Stock Price Analysis and LSTM Prediction

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1. Abstract

In this report, it is mentioned about Tesla Motors' stock price prediction in a traditional way using technical indicators like Moving Average, Relative Strength Index, Parabolic SAR, Commodity Channel Index, Stochastic Oscillator and Awesome Oscillator in the first part. After the analyzing Tesla Motors' stock price with traditional technical indicators, it is predicted by long short term memory model as a second part. In long short term memory (LSTM) model, closing stock prices of Tesla Motors' for two years are used. The model can predict the trend successfully. The technical indicators can provide context to trends, be used to identify divergences, and even help with timing of potential entry and exit signals. But using just one of the technical indicators is a risky decision because one must be aware of announcements and headlines that play a crucial role to determine the stock price.

2. Introduction

The aim of the project is to predict what will be a stock price in near future. To predict a stock price, the traditional stock price analysis tools and Long Short Term Memory Model through machine learning is used in this project. Specifically, the stock price of Tesla Motors is used to compare the techniques in the study. The estimation is done using Pandas, NumPy, Seaborn libraries in Python. First, summary information and summary statistics of the company are shown, including the number of observations, maximum and minimum prices in the analyzing period, standard deviation, and the 50 and 75 percentile of the stock prices. Secondly, historical closing prices, moving averages, moving averages convergence – divergence (MACD), it is used the following indicators to analyze stock prices: relative strength index, parabolic stop and reverse, stochastic oscillator, commodity channel index and awesome oscillator.

3. About the Company

Martin Eberhard and Marc Tarpenning founded Tesla Motors in 2003. The headquarter of the company settles in Palo Alto, California. The main objective of Tesla Motors is designing and improving electric vehicles and their components and proving that clean energy is better than fossil fuels. Tesla has own sales and service network. Basically, it produces automobiles which have electrical power. In addition, the company's mission is being an innovator of energy. It can be said that well established automobile companies, BMW and Mercedes, are the main competitors of Tesla Motors. But Tesla takes the leadership in electric vehicles because it has accomplished to produce faster electric vehicles and the consumers can charge their cars in their home in a very short period of time. Rapid innovation power and strong customer relationship of the company provides to get a big share of the electric vehicles industry that is a relatively new industry.

The company took 60 million dollars investment in 2007. Tesla's first IPO was held in 2010. The IPO price of TSLA was $17. In this report, TSLA's closing prices is used for the analysis from July 2017 to June 2021. In the period, revenue of the company has risen constantly. In 2017 revenue was $11.76 billion, $21.46 billion in 2018, $24.58 billion in 2019 and $31.54 billion. Market cap of the company is $593.3billion right now. [1] EBITDA of the company was $95 million in 2017, $1.67 billion in 2018, $2,273 billion in 2019 and $4,49 billion in 2020.

4. Stock Price Analysis

In this part of the study, it will be estimated the future price using traditional technical analysis tools. Firstly, summary statistics and the closing price history of the stock will be explained then technical indicators and oscillators will be used.

4.1 Summary Statistics

In the following data, some basic summary statistics can be seen for TSLA. For the last two years, there are 505 closing prices are analyzed. The average stock price for these 505 closing prices is $314.04. Deviation from this number $263.4. In this period, the minimum closing price of the stock was $41.85 and maximum price of the stock was $883.09. 25 percentile of the closing prices is at $70.44, 50 percentile of them is at $188.13 and 75 percentile of the closing prices is at $576.83.

4.2 Closing Price History

In a regular trading day, the closing price is the last price that security traded. Dataset is set for two years. As the following chart, it can be seen closing prices of TSLA.

Graph 1. TSLA's Closing Price History

The closing prices of TSLA were not over volatile between July 2019 and July 2020. However, by the last months of 20120, the prices started to increase and have become more volatile and it enters and upward trend.

4.3 Moving Average

Moving average is used to analyze stock prices creating different types of averages in the analyzing period. It is also called as rolling average or running average. There are different kinds of moving averages, because of this reason this tool generally called as Simple Moving Average (SMA). The analysts use simple moving averages for determining stock price direction. Through the moving averages, noise terms of a stock price can be eliminated. So that the analyst can observe the main trends clearly. [2]

Simple Moving Average for a stock price is calculated by summing all closing prices and dividing this sum by the number of days in the analyzing period. It is said as moving because the value is recalculated every day. It is a technical indicator that an analyst applies to find out buying or selling signals for a stock price. Simple moving averages assist to find entry and exit prices defining resistance and support prices.

