

Hybrid Deep Learning Model for Stock Price Prediction

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Abstract—In this paper, we propose a novel stock price prediction model based on *deep learning*. With the success of deep learning algorithms in the field of Artificial Neural Network (ANN), we choose to solve the regression based problems (stock price prediction in our case). Stock price prediction is a challenging problem due to its random movement. This hybrid model is a combination of two well-known networks, Long Short Term Memory (LSTM) and Gated Recurrent Unit (GRU). We choose the S&P 500 historical time series data and use significant evaluation metrics such as mean squared error, mean absolute percentage error etc., that conventional approaches have used. In experiment section, we have described the effectiveness of each of the component of our model along with its performance gain over the state-of-the-art approach. Our prediction model provides less error by considering this random nature (change) for a large scale of data.

Index Terms—LSTM, GRU, DNN, Hybrid-network, Stock price prediction

I. INTRODUCTION

In recent years, stock price prediction has been one of the continuously studied area in computational finance research. Stock price prediction is one of the most challenging task due to its highly dynamic nature. The movement of price seems to be highly random event and capturing price movement is a challenging task. With the success of Artificial Neural Network (ANN) in different prediction tasks, researchers are more interested to deploy high level machine learning approaches to build better prediction models. Some of the modern application areas of ANN include autonomic car driving, robot aided surgery, guidance of intelligent drones, software development, nuclear physics, and finance [1].

Deep Neural Network (DNN) is an advanced branch of ANN. During past few decades, DNN has gained enormous popularity due to its effectiveness on prediction based problems. DNN has been showing promising performance for problems such as speech recognition, natural language processing, computer vision, robotics, computational finance. By

considering these as motivation, we propose a stock price prediction model based on DNN. Stock price prediction is a regression based problem. The problem of predicting stock price can be formally stated as, given historical data (open/ close/ high/ low price, trading volume etc.) of last n number of days for a particular stock or index, predict the next day closing price.

In applying advanced machine learning approach for stock price prediction, the problem is formulated as a regression based problem. With the evolution of Recurrent Neural Network (RNN) [2] in different research areas, researchers started applying RNN to solve regression based problems with sequence data. One most important problem encountered while training the network using RNN is that it can not keep track of long input dependencies [3] while training. To process big dataset, RNN and conventional approaches take long time. The main goal of this research is to provide a faster and more accurate neural network method.

To achieve our goal, we propose hybrid model that consists of two well-known DNN approaches: Long Short Term Memory (LSTM) [4] and Gated Recurrent Unit (GRU) [5]. These architectures allow us to deal with providing prediction based on (historical) stock prices. We have done extensive experiments to show the effectiveness of the proposed hybrid model in the experiment section. The architecture of propose network is simple enough to deal with training, testing and validating the dataset. Our dataset is S&P 500 time series data. The major contributions of this study are:

- Our proposed model is trained on large historical data (about 66 years). We compare our model with state-of-the-art work in literature and show that our model yields better result in terms of mean square error(MSE).
- The proposed model is capable of handling the large variations in stock price by avoiding over-fitting.
- To the best of our knowledge, this is a first attempt in using deep learning based hybrid approach to solve stock