal_ma = NULL,
  mtry = NULL,
  trees = NULL,
  min_n = NULL,
  tree_depth = NULL,
  learn_rate = NULL,
  loss_reduction = NULL,
  sample_size = NULL,
  stop_iter = NULL
)
```

Arguments

`mode` A single character string for the type of model. The only possible value for this model is "regression".

`seasonal_period` A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.

`non_seasonal_ar` The order of the non-seasonal auto-regressive (AR) terms. Often denoted "p" in pdq-notation.

`non_seasonal_differences` The order of integration for non-seasonal differencing. Often denoted "d" in pdq-notation.

`non_seasonal_ma`
: The order of the non-seasonal moving average (MA) terms. Often denoted "q" in pdq-notation.

`seasonal_ar`
: The order of the seasonal auto-regressive (SAR) terms. Often denoted "P" in PDQ-notation.

`seasonal_differences`
: The order of integration for seasonal differencing. Often denoted "D" in PDQ-notation.

`seasonal_ma`
: The order of the seasonal moving average (SMA) terms. Often denoted "Q" in PDQ-notation.

`mtry`
: A number for the number (or proportion) of predictors that will be randomly sampled at each split when creating the tree models (`xgboost` only).

`trees`
: An integer for the number of trees contained in the ensemble.

`min_n`
: An integer for the minimum number of data points in a node that are required for the node to be split further.

`tree_depth`
: An integer for the maximum depth of the tree (i.e. number of splits) (`xgboost` only).

`learn_rate`
: A number for the rate at which the boosting algorithm adapts from iteration-to-iteration (`xgboost` only).

`loss_reduction`
: A number for the reduction in the loss function required to split further (`xgboost` only).

`sample_size`
: A number for the number (or proportion) of data that is exposed to the fitting routine. For `xgboost`, the sampling is done at at each iteration while `C5.0` samples once during training.

`stop_iter`
: The number of iterations without improvement before stopping (`xgboost` only).

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `arima_boost()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "auto_arima_xgboost" (default) - Connects to `forecast::auto.arima()` and xgboost::xgb.train
- "arima_xgboost" - Connects to `forecast::Arima()` and xgboost::xgb.train

Main Arguments

The main arguments (tuning parameters) for the **ARIMA model** are:

- `seasonal_period`: The periodic nature of the seasonality. Uses "auto" by default.
- `non_seasonal_ar`: The order of the non-seasonal auto-regressive (AR) terms.
- `non_seasonal_differences`: The order of integration for non-seasonal differencing.
- `non_seasonal_ma`: The order of the non-seasonal moving average (MA) terms.
- `seasonal_ar`: The order of the seasonal auto-regressive (SAR) terms.
- `seasonal_differences`: The order of integration for seasonal differencing.

- `seasonal_ma`: The order of the seasonal moving average (SMA) terms.

The main arguments (tuning parameters) for the model **XGBoost model** are:

- `mtry`: The number of predictors that will be randomly sampled at each split when creating the tree models.
- `trees`: The number of trees contained in the ensemble.
- `min_n`: The minimum number of data points in a node that are required for the node to be split further.
- `tree_depth`: The maximum depth of the tree (i.e. number of splits).
- `learn_rate`: The rate at which the boosting algorithm adapts from iteration-to-iteration.
- `loss_reduction`: The reduction in the loss function required to split further.
- `sample_size`: The amount of data exposed to the fitting routine.
- `stop_iter`: The number of iterations without improvement before stopping.

These arguments are converted to their specific names at the time that the model is fit.

Other options and argument can be set using `set_engine()` (See Engine Details below).

If parameters need to be modified, `update()` can be used in lieu of recreating the object from scratch.

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

Model 1: ARIMA:

modeltime	forecast::auto.arima	forecast::Arima
seasonal_period	ts(frequency)	ts(frequency)
non_seasonal_ar, non_seasonal_differences, non_seasonal_ma	max.p, max.d, max.q	order = c(p,d,q)
seasonal_ar, seasonal_differences, seasonal_ma	max.P, max.D, max.Q	seasonal = c(P,D,Q)

Model 2: XGBoost:

modeltime	xgboost::xgb.train
tree_depth	max_depth
trees	nrounds
learn_rate	eta
mtry	colsample_bytree
min_n	min_child_weight
loss_reduction	gamma
sample_size	subsample

Other options can be set using `set_engine()`.

auto_arima_xgboost (default engine)

Model 1: Auto ARIMA (`forecast::auto.arima`):

```
## function (y, d = NA, D = NA, max.p = 5, max.q = 5, max.P = 2, max.Q = 2,
##     max.order = 5, max.d = 2, max.D = 1, start.p = 2, start.q = 2, start.P = 1,
##     start.Q = 1, stationary = FALSE, seasonal = TRUE, ic = c("aicc", "aic",
##       "bic"), stepwise = TRUE, nmodels = 94, trace = FALSE, approximation = (length(x) >
##         150 | frequency(x) > 12), method = NULL, truncate = NULL, xreg = NULL,
##     test = c("kpss", "adf", "pp"), test.args = list(), seasonal.test = c("seas",
##         "ocsb", "hegy", "ch"), seasonal.test.args = list(), allowdrift = TRUE,
##     allowmean = TRUE, lambda = NULL, biasadj = FALSE, parallel = FALSE,
##     num.cores = 2, x = y, ...)
```

Parameter Notes:

- All values of nonseasonal pdq and seasonal PDQ are maximums. The `auto.arima` will select a value using these as an upper limit.
- `xreg` - This should not be used since XGBoost will be doing the regression

Model 2: XGBoost (`xgboost::xgb.train`):

```
## function (params = list(), data, nrounds, watchlist = list(), obj = NULL,
##     feval = NULL, verbose = 1, print_every_n = 1L, early_stopping_rounds = NULL,
##     maximize = NULL, save_period = NULL, save_name = "xgboost.model", xgb_model = NULL,
##     callbacks = list(), ...)
```

Parameter Notes:

- XGBoost uses a `params = list()` to capture. Parsnip / Modeltime automatically sends any args provided as `...` inside of `set_engine()` to the `params = list(...)`.

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The `fit()` interface accepts date and date-time features and handles them internally.

- `fit(y ~ date)`

Seasonal Period Specification

The period can be non-seasonal (`seasonal_period = 1`) or seasonal (e.g. `seasonal_period = 12` or `seasonal_period = "12 months"`). There are 3 ways to specify:

1. `seasonal_period = "auto"`: A period is selected based on the periodicity of the data (e.g. 12 if monthly)
2. `seasonal_period = 12`: A numeric frequency. For example, 12 is common for monthly data
3. `seasonal_period = "1 year"`: A time-based phrase. For example, "1 year" would convert to 12 for monthly data.

Univariate (No xregs, Exogenous Regressors):

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"], y = data$y)` will ignore xreg's.

Multivariate (xregs, Exogenous Regressors)

The `xreg` parameter is populated using the `fit()` or `fit_xy()` function:

- Only `factor`, ordered factor, and `numeric` data will be used as xregs.
- Date and Date-time variables are not used as xregs
- `character` data should be converted to factor.

Xreg Example: Suppose you have 3 features:

1. `y` (target)
2. `date` (time stamp),
3. `month.lbl` (labeled month as a ordered factor).

The `month.lbl` is an exogenous regressor that can be passed to the `arima_boost()` using `fit()`:

- `fit(y ~ date + month.lbl)` will pass `month.lbl` on as an exogenous regressor.
- `fit_xy(data[,c("date", "month.lbl")], y = data$y)` will pass x, where x is a data frame containing `month.lbl` and the `date` feature. Only `month.lbl` will be used as an exogenous regressor.

Note that date or date-time class values are excluded from `xreg`.

See Also

`fit.model_spec()`, `set_engine()`

Examples

```
library(tidyverse)
library(lubridate)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)


# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# MODEL SPEC ----

# Set engine and boosting parameters
model_spec <- arima_boost(

    # ARIMA args
```

```
    seasonal_period = 12,
    non_seasonal_ar = 0,
    non_seasonal_differences = 1,
    non_seasonal_ma = 1,
    seasonal_ar     = 0,
    seasonal_differences = 1,
    seasonal_ma     = 1,

    # XGBoost Args
    tree_depth = 6,
    learn_rate = 0.1
) %>%
    set_engine(engine = "arima_xgboost")

# FIT ----

## Not run:
# Boosting - Happens by adding numeric date and month features
model_fit_boosted <- model_spec %>%
    fit(value ~ date + as.numeric(date) + month(date, label = TRUE),
        data = training(splits))

model_fit_boosted

## End(Not run)
```

`Arima_fit_impl` *Low-Level ARIMA function for translating modeltime to forecast*

Description

Low-Level ARIMA function for translating modeltime to forecast

Usage

```
Arima_fit_impl(
  x,
  y,
  period = "auto",
  p = 0,
  d = 0,
  q = 0,
  P = 0,
  D = 0,
  Q = 0,
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
period	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
p	The order of the non-seasonal auto-regressive (AR) terms. Often denoted "p" in pdq-notation.
d	The order of integration for non-seasonal differencing. Often denoted "d" in pdq-notation.
q	The order of the non-seasonal moving average (MA) terms. Often denoted "q" in pdq-notation.
P	The order of the seasonal auto-regressive (SAR) terms. Often denoted "P" in PDQ-notation.
D	The order of integration for seasonal differencing. Often denoted "D" in PDQ-notation.
Q	The order of the seasonal moving average (SMA) terms. Often denoted "Q" in PDQ-notation.
...	Additional arguments passed to `forecast::Arima`

---

arima_params *Tuning Parameters for ARIMA Models*

Description

Tuning Parameters for ARIMA Models

Usage

```
non_seasonal_ar(range = c(0L, 5L), trans = NULL)

non_seasonal_differences(range = c(0L, 2L), trans = NULL)

non_seasonal_ma(range = c(0L, 5L), trans = NULL)

seasonal_ar(range = c(0L, 2L), trans = NULL)

seasonal_differences(range = c(0L, 1L), trans = NULL)

seasonal_ma(range = c(0L, 2L), trans = NULL)
```

Arguments

`range`	A two-element vector holding the *defaults* for the smallest and largest possible values, respectively.
`trans`	A `trans` object from the `scales` package, such as `scales::log10_trans()` or `scales::reciprocal_trans()`. If not provided, the default is used which matches the units used in `range`. If no transformation, `NULL`.

Details

The main parameters for ARIMA models are:

- `non_seasonal_ar`: The order of the non-seasonal auto-regressive (AR) terms.
- `non_seasonal_differences`: The order of integration for non-seasonal differencing.
- `non_seasonal_ma`: The order of the non-seasonal moving average (MA) terms.
- `seasonal_ar`: The order of the seasonal auto-regressive (SAR) terms.
- `seasonal_differences`: The order of integration for seasonal differencing.
- `seasonal_ma`: The order of the seasonal moving average (SMA) terms.

