Time Series Analysis and Forecasting

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Problem

Comparison between algorithms for time series forecasting. The main focus of the project is to study performance of statistical models (AR, MA, ARIMA) and machine learning models (LSTM).

Motivation

- A time series is a series of data points indexed in time order.
- Time series forecasting is the use of a model to predict future values based on previously observed values.
- The motivation for this study is to present performance evaluation for state-of-the-art algorithms for time series forecasting.

Objectives

- Data collection (Data acquisition)
- Data preprocessing
- Develop models
- Evaluate algorithmic performance

Data collection and preprocessing

- Historical stock prices
- Stock market API
- Handling NA values
- Feature engineering and scaling

Detecting stationarity in time series

Rolling (moving) statistics

- Additive time series
- Multiplicative time series
- Visual Test
- Rolling Mean
- Rolling Standard Deviation

Augmented Dickey Fuller Test

- Additive time series
- Statistical Tests
- p-value threshold 5%
- (H0): Time series is non-stationary. It has some time dependent structure.
- (H1): Time series is stationary

Kwiatkowski–Phillips–Schmidt–Shin Test

- Multiplicative time series
- Statistical Tests
- p-value threshold 5%
- (H0): Time series is non-stationary. It has some time dependent structure.
- (H1): Time series is stationary

Techniques for making time series stationary

- Differencing (Time Shift Transformation)
- Decomposition (Time series = Trend + Seasonality + Noise)

Differencing

Given a set of observation on the time series:

$$x0, x1, x2, x3, \ldots . xn$$

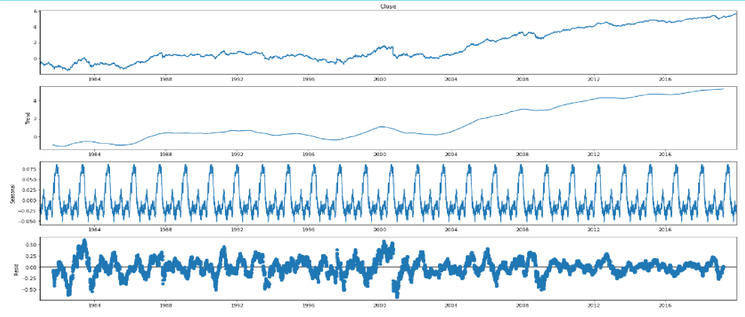
The shifted values will be:

$$null, x0, x1, x2, \ldots . xn$$ ⟵ - basically all xi's shifted by 1 pos to right

Thus, the time series with time shifted values are:

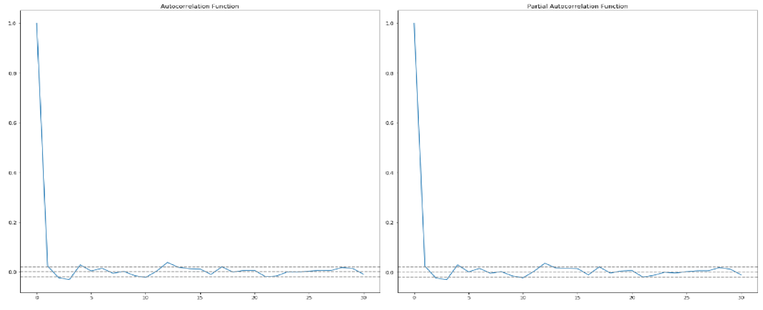
$$null, (x1 - x0), (x2 - x1), (x3 - x2), (x4 - x3), \ldots . (xn - x_{n-1})$$

Decomposition



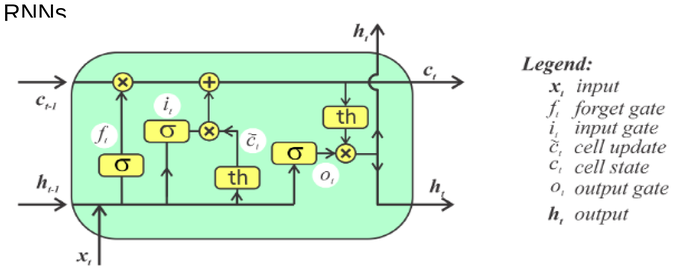
Statistical Models

- The Autoregressive AR(p) Part of ARIMA : describes relationship between a current observation and previous observations.
- The Integrated I(d) Part of ARIMA: describes number of lags (shifts) until time series becomes stationary.
- The Moving Average MA(q) Part of ARIMA: describes relationship between an observation and a residual error from previous observations.



Machine learning models

- Long short-term memory (LSTM) is an artificial recurrent neural network (RNN) architecture.
- Capable of handling sequential data (time series)
- A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate. The cell remembers values over arbitrary time intervals and the three gates regulate the flow of information into and out of the cell.
- LSTMs were developed to deal with the exploding and vanishing gradient problems that can be encountered when training traditional RNNs.



Tuning Models

- Grid search method (AR, MA, ARIMA)
- Trial and error method (LSTM)

Evaluation

- ARIMA Root Mean Square Error (RMSE): 23.2218
- LSTM Root Mean Square Error (RMSE): 9.4728