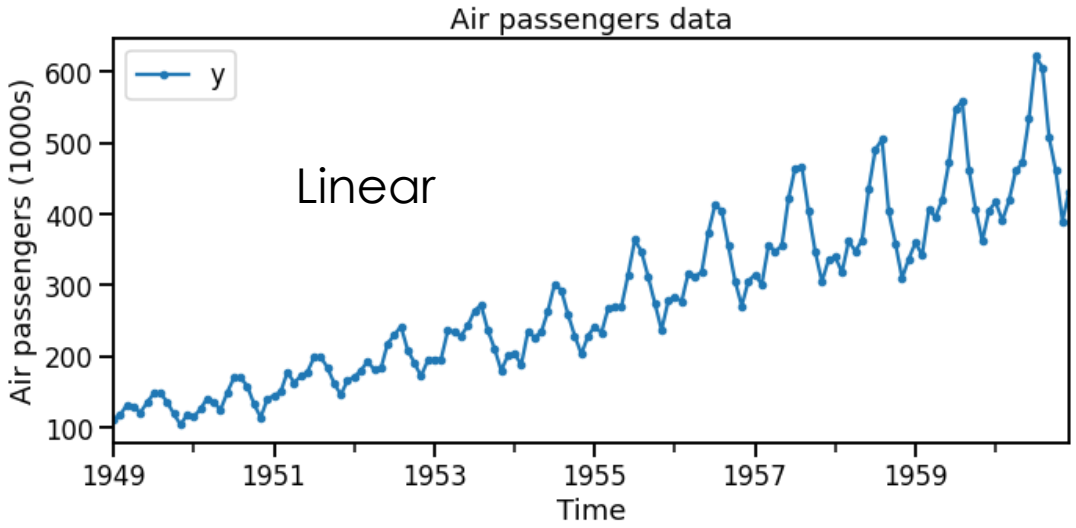
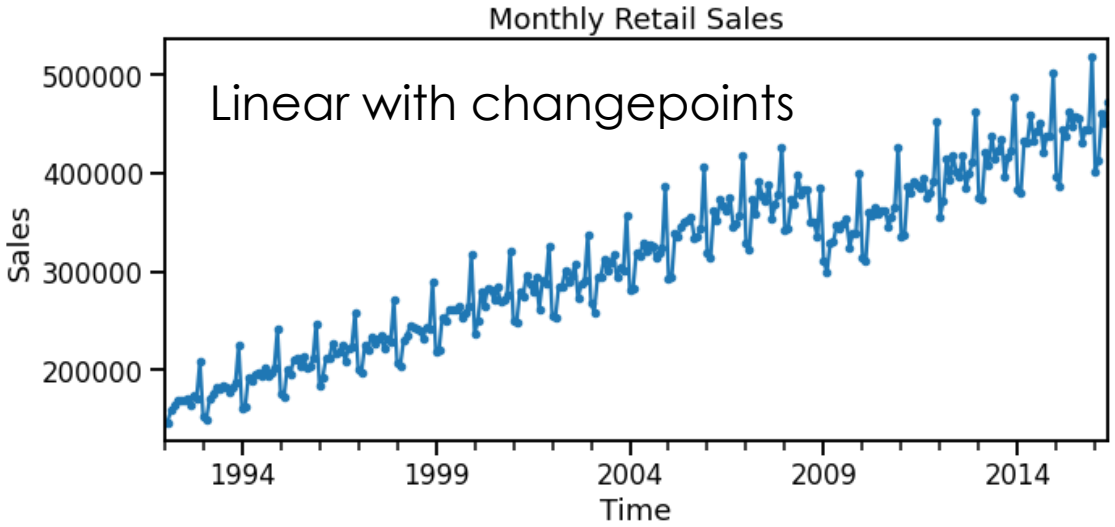
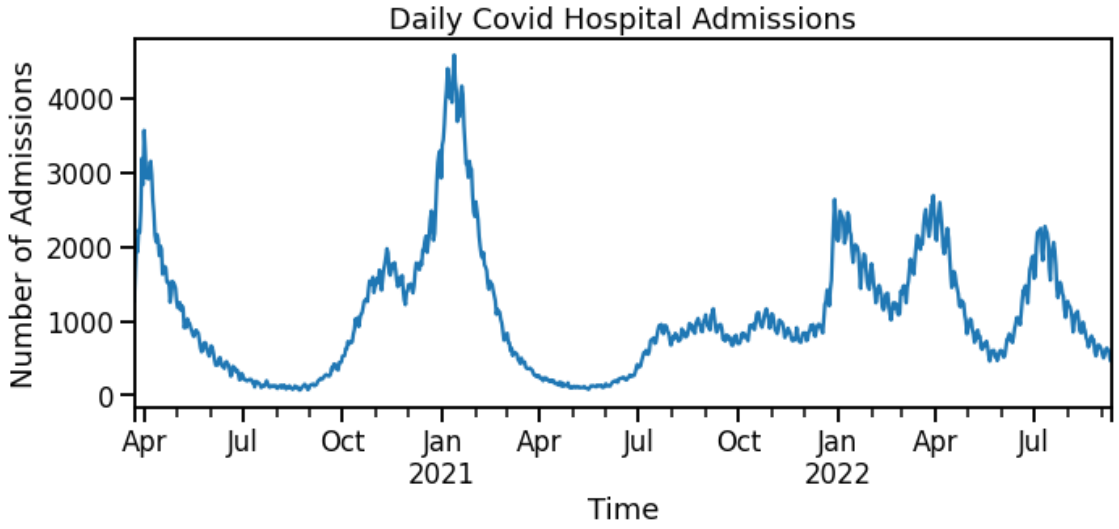
Summary of trend features

