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***Abstract*—This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet. **CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.* (*Abstract*)**

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I. INTRODUCTION (*HEADING 1*)

In the twenty-first century, the economic well-being of every developing country and society mainly relies on their market economies and stock price [1]. However, as there are various uncertainty factors associated with these economic indexes, including social factors, pandemics, and political events, the financial markets are often difficult to predict [2]. For stock market prediction, three main approaches namely fundamental analysis, technical analysis, and technology methods are used. Fundamental analysis concerned about the company itself, rather than the actual stock. However, the data used by fundamental analysis are often unstructured, and difficult to analyze [3]. Meanwhile, technical analysis predicts the stock price based on the trends in the past and present stock price. However, the accuracy of traditional technical analysis is limited by the current computational abilities [4].

Due to the advancement of electronics industries and associated computation technologies, there has been numerous interests on using the artificial intelligence (AI) technologies in stock price prediction. In the context of using AI in stock price prediction, machine learning has been widely reported among the stock prediction community. In a recent study, Chen et al. reported a two-stage prediction model for stock price prediction. In the 1st stage, next-instance stock price was predicted using a proposed hybrid model combining eXtreme Gradient Boosting (XGBoost) with an improved firefly algorithm (IFA). Next, mean-variant model is utilized for the selection of portfolio, based on the shortlisted high-return stocks. The advantage of this model includes capturing the future traits of stock market and utilizing XGBoostxIFA model to improve the accuracy, but it is challenging to use XGBoost to accurately predict the complexity and diversity of the input data [5]. On the other hand, Vijh et al. utilizes machine learning techniques to predict the next-day stock closing price using algorithms such as Artificial Neural Network (ANN) and Random Forest (RF) techniques. ANN is used for predicting the next day closing price of the stock, whereas RF is used for a comparative analysis. The best values obtained by ANN model gives RMSE (0.42), MAPE (0.77) and MBE (0.013) [6]. Nevertheless, machine learning has limitations in accuracy, due to excessive sensitivity and over-fitting [7]. Thus, other approaches, such as deep learning and reinforcement learning shall be explored.

As a subset of machine learning, deep learning is also explored in stock price prediction. Fundamentally, machine learning uses algorithms to parse data, learn from that data, and make informed decisions based on what it has learned [2], [8], [9]. In the context of stock prediction, the data will be Level 2 data, which includes the scope of bid and ask prices for a given stock that shows the total quantity of units of the asset available to buy or to sell at each price which has been quoted [10]. On the other hand, deep learning structures algorithms in layers to create an ANN that can learn and make intelligent decisions on its own. A recent work reported by Althelaya et al. evaluates Long- Short Term Memory (LSTM) deep learning architectures for short- and long-term prediction of financial time series. In the reported work, Bidirectional LSTM (BLSTM) where the preceding and succeeding input sequences can be used to exploit all input data, and Stacked LSTM (SLSTM) network where several LSTM layers are stacked, are used in long- and short-term stock market prediction. The results showed that both BLSTM and stacked LSTM networks produced better performance for predicting short-term prices as opposed to the long-term prediction results [11]. As compared to machine learning technique, deep learning technique has higher complexity which can predicts the stock market more accurately. However, Selvin et al. reported that LSTM is not able to capture sudden changes in stock market. The changes occuring in the stock market may not always be in a regular pattern or may not always follow the same cycle [9]. Thus, the stock prediction community proposed more sophisticated prediction algorithm, such as reinforcement learning.

Reinforcement learning is an autonomous, self-teaching system that essentially learns by trial and error. As differed from deep learning, deep learning is learning from a training set and then applying that learning to a new data set, while reinforcement learning is dynamically learning by adjusting

actions based in continuous feedback to maximize a reward. Reinforcement learning has various algorithm, one of them is the state-of-the-art Asynchronous Advantage Actor-Critic (A3C) developed by Google Deep Mind [12]. In the context of stock price prediction, Zhang et al. recently reported that reinforcement learning algorithms (including A3C) outperformed baseline models on 50 liquid futures contracts from 2011 to 2019, delivering profits even under heavy transaction costs [13]. In developing a deep robust reinforcement learning for algorithm-based stock trading, Li et al. proposed a combined LSTM unit and A3Calgorithm, enabling to resolve the partial observability and discover latent patterns [14].

In this work, both machine learning and deep learning techniques will be used for the stock price prediction using Level-2 market data. Taking various factors into considerations (robustness, complexity, access to resources, project timeline etc.), algorithms, including Xgboost and LSTM will be used. The details of the algorithm development will be described in the next sections.

II. Approaches Attempted

A. *Approach 1*

Explanations on approaches tried and rationale for each

B. *Approach 2*

Explanations on approaches tried and rationale for each

III. Visualization

A. Subchapter 1

Text here

B. Subchapter 2

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IV. Analysis

A. Subchapter 1

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B. Subchapter 2

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V. Discussions of Results

A. Subchapter 1

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B. Subchapter 2

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