Examples

```
non_seasonal_ar()

non_seasonal_differences()

non_seasonal_ma()
```

`Arima_predict_impl` *Bridge prediction function for ARIMA models*

Description

Bridge prediction function for ARIMA models

Usage

```
Arima_predict_impl(object, new_data, ...)
```

Arguments

`object`	An object of class `model_fit`
`new_data`	A rectangular data object, such as a data frame.
`...`	Additional arguments passed to `forecast::Arima()`

arima_reg *General Interface for ARIMA Regression Models*

Description

arima_reg() is a way to generate a *specification* of an ARIMA model before fitting and allows the model to be created using different packages. Currently the only package is forecast.

Usage

```
arima_reg(
  mode = "regression",
  seasonal_period = NULL,
  non_seasonal_ar = NULL,
  non_seasonal_differences = NULL,
  non_seasonal_ma = NULL,
  seasonal_ar = NULL,
  seasonal_differences = NULL,
  seasonal_ma = NULL
)
```

Arguments

mode
: A single character string for the type of model. The only possible value for this model is "regression".

seasonal_period
: A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.

non_seasonal_ar
: The order of the non-seasonal auto-regressive (AR) terms. Often denoted "p" in pdq-notation.

non_seasonal_differences
: The order of integration for non-seasonal differencing. Often denoted "d" in pdq-notation.

non_seasonal_ma
: The order of the non-seasonal moving average (MA) terms. Often denoted "q" in pdq-notation.

seasonal_ar
: The order of the seasonal auto-regressive (SAR) terms. Often denoted "P" in PDQ-notation.

seasonal_differences
: The order of integration for seasonal differencing. Often denoted "D" in PDQ-notation.

seasonal_ma
: The order of the seasonal moving average (SMA) terms. Often denoted "Q" in PDQ-notation.

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `arima_reg()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "auto_arima" (default) - Connects to `forecast::auto.arima()`
- "Arima" - Connects to `forecast::Arima()`

Main Arguments

The main arguments (tuning parameters) for the model are:

- `seasonal_period`: The periodic nature of the seasonality. Uses "auto" by default.
- `non_seasonal_ar`: The order of the non-seasonal auto-regressive (AR) terms.
- `non_seasonal_differences`: The order of integration for non-seasonal differencing.
- `non_seasonal_ma`: The order of the non-seasonal moving average (MA) terms.
- `seasonal_ar`: The order of the seasonal auto-regressive (SAR) terms.
- `seasonal_differences`: The order of integration for seasonal differencing.
- `seasonal_ma`: The order of the seasonal moving average (SMA) terms.

These arguments are converted to their specific names at the time that the model is fit.

Other options and argument can be set using `set_engine()` (See Engine Details below).

If parameters need to be modified, `update()` can be used in lieu of recreating the object from scratch.

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

modeltime	forecast::auto.arima	forecast::Arima
seasonal_period	ts(frequency)	ts(frequency)
non_seasonal_ar, non_seasonal_differences, non_seasonal_ma	max.p, max.d, max.q	order = c(p,d,q)
seasonal_ar, seasonal_differences, seasonal_ma	max.P, max.D, max.Q	seasonal = c(P,D,Q)

Other options can be set using `set_engine()`.

auto_arima (default engine)

The engine uses `forecast::auto.arima()`.

Function Parameters:

```
## function (y, d = NA, D = NA, max.p = 5, max.q = 5, max.P = 2, max.Q = 2,
##     max.order = 5, max.d = 2, max.D = 1, start.p = 2, start.q = 2, start.P = 1,
##     start.Q = 1, stationary = FALSE, seasonal = TRUE, ic = c("aicc", "aic",
##      "bic"), stepwise = TRUE, nmodels = 94, trace = FALSE, approximation = (length(x) >
##         150 | frequency(x) > 12), method = NULL, truncate = NULL, xreg = NULL,
```

```
##    test = c("kpss", "adf", "pp"), test.args = list(), seasonal.test = c("seas",
##        "ocsb", "hegy", "ch"), seasonal.test.args = list(), allowdrift = TRUE,
##     allowmean = TRUE, lambda = NULL, biasadj = FALSE, parallel = FALSE,
##     num.cores = 2, x = y, ...)
```

The *MAXIMUM* nonseasonal ARIMA terms (max.p, max.d, max.q) and seasonal ARIMA terms (max.P, max.D, max.Q) are provided to forecast::auto.arima() via arima_reg() parameters. Other options and argument can be set using set_engine().

Parameter Notes:

- All values of nonseasonal pdq and seasonal PDQ are maximums. The forecast::auto.arima() model will select a value using these as an upper limit.
- xreg - This is supplied via the parsnip / modeltime fit() interface (so don't provide this manually). See Fit Details (below).

arima

The engine uses forecast::Arima().

Function Parameters:

```
## function (y, order = c(0, 0, 0), seasonal = c(0, 0, 0), xreg = NULL, include.mean = TRUE,
##    include.drift = FALSE, include.constant, lambda = model$lambda, biasadj = FALSE,
##     method = c("CSS-ML", "ML", "CSS"), model = NULL, x = y, ...)
```

The nonseasonal ARIMA terms (order) and seasonal ARIMA terms (seasonal) are provided to forecast::Arima() via arima_reg() parameters. Other options and argument can be set using set_engine().

Parameter Notes:

- xreg - This is supplied via the parsnip / modeltime fit() interface (so don't provide this manually). See Fit Details (below).
- method - The default is set to "ML" (Maximum Likelihood). This method is more robust at the expense of speed and possible selections may fail unit root inversion testing. Alternatively, you can add method = "CSS-ML" to evaluate Conditional Sum of Squares for starting values, then Maximium Likelihood.

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The fit() interface accepts date and date-time features and handles them internally.

- fit(y ~ date)

Seasonal Period Specification

The period can be non-seasonal (seasonal_period = 1 or "none") or yearly seasonal (e.g. For monthly time stamps, seasonal_period = 12, seasonal_period = "12 months", or seasonal_period = "yearly"). There are 3 ways to specify:

1. `seasonal_period = "auto"`: A seasonal period is selected based on the periodicity of the data (e.g. 12 if monthly)
2. `seasonal_period = 12`: A numeric frequency. For example, 12 is common for monthly data
3. `seasonal_period = "1 year"`: A time-based phrase. For example, "1 year" would convert to 12 for monthly data.

Univariate (No xregs, Exogenous Regressors):

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"], y = data$y)` will ignore xreg's.

Multivariate (xregs, Exogenous Regressors)

The `xreg` parameter is populated using the `fit()` or `fit_xy()` function:

- Only `factor`, ordered factor, and `numeric` data will be used as xregs.
- Date and Date-time variables are not used as xregs
- `character` data should be converted to factor.

Xreg Example: Suppose you have 3 features:

1. `y` (target)
2. `date` (time stamp),
3. `month.lbl` (labeled month as a ordered factor).

The `month.lbl` is an exogenous regressor that can be passed to the `arima_reg()` using `fit()`:

- `fit(y ~ date + month.lbl)` will pass `month.lbl` on as an exogenous regressor.
- `fit_xy(data[,c("date", "month.lbl")], y = data$y)` will pass x, where x is a data frame containing `month.lbl` and the `date` feature. Only `month.lbl` will be used as an exogenous regressor.

Note that date or date-time class values are excluded from `xreg`.

See Also

`fit.model_spec()`, `set_engine()`

Examples

```
library(dplyr)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)

# Data
m750 <- m4_monthly %>% filter(id == "M750")
m750
```

```
# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.8)

# ---- AUTO ARIMA ----

# Model Spec
model_spec <- arima_reg() %>%
    set_engine("auto_arima")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit


# ---- STANDARD ARIMA ----

# Model Spec
model_spec <- arima_reg(
        seasonal_period          = 12,
        non_seasonal_ar          = 3,
        non_seasonal_differences = 1,
        non_seasonal_ma          = 3,
        seasonal_ar              = 1,
        seasonal_differences     = 0,
        seasonal_ma              = 1
    ) %>%
    set_engine("arima")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit
```

`arima_workflow_tuned` *Example ARIMA Tuning Results*

Description

These objects are the results of an analysis of the M750 data set, which came from the M4 Forecast Competition.

Usage

```
arima_workflow_tuned
```

Format

An object of class `tune_results` (inherits from `time_series_cv`, `rset`, `tbl_df`, `tbl`, `data.frame`) with 2 rows and 4 columns.

Value

This is the output of `tune_grid()` for an ARIMA model created with `arima_reg()`.

Examples

```
arima_workflow_tuned
```

`arima_xgboost_fit_impl` *Bridge ARIMA-XGBoost Modeling function*

Description

Bridge ARIMA-XGBoost Modeling function

Usage

```
arima_xgboost_fit_impl(
  x,
  y,
  period = "auto",
  p = 0,
  d = 0,
  q = 0,
  P = 0,
  D = 0,
  Q = 0,
  include.mean = TRUE,
  include.drift = FALSE,
  include.constant,
  lambda = model$lambda,
  biasadj = FALSE,
  method = c("CSS-ML", "ML", "CSS"),
  model = NULL,
  max_depth = 6,
  nrounds = 15,
  eta = 0.3,
  colsample_bytree = 1,
  min_child_weight = 1,
  gamma = 0,
  subsample = 1,
  validation = 0,
  early_stop = NULL,
  ...
)
```

Arguments

`x`	A dataframe of xreg (exogenous regressors)
`y`	A numeric vector of values to fit
`period`	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
`p`	The order of the non-seasonal auto-regressive (AR) terms.
`d`	The order of integration for non-seasonal differencing.
`q`	The order of the non-seasonal moving average (MA) terms.
`P`	The order of the seasonal auto-regressive (SAR) terms.
`D`	The order of integration for seasonal differencing.
`Q`	The order of the seasonal moving average (SMA) terms.
`include.mean`	Should the ARIMA model include a mean term? The default is `TRUE` for undifferenced series, `FALSE` for differenced ones (where a mean would not affect the fit nor predictions).
`include.drift`	Should the ARIMA model include a linear drift term? (i.e., a linear regression with ARIMA errors is fitted.) The default is `FALSE`.
`include.constant`	If `TRUE`, then `include.mean` is set to be `TRUE` for undifferenced series and `include.drift` is set to be `TRUE` for differenced series. Note that if there is more than one difference taken, no constant is included regardless of the value of this argument. This is deliberate as otherwise quadratic and higher order polynomial trends would be induced.
`lambda`	Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
`biasadj`	Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
`method`	Fitting method: maximum likelihood or minimize conditional sum-of-squares. The default (unless there are missing values) is to use conditional-sum-of-squares to find starting values, then maximum likelihood.
`model`	Output from a previous call to `Arima`. If model is passed, this same model is fitted to `y` without re-estimating any parameters.
`max_depth`	An integer for the maximum depth of the tree.
`nrounds`	An integer for the number of boosting iterations.
`eta`	A numeric value between zero and one to control the learning rate.
`colsample_bytree`	Subsampling proportion of columns.
`min_child_weight`	A numeric value for the minimum sum of instance weights needed in a child to continue to split.