Trend features

Different types of trend need different features







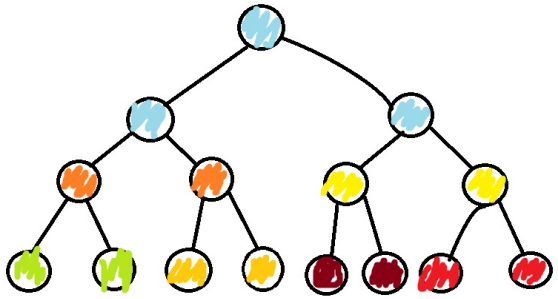
Non-linear (exponential) with change points

The trend section is structured as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots$$

Linear models

Type of feature	Type of trend
Feature which track time.	• Linear trend. • Non-linear trends.
Features for piecewise linear regression.	• Changepoints. • Non-linear trends.
Transformations to make the target linear.	• Non-linear trends.

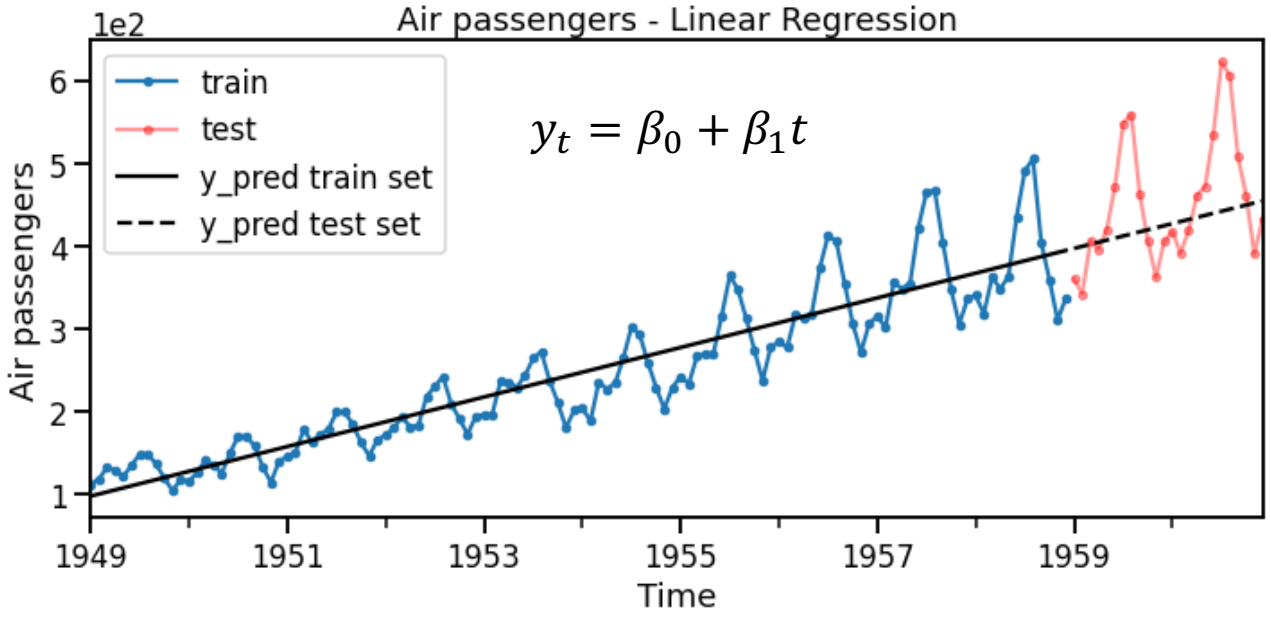


Tree-based models

