Prophet – structural time series model

Prophet time series = Trend + Seasonality + Holiday + error

$$y(t) = g(t) + s(t) + h(t) + \epsilon$$

- Trend models non periodic changes in the value of the time series.
- Seasonality is the periodic changes like daily, weekly, or yearly seasonality.
- Holiday effect which occur on irregular schedules over a day or a period of days.
- Error terms is what is not explained by the model.

Trend Model

$$g(t) = \frac{C(t)}{1 + \exp(-k(t)(t - m))}$$

- Borrow the concept of population growth model
- C(t) is a time varing carry capacity
- k(t) is a time varing growth rate that has several changing points
- m is the offset parameter

Seasonal Model

$$s(t) = \sum_{n=1}^{N} (a_n \cos\left(\frac{2\pi nt}{P}\right) + b_n \sin(\frac{2\pi nt}{P}))$$

- It is based on a standard Fourior Series.
- The parameter are selected by model performance, such as AIC
- For yearly and weekly seasonality we have found N = 10 and N = 3 respectively to work well for most problems.

Holiday and Event Model

$$Z(t) = [\mathbf{1}(t \in D_1), \ldots, \mathbf{1}(t \in D_L)]$$

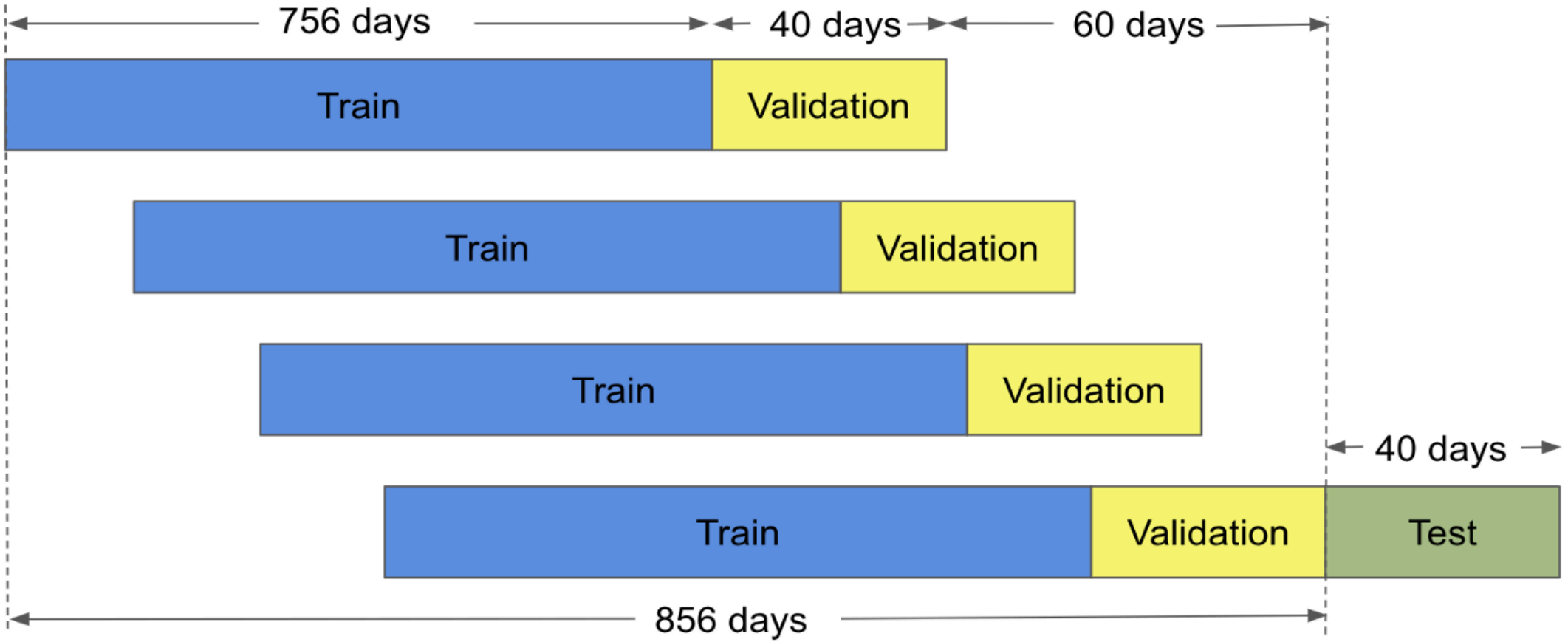
$$h(t) = Z(t)\kappa$$

- κ is a prior to adjust for seasonality
- by assuming that the effects of holidays are independent, it uses indicator function (whether the date is holiday or not) to model the time series.
- For days around the holiday, it labels them as a holiday itself.

