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Research Paper

Presenting the Forecasting Model of Analysis of Capital Market Signals Using (CEEMD-DL(LSTM)) Approach[1]

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INTRODUCTION

Machine learning (ML) is a branch of artificial intelligence that progressively enhances its performance on a specific problem by devising various algorithms. Numerous studies have demonstrated that predictions based on ML models exhibit relatively superior performance compared to classic time series forecasting techniques. Recently, deep learning (DL), a subset of machine learning methods based on neural networks, has garnered significant attention in financial forecasting. The profound capabilities of DL in extracting valid information from datasets and identifying powerful patterns have prompted many recent articles to focus on integrating DL algorithms with market predictions, making it one of the most intriguing topics in financial literature (Cavalcante et al., 2016).

Concurrently, signal decomposition methods have emerged as new and highly effective techniques in signal and time series analysis. In these methods, the original signal is decomposed into several sub-series, and the resulting data is fitted with

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appropriate equations to develop a predictive model. One such method is the complete ensemble empirical mode decomposition (CEEMD).

Given the critical role of forecasting in financial markets, this research introduces the hybrid CEEMD-DL (LSTM) model for the first time in Iran, combining deep learning models with the CEEMD method, to forecast the Tehran Stock Exchange index. Subsequently, the efficiency of the proposed model is compared with traditional models in the field based on efficiency measurement criteria. It is anticipated that utilizing the CEEMD-DL (LSTM) model will enhance the efficiency and accuracy of forecasting stock market indicators.

MATERIALS AND METHODS

In this research, the Tehran Stock Exchange index is forecasted using the CEEMD-DL (LSTM) hybrid model. In this model, the original time series is decomposed into intrinsic mode functions (IMF) using the CEEMD algorithm. Subsequently, deep learning models with LSTM structure and specialized aggregation rules are employed to generate the final predictions. To assess the performance of the presented model and compare it with competing models, three criteria—SMAPE, MAPE, and RMSE—are utilized.

RESULTS AND DISCUSSION

To estimate the final model of the research, the total index of the Tehran Stock Exchange underwent a decomposition stage where seven intrinsic mode functions (IMF) were extracted. These IMFs were then utilized in the training process of the deep learning model with LSTM layers. Subsequently, the final consolidation process was employed to forecast the Tehran Stock Exchange index. Efficiency measurement criteria were calculated for the main research model, CEEMD-DL (LSTM), as well as two traditional models commonly used in this field (LSTM and CNN). The results indicate that the CEEMD-DL (LSTM) model exhibits higher efficiency compared to the other two models. Additionally, the deep learning model with LSTM structure ranks next in terms of efficiency. These findings underscore the positive impact of utilizing signal analysis algorithms in enhancing the efficiency and accuracy of deep learning models.

CONCLUSION

In this research, the hybrid CEEMD-DL (LSTM) model was utilized to forecast the Tehran Stock Exchange index by combining deep learning models and complete ensemble empirical mode decomposition (CEEMD). Daily data of the total index of the Tehran Stock Exchange spanning from December 1, 2012, to February 20, 2022, was employed, and the results were compared with those of competing models using efficiency measurement criteria. The findings indicate that the introduced model (CEEMD-DL (LSTM)) exhibits higher efficiency and accuracy in forecasting the stock exchange index. These results align with recent studies in this field, such as those by Lin et al. (2021) and Zhang et al. (2020), which highlight the enhanced efficiency of deep learning models through the use of signal decomposition algorithms.

Keywords: Deep Learning Models (DL), Complete Integrated Empirical Mode Decomposition (CEEMD), Tehran Stock Exchange Index, Long-Short-Term Memory (LSTM), Convolutional Neural Network (CNN).

JEL Classification: E37, C61, C45, G18.