The formula of simple moving average is as the following:

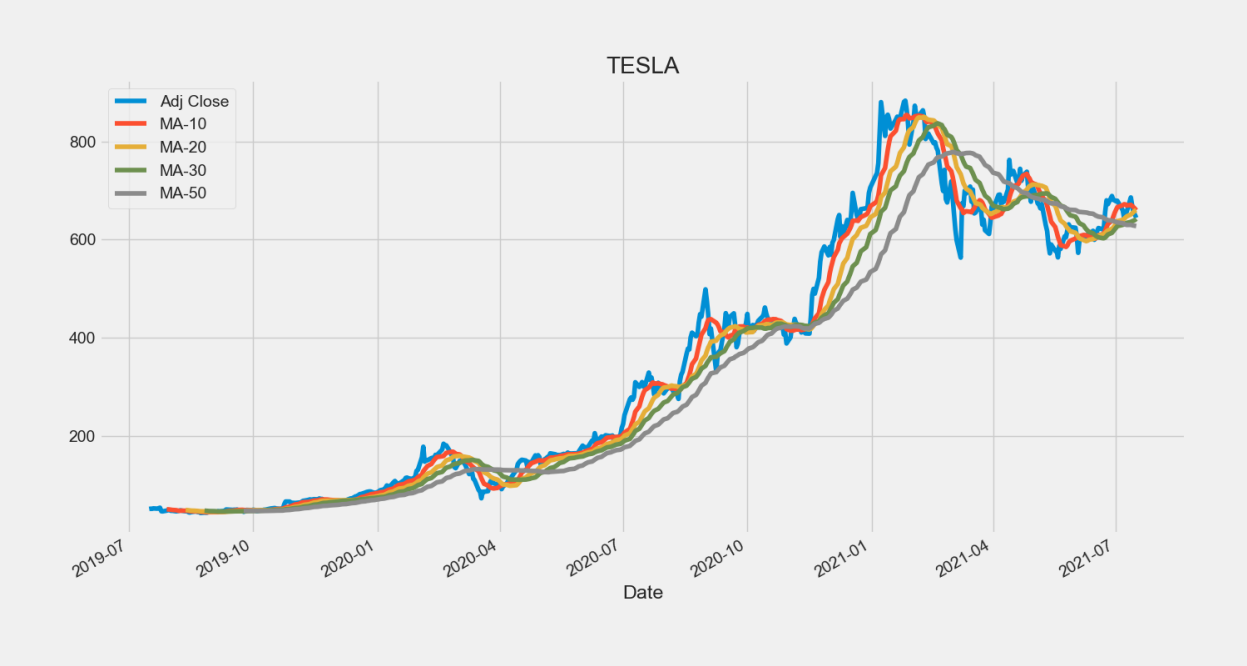
$$SMA = (A_1 + A_2 + \ldots\ldots\ldots A_n) / n$$

In this formula, A is the closing prices in period n and n is the number of periods.

To find simple moving averages of TSLA, it is used 10, 20, 30, and 50 days as n. Using more than 50 days, like 200 days, reflects the direction of the trend later than the shorter periods.

If the moving average of a stock price has increased, it means that it is in an uptrend or if the moving average of it has decreased, it means that it is in a downtrend. But this way is not enough to determine an investment strategy. In addition to this, a couple of moving averages should be used. If a stock price enters in an uptrend, the short-term SMAs should be above the long-term SMAs. If a stock price enters in a downtrend, short term SMAs should be below the long term SMAs.

In the project, TSLA's moving averages have been as the following chart. To be able to see the trend clearly, smoothing out the noise terms is a useful way. 10 and 20-day moving average lines can predict better than the others, because when the trend is upward, the price line stays above the 10 and 20-day lines. However, 30 or 50-day moving average lines do not stay above or below the price line, they are late to make a decision about the strategy.



Graph 2. Moving Averages of TSLA

4.4 Moving Average Convergence – Divergence (MACD)

Gerald Appel discovered this indicator in 1970's. To be able to calculate MACD, closing price is used as in the moving average calculation. Appel mentions about basic concepts of MACD as in the following. MACD is calculated by the difference of the short-term exponential moving average minus the long-term exponential average Generally, 26-day exponential moving average is simply deducted from 12-day exponential moving average. When the trends have upward direction, short term averages will increase faster than long term averages. In this case, MACD lines will disperse. If the trends are losing power being downward, shorter-term averages

will be flattened. If the reduction continues, it will be below longer-term averages. MACD lines will fall below 0. It can be said that changing trends influences the direction of MACD. However, every trend reversal can not be considered as settled till other signs occur. Because while the path of price movements, short-term moving averages will diverge and converge with longer-term moving averages. Therefore, this indicator called as moving average convergence-divergence.