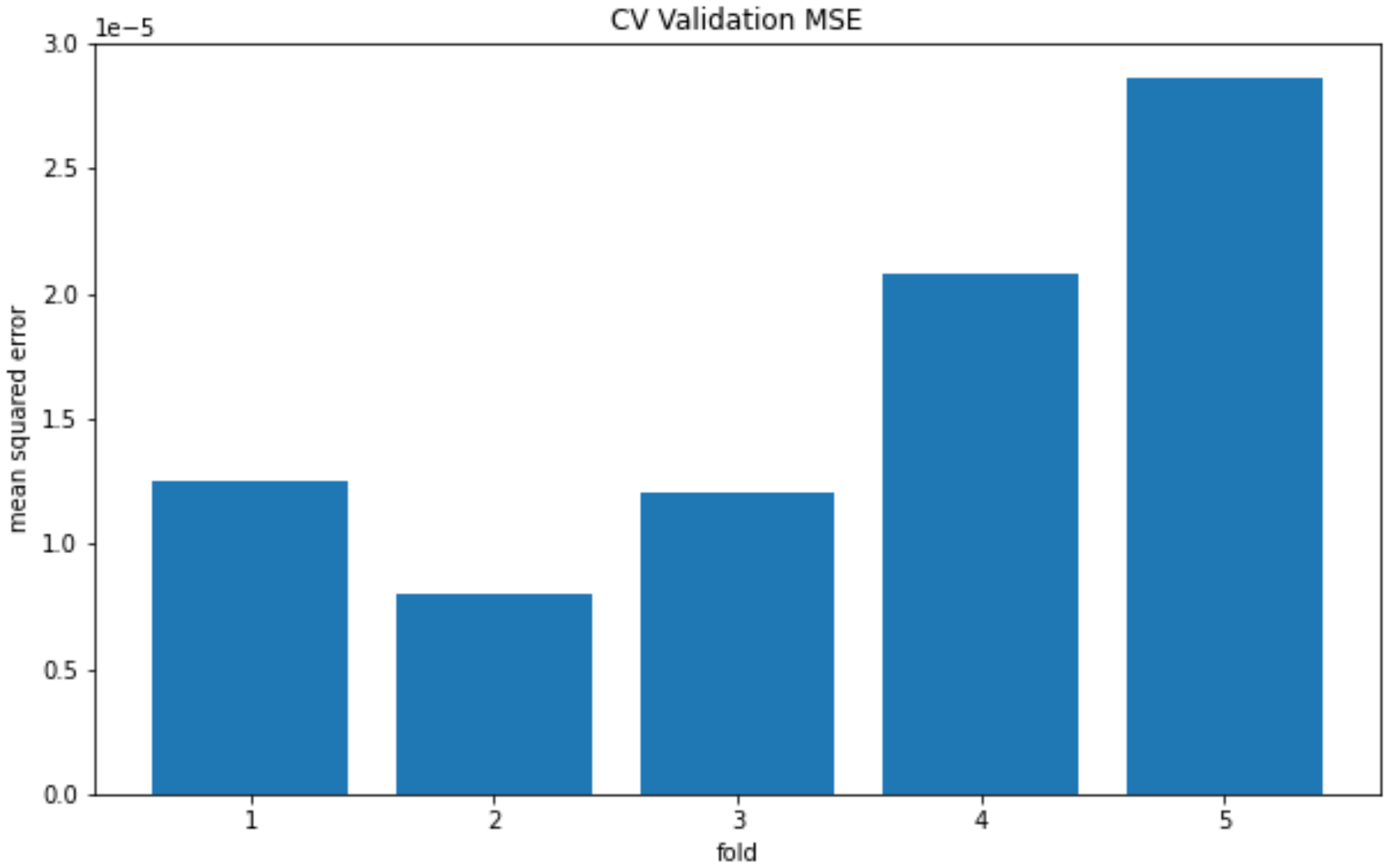
Advantages

- Decompose easily / accommodates new components
- Flexibility: Accommodates seasonality with multiple periods
- Prophet is resilient to missing values
- Fitting of the model is fast
- Intuitive hyper parameters which are easy to tune
- Easy to interpret the model

