

HYBRID CNN-LSTM MODEL FOR MINUTE-WISE STOCK MARKET PRICE PREDICTION

Mudiyanse Rasika Gayani Vijithasena
209387N

Master of Science in Computer Science

Department of Computer Science and Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka

August 2022

HYBRID CNN-LSTM MODEL FOR MINUTE-WISE STOCK MARKET PRICE PREDICTION

Mudiyanse Rasika Gayani Vijithasena

209387N

Thesis submitted in partial fulfillment of the requirements for the degree
Master of Science in Computer Science

Department of Computer Science and Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka

August 2022

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The supervisor/s should certify the thesis/dissertation with the following declaration.

The above candidate has carried out research for the Masters thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of the supervisor: Dr. Sapumal Ahangama

Signature of the supervisor:

Date:

ACKNOWLEDGEMENT

First and foremost, I'd want to express my heartfelt gratitude to Dr. Sapumal Ahangama, my research supervisor, who guided me by providing supervision and direction, which greatly aided the research's progress and smoothness. Dr. Charith Chitraranjan and all of the lecturers at the Department of Computer Science and Engineering have been extremely supportive, encouraging, and guiding us in making the most use of our knowledge and abilities.

In addition, I would like to thank all of my colleagues for their help in locating useful study materials, sharing their knowledge and experience, and supporting me.

As usual, my parents and sisters deserve special thanks for their unfailing love and support throughout my life. Last but not least, I'd like to express my gratitude to all of my classmates for extending their kind hands in support of the research's success.

Abstract

Stock market prediction is considered as a challenging problem because of the non-linear and dynamic price changes in stock markets. And need to deal with high volume and high frequency data. Despite the fact that a variety of machine learning and deep learning approaches can be applied to construct prediction algorithms, stock value prediction is difficult due to the high frequency data. Economic factors such as change in corporate policy, economic shifts, expectations of investors, other stock markets' movements and government change influence the stock market movements. When developing a prediction model, these influenced factors need to be considered to get highly accurate results. The successful stock market prediction results in better decisions and high profits.

Minute-wise stock market prices provide better understanding about stock price behavior within a particular day. Since it is very important to thoroughly analyze stock price behavior to make trading decisions, analyzing and predicting trading trends within a day is very crucial. Rather than predicting daily close price, open price and highest price, if we can predict the next upcoming couple of minutes or hours stock price with highest accuracy, then it is a great improvement in stock market prediction. Stakeholders including buyers and sellers can get good predictions and they can make proficient decisions on time.

This paper considers implementing a hybrid CNN-LSTM model to predict minute wise stock market prices by using minute-wise stock market data which provides a best performance. Stock market data of different companies including Apple, Google and Amazon were collected from Yahoo Finance API. As for the evaluation, several benchmark models were created and compared their performance with the proposed model. Furthermore, proposed model was evaluated using various datasets and timeframes. The next 5 minutes forecasted stock prices were compared with the actual prices and measured the performance of model. In this research, as for the evaluation metrics, Mean Absolute Percentage Error and Root Mean Square Error were used and the best model was selected considering the validation results. Models were fine-tuned using different time windows, model parameters and selected the best parameters for the forecasting model. Finally, the proposed model outperformed the state-of-art models for predicting short-term stock market values.

Keywords - Deep learning; LSTM; CNN; Hybrid CNN-LSTM; Machine Learning; Stock price prediction;

TABLE OF CONTENTS

Declaration	i
Acknowledgement	ii
Abstract	iii
Table of contents.....	iv
List of Figures	vi
List of Tables	vii
List of Abbreviations.....	viii
1. Introduction	1
1.1 Introduction	1
1.2 Background	1
1.2.1 Usage of Machine Learning and Deep learning for Stock market Prediction	2
1.3 Research problem	3
1.4 Objectives	4
1.5 Motivation	4
1.6 Summary	5
2. Literature Review	6
2.1 Introduction	6
2.2 Stock market prediction	6
2.3 Process of developing stock market developing system	8
2.4 Machine Learning based related works	9
2.5 Deep Learning based related works	11
2.6 Minute-wise stock price prediction research studies	22
2.7 Summary	25
3. Methodology	26
3.1 Introduction	26
3.2 Data Collection	26
3.3 Analyzing data	27
3.4 Data Pre-processing	27
3.5 Attribute Selection	28
3.6 Model Development	29
3.7 Summary	36
4. Evaluation	37
4.1 Introduction	37
4.2 Descriptive Data Analysis Results	37
4.3 Evaluation for forecasting model	41
4.4 Evaluation metrics	42
4.5 Evaluation results	43

4.6	Discussion	54
4.7	Summary	56
5.	Conclusion	57
5.1	Introduction	57
5.2	Overview of research	57
5.3	Limitations	58
5.4	Future works	59
5.5	Summary	59
	References	60

LIST OF FIGURES

Figure	Description	
Figure 2.1	Fundamental Analysis approach	7
Figure 2.2	Technical Analysis Approach	7
Figure 2.3	The process of Stock market prediction model	8
Figure 2.4	Real time stock market prediction model	13
Figure 2.5	CNN-LSTM model structure	14
Figure 2.6	Process flow diagram of Proposed IKN-ConvLSTM model	15
Figure 3.1	LSTM logic	30
Figure 3.2	The architecture of CNN-LSTM.....	31
Figure 3.3	CNN-LSTM architecture	31
Figure 4.1	Apple closing price visualization	37
Figure 4.2	Google closing price visualization	38
Figure 4.3	Amazon closing price visualization	38
Figure 4.4	Apple moving average visualization	39
Figure 4.5	Amazon moving average visualization	39
Figure 4.6	Google moving average visualization	39
Figure 4.7	Apple Volume change visualization	40
Figure 4.8	Google Volume change visualization	40
Figure 4.9	Amazon Volume change visualization	41

LIST OF TABLES

Table	Description
Table 2.1	Summary of Deep Learning based stock price prediction models 17
Table 2.2	Summary of Minute wise stock price prediction models 23
Table 3.1	Parameter details of proposed model 33
Table 3.2	Parameter details of benchmark model 1 34
Table 3.3	Parameter details of benchmark model 2 34
Table 3.4	Parameter details of benchmark model 3 35
Table 3.5	Parameter details of benchmark model 4 36
Table 4.1	Comparisons results with benchmarks for Apple dataset 44
Table 4.2	Comparisons results with benchmarks for Amazon dataset 44
Table 4.3	Comparisons results with benchmarks for Google dataset 44
Table 4.4	Validation results of proposed model 46
Table 4.5	Validation results on different datasets from different domains 47
Table 4.6	Validation results for different time windows 48
Table 4.7	Comparison results based on different model parameters 50
Table 4.8	Evaluation results of forecasting results 51
Table 4.9	Evaluation results of parameter analysis - benchmark 1 52
Table 4.10	Evaluation results of parameter analysis - benchmark 2 53
Table 4.11	Evaluation results of parameter analysis - benchmark 3 53
Table 4.12	Evaluation results of parameter analysis - benchmark 4 54

LIST OF ABBREVIATIONS

Abbreviation	Description
ANN	Artificial Neural Network
RF	Random Forest
CNN	Convolutional Neural Network
RNN	Recurrent Neural Network
NN	Neural Network
MAPE	Mean Absolute Percentage Error
LSTM	Long Short-Term Memory
SVM	Support Vector Machine
RMSE	Root Mean Square Error
HMM	Hidden Markov Model
DL	Deep Learning
SVR	Support Vector Regression