Signal line can be used for deciding buying and selling of a stock. There are three ways to use MACD indicator. First one is crossovers. If the MACD falls below signal line, this condition creates a downside signal or rises upside of it, it means that it is time to buy the asset. Second way to use it is divergence. When the price of an asset diverges from MACD, it means the trend is over. The last way is that looking at abnormal rises in MACD. If MACD indicator increases abnormally, this means that the short-term moving averages pushes up the long-term moving averages so the asset takes place in overbought points, in a short period, it will turn its normal condition. Additionally, investors should pay attention zero line. If MACD is above the zero-line, short-term moving averages is above the long-term averages and the upside movement can go on. If MACD is below the zero-line, short term averages are below the long term averages and the downside movement can go on.

In the following chart, TSLA stock price, MACD and signal line can be observed for the analyzing period. It can be said that there is a good estimation of the prices. When the stock price falls down, MACD is below the signal line, when it rises up, MACD is above the signal line. It can be said that the MACD is a good indicator for estimating TSLA stock price.

Graph 3. Moving Averages Converges Divergence of TSLA

4.5 Relative Strength Index (RSI)

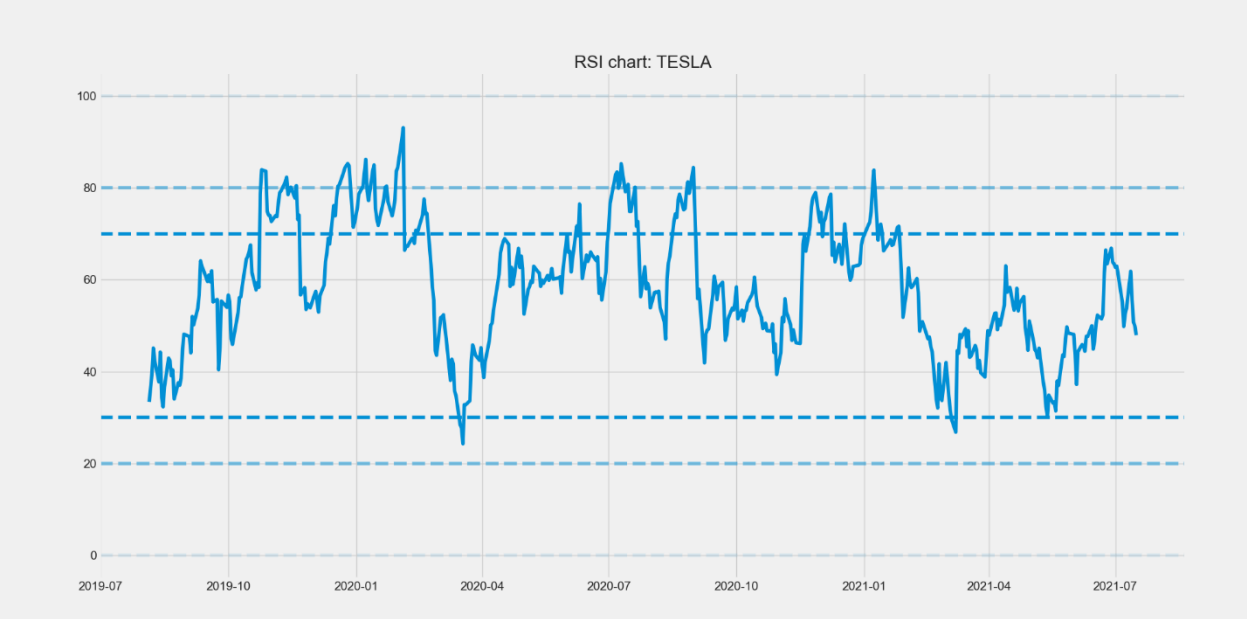
Relative Strength Index or RSI is an indicator that predicts the direction of short term and medium term using previous period's closing price. It is created by J. Welles Wilder in 1978. RSI shows signals whether overbought and oversold of a stock. Basically, it measures the anomalies of price movements and the speed of becoming normal price. Usually, fourteen-day period is used and this fourteen-day period falls below 30, the investor should buy and rises above 70, the investor should sell the asset.

The formula of the RSI has two steps. In the following it can be seen these two steps:

$$RSI_{step\ one} = 100 - \frac{100}{1 + Average\ gain/average\ loss}$$

$$RSI_{step\ two} = 100 - \frac{100}{1 + \frac{previous\ average\ gain * 13 + current\ gain}{-(previous\ loss * 13 + current\ loss\ )}}$$

Relative strength index of TSLA can be seen as the following chart. In march 2020 and 2021 RSI falls below 30. After march 2020, it can be observed that the index increases and never fall below 30 until march 2021. When it is look January 2021 closing prices, it can be seen that TSLA's prices hit the new record then started to fall. Relative strength index of TSLA was above 70. So, it showed selling signals.