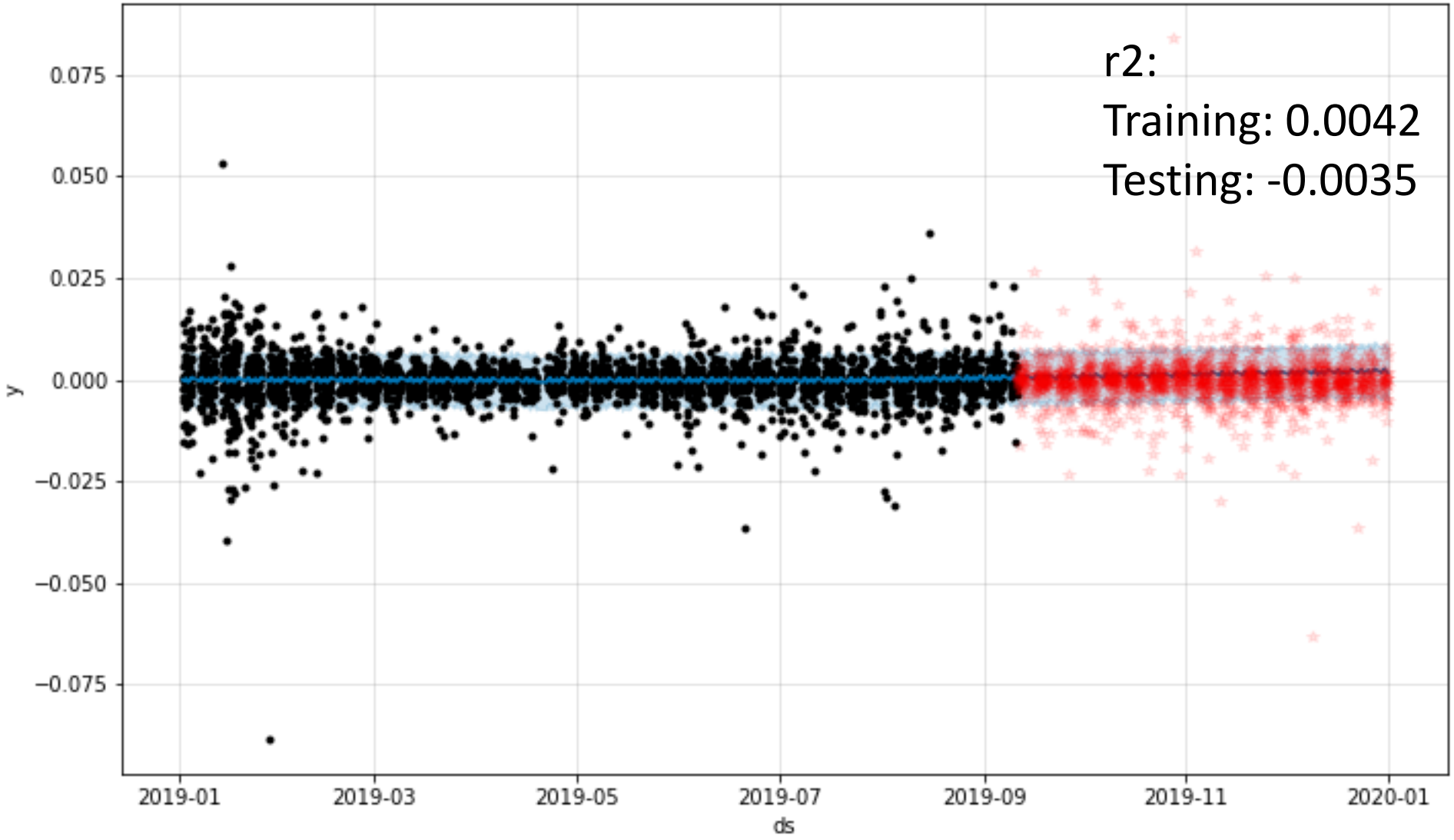
Time Series Cross Validation



Result – CV performance

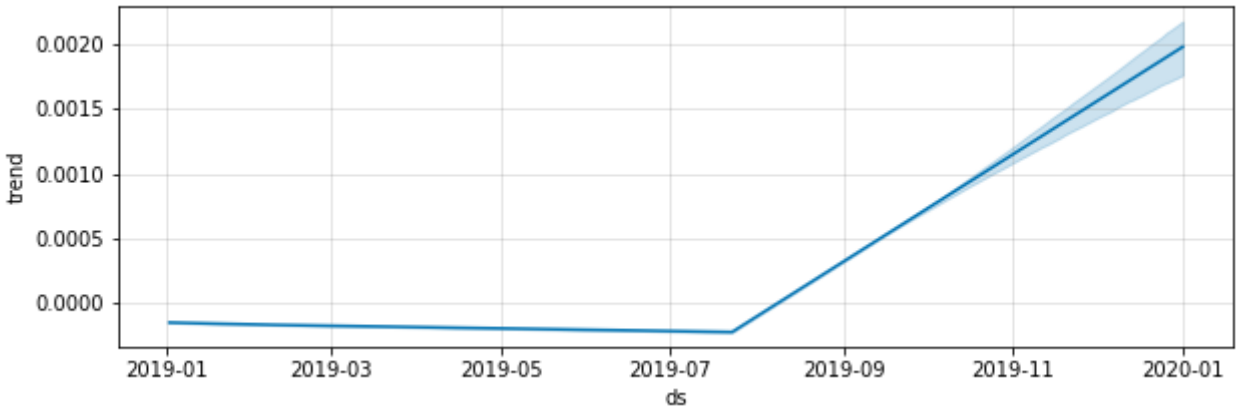


Result – Final Model

