Exploration of predicting power of ARIMA, Facebook Prophet and LSTM on time series

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Presentation Link: https://youtu.be/CmsFhF9ROns

Goal and Models

The goal of our project is to predict the future price movement using historical information. We used daily SPY data and Fed Reserve minutes schedule to test three models including **ARIMA**, **Facebook Prophet**, and **LSTM.** Based on errors and trading performance, we found LSTM superior.

Data Description

We obtained SP500 historical daily market prices from Yahoo Finance ranging from 1950 to present, and FED Reserve minutes schedule from Bloomberg terminal from 1997 to 2020. We applied Daubechies wavelet and Kalman filter to de-noise the daily adjusted closing prices and derived daily log returns as stationary inputs to feed LSTM.

Future

Expand data scope - More securities
Expand dimension - Multi features

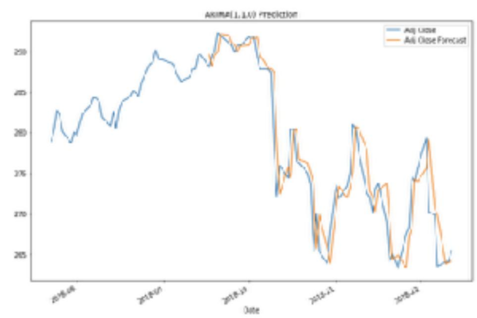
Reference

[1] Colah's Blog, "Understanding LSTM Networks", 2015
[2] S.Taylor, B.Letham, "Forecasting at Scale", 2017
[3] R.Nau, Introduction to ARIMA: Nonseasonal Models, Available: https://people.duke.edu/~rnau/411arim.htm

ARIMA (p,d,q)

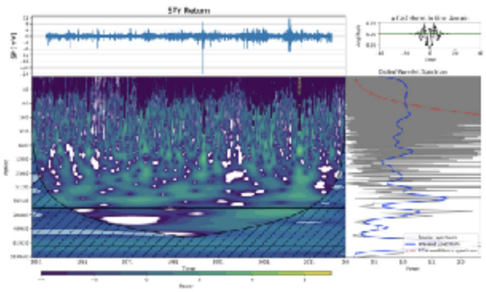
$$\hat{y}_t = \mu + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q}$$

We tried different parameters to achieve stationarity of input and accuracy in prediction, however the results were not satisfying. Possible reason could be the changing trend in price data.



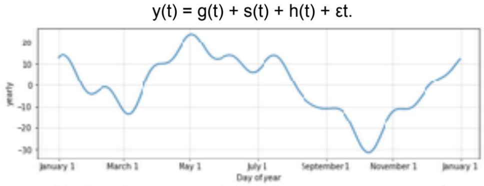
Data Revisit

Wavelet heat spectrum from 1950 to 2018 shows low frequency cyclical signals at 60Days, supporting our choice of 60D sliding window in LSTM model

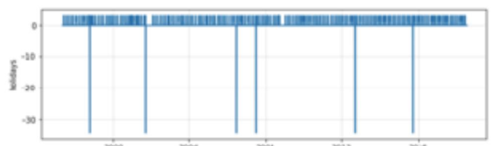


Facebook Prophet

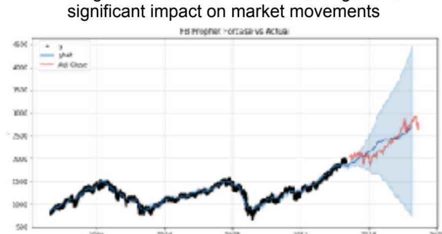
$$y(t) = g(t) + s(t) + h(t) + \epsilon t.$$



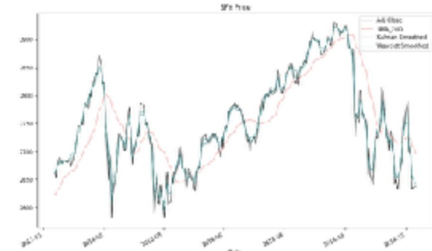
Finding: Decomposed data shows strong support for trading adages such as 'January Effect'



Finding: FED Reserve minutes meetings have significant impact on market movements

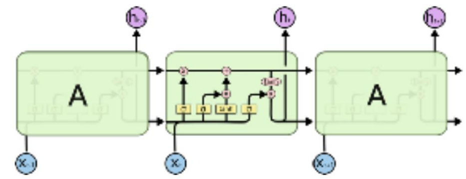


De-noised Data



LSTM

Log return of de-noised price data was fed into LSTM. The frame includes two hidden layers, whose dimensions are 256*128. A moving 60D window is used to predict the next 5D price trend. Dropout rate is 0.1. Epoch 200. Training and testing split is 80/20 from 1997 to 2018



Results - LSTM comparisons

	Training Error	Testing Error	Testing Period Performance
FbProphet	NAN	7.49E-06	-2.29%
LSTM w/o Filter	9.62E-03	7.76E-06	-10.98%
LSTM w/ Wavelet Filter	1.53E-04	8.46E-06	10.55%
LSTM w/ Kalman Filter	1.02E-04	7.74E-06	25.93%