Stock Prediction Methodology using Artificial Neural Network: Application in Tesla stock price

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Abstract. Contemporarily, the stock price fluctuates dramatically under the impact of lots of stochastic events (e.g., COVID-19, Russian-Ukraine conflicts). With the progress of machine learning techniques, it is feasible to predict the price accurately so that to inhibit the impacts of price variation. In this paper, the feasibility to forecast the price of underlying assets based on artificial neural network is investigated and discussed. For the sake of implementing the forecasting approach, the python Keras model is applied and different parameters are scanned. To give an intuitive example, the high volatility stock Tesla is selected as the target. According to the analysis, the state-of-art deep learning scenario is capable of prediction the price with high accuracy (i.e., above 95% R-square value). Nevertheless, some of the overfitting effects should be considered for applying such approach. Overall, these results shed light on guiding further exploration of implementing advanced machine learning approach to forecast the price of stock.

Keywords: Stock price prediction; Artificial Neural Network; Tesla.

1. Introduction

In the growing economy nowadays, stock is an important channel for new energy vehicle companies to raise funds, and stock exchange is at highly volume everyday along with fluctuating prices. Stock price prediction is of great significance to new energy vehicle companies' equity financing, risk identification and policy formulation.

Stock market forecasting has been an area of interest for investors and researchers for many years because of its volatility, complexity and regularly changing nature, which makes it difficult to make reliable predictions. There exist two main traditional schools of thoughts and strategies to predict stock in stock market, Fundamental Analysis and Technical Analysis, which financial analysts keep practicing in their daily work. Fundamental Analysis is performed basing on a company's intrinsic values or economic factors, including profits, assets, revenues, and expenses [1]. The investors need to spend great amount of time gathering and comparing information from yearly fiscal reports, balance sheets and so on. Technical Analysis relies only on historical share values and trade volume that had already been reflected by all the fundamental factors. Analysts usually examine the graphs and tables of prices to predict the stock direction and prove their invest recommendation. This means Technical Analysis often costs relatively less time (days or weeks) while Fundamental Analysis may require several years periods [1]. Besides the time-consuming drawbacks, the other weakness of these two methods such as lack of theoretical support, insufficient financial factors, and non-linearity pattern [2]. Since years of development, the use of mathematical models and the popularization of computers make online transactions even faster. It creates a market where long-term prospects shift to short-term moves and sell-offs. Significant advances in modeling techniques have prompted a variety of researchers to apply new innovated methods incorporating machine learning and stock market prediction.

The main modern algorithmic models have been used are Artificial Neural Network (often abbreviated as ANN), Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Long Short-Term Memory Networks (LSTM), Decision Trees, Time Series, etc. Here, the first two ANN and SVM models will be specially discussed since ANN and SVM are the most widely used and in an accuracy up to 99.9% using tick data [3]; KNN is the simplest model when little or no information about the data distribution is given [4].

Artificial Neural Network (ANN) is a bio-inspired dense network of neuron inter-connected by joint mechanisms and activated by inputs [5]. The inputs are ten different indicators, and the outputs are continuous values between 0 and 1. An output greater than or equal to 0.5 threshold predicts an upwards movement and downwards elsewise. Many researchers have found that ANN proved to be one of the best machine learning methods of stock prediction because it can avoid noisy data and adopt changing environment in stock market [6].

Yetis et al. [7] tested Artificial Neural Network (ANN) to predict the stock market prices. The trained ANN focuses on a layer feed-forward networks named Multi-Layer Perception (MLP). Under this setting, the NASDAQ historical data is split for training, validation, and testing generalization ability. They use regression to validate the performance and R score to measure the scoring metric. The result shows that the R scores for each step is of 0.99 or above, which means that when the stock price is greater than 3000, the error rate must be smaller than 2%. This indicates that ANN could provide individual or corporative investors with a reliable prediction of stock prices.

Akyildirim et al. [8] tested the return predictability of cryptocurrency by using Artificial Neural Networks and combining their classification algorithm with other machine learning techniques such as Support Vector Machine, Logistic Regression, and Random Forest. They considered twelve most liquid cryptocurrency and analyzed at the frequency of daily and minute level. It turned out that the returns in cryptocurrency markets can be predicted in daily or minute timescales consistently with classification accuracies successfully reaching up to 69%. The cryptocurrencies research average accuracy for all sample is around 55-60%.