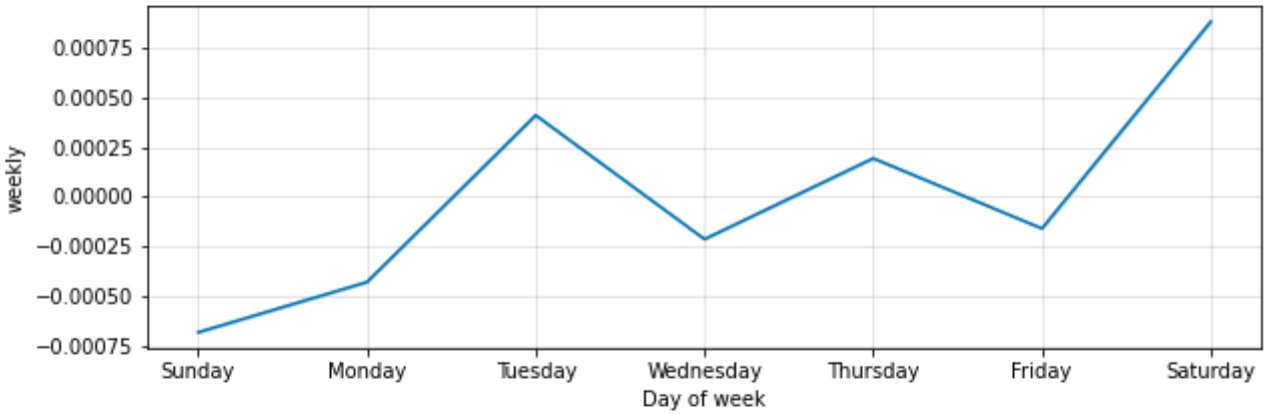


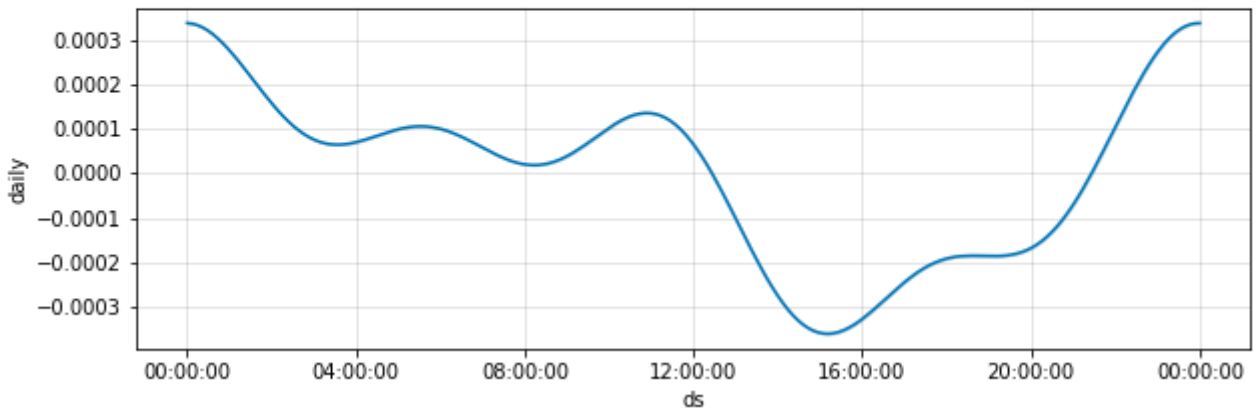
Result – Final Model

Trend



Seasonality (weekly & daily)