gamma	A number for the minimum loss reduction required to make a further partition on a leaf node of the tree
subsample	Subsampling proportion of rows.
validation	A positive number. If on [0, 1) the value, validation is a random proportion of data in x and y that are used for performance assessment and potential early stopping. If 1 or greater, it is the *number* of training set samples use for these purposes.
early_stop	An integer or NULL. If not NULL, it is the number of training iterations without improvement before stopping. If validation is used, performance is base on the validation set; otherwise the training set is used.
...	Additional arguments passed to xgboost::xgb.train

arima_xgboost_predict_impl *Bridge prediction Function for ARIMA-XGBoost Models*

Description

Bridge prediction Function for ARIMA-XGBoost Models

Usage

```
arima_xgboost_predict_impl(object, new_data, ...)
```

Arguments

object	An object of class model_fit
new_data	A rectangular data object, such as a data frame.
...	Additional arguments passed to predict.xgb.Booster()

auto_arima_fit_impl *Low-Level ARIMA function for translating modeltime to forecast*

Description

Low-Level ARIMA function for translating modeltime to forecast

Usage

```
auto_arima_fit_impl(
  x,
  y,
  period = "auto",
  max.p = 5,
  max.d = 2,
  max.q = 5,
  max.P = 2,
  max.D = 1,
  max.Q = 2,
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
period	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
max.p	The maximum order of the non-seasonal auto-regressive (AR) terms.
max.d	The maximum order of integration for non-seasonal differencing.
max.q	The maximum order of the non-seasonal moving average (MA) terms.
max.P	The maximum order of the seasonal auto-regressive (SAR) terms.
max.D	The maximum order of integration for seasonal differencing.
max.Q	The maximum order of the seasonal moving average (SMA) terms.
...	Additional arguments passed to `forecast::auto.arima`

---

auto_arima_xgboost_fit_impl

Bridge ARIMA-XGBoost Modeling function

Description

Bridge ARIMA-XGBoost Modeling function

Usage

```
auto_arima_xgboost_fit_impl(
  x,
  y,
  period = "auto",
  max.p = 5,
```

```
  max.d = 2,
  max.q = 5,
  max.P = 2,
  max.D = 1,
  max.Q = 2,
  max.order = 5,
  d = NA,
  D = NA,
  start.p = 2,
  start.q = 2,
  start.P = 1,
  start.Q = 1,
  stationary = FALSE,
  seasonal = TRUE,
  ic = c("aicc", "aic", "bic"),
  stepwise = TRUE,
  nmodels = 94,
  trace = FALSE,
  approximation = (length(x) > 150 | frequency(x) > 12),
  method = NULL,
  truncate = NULL,
  test = c("kpss", "adf", "pp"),
  test.args = list(),
  seasonal.test = c("seas", "ocsb", "hegy", "ch"),
  seasonal.test.args = list(),
  allowdrift = TRUE,
  allowmean = TRUE,
  lambda = NULL,
  biasadj = FALSE,
  max_depth = 6,
  nrounds = 15,
  eta = 0.3,
  colsample_bytree = 1,
  min_child_weight = 1,
  gamma = 0,
  subsample = 1,
  validation = 0,
  early_stop = NULL,
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
period	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.

`max.p`	The maximum order of the non-seasonal auto-regressive (AR) terms.
`max.d`	The maximum order of integration for non-seasonal differencing.
`max.q`	The maximum order of the non-seasonal moving average (MA) terms.
`max.P`	The maximum order of the seasonal auto-regressive (SAR) terms.
`max.D`	The maximum order of integration for seasonal differencing.
`max.Q`	The maximum order of the seasonal moving average (SMA) terms.
`max.order`	Maximum value of p+q+P+Q if model selection is not stepwise.
`d`	Order of first-differencing. If missing, will choose a value based on `test`.
`D`	Order of seasonal-differencing. If missing, will choose a value based on `season.test`.
`start.p`	Starting value of p in stepwise procedure.
`start.q`	Starting value of q in stepwise procedure.
`start.P`	Starting value of P in stepwise procedure.
`start.Q`	Starting value of Q in stepwise procedure.
`stationary`	If `TRUE`, restricts search to stationary models.
`seasonal`	If `FALSE`, restricts search to non-seasonal models.
`ic`	Information criterion to be used in model selection.
`stepwise`	If `TRUE`, will do stepwise selection (faster). Otherwise, it searches over all models. Non-stepwise selection can be very slow, especially for seasonal models.
`nmodels`	Maximum number of models considered in the stepwise search.
`trace`	If `TRUE`, the list of ARIMA models considered will be reported.
`approximation`	If `TRUE`, estimation is via conditional sums of squares and the information criteria used for model selection are approximated. The final model is still computed using maximum likelihood estimation. Approximation should be used for long time series or a high seasonal period to avoid excessive computation times.
`method`	fitting method: maximum likelihood or minimize conditional sum-of-squares. The default (unless there are missing values) is to use conditional-sum-of-squares to find starting values, then maximum likelihood. Can be abbreviated.
`truncate`	An integer value indicating how many observations to use in model selection. The last `truncate` values of the series are used to select a model when `truncate` is not `NULL` and `approximation=TRUE`. All observations are used if either `truncate=NULL` or `approximation=FALSE`.
`test`	Type of unit root test to use. See `ndiffs` for details.
`test.args`	Additional arguments to be passed to the unit root test.
`seasonal.test`	This determines which method is used to select the number of seasonal differences. The default method is to use a measure of seasonal strength computed from an STL decomposition. Other possibilities involve seasonal unit root tests.
`seasonal.test.args`	Additional arguments to be passed to the seasonal unit root test. See `nsdiffs` for details.
`allowdrift`	If `TRUE`, models with drift terms are considered.

allowmean	If TRUE, models with a non-zero mean are considered.
lambda	Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
biasadj	Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
max_depth	An integer for the maximum depth of the tree.
nrounds	An integer for the number of boosting iterations.
eta	A numeric value between zero and one to control the learning rate.
colsample_bytree	Subsampling proportion of columns.
min_child_weight	A numeric value for the minimum sum of instance weights needed in a child to continue to split.
gamma	A number for the minimum loss reduction required to make a further partition on a leaf node of the tree
subsample	Subsampling proportion of rows.
validation	A positive number. If on [0, 1) the value, validation is a random proportion of data in x and y that are used for performance assessment and potential early stopping. If 1 or greater, it is the *number* of training set samples use for these purposes.
early_stop	An integer or NULL. If not NULL, it is the number of training iterations without improvement before stopping. If validation is used, performance is base on the validation set; otherwise the training set is used.
...	Additional arguments passed to xgboost::xgb.train

---

create_xreg_recipe *Developer Tools for preparing XREGS (Regressors)*

Description

These functions are designed to assist developers in extending the modeltime package. create_xregs_recipe() makes it simple to automate conversion of raw un-encoded features to machine-learning ready features.

Usage

```
create_xreg_recipe(
  data,
  prepare = TRUE,
  clean_names = TRUE,
  dummy_encode = TRUE,
  one_hot = FALSE
)
```

Arguments

`data`	A data frame
`prepare`	Whether or not to run `recipes::prep()` on the final recipe. Default is to prepare. User can set this to FALSE to return an un prepared recipe.
`clean_names`	Uses `janitor::clean_names()` to process the names and improve robustness to failure during dummy (one-hot) encoding step.
`dummy_encode`	Should `factors` (categorical data) be
`one_hot`	If `dummy_encode = TRUE`, should the encoding return one column for each feature or one less column than each feature. Default is `FALSE`.

Details

The default recipe contains steps to:

1. Remove date features
2. Clean the column names removing spaces and bad characters
3. Convert ordered factors to regular factors
4. Convert factors to dummy variables
5. Remove any variables that have zero variance

Value

A `recipe` in either prepared or un-prepared format.

Examples

```
library(dplyr)
library(timetk)
library(recipes)
library(lubridate)

predictors <- m4_monthly %>%
    filter(id == "M750") %>%
    select(-value) %>%
    mutate(month = month(date, label = TRUE))
predictors

# Create default recipe
xreg_recipe_spec <- create_xreg_recipe(predictors, prepare = TRUE)

# Extracts the preprocessed training data from the recipe (used in your fit function)
juice_xreg_recipe(xreg_recipe_spec)

# Applies the prepared recipe to new data (used in your predict function)
bake_xreg_recipe(xreg_recipe_spec, new_data = predictors)
```

default_forecast_accuracy_metric_set
Forecast Accuracy Metrics Sets

Description

This is a wrapper for `metric_set()` with several common forecast / regression accuracy metrics included. These are the default time series accuracy metrics used with `modeltime_accuracy()`.

Usage

```
default_forecast_accuracy_metric_set()
```

Details

The primary purpose is to use the default accuracy metrics to calculate the following forecast accuracy metrics using `modeltime_accuracy()`:

- MAE - Mean absolute error, `mae()`
- MAPE - Mean absolute percentage error, `mape()`
- MASE - Mean absolute scaled error, `mase()`
- SMAPE - Symmetric mean absolute percentage error, `smape()`
- RMSE - Root mean squared error, `rmse()`
- RSQ - R-squared, `rsq()`

Examples

```
library(tibble)
library(dplyr)
library(timetk)

set.seed(1)
data <- tibble(
    time  = tk_make_timeseries("2020", by = "sec", length_out = 10),
    y     = 1:10 + rnorm(10),
    y_hat = 1:10 + rnorm(10)
)

# Default Metric Specification
default_forecast_accuracy_metric_set()

# Create a metric summarizer function from the metric set
calc_default_metrics <- default_forecast_accuracy_metric_set()

# Apply the metric summarizer to new data
calc_default_metrics(data, y, y_hat)
```

ets_fit_impl *Low-Level Exponential Smoothing function for translating modeltime to forecast*

Description

Low-Level Exponential Smoothing function for translating modeltime to forecast

Usage

```
ets_fit_impl(
  x,
  y,
  period = "auto",
  error = "auto",
  trend = "auto",
  season = "auto",
  damping = "auto",
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
period	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
error	The form of the error term: "auto", "additive", or "multiplicative". If the error is multiplicative, the data must be non-negative.
trend	The form of the trend term: "auto", "additive", "multiplicative" or "none".
season	The form of the seasonal term: "auto", "additive", "multiplicative" or "none"..
damping	Apply damping to a trend: "auto", "damped", or "none".
...	Additional arguments passed to `forecast::ets`

ets_predict_impl *Bridge prediction function for Exponential Smoothing models*

Description

Bridge prediction function for Exponential Smoothing models

Usage