Graph 4. Relative Strength Index of TSLA

4.6 Parabolic Stop and Reverse (Parabolic SAR)

The Parabolic Stop and Reverse is created by J. Welles Wilder, too. It determines the direction of an asset's price. Stop and Reverse is generally called as SAR. An analyst uses Parabolic SARs to analyze possible turnabout in the price movement of a stock price. In addition to this, it can be used to decide entry and exit prices.

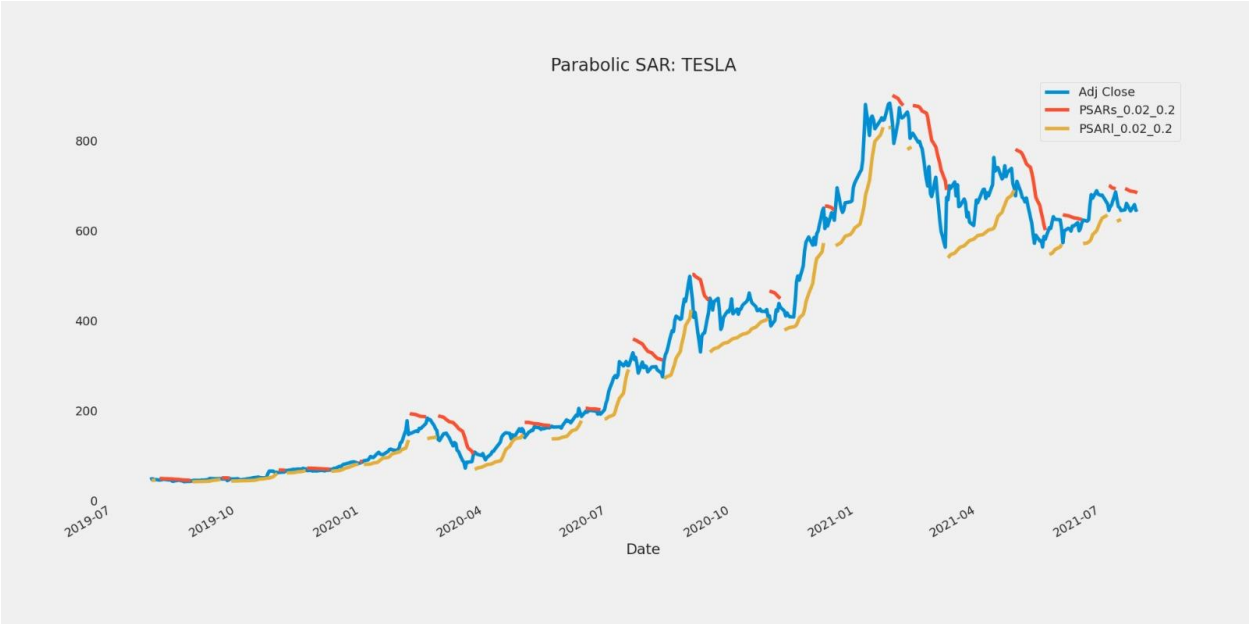
The Parabolic SAR decreases below the current stock price, it means that this is a buying signal. If it takes place above the current price, it will be a selling signal. To establish stop losses and target profits, these signals can be used by the analysts. Generally, near the price bars, there are a set of dots representing the asset. If the points stay below the price, it indicates that the stock price direction is upward and it shows a buying signal. If there is a change in the direction of the dots, there might be a profit opportunity. Because of this, Parabolic SAR is not a good indicator in a flat or ranging market. [3]

To identify the place of the indicator, the highest and lowest price and the acceleration factor is used to calculate Parabolic SAR. The formula of it is as in the following:

Uptrend Parabolic SAR = Prior SAR + Prior AF (Prior EP – Prior SAR)

Downtrend Parabolic SAR = Prior SAR – Prior AF (Prior SAR – Prior EP)

EP stands for the highest or lowest point in a trend. AF means the acceleration factor and it starts at 0.02 (when the EP is recorded, acceleration factor is increased by 0.02 each time, with a maximum of 0.20).



Graph 5. Parabolic Stop and Reverse of TSLA

4.7 Stochastic Oscillator

Stochastic oscillator is a technical analysis tool which is developed by Dr. George Lane in the late 1950s. Within a specific period of time, Stochastic Oscillator compares the most recent closing price of a security to the highest and lowest prices. This technical analysis tool might give an idea about the momentum of a stock price. It generally shows as a percentage and uses a 14-day period as an analyzing period. Zero means it is the lowest point of the analyzing period. 100 shows the highest point of the period. 80 and 20 are the two default lines. Any value above 80 line shows that the stock is overbought. Any value below the 20 line shows the stock is oversold. [4]

Stochastic oscillator gives indications of overbought and oversold. It looks at the current price and compares it to the previous period. It is factoring in highest high and lowest low across the period of its lookback in making its comparison.