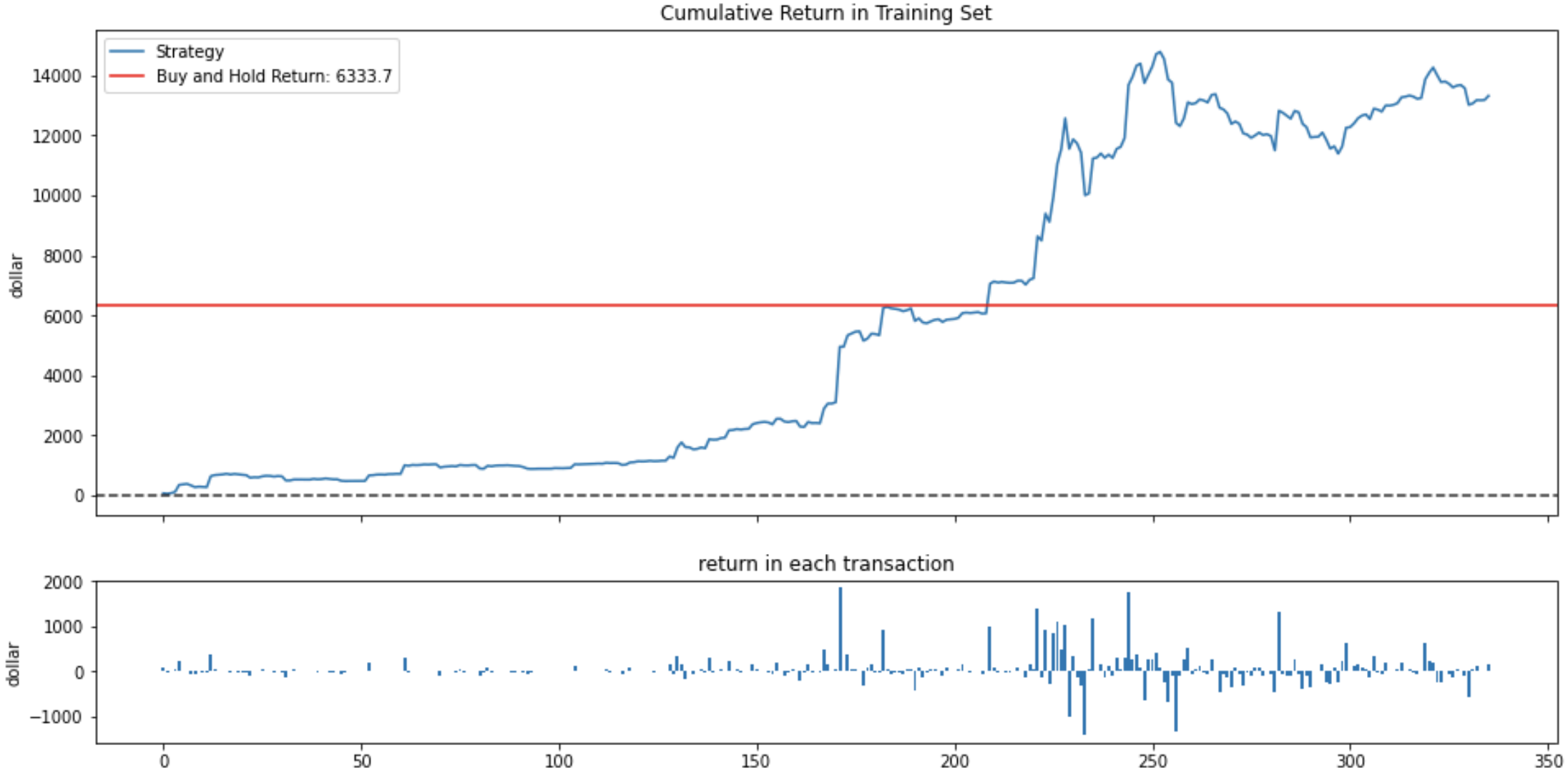
Strategy

- Long and Short strategy:
  - Long: when three consecutive prediction of log return are larger than zero
  - Short: when three consecutive prediction of log return are smaller than zero
  - Hold: otherwise