```
ets_predict_impl(object, new_data, ...)
```

Arguments

object	An object of class model_fit
new_data	A rectangular data object, such as a data frame.
...	Additional arguments passed to forecast::ets()

---

exp_smoothing — *General Interface for Exponential Smoothing State Space Models*

Description

exp_smoothing() is a way to generate a *specification* of an Exponential Smoothing model before fitting and allows the model to be created using different packages. Currently the only package is forecast.

Usage

```
exp_smoothing(
  mode = "regression",
  seasonal_period = NULL,
  error = NULL,
  trend = NULL,
  season = NULL,
  damping = NULL
)
```

Arguments

mode	A single character string for the type of model. The only possible value for this model is "regression".
seasonal_period	A seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.
error	The form of the error term: "auto", "additive", or "multiplicative". If the error is multiplicative, the data must be non-negative.
trend	The form of the trend term: "auto", "additive", "multiplicative" or "none".
season	The form of the seasonal term: "auto", "additive", "multiplicative" or "none"..
damping	Apply damping to a trend: "auto", "damped", or "none".

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `exp_smoothing()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "ets" (default) - Connects to `forecast::ets()`

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

modeltime	forecast::ets
seasonal_period()	ts(frequency)
error(), trend(), season()	model
damping()	damped

Other options can be set using `set_engine()`.

ets (default engine)

The engine uses `forecast::ets()`.

Function Parameters:

```
## function (y, model = "ZZZ", damped = NULL, alpha = NULL, beta = NULL, gamma = NULL,
##     phi = NULL, additive.only = FALSE, lambda = NULL, biasadj = FALSE,
##    lower = c(rep(1e-04, 3), 0.8), upper = c(rep(0.9999, 3), 0.98), opt.crit = c("lik",
##         "amse", "mse", "sigma", "mae"), nmse = 3, bounds = c("both", "usual",
##      "admissible"), ic = c("aicc", "aic", "bic"), restrict = TRUE, allow.multiplicative.trend = FALS
##     use.initial.values = FALSE, na.action = c("na.contiguous", "na.interp",
##         "na.fail"), ...)
```

The main arguments are `model` and `damped` are defined using:

- `error()` = "auto", "additive", and "multiplicative" are converted to "Z", "A", and "M"
- `trend()` = "auto", "additive", "multiplicative", and "none" are converted to "Z","A","M" and "N"
- `season()` = "auto", "additive", "multiplicative", and "none" are converted to "Z","A","M" and "N"
- `damping()` - "auto", "damped", "none" are converted to NULL, TRUE, FALSE

By default, all arguments are set to "auto" to perform automated Exponential Smoothing using *in-sample data* following the underlying `forecast::ets()` automation routine.

Other options and argument can be set using `set_engine()`.

Parameter Notes:

- `xreg` - This model is not set up to use exogenous regressors. Only univariate models will be fit.

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The `fit()` interface accepts date and date-time features and handles them internally.

- `fit(y ~ date)`

Seasonal Period Specification

The period can be non-seasonal (`seasonal_period = 1` or `"none"`) or seasonal (e.g. `seasonal_period = 12` or `seasonal_period = "12 months"`). There are 3 ways to specify:

1. `seasonal_period = "auto"`: A period is selected based on the periodicity of the data (e.g. 12 if monthly)
2. `seasonal_period = 12`: A numeric frequency. For example, 12 is common for monthly data
3. `seasonal_period = "1 year"`: A time-based phrase. For example, "1 year" would convert to 12 for monthly data.

Univariate:

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"],y = data$y)` will ignore xreg's.

Multivariate (xregs, Exogenous Regressors)

This model is not set up for use with exogenous regressors.

See Also

`fit.model_spec()`, `set_engine()`

Examples

```
library(dplyr)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)

# Data
m750 <- m4_monthly %>% filter(id == "M750")
m750

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.8)

# ---- AUTO ETS ----

# Model Spec - The default parameters are all set
# to "auto" if none are provided
model_spec <- exp_smoothing() %>%
```

```
    set_engine("ets")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit


# ---- STANDARD ETS ----

# Model Spec
model_spec <- exp_smoothing(
        seasonal_period  = 12,
        error            = "multiplicative",
        trend            = "additive",
        season           = "multiplicative"
    ) %>%
    set_engine("ets")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit
```

`exp_smoothing_params` *Tuning Parameters for Exponential Smoothing Models*

Description

Tuning Parameters for Exponential Smoothing Models

Usage

```
error(values = c("additive", "multiplicative"))

trend(values = c("additive", "multiplicative", "none"))

season(values = c("additive", "multiplicative", "none"))

damping(values = c("damped", "none"))
```

Arguments

values	A character string of possible values.

Details

The main parameters for Exponential Smoothing models are:

- `error`: The form of the error term: additive", or "multiplicative". If the error is multiplicative, the data must be non-negative.
- `trend`: The form of the trend term: "additive", "multiplicative" or "none".
- `season`: The form of the seasonal term: "additive", "multiplicative" or "none"..
- `damping`: Apply damping to a trend: "damped", or "none".

Examples

```
error()

trend()

season()
```

`get_arima_description` *Get model descriptions for Arima objects*

Description

Get model descriptions for Arima objects

Usage

```
get_arima_description(object, padding = FALSE)
```

Arguments

`object`	Objects of class `Arima`
`padding`	Whether or not to include padding

Source

- Forecast R Package, `forecast:::arima.string()`

Examples

```
library(forecast)

arima_fit <- forecast::Arima(1:10)

get_arima_description(arima_fit)
```

get_model_description *Get model descriptions for parsnip, workflows & modeltime objects*

Description

Get model descriptions for parsnip, workflows & modeltime objects

Usage

```
get_model_description(object, indicate_training = FALSE, upper_case = TRUE)
```

Arguments

object	Parsnip or workflow objects
indicate_training	Whether or not to indicate if the model has been trained
upper_case	Whether to return upper or lower case model descriptions

Examples

```
library(dplyr)
library(timetk)
library(parsnip)
library(modeltime)

# Model Specification ----

arima_spec <- arima_reg() %>%
    set_engine("auto_arima")

get_model_description(arima_spec, indicate_training = TRUE)

# Fitted Model ----

m750 <- m4_monthly %>% filter(id == "M750")

arima_fit <- arima_spec %>%
    fit(value ~ date, data = m750)

get_model_description(arima_fit, indicate_training = TRUE)
```

modeltime_accuracy *Calculate Accuracy Metrics*

Description

This is a wrapper for yardstick that simplifies time series regression accuracy metric calculations from a fitted workflow (trained workflow) or model_fit (trained parsnip model).

Usage

```
modeltime_accuracy(
  object,
  new_data = NULL,
  metric_set = default_forecast_accuracy_metric_set(),
  quiet = TRUE,
  ...
)
```

Arguments

object	A fitted model object that is either (1) a workflow that has been fit by fit.workflow() or (2) a parsnip model that has been fit using fit.model_spec()
new_data	A tibble containing future information (timestamps and actual values).
metric_set	A metric_set() that is used to summarize one or more forecast accuracy (regression) metrics.
quiet	Hide errors (TRUE, the default), or display them as they occur?
...	Additional arguments passed to modeltime_forecast().

Details

The following accuracy metrics are included by default via default_forecast_accuracy_metric_set():

- MAE - Mean absolute error, mae()
- MAPE - Mean absolute percentage error, mape()
- MASE - Mean absolute scaled error, mase()
- SMAPE - Symmetric mean absolute percentage error, smape()
- RMSE - Root mean squared error, rmse()
- RSQ - R-squared, rsq()

Value

A tibble with accuracy estimates.

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- ACCURACY ----

models_tbl %>%
    modeltime_calibrate(new_data = testing(splits)) %>%
    modeltime_accuracy(
        metric_set = metric_set(mae, rmse, rsq)
    )
```

`modeltime_calibrate` *Preparation for forecasting*

Description

Calibration sets the stage for accuracy and forecast confidence by computing predictions and residuals from out of sample data.

Usage

```
modeltime_calibrate(object, new_data, quiet = TRUE, ...)
```

Arguments

- `object` — A fitted model object that is either:
  1. A modeltime table that has been created using `modeltime_table()`
  2. A workflow that has been fit by `fit.workflow()` or
  3. A parsnip model that has been fit using `fit.model_spec()`
- `new_data` — A test data set `tibble` containing future information (timestamps and actual values).
- `quiet` — Hide errors (`TRUE`, the default), or display them as they occur?
- `...` — Additional arguments passed to `modeltime_forecast()`.

Details

The results of calibration are used for:

- **Forecast Confidence Interval Estimation**: The out of sample residual data is used to calculate the confidence interval. Refer to `modeltime_forecast()`.
- **Accuracy Calculations:** The out of sample actual and prediction values are used to calculate performance metrics. Refer to `modeltime_accuracy()`

The calibration steps include:

1. If not a Modeltime Table, objects are converted to Modeltime Tables internally
2. Two Columns are added:

- `.type`: Indicates the sample type. Only "Test" is currently available.
- `.calibration_data`: Contains a tibble with Timestamps, Actual Values, Predictions and Residuals calculated from `new_data` (Test Data)

Value

A Modeltime Table (`mdl_time_tbl`) with nested `.calibration_data` added

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
```

```
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- CALIBRATE ----

calibration_tbl <- models_tbl %>%
    modeltime_calibrate(new_data = testing(splits))

# ---- ACCURACY ----

calibration_tbl %>%
    modeltime_accuracy()

# ---- FORECAST ----

calibration_tbl %>%
    modeltime_forecast(
        new_data    = testing(splits),
        actual_data = m750
    )
```

`modeltime_forecast` *Forecast future data*

Description

The goal of `modeltime_forecast()` is to simplify the process of forecasting future data.

Usage

