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Investor Driven Adaptive and Automated Stock Market Portfolio Management Platform with Stock Prices Prediction for Colombo Stock Exchange of Sri Lanka

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ABSTRACT Over the past few years various studies have been conducted to develop an optimum stock market related portfolio management platform that will assist investors to actively perform the portfolio management process. Risk and level of investor participation is considered to be one of the challenging aspects identified for optimum portfolio management. Along with portfolio management, stock price prediction is one of the key contributing factors that helps an investor to make mid and long-term strategic investment decisions. Various concepts are evaluated and studied thoroughly to determine the most accurate algorithm to implement a stock price-based prediction system. Currently, Colombo Stock Exchange have identified a desperate requirement of a portfolio management system with prediction capabilities to support the local and foreign investors to actively engage in trading activities in different stock exchanges in different countries. A critical study has been conducted using supportive research papers, studying similar applications which are developed so far and using various requirement elicitation techniques to determine the functional requirements, non-functional requirements, investor requirements and User Interface/User Experience (UI/UX) considerations. The paper further describes various technological mechanisms implemented and system architectures used to develop the portfolio management and stock price prediction system. Accordingly, the implementation of Brownian Motion algorithm-based model and LSTM (Long Short-Term Memory) model are presented in detail by the author. Finally, evaluation and testing results of the completed system and stock price prediction models are presented to prove the successfulness of the completed application and accuracy of the models implemented.

KEYWORDS: CSE, LSTM, portfolio, prediction, stock

I INTRODUCTION

[1] Stock market portfolio management can be defined as a technique or an art of analyzing or overseeing, selected number of interested group of shares in order to achieve long term financial goals and objectives. The ultimate requirement of the portfolio management is to weigh the strengths, weaknesses, opportunities, and potential threats over selected number of stocks. In portfolio management an investor is intended to increase the investment returns under a deuterated risk level within a specific period of time. In the non-automated process, an investor requires to re-balance his/her stock portfolio manually according to the trading activities conducted over the time. Following are the actions or tasks that needed to be performed by an investor in the manual process to manage the stock market related investments:- re-evaluate the financial value of the current stocks if purchased before, re-evaluating the investor depending on the investment strategy by analyzing the stock selection criteria used previously such as stock purchasing sectors e.g.-health care, leisure and entertainment, business etc., manually analyzing the current market value of stocks which are preferred to be purchased by each public listed company, summing up the total investment and deciding the percentages of possible returns expected, calculating and evaluating the expected returns with real returns and deciding sectors to add or drop based on returns[2].

Stock prices prediction is an act of forecasting the future stock prices of a particular public listed company. Currently many countries including NYSE (New York Stock Exchange) provide predictions to the investors to increase the profits or return of investors by investing at the present time. There are various arguments related to success of prediction, since there could be various macro and micro economic factors influencing to fluctuate the stock prices. Stock market related operations are uncertain in nature and most of the investors feel insecure and unconfident when managing their investment portfolio on

stock exchanges among different countries. One of the prime concern of investors, stakeholders and any other individual in the financial market is to successfully manage the stock market portfolio. On the other hand, investors face various difficulties in identifying public listed companies which have a sound growth prospects for investment.

In the current situation, Colombo Stock Exchange would not offer a feasible platform for the investors to manage, view, analyze and forecast the future behaviour of the stocks purchased by an investor. Currently many investors driven stock purchasing platforms are introduced in Srilanka and as well as in other foreign countries where investor could directly engage in buying/selling without any assistance from stockbroker or brokerage firm. With the development of said platforms, a need of a stock portfolio management and prediction platform are identified. Web and mobile responsive application is developed to facilitate the investors to manage and analyze local and foreign stock portfolio by including stock prices prediction module which support the investors to make decisions based on predicted behaviour of a particular stock.