- De-trend $\tilde{y}_t = y_t - T_t$, use tree to forecast $\tilde{y}_t$, and forecast trend separately T_t.
- More advance tree algorithms.
- Feature which tracks time needed alongside the above points.

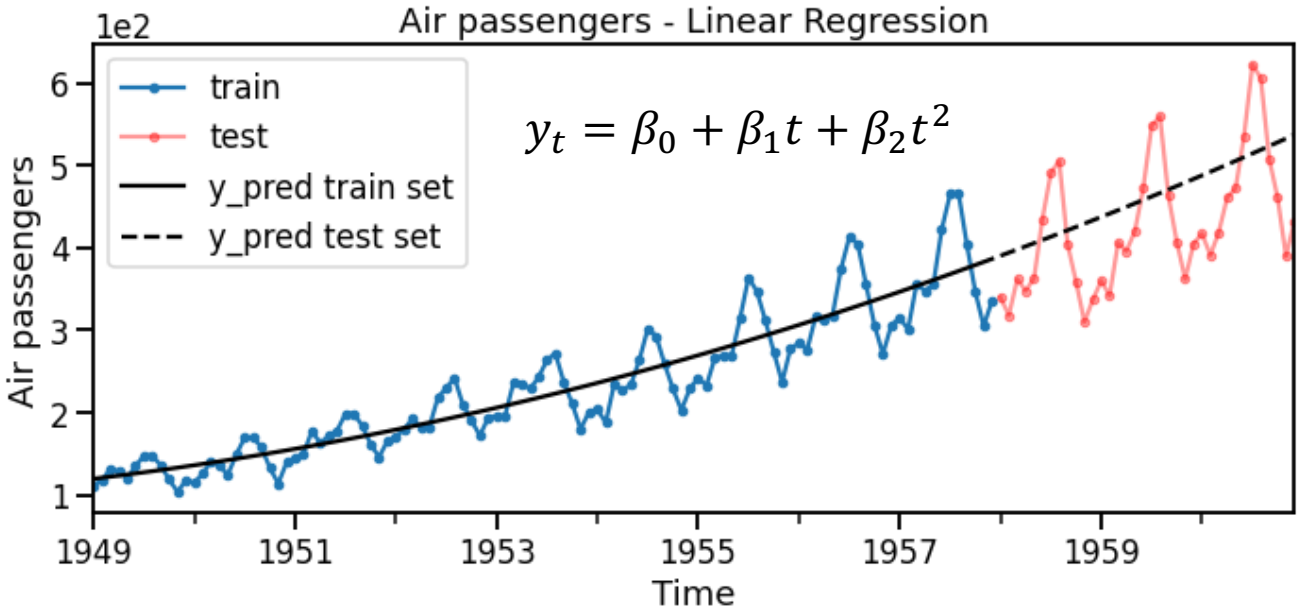
Fitting a linear trend using time

Time	Daily Sales	t
2020-02-12	23	0
2020-02-13	30	1
2020-02-14	35	2
2020-02-15	30	3
2020-02-16	?	4
2020-02-17	?	5
2020-02-18	?	6



Fitting a non-linear trend using time

Time	Daily Sales	t	t^2
2020-02-12	23	0	0
2020-02-13	30	1	1
2020-02-14	35	2	4
2020-02-15	30	3	9
2020-02-16	?	4	16
2020-02-17	?	5	25
2020-02-18	?	6	36