```
modeltime_forecast(
  object,
  new_data = NULL,
  h = NULL,
  actual_data = NULL,
  conf_interval = 0.95,
  ...
)
```

Arguments

object	A Modeltime Table that has been calibrated with modeltime_calibrate()
new_data	A tibble containing future information to forecast. If NULL, forecasts the calibration data.
h	The forecast horizon (can be used instead of new_data for time series with no exogenous regressors). Extends the calibration data h periods into the future.
actual_data	Reference data that is combined with the output tibble and given a .key = "actual"
conf_interval	An estimated confidence interval based on the in-sample residuals
...	Not currently used

Details

The key parameters are (controlled by new_data or h) and combining with existing data (controlled by actual_data) in preparation for visualization with plot_modeltime_forecast().

Specifying New Data or Horizon (h)

When forecasting you can specify future data using:

1. new_data: This is a future tibble with date column and columns for xregs extending the trained dates and exogonous regressors (xregs) if used.
    - **Forecasting Evaluation Data**: By default, the new_data will use the .calibration_data if new_data is not provided. This is the equivalent of using rsample::testing() for getting test data sets.
    - **Forecasting Future Data**: See future_frame() for creating future tibbles.
    - **Xregs**: Can be used with this method
2. h: This is a phrase like "1 year", which extends the .calibration_data into the future.
    - **Forecasting Future Data**: All forecasts using h are **extended after the calibration data**, which is desirable *after refitting* with modeltime_refit(). Internally, a call is made to future_frame() to expedite creating new data using the date feature.
    - **Xregs**: Cannot be used because future data must include new xregs.

Actual Data

This is reference data that contains the true values of the time-stamp data. It helps in visualizing the performance of the forecast vs the actual data.

Confidence Interval Estimation

Confidence intervals (.conf_lo, .conf_hi) are estimated based on the normal estimation of the testing errors (out of sample) from modeltime_calibrate(). The out-of-sample error estimates are then carried through and applied to applied to any future forecasts.

The confidence interval can be adjusted with the conf_interval parameter. An 80% confidence interval estimates a normal (Gaussian distribution) that assumes that 80% of the future data will fall within the upper and lower confidence limits.

The confidence interval is *mean-adjusted*, meaning that if the mean of the residuals is non-zero, the confidence interval is adjusted to widen the interval to capture the difference in means.

Refitting has no affect on the confidence interval since this is calculated independently of the refitted model (on data with a smaller sample size). New observations typically improve future accuracy, which in most cases makes the out-of-sample confidence intervals conservative.

Value

A tibble with predictions and time-stamp data. For ease of plotting and calculations, the column names are transformed to:

- `.key`: Values labeled either "prediction" or "actual"
- `.index`: The timestamp index.
- `.value`: The value being forecasted.
- `.conf_lo`: The lower limit of the confidence interval.
- `.conf_hi`: The upper limit of the confidence interval.

Additional descriptive columns are included:

- `.model_id`: Model ID from the Modeltime Table
- `.model_desc`: Model Description from the Modeltime Table

Unnecessary columns are *dropped* to save space:

- `.model`
- `.calibration_data`

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- CALIBRATE ----
```

```
calibration_tbl <- models_tbl %>%
    modeltime_calibrate(new_data = testing(splits))

# ---- ACCURACY ----

calibration_tbl %>%
    modeltime_accuracy()

# ---- FORECAST ----

calibration_tbl %>%
    modeltime_forecast(
        new_data    = testing(splits),
        actual_data = m750
    )
```

`modeltime_refit` *Refit one or more trained models to new data*

Description

This is a wrapper for `fit()` that takes a Modeltime Table and retrains each model on *new data* re-using the parameters and preprocessing steps used during the training process.

Usage

```
modeltime_refit(object, data, control = NULL, ...)
```

Arguments

`object`	A Modeltime Table
`data`	A `tibble` that contains data to retrain the model(s) using.
`control`	Either `control_parsnip()` or `control_workflow()` depending on the object. If NULL, created automatically.
`...`	Additional arguments passed to `fit()`.

Details

Refitting is an important step prior to forecasting time series models. The `modeltime_refit()` function makes it easy to recycle models, retraining on new data.

Recycling Parameters

Parameters are recycled during retraining using the following criteria:

- **Automated models** (e.g. "auto arima") will have parameters recalculated.
- **Non-automated models** (e.g. "arima") will have parameters preserved.
- All preprocessing steps will be reused on the data

Refit

The `modeltime_refit()` function is used to retrain models trained with `fit()`.

Refit XY

The XY format is not supported at this time.

Value

A Modeltime Table containing one or more re-trained models.

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

model_fit_auto_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_auto_arima
)

# ---- CALIBRATE ----
# - Calibrate on training data set

calibration_tbl <- models_tbl %>%
    modeltime_calibrate(new_data = testing(splits))


# ---- REFIT ----
# - Refit on full data set

refit_tbl <- calibration_tbl %>%
    modeltime_refit(m750)
```

modeltime_table *Scale forecast analysis with a Modeltime Table*

Description

Designed to perform forecasts at scale using models created with modeltime, parsnip, workflows, and regression modeling extensions in the tidymodels ecosystem.

Usage

```
modeltime_table(...)
```

Arguments

...	Fitted parsnip model or workflow objects

Details

This function:

1. Creates a table of models
2. Validates that all objects are models (parsnip or workflows objects) and all models have been fitted (trained)
3. Provides an ID and Description of the models

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----
```

```
models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- CALIBRATE ----

calibration_tbl <- models_tbl %>%
    modeltime_calibrate(new_data = testing(splits))

# ---- ACCURACY ----

calibration_tbl %>%
    modeltime_accuracy()

# ---- FORECAST ----

calibration_tbl %>%
    modeltime_forecast(
        new_data    = testing(splits),
        actual_data = m750
    )
```

`new_modeltime_bridge` *Constructor for creating modeltime models*

Description

These functions are used to construct new `modeltime` bridge functions that connect the `tidymodels` infrastructure to time-series models containing date or date-time features.

Usage

```
new_modeltime_bridge(class, models, data, extras = NULL, desc = NULL)
```

Arguments

`class`	A class name that is used for creating custom printing messages
`models`	A list containing one or more models
`data`	A data frame (or tibble) containing 4 columns: (date column with name that matches input data), .actual, .fitted, and .residuals.
`extras`	An optional list that is typically used for transferring preprocessing recipes to the predict method.
`desc`	An optional model description to appear when printing your modeltime objects

Examples

```
library(stats)
library(tidyverse)
library(lubridate)
library(timetk)

lm_model <- lm(value ~ as.numeric(date) + hour(date) + wday(date, label = TRUE),
               data = taylor_30_min)

data = tibble(
   date      = taylor_30_min$date, # Important - The column name must match the modeled data
    # These are standardized names: .actual, .fitted, .residuals
    .actual     = taylor_30_min$value,
    .fitted     = lm_model$fitted.values %>% as.numeric(),
    .residuals  = lm_model$residuals %>% as.numeric()
)

new_modeltime_bridge(
    class  = "lm_time_series_impl",
    models = list(model_1 = lm_model),
    data   = data,
    extras = NULL
)
```

`parse_index` *Developer Tools for parsing date and date-time information*

Description

These functions are designed to assist developers in extending the `modeltime` package.

Usage

```
parse_index_from_data(data)

parse_period_from_index(data, period)
```

Arguments

`data`	A data frame
`period`	A period to calculate from the time index. Numeric values are returned as-is. "auto" guesses a numeric value from the index. A time-based phrase (e.g. "7 days") calculates the number of timestamps that typically occur within the time-based phrase.

Value

- parse_index_from_data(): Returns a tibble containing the date or date-time column.
- parse_period_from_index(): Returns the numeric period from a tibble containing the index.

Examples

```
library(dplyr)
library(timetk)

predictors <- m4_monthly %>%
    filter(id == "M750") %>%
    select(-value)

index_tbl <- parse_index_from_data(predictors)
index_tbl

period <- parse_period_from_index(index_tbl, period = "1 year")
period
```

---

plot_modeltime_forecast *Interactive Forecast Visualization*

Description

This is a wrapper for `plot_time_series()` that generates an interactive (`plotly`) or static (`ggplot2`) plot with the forecasted data.

Usage

```
plot_modeltime_forecast(
  .data,
  .conf_interval_show = TRUE,
  .conf_interval_fill = "grey20",
  .conf_interval_alpha = 0.2,
  .legend_show = TRUE,
  .legend_max_width = 40,
  .title = "Forecast Plot",
  .x_lab = "",
  .y_lab = "",
  .color_lab = "Legend",
  .interactive = TRUE,
  .plotly_slider = FALSE,
  ...
)
```

Arguments

.data — A tibble that is the output of modeltime_forecast()

.conf_interval_show — Logical. Whether or not to include the confidence interval as a ribbon.

.conf_interval_fill — Fill color for the confidence interval

.conf_interval_alpha — Fill opacity for the confidence interval. Range (0, 1).

.legend_show — Logical. Whether or not to show the legend. Can save space with long model descriptions.

.legend_max_width — Numeric. The width of truncation to apply to the legend text.

.title — Title for the plot

.x_lab — X-axis label for the plot

.y_lab — Y-axis label for the plot

.color_lab — Legend label if a color_var is used.

.interactive — Returns either a static (ggplot2) visualization or an interactive (plotly) visualization

.plotly_slider — If TRUE, returns a plotly date range slider.

... — Additional arguments passed to timetk::plot_time_series().

Value

A static ggplot2 plot or an interactive plotly plot containing a forecast

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))
```

```
# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- FORECAST ----

models_tbl %>%
    modeltime_calibrate(new_data = testing(splits)) %>%
    modeltime_forecast(
        new_data    = testing(splits),
        actual_data = m750
    ) %>%
    plot_modeltime_forecast(.interactive = FALSE)
```

---

prophet_boost   *General Interface for Boosted PROPHET Time Series Models*

Description

`prophet_boost()` is a way to generate a *specification* of a Boosted PROPHET model before fitting and allows the model to be created using different packages. Currently the only package is `prophet`.

Usage