II PROBLEM DOMAIN

Currently in Sri Lanka, investors obtain assistance from various stock-brokering firms where stock broking advisors would assist an investor by advising, predicting the market, and managing the portfolio for the best investment return. On each transaction conducted on behalf of the investor a certain amount of brokerage is charged by the stock-brokering firm. If a local investor is interested to invest on international stock market either an investor could start purchasing stocks through an online platform using an E-wallet with dollar account or through a stock-brokering firm who is specialized in with international stock market transactions [3]. On considering the local/international situations if an investor needs to obtain a quick analysis or update of the current portfolio status, gains, loss, or any other information, he/she needs to request a portfolio summary through the broker or through the portfolio management access granted by the stock brokering firms. [4] CSE and Central bank of Sri Lanka have identified various frauds or illegal attempts actioned by stockbrokers due to lack of proper concertation, lack of knowledge on share market activities or lack of updated portfolio analysis knowledge with the investor. Due to the continuous fraud, malpractices and untransparent actions conducted by stockbrokers, CSE have identified a reluctance of potential investors to invest on share market and actively engage in large volumes of shares. One of the most popular incidents is Securities and Exchange Commission (SEC) filing a court cases against four well known stock brokering firms that have been operating over past few years. According to the SEC, these stocks brokering firms had involve in certain manipulation or creating abnormal/misleading situation with regard to a share price named “Radiant Gems International PLC” in 2011 which have interfered the smooth functioning of the share market. This has result in losing the credibility with regard to the shares among investors who have currently purchased shares or intended to purchase in the future.

At present Colombo Stock Exchange does not facilitate investors with an official stock market portfolio management platform with prediction capabilities. In the course of addressing the above-mentioned problems one of the drawbacks CSE has identified is the unavailability of fully responsive, functional, user friendly, ubiquitous, and free platform to add and manage the stocks own by an investor in his/her local or international portfolio. Stock prices prediction system would also assist an investor to make the most accurate financial strategic decisions before investing in a particular share according to the predicted data. This development will be the first official stock market portfolio management and prediction system for CSE in Sri Lanka.

III LITRETURE REVIEW

A thorough analysis of previous literature has been conducted prior to the design and development of the system to obtain an in-depth knowledge on related theories, concepts that are related to the study.

A *A. Stock Price Prediction Using LSTM, RNN AND CNN-Sliding Window Model*

[5] Forecasting could be defined as predicting the future behaviour or trends based on analyzing the relevant past historic data. Predictions are used in various systems in the industry such as in business sector, health care, education, time related activities etc. According to the paper forecasting could be divided in to three types- short term, medium term, and long-term forecasting. The main difference between forecasting types is the duration predicted in the future. To provide prediction a variable is considered, in the paper **”price”** is considered as an important variable. Stock price forecasting could be performed using various methods such as technical analysis, fundamental analysis, and time series-based forecasting. In Fundamental analysis the investment on a particular stock price is decided based upon the analysis on profits/returns, sales and other economic (micro and macro) factors. This is mainly suited for long term forecasting. Technical analysis uses the previous data (past stock prices) in order to predict the possible future price. Average/Mean is considered to be the main algorithm used to provide the predictions on the said type of analysis. It is mainly suited for short term forecasting. Time series-based forecasting mainly involve two types of algorithms namely, linear model and non-linear model.

Series of time related data are analyzed and studied along with algorithms to predict the future. Based on the two types of algorithms the paper has stated linear models are not capable to identify a pattern or trend in a set of considered data. Inability to identify the latent dynamics within the data is considered to be the main reason for the above said drawback. Nonlinear model utilizes methods such as deep learning, neural networks and various other algorithms in order to provide predictions. The paper further evaluates concepts such as Multi-Layer Perceptron (MLP), Recursive Neural Networks (RNN), Convolutional Neural Network (CNN) and other types of machine learning techniques such as image processing, natural language processing which are utilized in testing the suitability to stock price predictions. One of the most feasible and proven method suggested by the paper is algorithms based on deep learning concepts. After completing several levels of self-learning process, deep learning has been able to identify a pattern, hidden trend and dynamics underlying with in the data analyzed.