Fitting a piecewise linear trend

$$y_t = \beta_0 + \beta_1 t + \beta_2 t_2 + \beta_3 t_3$$

$$t_2 = 0 \quad \text{if } t < T_1$$
$$= t - T_1 \quad \text{if } t \geq T_1$$

$$t_3 = 0 \quad \text{if } t < T_2$$
$$= t - T_2 \quad \text{if } t \geq T_2$$

Time	y
2020-02-12	23
2020-02-13	30
2020-02-14	35
2020-02-15	30
2020-02-16	20
2020-02-17	34
2020-02-18	12
2020-02-19	?
2020-02-20	?
2020-02-21	?

Fitting a piecewise linear trend

$$y_t = \beta_0 + \boldsymbol{\beta_1 t} + \beta_2 t_2 + \beta_3 t_3$$

$$t_2 = 0 \quad \text{if } t < T_1$$
$$= t - T_1 \quad \text{if } t \geq T_1$$

$$t_3 = 0 \quad \text{if } t < T_2$$
$$= t - T_2 \quad \text{if } t \geq T_2$$

T_1

Time	y	t (days)
2020-02-12	23	0
2020-02-13	30	1
2020-02-14	35	2
2020-02-15	30	3
2020-02-16	20	4
2020-02-17	34	5
2020-02-18	12	6
2020-02-19	?	7
2020-02-20	?	8
2020-02-21	?	9

Fitting a piecewise linear trend

$$y_t = \beta_0 + \beta_1 t + \boldsymbol{\beta_2 t_2} + \beta_3 t_3$$

$$t_2 = 0 \quad \text{if } t < T_1$$
$$= t - T_1 \quad \text{if } t \geq T_1$$

$$t_3 = 0 \quad \text{if } t < T_2$$
$$= t - T_2 \quad \text{if } t \geq T_2$$

	Time	y	t (days)	t_2 (days)
	2020-02-12	23	0	0
	2020-02-13	30	1	0
T_1	2020-02-14	35	2	0
	2020-02-15	30	3	1
	2020-02-16	20	4	2
T_2	2020-02-17	34	5	3
	2020-02-18	12	6	4
	2020-02-19	?	7	5
	2020-02-20	?	8	6
	2020-02-21	?	9	7

