# Types of trend

1. Motivation

* Time series can be modeled by different types of trend
* Different types of trend require different features

1. Linear trend
2. Changepoints

* Abrupt change in the property of a time series (e.g., trend, seasonality, autoregressive properties)

A graph showing the growth of retail sales

Description automatically generated

* Piecewise linear trend

1. Non-linear trends

A graph of a patient

Description automatically generated with medium confidence

* Can try transforming time series to make more linear

A graph of a line graph

Description automatically generated with medium confidence

1. Different types of trend need different features

A screenshot of a computer

Description automatically generated

# Linear trend: using time as a feature

1. Linear trend

* Let’s consider a linear model:
* Model linear trend using time passed since a reference time, , as feature
* We typically set to the start time of the time series:

1. Creating the feature for training and prediction

A screenshot of a calendar

Description automatically generated

1. Forecasting with just the time feature

* Out of sample prediction

A screenshot of a computer

Description automatically generated

1. Tree based models with time feature

A graph of growth and growth of trees

Description automatically generated with medium confidence

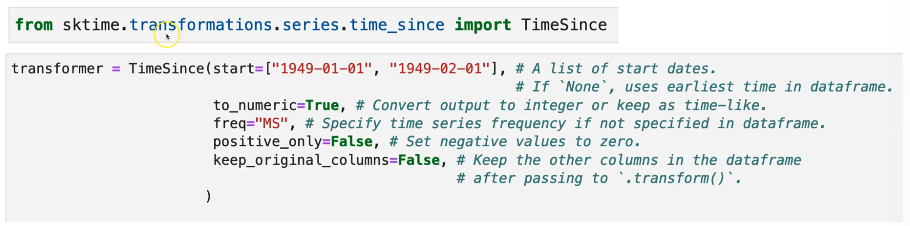
1. Implementation

* Pandas & numpy

A screen shot of a computer

Description automatically generated

* Sktime



1. Summary

* For standard tree-based models, will not be able to use this feature to extrapolate

# Non-linear trends: using time as a feature

1. Non-linear trends with linear models

* Consider the model:
* When extrapolated, the resulting forecasts are often unrealistic
* Risk of overfitting to the training data and extrapolating poorly
* Piecewise linear trend is recommended instead for non-linear trends
* Alternative: try regularizing to limit overfitting

1. Example

* Linear regression with t

A graph of a graph showing the number of air passengers

Description automatically generated with medium confidence

* Linear regression with

A graph with numbers and lines

Description automatically generated

* Linear regression with

A graph of a graph with numbers and symbols

Description automatically generated with medium confidence

* Linear regression with and less data

A graph of a train passenger

Description automatically generated

* Linear regression with and less data

A graph of a graph showing the number of passengers

Description automatically generated with medium confidence

* Ridge regression with and less data

A graph of a graph showing the number of passengers

Description automatically generated with medium confidence

1. Implementation

* Pandas
* Sklearn

A screenshot of a computer

Description automatically generated

1. Summary

* Possible but not recommended to use non-linear time features to model non-linear trends
* Risk of overfitting and poor extrapolation
* Regularization can help reduce overfitting

# Recursive forecasting with lags, windows, and trends

1. Recursive forecasting: features built with target

* Lag features
* Rolling window features

A table with numbers and letters

Description automatically generated

* Impute or drop the missing values at the start of the time series

A table with numbers and a number

Description automatically generated with medium confidence

* Predicts one time step into the future -> recursive forecasting

A table with numbers and symbols

Description automatically generated with medium confidence

1. Example: linear regression

A graph of air passenger numbers

Description automatically generated

* If > 1 then will increase exponentially

1. Recursive forecasting: lags, window, and time

A table with numbers and a number

Description automatically generated

# Piecewise linear trend

1. Motivation: a time series with non-linear trend

* We could try fitting only on recent data to capture recent trend
* Simple to do. If data isn’t very complex then this should be sufficient
* If the time series is more complex and we have a lot of other features, we don’t want to reduce the training data too much
* Is there a way to capture recent trend but still use the whole dataset?
* Sample weights
* Piecewise regression (linear models)

1. Piecewise linear regression

A graph of a line graph

Description automatically generated with medium confidence

1. Creating the features

A table of numbers with different colors

Description automatically generated

* Example

A graph showing the sales of a retail sales

Description automatically generated with medium confidence

1. Implementation

* Sktime

1. Summary

* Simple changes in trend can be modelled using piecewise regression
* Piecewise regression amounts to creating new features, one for each changepoint
* Enables linear models to handle non-linear trends in the time series