```
prophet_boost(
  mode = "regression",
  growth = NULL,
  num_changepoints = NULL,
  season = NULL,
  prior_scale_changepoints = NULL,
  prior_scale_seasonality = NULL,
  prior_scale_holidays = NULL,
  mtry = NULL,
  trees = NULL,
  min_n = NULL,
  tree_depth = NULL,
  learn_rate = NULL,
  loss_reduction = NULL,
  sample_size = NULL,
  stop_iter = NULL
)
```

Arguments

`mode`	A single character string for the type of model. The only possible value for this model is "regression".

`growth` String 'linear' or 'logistic' to specify a linear or logistic trend.

`num_changepoints`
: Number of potential changepoints to include for modeling trend.

`season` 'additive' (default) or 'multiplicative'.

`prior_scale_changepoints`
: Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.

`prior_scale_seasonality`
: Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality.

`prior_scale_holidays`
: Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.

`mtry` A number for the number (or proportion) of predictors that will be randomly sampled at each split when creating the tree models (`xgboost` only).

`trees` An integer for the number of trees contained in the ensemble.

`min_n` An integer for the minimum number of data points in a node that are required for the node to be split further.

`tree_depth` An integer for the maximum depth of the tree (i.e. number of splits) (`xgboost` only).

`learn_rate` A number for the rate at which the boosting algorithm adapts from iteration-to-iteration (`xgboost` only).

`loss_reduction` A number for the reduction in the loss function required to split further (`xgboost` only).

`sample_size` A number for the number (or proportion) of data that is exposed to the fitting routine. For `xgboost`, the sampling is done at at each iteration while `C5.0` samples once during training.

`stop_iter` The number of iterations without improvement before stopping (`xgboost` only).

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `prophet_boost()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "prophet_xgboost" (default) - Connects to `prophet::prophet()` and `xgboost::xgb.train()`

Main Arguments

The main arguments (tuning parameters) for the **PROPHET** model are:

- `growth`: String 'linear' or 'logistic' to specify a linear or logistic trend.
- `num_changepoints`: Number of potential changepoints to include for modeling trend.
- `season`: 'additive' (default) or 'multiplicative'.

- `prior_scale_changepoints`: Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.
- `prior_scale_seasonality`: Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality.
- `prior_scale_holidays`: Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.

The main arguments (tuning parameters) for the model **XGBoost model** are:

- `mtry`: The number of predictors that will be randomly sampled at each split when creating the tree models.
- `trees`: The number of trees contained in the ensemble.
- `min_n`: The minimum number of data points in a node that are required for the node to be split further.
- `tree_depth`: The maximum depth of the tree (i.e. number of splits).
- `learn_rate`: The rate at which the boosting algorithm adapts from iteration-to-iteration.
- `loss_reduction`: The reduction in the loss function required to split further.
- `sample_size`: The amount of data exposed to the fitting routine.
- `stop_iter`: The number of iterations without improvement before stopping.

These arguments are converted to their specific names at the time that the model is fit.

Other options and argument can be set using `set_engine()` (See Engine Details below).

If parameters need to be modified, `update()` can be used in lieu of recreating the object from scratch.

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

Model 1: PROPHET:

modeltime	prophet
growth	growth
num_changepoints	n.changepoints
season	seasonality.mode
prior_scale_changepoints	changepoint.prior.scale
prior_scale_seasonality	seasonality.prior.scale
prior_scale_holidays	holidays.prior.scale

Model 2: XGBoost:

modeltime	xgboost::xgb.train
tree_depth	max_depth

trees	nrounds
learn_rate	eta
mtry	colsample_bytree
min_n	min_child_weight
loss_reduction	gamma
sample_size	subsample

Other options can be set using `set_engine()`.

prophet_xgboost

Model 1: PROPHET (`prophet::prophet`):

```
## function (df = NULL, growth = "linear", changepoints = NULL, n.changepoints = 25,
##    changepoint.range = 0.8, yearly.seasonality = "auto", weekly.seasonality = "auto",
##     daily.seasonality = "auto", holidays = NULL, seasonality.mode = "additive",
##    seasonality.prior.scale = 10, holidays.prior.scale = 10, changepoint.prior.scale = 0.05,
##      mcmc.samples = 0, interval.width = 0.8, uncertainty.samples = 1000,
##      fit = TRUE, ...)
```

Parameter Notes:

- `df`: This is supplied via the parsnip / modeltime `fit()` interface (so don't provide this manually). See Fit Details (below).
- `holidays`: A data.frame of holidays can be supplied via `set_engine()`
- `uncertainty.samples`: The default is set to 0 because the prophet uncertainty intervals are not used as part of the Modeltime Workflow. You can override this setting if you plan to use prophet's uncertainty tools.

Limitations:

- `prophet::add_seasonality()` is not currently implemented. It's used to specify non-standard seasonalities using fourier series. An alternative is to use `step_fourier()` and supply custom seasonalities as Extra Regressors.

Model 2: XGBoost (`xgboost::xgb.train`):

```
## function (params = list(), data, nrounds, watchlist = list(), obj = NULL,
##     feval = NULL, verbose = 1, print_every_n = 1L, early_stopping_rounds = NULL,
##    maximize = NULL, save_period = NULL, save_name = "xgboost.model", xgb_model = NULL,
##      callbacks = list(), ...)
```

Parameter Notes:

- XGBoost uses a `params = list()` to capture. Parsnip / Modeltime automatically sends any args provided as `...` inside of `set_engine()` to the `params = list(...)`.

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The `fit()` interface accepts date and date-time features and handles them internally.

- `fit(y ~ date)`

Univariate (No Extra Regressors):

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"], y = data$y)` will ignore xreg's.

Multivariate (Extra Regressors)

Extra Regressors parameter is populated using the `fit()` or `fit_xy()` function:

- Only `factor`, ordered factor, and `numeric` data will be used as xregs.
- Date and Date-time variables are not used as xregs
- `character` data should be converted to factor.

Xreg Example: Suppose you have 3 features:

1. `y` (target)
2. `date` (time stamp),
3. `month.lbl` (labeled month as a ordered factor).

The `month.lbl` is an exogenous regressor that can be passed to the `arima_reg()` using `fit()`:

- `fit(y ~ date + month.lbl)` will pass `month.lbl` on as an exogenous regressor.
- `fit_xy(data[,c("date","month.lbl")], y = data$y)` will pass x, where x is a data frame containing `month.lbl` and the `date` feature. Only `month.lbl` will be used as an exogenous regressor.

Note that date or date-time class values are excluded from `xreg`.

See Also

`fit.model_spec()`, `set_engine()`

Examples

```
library(dplyr)
library(lubridate)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)

# Data
m750 <- m4_monthly %>% filter(id == "M750")
```

```
m750

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.8)

# ---- PROPHET ----

# Model Spec
model_spec <- prophet_boost(
    learn_rate = 0.1
) %>%
    set_engine("prophet_xgboost")

# Fit Spec
## Not run:
model_fit <- model_spec %>%
    fit(log(value) ~ date + as.numeric(date) + month(date, label = TRUE),
        data = training(splits))
model_fit

## End(Not run)
```

`prophet_fit_impl` *Low-Level PROPHET function for translating modeltime to PROPHET*

Description

Low-Level PROPHET function for translating modeltime to PROPHET

Usage

```
prophet_fit_impl(
  x,
  y,
  growth = "linear",
  n.changepoints = 25,
  seasonality.mode = "additive",
  changepoint.prior.scale = 0.05,
  seasonality.prior.scale = 10,
  holidays.prior.scale = 10,
  ...
)
```

Arguments

`x`	A dataframe of xreg (exogenous regressors)
`y`	A numeric vector of values to fit
`growth`	String 'linear' or 'logistic' to specify a linear or logistic trend.
`n.changepoints`	Number of potential changepoints to include. Not used if input 'changepoints' is supplied. If 'changepoints' is not supplied, then n.changepoints potential changepoints are selected uniformly from the first 'changepoint.range' proportion of df$ds.
`seasonality.mode`	'additive' (default) or 'multiplicative'.
`changepoint.prior.scale`	Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.
`seasonality.prior.scale`	Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality. Can be specified for individual seasonalities using add_seasonality.
`holidays.prior.scale`	Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.
`...`	Additional arguments passed to `prophet::prophet`

`prophet_params` *Tuning Parameters for Prophet Models*

Description

Tuning Parameters for Prophet Models

Usage

```
growth(values = c("linear", "logistic"))

num_changepoints(range = c(0L, 50L), trans = NULL)

prior_scale_changepoints(range = c(-3, 2), trans = log10_trans())

prior_scale_seasonality(range = c(-3, 2), trans = log10_trans())

prior_scale_holidays(range = c(-3, 2), trans = log10_trans())
```

Arguments

`values`	A character string of possible values.
`range`	A two-element vector holding the *defaults* for the smallest and largest possible values, respectively.
`trans`	A `trans` object from the `scales` package, such as `scales::log10_trans()` or `scales::reciprocal_trans()`. If not provided, the default is used which matches the units used in `range`. If no transformation, `NULL`.

Details

The main parameters for Prophet models are:

- `growth`: The form of the trend: "linear", or "logistic".
- `num_changepoints`: The number of trend changepoints allowed in modeling the trend
- `season`:
  - The form of the seasonal term: "additive" or "multiplicative".
  - See `season()`.
- "Prior Scale": Controls flexibility of
  - *Changepoints:* `prior_scale_changepoints`
  - *Seasonality:* `prior_scale_seasonality`
  - *Holidays:* `prior_scale_holidays`
  - The `log10_trans()` converts priors to a scale from 0.001 to 100, which effectively weights lower values more heavily than larger values.

Examples

```
growth()

num_changepoints()

season()

prior_scale_changepoints()
```

`prophet_predict_impl` *Bridge prediction function for PROPHET models*

Description

Bridge prediction function for PROPHET models

Usage

```
prophet_predict_impl(object, new_data, ...)
```

Arguments

object	An object of class model_fit
new_data	A rectangular data object, such as a data frame.
...	Additional arguments passed to prophet::predict()

---

prophet_reg *General Interface for PROPHET Time Series Models*

Description

prophet_reg() is a way to generate a *specification* of a PROPHET model before fitting and allows the model to be created using different packages. Currently the only package is prophet.

Usage

```
prophet_reg(
  mode = "regression",
  growth = NULL,
  num_changepoints = NULL,
  season = NULL,
  prior_scale_changepoints = NULL,
  prior_scale_seasonality = NULL,
  prior_scale_holidays = NULL
)
```

Arguments

mode	A single character string for the type of model. The only possible value for this model is "regression".
growth	String 'linear' or 'logistic' to specify a linear or logistic trend.
num_changepoints	Number of potential changepoints to include for modeling trend.
season	'additive' (default) or 'multiplicative'.
prior_scale_changepoints	Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.
prior_scale_seasonality	Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality.
prior_scale_holidays	Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `prophet_reg()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "prophet" (default) - Connects to `prophet::prophet()`

Main Arguments

The main arguments (tuning parameters) for the model are:

- `growth`: String 'linear' or 'logistic' to specify a linear or logistic trend.
- `num_changepoints`: Number of potential changepoints to include for modeling trend.
- `season`: 'additive' (default) or 'multiplicative'.
- `prior_scale_changepoints`: Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.
- `prior_scale_seasonality`: Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality.
- `prior_scale_holidays`: Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.

These arguments are converted to their specific names at the time that the model is fit.

Other options and argument can be set using `set_engine()` (See Engine Details below).

If parameters need to be modified, `update()` can be used in lieu of recreating the object from scratch.

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

modeltime	prophet
growth	growth
num_changepoints	n.changepoints
season	seasonality.mode
prior_scale_changepoints	changepoint.prior.scale
prior_scale_seasonality	seasonality.prior.scale
prior_scale_holidays	holidays.prior.scale

Other options can be set using `set_engine()`.

prophet

The engine uses `prophet::prophet()`.

Function Parameters:

```
## function (df = NULL, growth = "linear", changepoints = NULL, n.changepoints = 25,
##     changepoint.range = 0.8, yearly.seasonality = "auto", weekly.seasonality = "auto",
##     daily.seasonality = "auto", holidays = NULL, seasonality.mode = "additive",
##     seasonality.prior.scale = 10, holidays.prior.scale = 10, changepoint.prior.scale = 0.05,
##     mcmc.samples = 0, interval.width = 0.8, uncertainty.samples = 1000,
##     fit = TRUE, ...)
```

Parameter Notes:

- `df`: This is supplied via the parsnip / modeltime `fit()` interface (so don't provide this manually). See Fit Details (below).
- `holidays`: A data.frame of holidays can be supplied via `set_engine()`
- `uncertainty.samples`: The default is set to 0 because the prophet uncertainty intervals are not used as part of the Modeltime Workflow. You can override this setting if you plan to use prophet's uncertainty tools.

Limitations:

- `prophet::add_seasonality()` is not currently implemented. It's used to specify non-standard seasonalities using fourier series. An alternative is to use `step_fourier()` and supply custom seasonalities as Extra Regressors.

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The `fit()` interface accepts date and date-time features and handles them internally.

- `fit(y ~ date)`

Univariate (No Extra Regressors):

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"],y = data$y)` will ignore xreg's.

Multivariate (Extra Regressors)

Extra Regressors parameter is populated using the `fit()` or `fit_xy()` function:

- Only `factor`, ordered factor, and `numeric` data will be used as xregs.
- Date and Date-time variables are not used as xregs
- `character` data should be converted to factor.

Xreg Example: Suppose you have 3 features:

1. `y` (target)
2. `date` (time stamp),
3. `month.lbl` (labeled month as a ordered factor).

The `month.lbl` is an exogenous regressor that can be passed to the `arima_reg()` using `fit()`:

- fit(y ~ date + month.lbl) will pass month.lbl on as an exogenous regressor.
- fit_xy(data[,c("date","month.lbl")],y = data$y) will pass x, where x is a data frame containing month.lbl and the date feature. Only month.lbl will be used as an exogenous regressor.

Note that date or date-time class values are excluded from xreg.

See Also

fit.model_spec(), set_engine()

Examples

```
library(dplyr)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)

# Data
m750 <- m4_monthly %>% filter(id == "M750")
m750

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.8)

# ---- PROPHET ----

# Model Spec
model_spec <- prophet_reg() %>%
    set_engine("prophet")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit
```

---

prophet_xgboost_fit_impl

Low-Level PROPHET function for translating modeltime to Boosted PROPHET

Description

Low-Level PROPHET function for translating modeltime to Boosted PROPHET

Usage

```
prophet_xgboost_fit_impl(
  x,
  y,
  df = NULL,
  growth = "linear",
  changepoints = NULL,
  n.changepoints = 25,
  changepoint.range = 0.8,
  yearly.seasonality = "auto",
  weekly.seasonality = "auto",
  daily.seasonality = "auto",
  holidays = NULL,
  seasonality.mode = "additive",
  seasonality.prior.scale = 10,
  holidays.prior.scale = 10,
  changepoint.prior.scale = 0.05,
  mcmc.samples = 0,
  interval.width = 0.8,
  uncertainty.samples = 1000,
  fit = TRUE,
  max_depth = 6,
  nrounds = 15,
  eta = 0.3,
  colsample_bytree = 1,
  min_child_weight = 1,
  gamma = 0,
  subsample = 1,
  validation = 0,
  early_stop = NULL,
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
df	(optional) Dataframe containing the history. Must have columns ds (date type) and y, the time series. If growth is logistic, then df must also have a column cap that specifies the capacity at each ds. If not provided, then the model object will be instantiated but not fit; use fit.prophet(m, df) to fit the model.
growth	String 'linear' or 'logistic' to specify a linear or logistic trend.
changepoints	Vector of dates at which to include potential changepoints. If not specified, potential changepoints are selected automatically.
n.changepoints	Number of potential changepoints to include. Not used if input 'changepoints' is supplied. If 'changepoints' is not supplied, then n.changepoints potential

changepoints are selected uniformly from the first ‘changepoint.range‘ proportion of df$ds.

`changepoint.range`
: Proportion of history in which trend changepoints will be estimated. Defaults to 0.8 for the first 80 ‘changepoints‘ is specified.

`yearly.seasonality`
: Fit yearly seasonality. Can be 'auto', TRUE, FALSE, or a number of Fourier terms to generate.

`weekly.seasonality`
: Fit weekly seasonality. Can be 'auto', TRUE, FALSE, or a number of Fourier terms to generate.

`daily.seasonality`
: Fit daily seasonality. Can be 'auto', TRUE, FALSE, or a number of Fourier terms to generate.

`holidays`
: data frame with columns holiday (character) and ds (date type)and optionally columns lower_window and upper_window which specify a range of days around the date to be included as holidays. lower_window=-2 will include 2 days prior to the date as holidays. Also optionally can have a column prior_scale specifying the prior scale for each holiday.

`seasonality.mode`
: 'additive' (default) or 'multiplicative'.

`seasonality.prior.scale`
: Parameter modulating the strength of the seasonality model. Larger values allow the model to fit larger seasonal fluctuations, smaller values dampen the seasonality. Can be specified for individual seasonalities using add_seasonality.

`holidays.prior.scale`
: Parameter modulating the strength of the holiday components model, unless overridden in the holidays input.

`changepoint.prior.scale`
: Parameter modulating the flexibility of the automatic changepoint selection. Large values will allow many changepoints, small values will allow few changepoints.

`mcmc.samples`
: Integer, if greater than 0, will do full Bayesian inference with the specified number of MCMC samples. If 0, will do MAP estimation.

`interval.width`
: Numeric, width of the uncertainty intervals provided for the forecast. If mcmc.samples=0, this will be only the uncertainty in the trend using the MAP estimate of the extrapolated generative model. If mcmc.samples>0, this will be integrated over all model parameters, which will include uncertainty in seasonality.

`uncertainty.samples`
: Number of simulated draws used to estimate uncertainty intervals. Settings this value to 0 or False will disable uncertainty estimation and speed up the calculation.

`fit`
: Boolean, if FALSE the model is initialized but not fit.

`max_depth`
: An integer for the maximum depth of the tree.

`nrounds`
: An integer for the number of boosting iterations.

`eta` A numeric value between zero and one to control the learning rate.

`colsample_bytree` Subsampling proportion of columns.

`min_child_weight` A numeric value for the minimum sum of instance weights needed in a child to continue to split.

`gamma` A number for the minimum loss reduction required to make a further partition on a leaf node of the tree

`subsample` Subsampling proportion of rows.

`validation` A positive number. If on [0, 1) the value, `validation` is a random proportion of data in `x` and `y` that are used for performance assessment and potential early stopping. If 1 or greater, it is the *number* of training set samples use for these purposes.

`early_stop` An integer or `NULL`. If not `NULL`, it is the number of training iterations without improvement before stopping. If `validation` is used, performance is base on the validation set; otherwise the training set is used.

`...` Additional arguments passed to `xgboost::xgb.train`

---

prophet_xgboost_predict_impl

Bridge prediction function for Boosted PROPHET models

Description

Bridge prediction function for Boosted PROPHET models

Usage

```
prophet_xgboost_predict_impl(object, new_data, ...)
```

Arguments

`object` An object of class `model_fit`

`new_data` A rectangular data object, such as a data frame.

`...` Additional arguments passed to `prophet::predict()`

recipe_helpers *Developer Tools for processing XREGS (Regressors)*

Description

Wrappers for using `recipes::bake` and `recipes::juice` to process data returning data in either data frame or `matrix` format (Common formats needed for machine learning algorithms).

Usage

```
juice_xreg_recipe(recipe, format = c("tbl", "matrix"))

bake_xreg_recipe(recipe, new_data, format = c("tbl", "matrix"))
```

Arguments

`recipe`	A prepared recipe
`format`	One of: • `tbl`: Returns a tibble (data.frame) • `matrix`: Returns a matrix
`new_data`	Data to be processed by a recipe

Value

Data in either the `tbl` (data.frame) or `matrix` formats

Examples

```
library(dplyr)
library(timetk)
library(recipes)
library(lubridate)

predictors <- m4_monthly %>%
    filter(id == "M750") %>%
    select(-value) %>%
    mutate(month = month(date, label = TRUE))
predictors

# Create default recipe
xreg_recipe_spec <- create_xreg_recipe(predictors, prepare = TRUE)

# Extracts the preprocessed training data from the recipe (used in your fit function)
juice_xreg_recipe(xreg_recipe_spec)

# Applies the prepared recipe to new data (used in your predict function)
bake_xreg_recipe(xreg_recipe_spec, new_data = predictors)
```

seasonal_decomp *General Interface for Seasonal Decomposition Regression Models*

Description

`seasonal_decomp()` is a way to generate a *specification* of an Seasonal Decomposition model before fitting and allows the model to be created using different packages. Currently the only package is `forecast`.

Usage

```
seasonal_decomp(
  mode = "regression",
  seasonal_period_1 = NULL,
  seasonal_period_2 = NULL,
  seasonal_period_3 = NULL
)
```

Arguments

`mode` A single character string for the type of model. The only possible value for this model is "regression".

`seasonal_period_1` (required) The primary seasonal frequency. Uses `"auto"` by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.

`seasonal_period_2` (optional) A second seasonal frequency. Is `NULL` by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.

`seasonal_period_3` (optional) A third seasonal frequency. Is `NULL` by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided. See Fit Details below.

Details

The data given to the function are not saved and are only used to determine the *mode* of the model. For `seasonal_decomp()`, the mode will always be "regression".

The model can be created using the `fit()` function using the following *engines*:

- "stlm_ets" (default) - Connects to `forecast::stlm()`, `method = "ets"`
- "stlm_arima" (default) - Connects to `forecast::stlm()`, `method = "arima"`

Engine Details

The standardized parameter names in `modeltime` can be mapped to their original names in each engine:

modeltime	forecast::stlm
seasonal_period_1, seasonal_period_2, seasonal_period_3	msts(seasonal.periods)

Other options can be set using `set_engine()`.

The engines use `forecast::stlm()`.

Function Parameters:

```
## function (y, s.window = 13, robust = FALSE, method = c("ets", "arima"),
##     modelfunction = NULL, model = NULL, etsmodel = "ZZN", lambda = NULL,
##     biasadj = FALSE, xreg = NULL, allow.multiplicative.trend = FALSE, x = y,
##     ...)
```

stlm_ets (default engine)

- **Method:** Uses `method = "ets"`, which by default is auto-ETS.
- **Xregs:** Cannot accept Exogenous Regressors (xregs). Xregs are ignored.

stlm_arima

- **Method:** Uses `method = "arima"`, which by default is auto-ARIMA.
- **Xregs:** Can accept Exogenous Regressors (xregs).

Fit Details

Date and Date-Time Variable

It's a requirement to have a date or date-time variable as a predictor. The `fit()` interface accepts date and date-time features and handles them internally.