Though the future is uncertain and unknown, people are still trying to find solutions to the turbulent stock market. Hence, this paper is to investigate some statistical methods combined with artificial intelligence algorithms that have been mainly studied and successfully applied to stock market prediction. To present and compare different models more precisely here, Tesla's stock price data is spectacularly being examined in this article. The reason for choosing Tesla as a case is that it has an impressive performance in the stock market during the past five years. Ever since new energy, especially electric vehicles have been taken part of the consumer market, Tesla has also been taking the lead in the high-tech companies as well as the stock market. In 2020, its share price increased 695% in merely one year and then rose another 50% in 2021. The projection of Tesla's outstanding performance certified that electric vehicles would still be a fast-growing segment of economy growth in the future. As a result, the study of Tesla's stock prediction seems to be more meaningful than other producer brands. The rest part of the paper is organized as follows. The Sec. 2 will introduce the data origination as well as the model construction. Subsequently, the results of the models will be demonstrated in Sec. 3. Afterwards, the explanation of the results and discussion of the interesting results will be presented in Sec. 4. Eventually, a brief summary will be given in Sec. 5.

2. Methodology

2.1 Model construction of ANN

As mentioned above, artificial neural networks are inspired by human neuron, where a sketch is presented in Fig. 1. The hundreds of millions of nuclei in the human brain are called neurons, and they are interconnected by axons. Synapses functions as transmitting signals between neurons, and dendrites are represented as receiving input [9]. Each neuron in this way receives signals from other neuron sides and transmits to each other. Synapses here is referred as weights, dendrites is referred as input, and axons is referred as output. In this figure, three layers of neurons are demonstrated, insist of one input layer, along with potentially multiple hidden layers and one output layer. Each node/neuron uses activation function that is activated when the total input exceeds a given threshold. The input layer is where raw information is collected from the environment. Whatever the type the information is, text or image, the value and its relative weight would be packaged and transmitted to the hidden layer. The hidden layer would construct transfer function and activation function to process

the complex mathematical algorithm on the input information. Once the functions have been called on, the output layer classifies the values and performs the results given from hidden layers.

The transfer function strictly follows the formula as:

$$f(x) = \sum_{i=0}^{n} x_i \omega_i + bias \tag{1}$$

The output of transfer function will be applied to the four types of activation functions, given by the formula below. They are known as binary step function, Sigmoid function, Tanh function, and Rectified Linear Unit (ReLU) function as following:

$$f(x) = \begin{cases} 0, x < 0 \\ 1, x \geq 0 \end{cases} \tag{2}$$

$$f(x) = \frac{1}{1 + e^{-x}} \tag{3}$$

$$f(x) = (e^{x} - e^{-x})/(e^{x} + e^{-x}) \tag{4}$$

$$f(x) = \max(0, x) \tag{5}$$

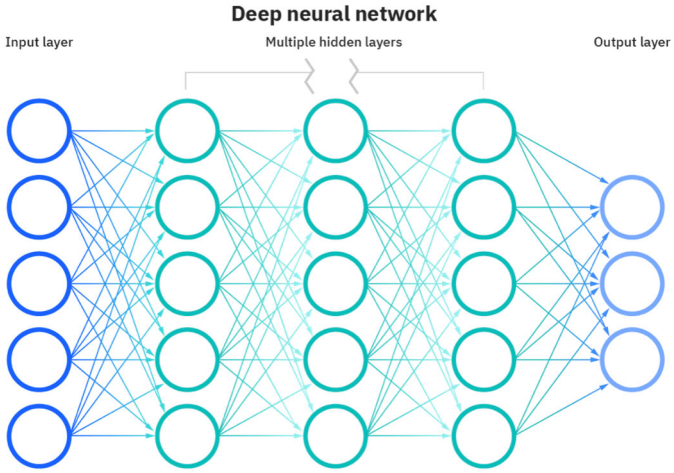

Fig. 1 Architecture of a multi-layer perception artificial neural network (ANN).