Based on results of an experiment conducted by the author the paper recommends Convolutional Neural Network (CNN) predictions are more accurate when compared with the predictions from Recursive Neural Networks (RNN) and Long Short-Term Memory networks (LSTM). Since CNN does not rely on previous/historic data or information for prediction CNN model has been able to provide proven results. The CNN prediction process understands the patterns/dynamic changes in the current window. This is considered as one of the prime reasons for providing more accurate prediction results. LSTM and RNN depends on the historic information or data to predict the instances of the future. However, for short term predictions RNN and LSTM model were able to provide more accurate predictions according to the results of the experiments concluded by the author.

B MobiMine-Stock market monitoring platform

[6] MobiMine is an intelligent cross platform accessible system for monitoring and analyzing stock market related data through a distributed data mining process. Investors could store the current portfolio related data on the application to manage and monitor the stocks. One of the important factors identified through the research paper is watchlist feature that allow investors to concentrate the stocks that they are interested to buy in the near future. The application is capable of constructing relationships between the data collected from various finance related data sources and the ultimate objective of identifying specific focus area of the investor to provide an enhance analysis process based on one's interest. Using the datamining process, details of a customized wish stock list will be delivered through the application. Existing portfolio management system depends on a manual input of wish stocks (stocks that are expected to purchase in the future). Manual based construction of watch list feature using the predefined focus area of the investor is often cumbersome and unpractical since investor cannot keep watch and analyze the market for a longer period of time when he/she is on the move. Investor based customize focus area development is the main requirement addressed through the application and it is focused on improving the watch stock list feature. Challenges faced by the author on developing above process are- difficulties on handling continuous flow of data from many incoming data streams, managing the limited wireless/ GSM network bandwidth when conducting the data mining process, representation of highly informative data within a limited small screen and managing the battery consumption when conducting high computational and processing tasks.

The application has been developed according to the client-server architecture where investors run the application on any type of handheld devices where as Mobine server sources the financial data streams. To ensure the smooth functioning of the application, it is designed to work without any issues on wireless low bandwidth network connections.
The main functional requirements addressed by the MobiMine application are as follows-
Portfolio Management- each investor is provided with a dashboard to manage, analyze stocks and to evaluate between different stocks performance, gains, losses etc. The investor could edit or delete details related to their stored portfolio from the application.
Area of Focus/Interest- The application delivers a more unique approach to track and monitor changes in the market by dividing the selected events as "interested to investor". The following are delivered through the focus area of the application- **Watchlist feature-** Each stock added by the investor on this section is assigned with a score. A higher score means more interesting and lower score means less interesting. The higher score marked stock are given more priority when delivering related data specific to that stock. Modules such as stock connection, stock nuggets and reporting module are different collection of services provided by the application to understand the dynamic and volatile nature of the market. MobiMine application employs various datamining techniques to collect and deliver stock market related data from variety of sources. One of the main function performed by the MobiMine server is, it collects related financial data from various related data sources available on the internet and stores them in the database in order to be used in the data mining process. The server receives the data feed in XML format. In order to perform the datamining various techniques such as clustering, statistical based algorithms, decision trees and Bayesian nets are used.

C *Predicting Stock Prices Using LSTM*

[7] Due to the changing nature of various financial indicators the prices of stocks would fluctuate unexpectedly. This has been a difficult and a challenging factor for many stock analysts, investors and researchers who are keen on knowing the future behaviour or situation of the stock prices [8]. With the rapid development of technology and correct/appropriate utilization of important and informative indicators, behavioural predictions could be performed up to certain aspects. According to the author a significant explanation has been provided on the RNN (Recurrent Neural Networks) which is described as one of the powerful and well proved models on processing sequential related data. On the in-depth analysis of RNN, LSTM (Long Short-Term Memory) is identified as the most successful RNN's architecture. LSTM consists of memory cells which could be described as a computational unit that replaces hidden layer artificial related neurons among the networks. This structure helps to dynamically identify the data structure and associated patterns to provide more accurate high-capacity predictions. The overall paper is focused on presenting an in-depth idea on developing a prediction system on predicting the returns of NIFTY (50) using an LSTM model. Using historic dataset which contain 5 years of past stock prices the model training and validation activities are conducted [9].