- `fit(y ~ date)`

Seasonal Period Specification

The period can be non-seasonal (seasonal_period = 1 or "none") or yearly seasonal (e.g. For monthly time stamps, `seasonal_period = 12`, `seasonal_period = "12 months"`, or `seasonal_period = "yearly"`). There are 3 ways to specify:

1. `seasonal_period = "auto"`: A seasonal period is selected based on the periodicity of the data (e.g. 12 if monthly)
2. `seasonal_period = 12`: A numeric frequency. For example, 12 is common for monthly data
3. `seasonal_period = "1 year"`: A time-based phrase. For example, "1 year" would convert to 12 for monthly data.

Univariate (No xregs, Exogenous Regressors):

For univariate analysis, you must include a date or date-time feature. Simply use:

- Formula Interface (recommended): `fit(y ~ date)` will ignore xreg's.
- XY Interface: `fit_xy(x = data[,"date"], y = data$y)` will ignore xreg's.

Multivariate (xregs, Exogenous Regressors)

- The `stlm_ets` engine *cannot* accept Xregs.
- The `stlm_arima` engine can accept Xregs

The `xreg` parameter is populated using the `fit()` or `fit_xy()` function:

- Only `factor`, ordered factor, and `numeric` data will be used as xregs.
- Date and Date-time variables are not used as xregs
- `character` data should be converted to factor.

Xreg Example: Suppose you have 3 features:

1. `y` (target)
2. `date` (time stamp),
3. `month.lbl` (labeled month as a ordered factor).

The `month.lbl` is an exogenous regressor that can be passed to the `seasonal_decomp()` using `fit()`:

- `fit(y ~ date + month.lbl)` will pass `month.lbl` on as an exogenous regressor.
- `fit_xy(data[,c("date","month.lbl")],y = data$y)` will pass x, where x is a data frame containing `month.lbl` and the `date` feature. Only `month.lbl` will be used as an exogenous regressor.

Note that date or date-time class values are excluded from `xreg`.

See Also

`fit.model_spec()`, `set_engine()`

Examples

```
library(dplyr)
library(parsnip)
library(rsample)
library(timetk)
library(modeltime)

# Data
taylor_30_min

# Split Data 80/20
splits <- initial_time_split(taylor_30_min, prop = 0.8)

# ---- STLM ETS ----

# Model Spec
model_spec <- seasonal_decomp() %>%
    set_engine("stlm_ets")
```

```
# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit


# ---- STLM ARIMA ----

# Model Spec
model_spec <- seasonal_decomp() %>%
    set_engine("stlm_arima")

# Fit Spec
model_fit <- model_spec %>%
    fit(log(value) ~ date, data = training(splits))
model_fit
```

`stlm_arima_fit_impl` *Low-Level stlm function for translating modeltime to forecast*

Description

Low-Level stlm function for translating modeltime to forecast

Usage

```
stlm_arima_fit_impl(
  x,
  y,
  period_1 = "auto",
  period_2 = NULL,
  period_3 = NULL,
  ...
)
```

Arguments

`x`	A dataframe of xreg (exogenous regressors)
`y`	A numeric vector of values to fit
`period_1`	(required) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
`period_2`	(optional) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.

`period_3`	(optional) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
`...`	Additional arguments passed to `forecast::stlm()`

`stlm_arima_predict_impl` *Bridge prediction function for ARIMA models*

Description

Bridge prediction function for ARIMA models

Usage

```
stlm_arima_predict_impl(object, new_data, ...)
```

Arguments

`object`	An object of class `model_fit`
`new_data`	A rectangular data object, such as a data frame.
`...`	Additional arguments passed to `forecast::Arima()`

`stlm_ets_fit_impl` *Low-Level stlm function for translating modeltime to forecast*

Description

Low-Level stlm function for translating modeltime to forecast

Usage

```
stlm_ets_fit_impl(
  x,
  y,
  period_1 = "auto",
  period_2 = NULL,
  period_3 = NULL,
  ...
)
```

Arguments

x	A dataframe of xreg (exogenous regressors)
y	A numeric vector of values to fit
period_1	(required) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
period_2	(optional) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
period_3	(optional) First seasonal frequency. Uses "auto" by default. A character phrase of "auto" or time-based phrase of "2 weeks" can be used if a date or date-time variable is provided.
...	Additional arguments passed to `forecast::stlm()`

`stlm_ets_predict_impl` *Bridge prediction function for ARIMA models*

Description

Bridge prediction function for ARIMA models

Usage

```
stlm_ets_predict_impl(object, new_data, ...)
```

Arguments

object	An object of class `model_fit`
new_data	A rectangular data object, such as a data frame.
...	Additional arguments passed to `forecast::Arima()`

`table_modeltime_accuracy` *Interactive Accuracy Tables*

Description

Converts results from `modeltime_accuracy()` into either interactive (`reactable`) or static (`gt`) tables.

Usage

```
table_modeltime_accuracy(
  .data,
  .round_digits = 2,
  .sortable = TRUE,
  .show_sortable = TRUE,
  .searchable = TRUE,
  .filterable = FALSE,
  .expand_groups = TRUE,
  .title = "Accuracy Table",
  .interactive = TRUE,
  ...
)
```

Arguments

`.data`	A `tibble` that is the output of `modeltime_accuracy()`
`.round_digits`	Rounds accuracy metrics to a specified number of digits. If `NULL`, rounding is not performed.
`.sortable`	Allows sorting by columns. Only applied to `reactable` tables. Passed to `reactable(sortable)`.
`.show_sortable`	Shows sorting. Only applied to `reactable` tables. Passed to `reactable(showSortable)`.
`.searchable`	Adds search input. Only applied to `reactable` tables. Passed to `reactable(searchable)`.
`.filterable`	Adds filters to table columns. Only applied to `reactable` tables. Passed to `reactable(filterable)`.
`.expand_groups`	Expands groups dropdowns. Only applied to `reactable` tables. Passed to `reactable(defaultExpanded)`.
`.title`	A title for static (`gt`) tables.
`.interactive`	Return interactive or static tables. If `TRUE`, returns `reactable` table. If `FALSE`, returns static `gt` table.
`...`	Additional arguments passed to `reactable::reactable()` or `gt::gt()` (depending on `.interactive` selection).

Details

Groups

The function respects `dplyr::group_by()` groups and thus scales with multiple groups.

Reactable Output

A `reactable()` table is an interactive format that enables live searching and sorting. When `.interactive = TRUE`, a call is made to `reactable::reactable()`.

`table_modeltime_accuracy()` includes several common options like toggles for sorting and searching. Additional arguments can be passed to `reactable::reactable()` via `...`.

GT Output

A `gt` table is an HTML-based table that is "static" (e.g. non-searchable, non-sortable). It's commonly used in PDF and Word documents that does not support interactive content.

When `.interactive = FALSE`, a call is made to `gt::gt()`. Arguments can be passed via `...`.

Table customization is implemented using a piping workflow (%>%). For more information, refer to the GT Documentation.

Value

A static `gt` table or an interactive `reactable` table containing the accuracy information.

Examples

```
library(tidyverse)
library(lubridate)
library(timetk)
library(parsnip)
library(rsample)

# Data
m750 <- m4_monthly %>% filter(id == "M750")

# Split Data 80/20
splits <- initial_time_split(m750, prop = 0.9)

# --- MODELS ---

# Model 1: auto_arima ----
model_fit_arima <- arima_reg() %>%
    set_engine(engine = "auto_arima") %>%
    fit(value ~ date, data = training(splits))


# ---- MODELTIME TABLE ----

models_tbl <- modeltime_table(
    model_fit_arima
)

# ---- ACCURACY ----

models_tbl %>%
    modeltime_calibrate(new_data = testing(splits)) %>%
    modeltime_accuracy() %>%
    table_modeltime_accuracy()
```

time_series_params *Tuning Parameters for Time Series (ts-class) Models*

Description

Tuning Parameters for Time Series (ts-class) Models

Usage

```
seasonal_period(values = c("none", "daily", "weekly", "yearly"))
```

Arguments

`values`	A time-based phrase

Details

Time series models (e.g. `Arima()` and `ets()`) use `stats::ts()` or `forecast::msts()` to apply seasonality. We can do the same process using the following general time series parameter:

- `period`: The periodic nature of the seasonality.

It's usually best practice to *not* tune this parameter, but rather set to obvious values based on the seasonality of the data:

- **Daily Seasonality:** Often used with **hourly data** (e.g. 24 hourly timestamps per day)
- **Weekly Seasonality:** Often used with **daily data** (e.g. 7 daily timestamps per week)
- **Yearly Seasonalty:** Often used with **weekly, monthly, and quarterly data** (e.g. 12 monthly observations per year).

However, in the event that users want to experiment with period tuning, you can do so with `seasonal_period()`.

Examples

```
seasonal_period()
```

type_sum.mdl_time_tbl *Succinct summary of Modeltime Tables*

Description

`type_sum` controls how objects are shown when inside tibble columns.

Usage

```
## S3 method for class 'mdl_time_tbl'
type_sum(x)
```

Arguments

x	A `mdl_time_tbl` object to summarise.

Value

A character value.

xgboost_impl *Wrapper for parsnip::xgb_train*

Description

Wrapper for parsnip::xgb_train

Usage

```
xgboost_impl(
  x,
  y,
  max_depth = 6,
  nrounds = 15,
  eta = 0.3,
  colsample_bytree = 1,
  min_child_weight = 1,
  gamma = 0,
  subsample = 1,
  validation = 0,
  early_stop = NULL,
  ...
)
```

Arguments

`x`	A data frame or matrix of predictors
`y`	A vector (factor or numeric) or matrix (numeric) of outcome data.
`max_depth`	An integer for the maximum depth of the tree.
`nrounds`	An integer for the number of boosting iterations.
`eta`	A numeric value between zero and one to control the learning rate.
`colsample_bytree`	Subsampling proportion of columns.
`min_child_weight`	A numeric value for the minimum sum of instance weights needed in a child to continue to split.
`gamma`	A number for the minimum loss reduction required to make a further partition on a leaf node of the tree
`subsample`	Subsampling proportion of rows.
`validation`	A positive number. If on [0, 1) the value, `validation` is a random proportion of data in `x` and `y` that are used for performance assessment and potential early stopping. If 1 or greater, it is the *number* of training set samples use for these purposes.
`early_stop`	An integer or `NULL`. If not `NULL`, it is the number of training iterations without improvement before stopping. If `validation` is used, performance is base on the validation set; otherwise the training set is used.
`...`	Other options to pass to `xgb.train`.

`xgboost_predict` *Wrapper for xgboost::predict*

Description

Wrapper for xgboost::predict

Usage

```
xgboost_predict(object, newdata, ...)
```

Arguments

`object`	a model object for which prediction is desired.
`newdata`	New data to be predicted
`...`	additional arguments affecting the predictions produced.

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