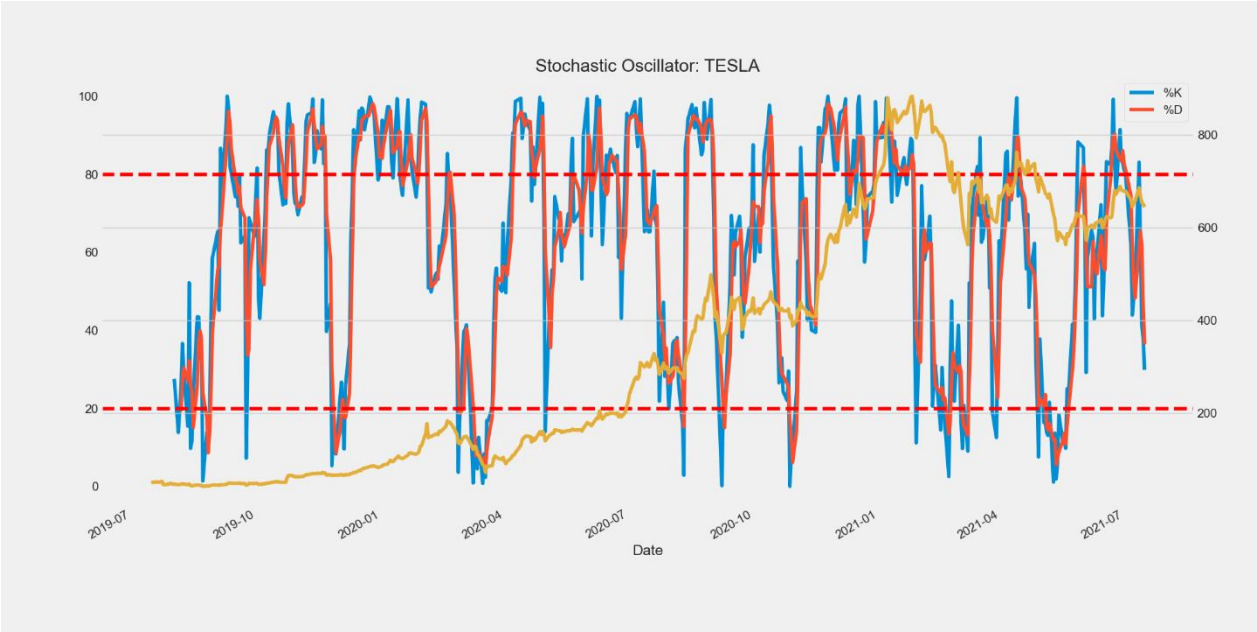
The Stochastic Oscillator formula is calculated by the following:

%K = (Last Closing Price – Lowest Price)/(Highest Price – Lowest Price) x 100

%D = 3-day SMA of %K

In the formula, C shows the last closing price, Lowest Low stands for the lowest stock price, Highest High stands for the highest price in the analyzing period.

There are three ways to use stochastic oscillator. First one, defining overbought and oversold regions as indications of potential reversals in the stock price. Another way is that looking crossovers of %K and %D and using those as trading signals. If the %K crosses below %D, the trader would sell the stock, if %K crosses %D, vice versa. The last way of using it is that looking divergences between the price and oscillator. If there is a divergence between the price and the oscillator that could be signal of potential reversal.



Graph 6. Stochastic Oscillator of TSLA

In Graph 6, it can be observed the stochastic oscillator for TSLA 14-day periods. The yellow line shows the historical closing price of TSLA. It can be said that the oscillator can predict the trend most of the time.

4.8 Commodity Channel Index

It had used in commodity price previously, then it has started to use in security prices. The CCI measures the relationship between the price of a security and its moving average. It is common to use 20-day moving average. The indicator contains three lines. One line is said as zero, the second one is -100 and the third one is +100. The CCI takes place -100 and +100. If the price movements above the moving average, the CCI line is above zero. If it crosses below the

moving average, the CCI falls below zero. But, if the price deviates significantly from the moving average, the CCI line crosses outside the other channel lines, and the underlying security could be considered overbought or oversold. These crosses channel line can be used to help identify potential entry and exit signals. If the CCI rises above the +100 line and then crosses back below it, an investor might see this as a potential exit signal. The CCI is used for defining the time of entry and exit signals. But the security price can continue to move higher because there is no upside or downside limit in CCI.