Fitting a piecewise linear trend

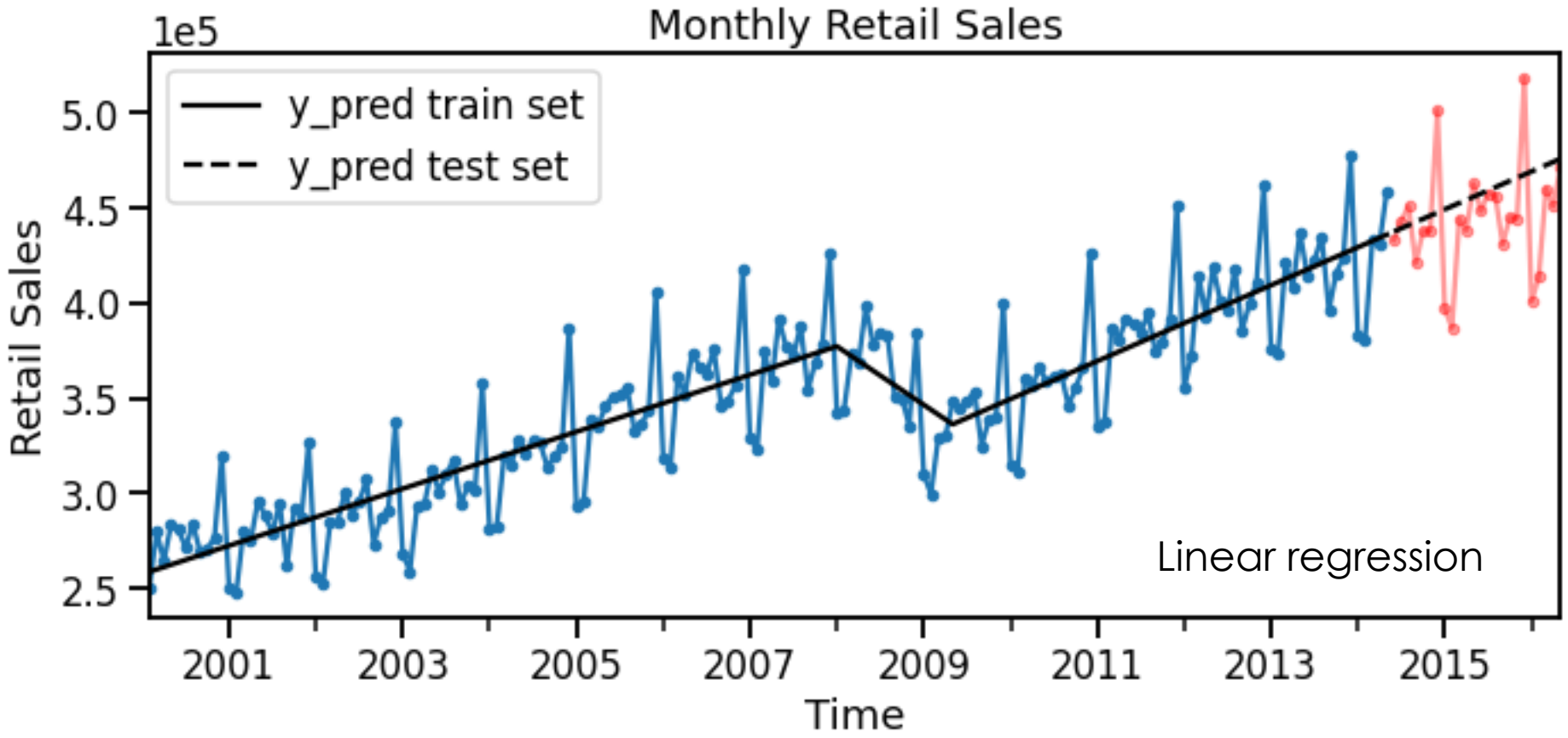
$$y_t = \beta_0 + \beta_1 t + \beta_2 t_2 + \beta_3 t_3$$

$$t_2 = 0 \quad \text{if } t < T_1$$
$$= t - T_1 \quad \text{if } t \geq T_1$$

$$t_3 = 0 \quad \text{if } t < T_2$$
$$= t - T_2 \quad \text{if } t \geq T_2$$

	Time	y	t (days)	t_2 (days)	t_3 (days)
	2020-02-12	23	0	0	0
	2020-02-13	30	1	0	0
T_1	2020-02-14	35	2	0	0
	2020-02-15	30	3	1	0
	2020-02-16	20	4	2	0
T_2	2020-02-17	34	5	3	0
	2020-02-18	12	6	4	1
	2020-02-19	?	7	5	2
	2020-02-20	?	8	6	3
	2020-02-21	?	9	7	4