2.2 Data splitting and training process

In this study, the dataset of Tesla stock price on a monthly basis from 2019/10 to 2022/04 is collected. The five inputs are the highest price, the lowest price, the open price, adjusted close price, and trade volume at each day. The visualization of the open and close prices for Tesla in this dataset is shown in Fig. 2.

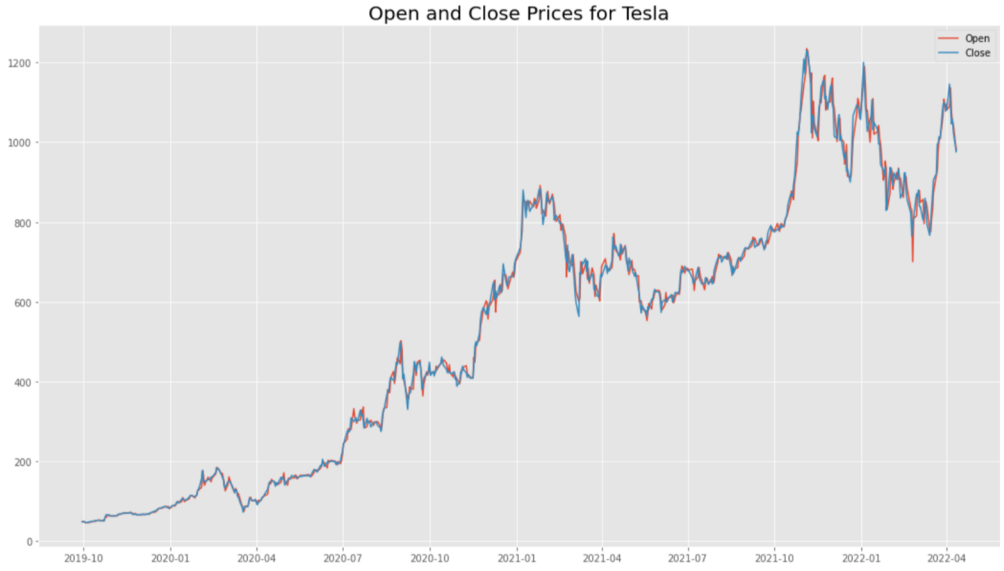

Fig. 2 Visulization of the Tesla price.

To split the data into training set and testing set for validation use, the original column "Date" will be dropped out since the data is already in the sequence of time. Under this setting, 30% of the cleaned dataset will then be randomly divided and used for testing. Keras sequential model in python is built to meets the network architecture. The first step is to ensure the input layer is consistent with input feature numbers, which can be clarified by specifying the input shape parameter in the code when creating the first layer. Here the parameter is set as (5,) meaning five input variables are examined as one vector. The next step is to decide which activation function to use in each layer. Though Sigmoid and Tanh function supposed be the better option for all layers, ReLU function shows better performance in Tesla dataset. The main reason is that it allows model to learn faster and work more efficiently when confronting with vanishing gradient. Fig-8 indicates that in the first layer, 16 nodes with 5 variables are set in and the function of ReLU will be executed. The training will pass through every row of the dataset, each one pass is called an epoch. Each epoch will be divided into several batches before weights getting updated.

3. Results

The training process of entire dataset by maximum 500 epochs is completed. The last line in Fig-9 gives the result that the R2 score for the neural network model is around 0.99. R2 score is the proportion of the predictable variable, which varies from 0 to 100%. Higher number means better correlation level of the valid model. Here, a 0.99 R2 score means that 99% of the total variance can be explained by the feedforward model. R2 score is closely related to Mean Squared Error (MSE), which is the average squared difference of the observed value and the predicted output. Lower number means smaller errors occurred. Here the result shows that the model fits 99% of the training data, the outcome and the original value are almost perfectly correlated. This result is reasonable because the regression plot of the output falls along a 45-degree line and follows a linear relation as depicted in Fig. 3. The figure represents that the actual data fits closely to the predicted data given by this feedforward neural network model (seen from Fig. 4).