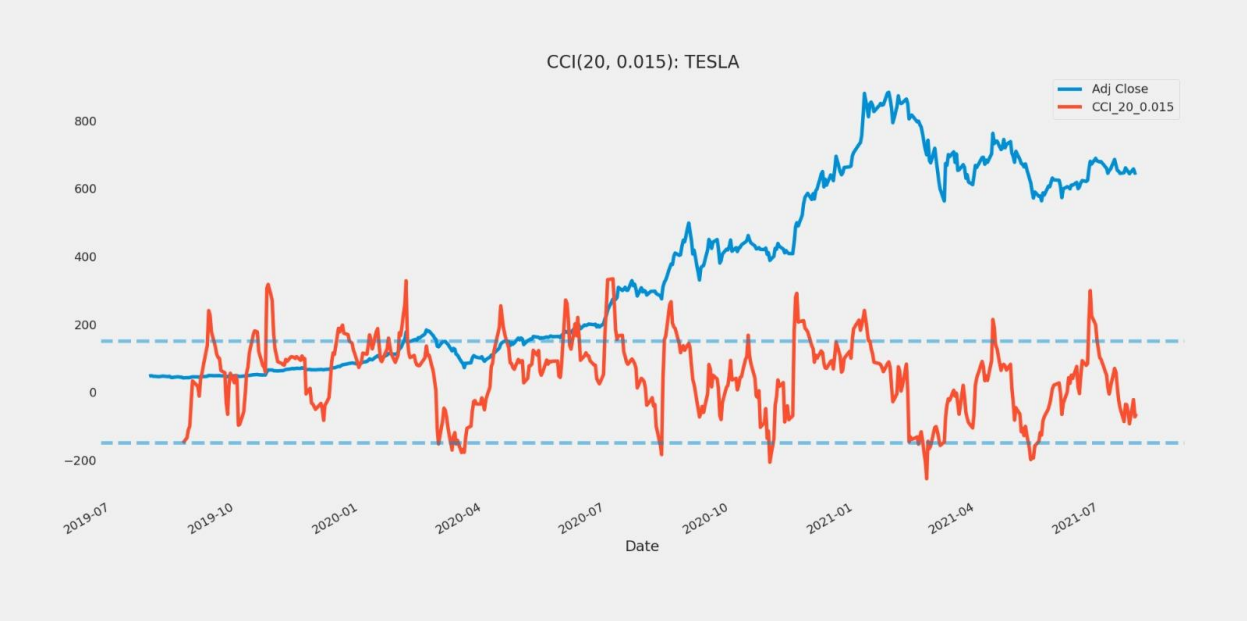
To be able to calculate The Commodity Channel Index (CCI), one should calculate the average stock price and the simple moving average in the analyzing period, subtract the SMA from the average price. The subtraction is divided by mean deviation multiply by .015. 0.015 is a constant number that allows 70 to 80 percent of CCI values reside in the +100 to -100 range.

*CCI = (AveP - SMA_of_AveP) / (0.015 * Mean Deviation)*

CCI = Commodity Channel Index

AveP = Average Price = (High + Low + Close) / 3

CCI of TSLA can bee seen in the graph 7. When the red line rises above the +100 line, this is an exit signal and stays below -100, this is an entry signal. Generally, it can be said that the index can predict the entry and exit signals.



Graph 7. Commodity Channel Index of TSLA

4.9 Awesome Oscillator

To be able to compare the recent market price changes, the awesome oscillator can be used. It is a market momentum indicator. There are two different moving averages and a zero line in the middle of these moving averages. Stock price movements are plotted according to these different moving averages.

The graph of the awesome oscillator consists of a sequence of green and red candles extending up and down around the 0 axis. Upward signals shows that the driving force is gradually increasing, while downward signals indicate that the strength is decreasing. There are three buy and three sell signals in awesome oscillator. Awesome signals give more consistent results in certain trending markets.