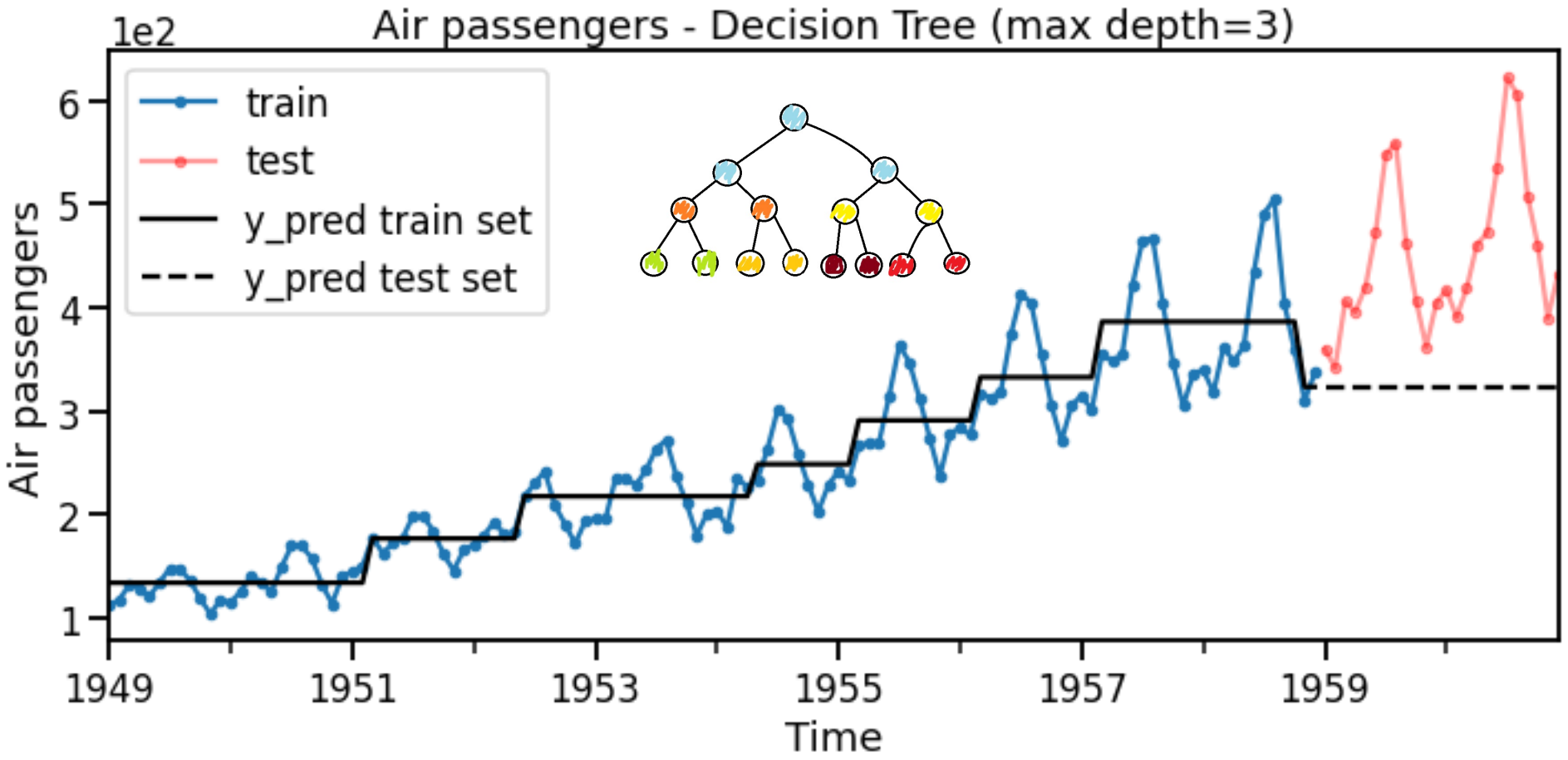
Fitting a piecewise linear trend



Features:

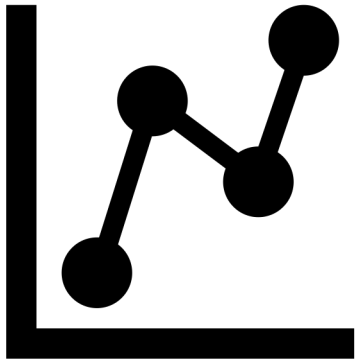
- Time since start (t)
- Changepoint 1
  - 2008-01-01
- Changepoint 2
  - 2009-05-01

Trees cannot extrapolate

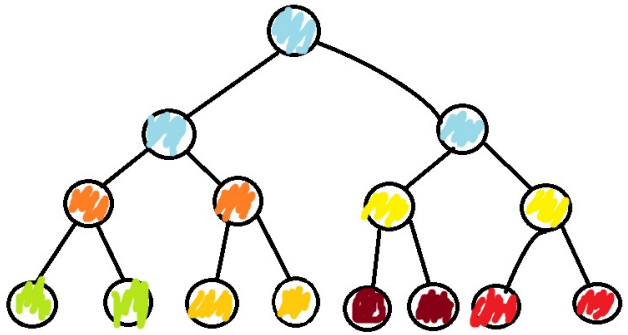


How to use Tree-based models if there is trend?