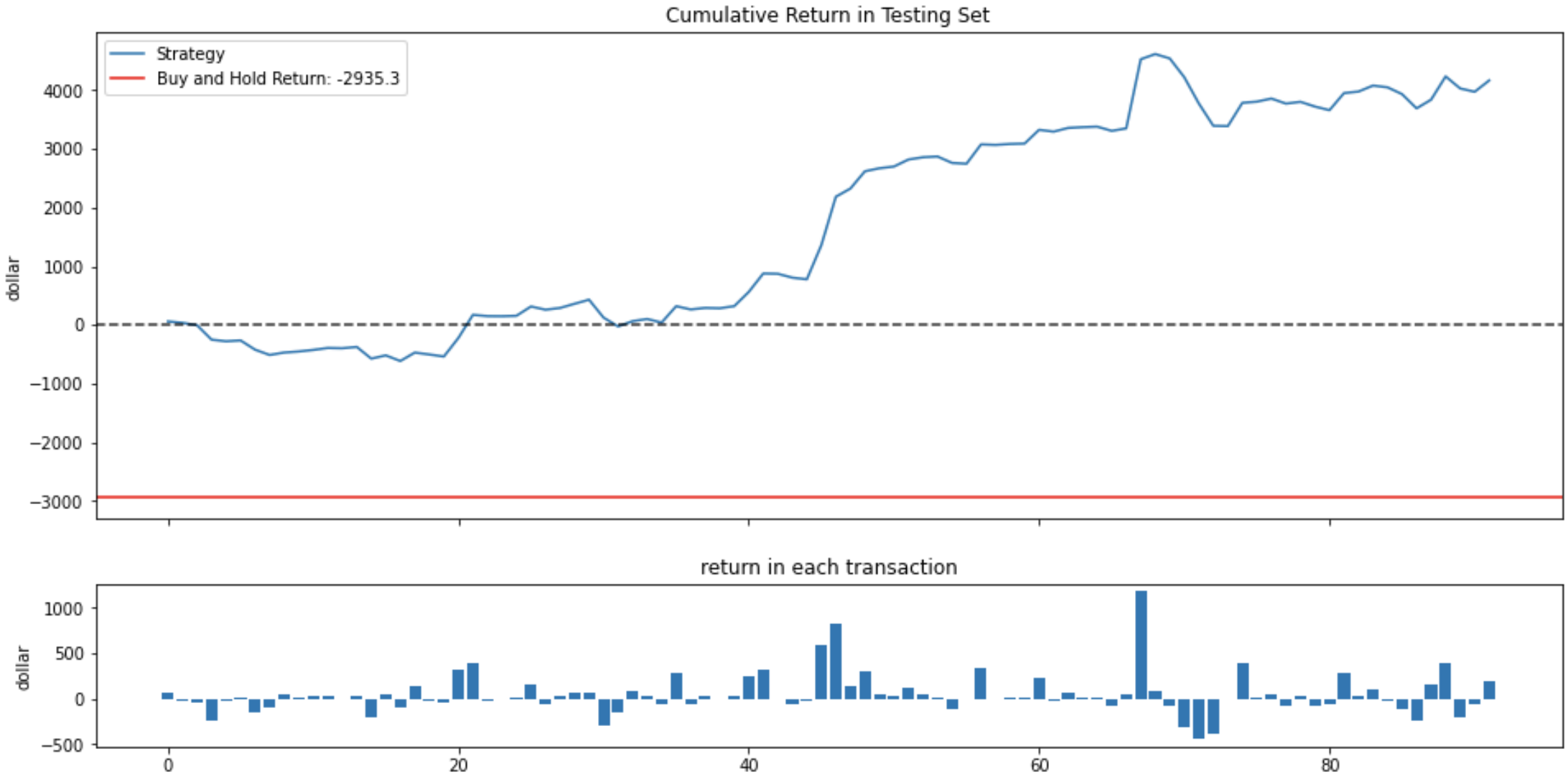
- If the long signal appears, we buy one unit of BTC. And if the short signal appears, we sell one unit of BTC.

- Our deposit starts with 10,000.

Performance in Training Set - Return Rate: 133.2%



Performance in Testing Set - Return Rate: 41.7%



Conclusion

- The performance of prophet on log return wasn’t ideal, but it can still make profitable strategy after doing some adjustment.

- The result may be different if we take tax and trading cost into account.

- Prophet is good at modelling time series with strong seasonality and having critical changing points. Prophet might perform better on market Index, which has an apparent trend.

Reference

- Paper: https://peerj.com/preprints/3190/
- Package: https://facebook.github.io/prophet/
- Medium blog: https://towardsdatascience.com/time-series-prediction-using-prophet-in-python-35d65f626236