Stock Price Prediction:
Fuzzy Clustering–Based Approach

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INTRODUCTION

Forecasting the stock market index and index movements is one of the most challenging time series analysis obstacles. Investors use two types of analysis, fundamental and technical analysis, before investing in stocks. With fundamental analysis, investors decide whether to invest, taking into account indicators such as the stock's actual value, the political climate, the industry's performance, and the economy. In technical analysis, the evaluation of stocks is provided by using statistics created by market movements such as historical values and transaction volumes (Pabuççu, 2019).

Investors are beginning to rely on forecasting systems to make critical business decisions. There is a lot of research done in this field, but no complete solution has yet been found. Difficulty in predicting the stock market depends not only on the influence of social, political and economic reasons but also on a vast amount of historical data about the stocks and currency (Iqbal et al., 2013). This study consists of many states of the art machine learning techniques to find optimum solutions for predicting stock values.

In the literature, there are two types of approaches to forecasting a stock price. These are qualitative and quantitative approaches. The quantitative approach uses past stock prices, such as the closing and opening price, the amount exchanged, neighbouring closing rates of the stock etc., to forecast the stock's future price. In the qualitative approach, the analysis is based on external factors: economic and political factors, company's identity, company's and general market situation etc. In this approach, textual information published in the magazine or web and social media blogs are used, written by economic experts (Hur et al., 2006).

This study aims to predict bank stocks: AKBNK, GARAN, HALKB, YKBNK and VAKBN in BIST 30 index. For that reason, the authors use the last three years' BIST 30 index values for predicting those stocks values. Also, the fuzzy clustering technique is applied to the dataset to find stocks in BIST 30 index and have similar characteristics with predicted bank stocks. The main reason for this approach is to test whether enlarging the data set to be used in the prediction phase positively affects the performance of the algorithms.

The authors applied classical machine learning algorithms such as Random Forest, Support Vector Machine etc. But, ensembling types of machine learning algorithms such as XGBoost, Catboost, LightGBM and GBDT produced more promising results with different hyperparameters for the prediction. Besides, the most successful models with their hyperparameters were ensembled according to their er-

ror rate's reciprocal for better prediction performance. These results were compared with the traditional methods, and it is discussed in the methodology section.

In this paper, the details of the methodology are provided in Section 2. Section 3 discusses the result of the findings, and Section 4 concludes the article.

BACKGROUND

In the era of big data and machine learning, with historical data usage, there are many studies conducted on the literature for predicting stock prices in several stock markets such as NASDAQ, Chinese Market etc. Recent works show us machine learning and deep learning technics can be used for predicting future stock prices. Li et al. (2017) and Oyeyemi et al. (2007) used neural networks such as Convolutional Neural Network (CNN), Artificial Neural Network (ANN), Long Short-Term Memory (LSTM) and Recurrent Neural Network (RNN) for predicting stock prices. Due to high-level noise in stock markets, Shen and Shafiq combined a customized deep learning-based system for predicting stock market price trends (Shen et al., 2020). Thus Artificial Neural Networks proves to be successful in predicting stock price; Wang et al. applied artificial neural networks for stock market price prediction with the dataset related to the S&P 500 (Xiaohua et al., 2003). Kim and Han also used ANN with genetic algorithms for predicting stock price index (Kim et al., 2000). Besides, RNN and LSTM prove to be successful in stock market price prediction. Selvin et al. built a comparative model approach for stock price prediction using LSTM, RNN and CNN-sliding window models (Selvin et al., 2017). Zhuge et al. (2017) used LSTM with Emotional Analysis to predict stock price. Jaiswal et al. (2022) applied a comparative analysis on stock price prediction model using deep learning technology. In addition to deep learning technics, machine learning technics are applied to solve stock price prediction problems. Shen et al. (2012) Hongming (2020), and Rajeswar et al. (2022) applied traditional machine learning algorithms such as SVM and Logistic Regression, Linear Regression to predict stock prices. Also, Khan et al. (2020) used the Random Forest classifier to improve forecasting accuracy using social media and news with natural language processing techniques. Known from the literature, ensembling machine learning algorithms have promising results in machine learning problems. Hongming (2020) applied ensembling type boosting algorithms such as Extreme Gradient Boosting etc., to stock data for predicting stock price prediction. Akşehir and Kılıç (2019) use some bank stocks in BIST market data for predicting their stock prices with machine learning technics. Demirel (2019) applies machine learning and deep learning techniques to predict stock prices in the BIST 100 index. Pabuççu (2019) aims to predict stock market movement using ANN and machine learning algorithms such as Naive Bayes and SVM in BIST 100 index. Deep learning technics and ensemble learning technics are also used together for predicting stock prices in the literature. Kumar and Lokesh (2022) use ensemble learning technics and Deep learning technics together for predicting stock prices.

Fuzzy logic is an area of great importance in the literature on its own. Although its use in machine learning approaches has increased recently, the number of fuzzy machine learning studies in the literature is insufficient. Not all of the features used in machine learning problems contain certainties such as 1 or 0. Combining the power of the fuzzy logic approach with machine learning can increase the success rate in prediction. Besides, Fuzzy logic is commonly utilized in the literature to expand machine learning and data mining research. Fuzzy logic methods are used for this purpose, particularly in clustering and association rule mining research.

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