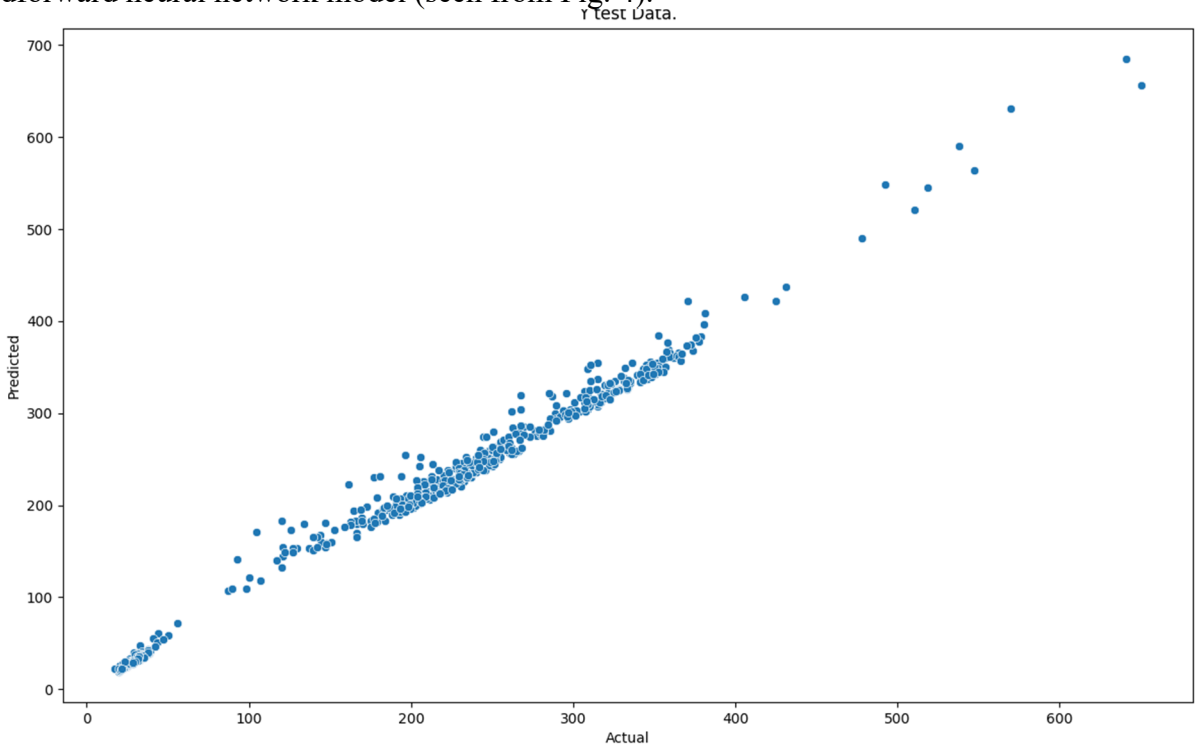

Fig. 3 Regression plot.