The methodology section of the paper is explained using the background research activities conducted on experimenting the prediction activities of the NIFTY (50) stock prices. The following series of activities are conducted by the author when developing RNN and LSTM based model.

Step 1 -Preparation activities of the historic stock prices data. According to the paper, the window size of the dataset is 22 days and stock prices related data ranges between 01/01/2011 and 31/12/2016. **Step 2- Pre-processing stage of data-** At the pre-processing stage the following activities are conducted such as discretization of data- sorting filtering and determining the important features to be used when developing the prediction model, transformation of data, cleaning and integration of data. After the pre-processing stage, the dataset is divided as testing data and training data. When selecting data for training, the most recent data values are used. **Step 3- Extraction of features-In** feature extraction process more refined and most relevant features are selected in order to be used as input for the neural network. **Step 4- Neural Network Training process-** By assigning random weights and biases the neural network is trained in order to conduct the experiments. According to the paper the author has developed a LSTM model with sequential input layer. Along with sequential input layer two dense layers and LSTM layers are used. Further LSTM model consists of activations namely **"ReLU"** and linear activation function with an output dense layer. **Step 5- Prediction of results-** In this final step the author evaluates the model by cross comparing the targeted values with the output values generated from the RNN output layer. Backpropagation algorithm could be identified as a significant action carried out by the author to reduce the difference between the derived results from the final model and targeted results. In here the initial biases and weights of the network set at earlier steps are readjusted to reduce the difference between the results. The paper highlights the analysis phase by which efficiency of the model is evaluated. In order to test the efficiency of the model a statistical equation namely, Root Mean Square Error (RMSE) is used. Using the value of the said equation the difference or error between the derived results and targeted results could be minimized. Accordingly, the figure below is extracted directly from the research paper to demonstrate the experimental results of the model outcomes. Various test cases with different parameter numbers and EPOCHS are stimulated by the author. Moreover, the stimulation conducted with the selected features such as High, Low, Open and Close along with 500 EPOCHS has provided the best results of 0.00983 and 0.00859 (testing with RMSE). Results of different parameters and EPOCHs is shown using the Figure 1.

Parameters	No. of Epochs	Training RMSE	Testing RMSE
Open/ Close	250	0.01491	0.01358
Open/ Close	500	0.01027	0.00918
High/Low/Close	250	0.01511	0.014
High/Low/Close	500	0.01133	0.01059
High/Low/Open/ Close	250	0.0133	0.01236
High/Low/Open/ Close	500	0.00983	0.00859

Figure 1 : Results on different Epochs. Source: Research Paper [7]

On concluding the paper, the author proposes Long Short-Term Memory (LSTM) and Recurrent Neural Network (RNN) as a successful approach on predicting more accurate stock prices.

IV METHODOLOGY

As the primary data source research papers were critically studied, analyzed, and evaluated to understand the functionalities, challenges, theories, and concepts to obtain an in-depth knowledge on the research area. Along with the critical literature review various requirement elicitation techniques were used as secondary data sources to identify the functional and non-functional requirements of investors/users and officials of Colombo Stock Exchange.