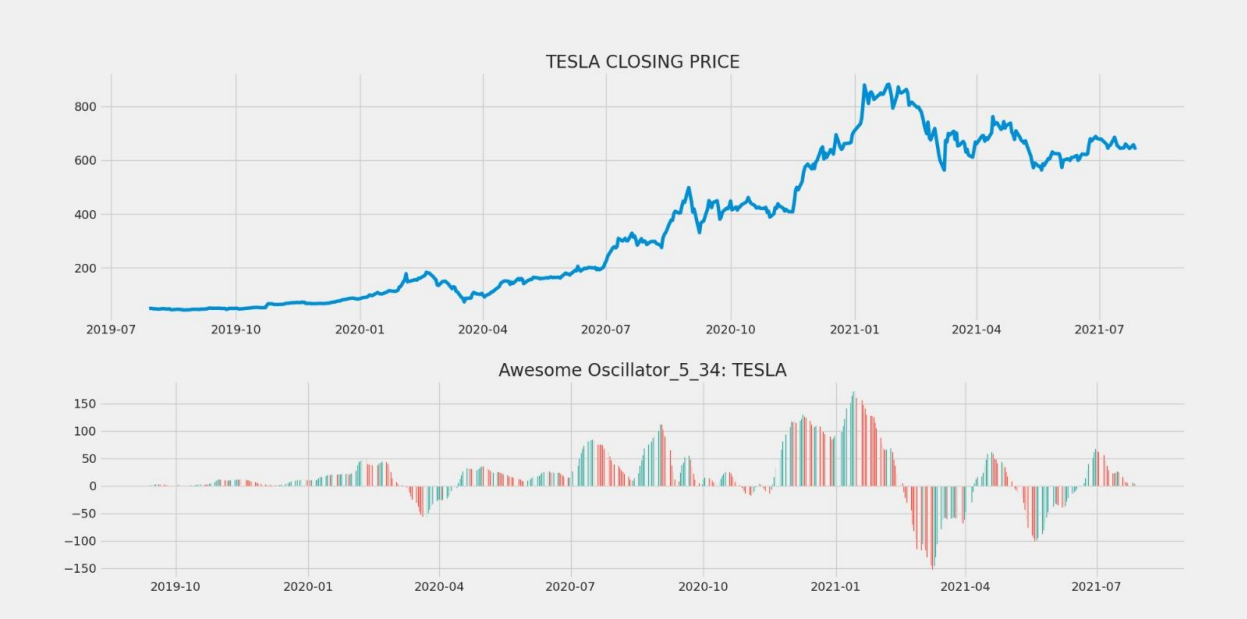
The Awesome Oscillator is a measure to find momentum dynamics. It compares the momentum of the last 5 candlesticks with the momentum of the last 34 candlesticks on a larger time frame. The value of the Awesome Oscillator indicator is calculated as the difference between the moving averages on timeframes larger than these timeframes. The Simple Moving Average used is calculated using the midpoint of each candlestick, not the closing price of the candlestick. There are three ways to use this oscillator. First, if the indicator goes above 0, the signal is bullish. If it drops below 0, the signal is bearish. Second, if the Awesome Oscillator has formed two peaks above 0 and the trough between them is also above 0, it is a bearish signal. The second high must be lower (closer to 0) than the first, followed by a red falling candlestick. Likewise, if the Awesome Oscillator has formed two bottoms below 0 and the trough between them is also below 0, it is a bullish signal. The second top needs to be higher (closer to 0) than the first, followed by a green ascending candlestick. The third signal is called "saucer". This is a pattern consisting of 3 candlesticks of the indicator. A bullish saucer consists of a red candlestick, followed by a shorter red candlestick, and then a green candlestick. All candlesticks must be above 0. The falling saucer consists of a green candlestick followed by a shorter green candlestick followed by a red one, all must be below 0.

The awesome oscillator formula is as follows:

Median price = (High price of a session + low price of a session) ÷ 2

Awesome oscillator = 5 period simple moving average (median price) – 34 period simple moving average (median price)

In the following graph, it can be observed the awesome oscillator of TSLA. As the other indicators, awesome oscillators can give the idea about the trend most of the time.