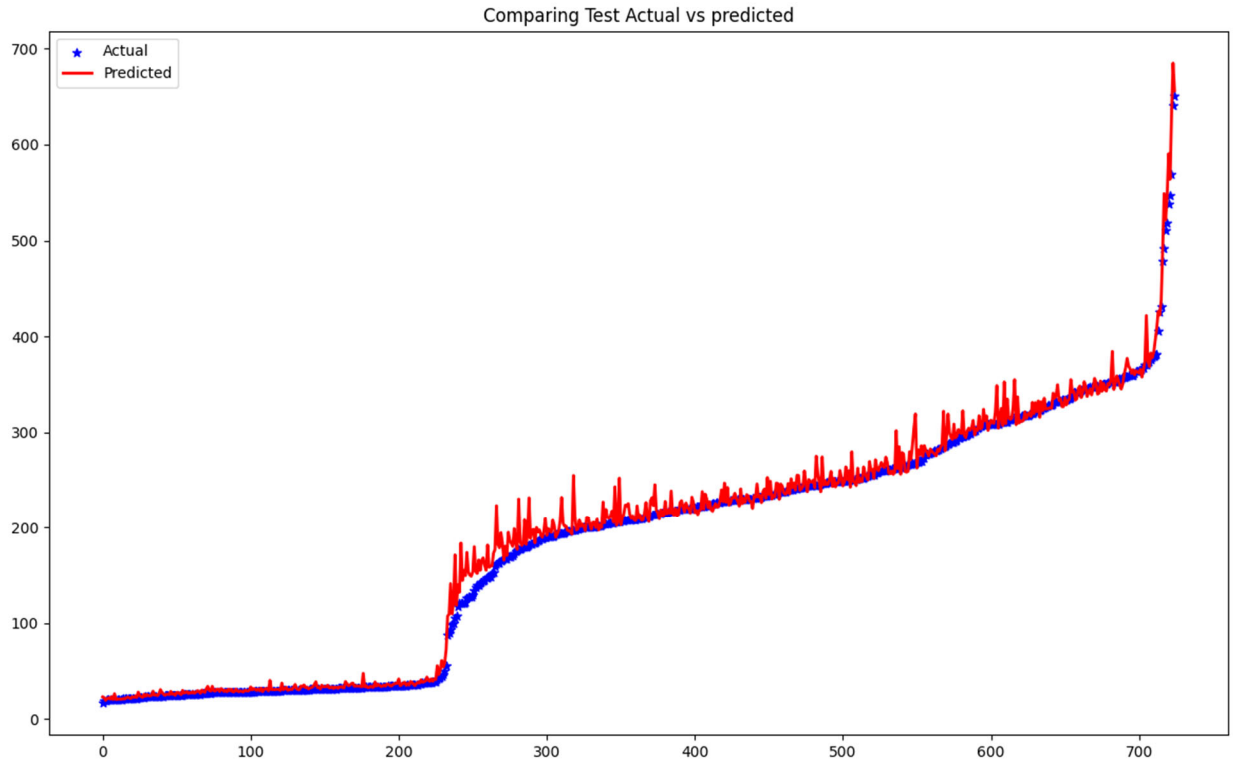

Fig. 4 Comparing Actual vs Predicted.

4. Discussion

Stock market data is fluctuant and non-stationary. It can be influenced by various non-economic related factors, such as word sense disambiguation. Hogenboom et al. consider that event detection is crucial to stock price prediction, since 70% of precision of buy and sell signal movement was improved after assessing high-impact events on stock market especially when looking into 2-days future [10]. Public sentiment arouse by news message can also imply the direction of stock price movement. Not to mention other exogenous shock such as international politic change, great pandemic spread like COVID-19. There is evidence everywhere show that the cruel oil price climbed to a considerably high level during the COVID-19 outbreak and even the post-COVID-19 period, which could reduce the market efficiency and thus impact forecasting accuracy. The ANN model in this experiment only takes 5 quantitative variables into account and gives a narrow analysis to the financial market.

In addition, the use of deep machine learning in stock field is limited to the vast majority. People usually start on stock trading with little expertise and techniques, which means most of the engagers buy and sell without actual analyzing. The manner of the stock trading market will be a chaos under this situation. Investors with good mentality may gain from this battle, but for those who play with luck it does not help them build a rational sense of stock transaction. The professional knowledge takes long time and effort to acquire. People may not be willing to master a model-building skill spending months or even years to make profits from stock. However, as machine learning has begun to penetrate almost every industries, the boundaries will one day be pushed and crashed by us own.

5. Conclusion

In conclusion, it has been proved that ANN as a machine learning model can perform extraordinarily in financial market forecasting. The fact ANN has been wildly recognized as one of the best methods in stock prediction attributed to its outstanding advantages. It is equipped with the ability of self-directed learning, storing information throughout the process, mapping with mass

information, processing unorganized data. In this case of using Tesla stock price for training and testing, ANN gives as high as 99% of accurate predictability with five input variables. In the future application of deep machine learning algorithm in stock prediction field, ANN model apparently worth further implementation and enhancement. It can also be presumed as a prior tool for individual and corporate investors to predict the movement of stock prices and make wiser trading decisions. However, some have found that the performance of accuracy and efficiency in prediction may vary according to different object selection. Similarly in this study, only Tesla's stock price data has been chosen as an experimental subject. There may exists other possibility that ANN model can give weak evidence against the hypothesis and fail to predict the ideal outcome. Overall, these results offer a guideline for implementing ANN model to stock price prediction.

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