De-trend the time series first



Use more advanced tree algorithms



$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots$

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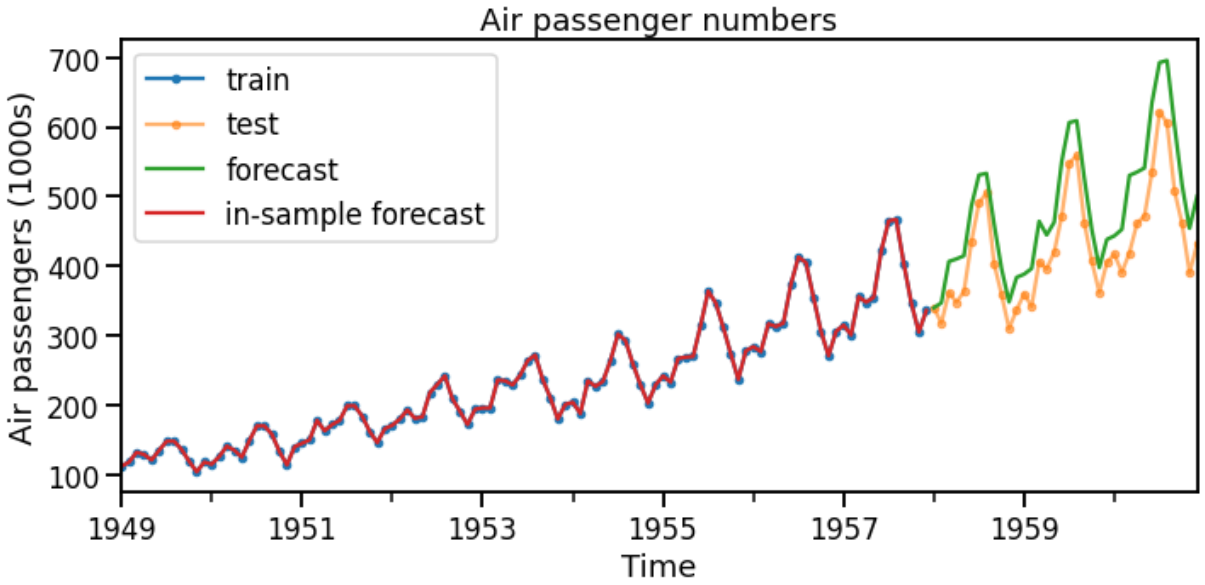
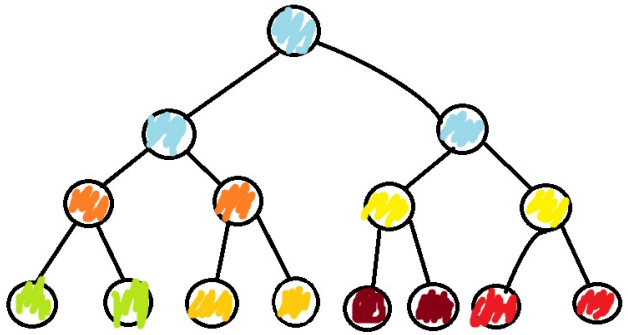
How to use Tree-based models if there is trend?