Graph 8. Awesome Oscillator of TSLA

5. Long - Short Term Memory

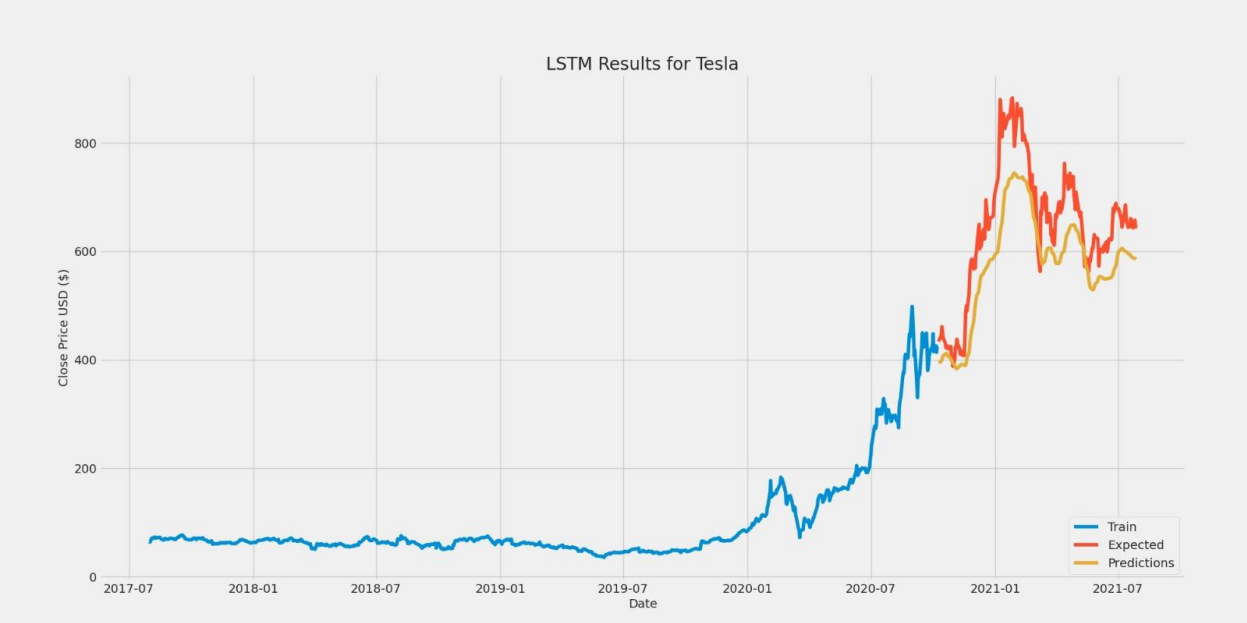
Long Short Term Memory is an architecture that is used in deep learning. It has an artificial recurrent neural network that can be capable of learning. [5]

The Long Short Term Memory (LSTM) networks are able to analyze linear problems. LSTM is a deep learning technique. Long-term Memory (LSTM) Units are enforced to learn very long sequences. This is a more general version of the gated recurrent system. LSTM has feedback connections. LSTM models are capable of storing information in a period of time. Because of this reason, it can be said that LSTM models have a memory capacity. In this way, LSTM can be used on time series data and it can classify, process and predict them. In addition to this, LSTM model can decide which information is useful and which is not through the gates.

LSTM networks are able to define long term dependencies. Long term dependencies are used for future prediction.[6]

The typical LSTM unit consists of a cell, an info door, an entrance door and a door with a view. The cell collects values over discretionary time intervals, and the three inputs manage the progress of data into and out of the cell. The ultimate advantage of the LSTM is ability to learn context-specific temporal dependence. Every unit in LSTM collects information for either a long or short period of time without explicitly using the activation function within the recurrent components. A significant certainty to note is that any cell state is uniquely increased by the output of the overlooked entryway, which changes somewhere in the range of 0 and 1. In other words, the overhead door in the LSTM cell is responsible for both the loads and the capacity to initiate the cell state. Subsequently, data from a past cell state can pass through a cell unaltered rather than expanding or decreasing exponentially at each time-step or layer, and loads can meet their ideal quality in a reasonable measure of time.

In this study, closing prices of TSLA have been used for the last two years. The train data is the 80% of it, the predicted data is the 20% of the last of it. It can be seen that the model can estimate the stock price trend successfully. To understand the power of the estimation, we can look at root mean square error (RMSE). It is calculated by squaring all of the errors, taking mean of it, then taking square root of this mean. RMSE is commonly used metric, because it is a successful general-purpose error metric for numerical predictions. [7] It is normalized in the study, so it occurs between 0 and 1. In this model the RMSE is approximately 0.2171. Additionally, as it can be seen in the following graph, it can predict the trend of the stock price.



Graph 9. Long Short Term Memory Model of TSLA

6. Conclusion

Making investment decision using traditional technical indicators is a risky choice. Because, a stock may remain oversold or overbought for a long time. The technical analysis tools use short periods to predict the price. This leads to give false signals about a stock price. Second risk is that there might be big events or announcements about the company. The tools can be used to define divergences and help with timing about potential entry and exit signals. But the using one of the tools is not enough to decide an investment strategy, the decision making process should be done by trending indicators besides oscillating indicators. So, the decision maker should combine these indicators.

To predict stock price trend, data processing technique and different kinds of algorithms can give good results. For a shorter period of time like 1-3 months, technical studies are frequently used to predict the trend. [8] In LSTM model, using one technique can be helpful to understand the trend, it consists the anomalies from the last two years. The model can be efficient for defining long term dependencies and uses them for future prediction. Because of this reason, it can be successful to predict the unexpected jumps in the stock price. The traditional way may not accomplish to predict these movements, because they consist short term period like 14 days. The ultimate achievement of the LSTM for stock price prediction is the prediction of the unexpected events.

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