De-trend the time series first



Features: time, lag 1 & 12 of y

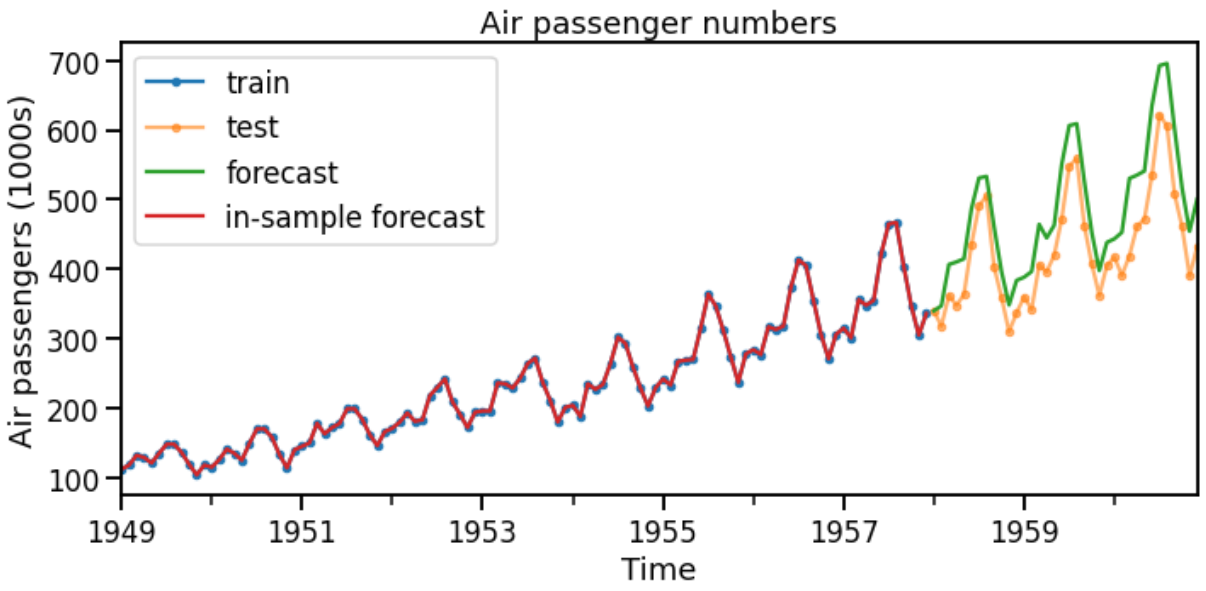
Use more advanced tree algorithms



$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots$ $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots$

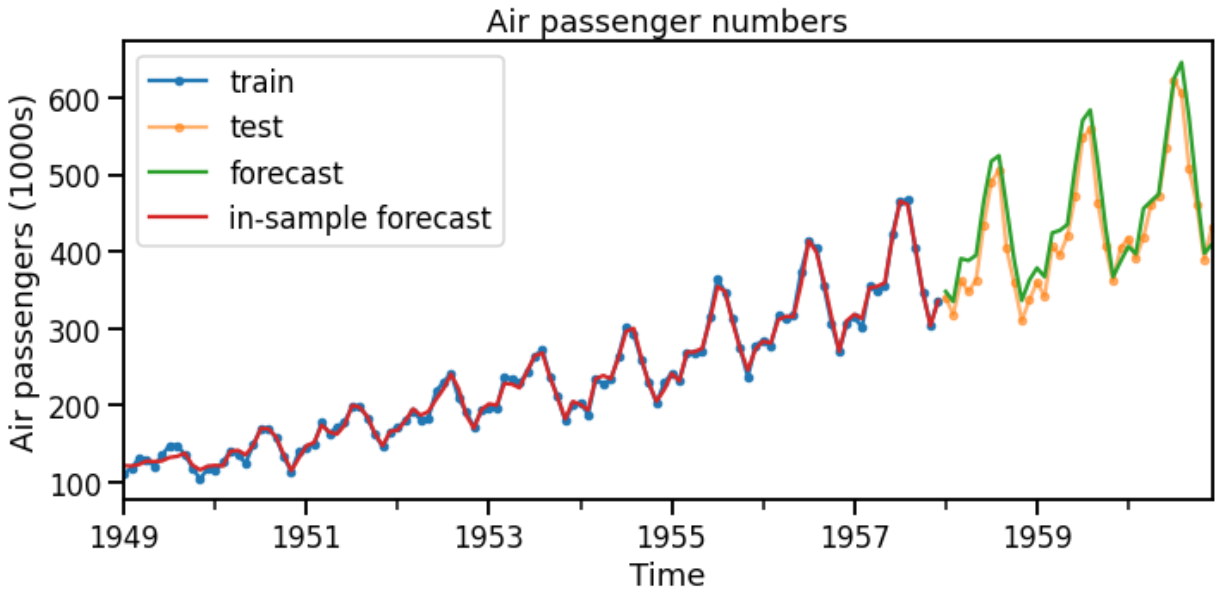
How to use Tree-based models if there is trend?

De-trend the time series first



Features: time, lag 1 & 12 of y

Use more advanced tree algorithms



Features:

- Time & lag 1, 2, 3, & 12 of y
- Window mean of size 12 of y

Summary

Time can be used to model different types of trend.

Linear models can model non-linear trends via feature engineering.

Tree-based models require a different approach to trend.