Several interviews were conducted to obtain detailed information from the CSE officials since the ultimate development is intended to be developed on behalf of CSE. By conducting an interview informative and detailed information from a broad perspective were collected from different type of stakeholders of the CSE. Several officials of CSE including head of R&D (Research and Development), Head of Public Relations Department and Chief Information Officer (CIO) of CSE were interviewed to obtain in-depth information on investor behaviour's, legal factors, functional requirements, and non-functional requirements. Questionnaires are used as the medium of collecting data from the investors. Questionnaire comprises of 17 questions covering a broad context with regard to system development including functional requirements, non-functional requirements, visual design aspects, UI/UX (User Interface/User Experience) and content management. Questionnaire was presented to a sample of 233 respondents and obtained their responses. As the participants investors who are currently engaged in various professions are selected such as doctors, engineers, judges, businessmen, teachers, accountants, architects etc. Responses derived from the questionnaire were subjected to a statistical analysis, which helped to determine functional requirements, non-functional requirements, important designing aspects considerations and user requirements. The responses from the questionnaire and information gathered from interviews are mainly considered when developing the proposed portfolio management and prediction system. After a comprehensive gap analysis, the following requirements and process were recognized as essential to the proposed system when addressing the important requirements identified throughout the study.

A A. Functional requirements

Initially an investor could sign up and login to the system. First user could add stocks details by entering stock code name and selecting the Stock Exchange (New York stock exchange, Colombo Stock exchange). Along with the stock code, user can include the buying price of the share and volume of the shares purchased. Similarly, user could add the entire portfolio to the system which could be diversified between different shares belonging to various countries. Once the system is updated, each user will be provided an analysis of profit returns/losses, updated stock price details etc. Portfolio will automatically be updated once the market transaction goes online on country wise/stock market wise.

- Live and summarized stock market transaction dashboard presented based on user's selection.
- Ability to generate a detailed summary report on current portfolio in PDF format.
- Delivery of E-mail and SMS-text messages notifications on profits and losses incurred on current portfolio.
- Ability of adding and removing stocks of different countries/stock exchange and conduct portfolio-based customizations.
- Informative analysis of a particular share using candle stick chart filtered according to different time slots such as monthly, weekly, 30 days, 90 days, 180 days, and 360 days.
- "Wish Stock list feature" is integrated to analyze the stocks that are intended to invest in the near future.
- Future stock prices predictions using line graph representations, provided on each share based on user selection.
- Ability to update and change user/investor account related details such as personal information and password.

Administrator-
Ability to obtain detailed analytics of the investors/users who are currently enrolled with the platform, Ability to obtain an overview of currently logged and active users and Ability to create new users and update personal information of existing users.

B Non-Functional requirements

Availability (24x7), user friendly and highly interactive platform, privacy/security, and high performance to cope up with large workloads.

C Design and Development of the Application

The following section of the paper provides a thorough insight of the developed application as a proposed solution to the stated problem. This sections deeply justifies various technological mechanisms implemented in order to develop and embed the previously identified requirements in the system.

Web based platform is developed using Hyper Text Markup Language (HTML), Materialize CSS, Bootstrap and React.js as frontend framework and back ended using PHP with required 3rd party libraries. MySQL relational databases will be used for managing and storing data. The whole application runs on the base of four API endpoints. Two JSON based API's will be used to retrieve data on international stock exchange and another XML based API is used to retrieve data from Colombo Stock Exchange (Officially provided by CSE to fulfill the current development purposes). The logic behind the portfolio management and stock analyzer goes along with the data return in JSON

format. Relevant data will be retrieved and passed to data structures where manipulation activities will be carried out and lastly will be stored on the database.

Machine learning based prediction system will be developed and implemented using API driven data sets. Two types of models are developed to provide price prediction categories based on short term (1-7 days) and midterm (15-30 days). For short term predictions stacked Long Short-Term Memory cell (LSTM) model is used to provide the predictions since LSTM is extremely powerful in providing solutions to sequence-based prediction problems by analyzing the past information. As well as for long term predictions Brownian Motion algorithm-based model is developed. Both models will be trained, tested and deployed on Azure Machine learning studio to avoid any difficulties or delays on model processing and rendering. Python language along with supportive libraries such as MatPlot libraries, Tensor Flow (Keras), Pandas Data reader will be used to implement the model training and other model-based manipulation tasks. One of the challenges identified when developing the stock price prediction module is the update factor of the dataset used to train the model. For example, if a particular investor uses the stock prices prediction system today, the dataset should contain yesterday's stock prices related data when training the model as it is used for forecasting the future stock price of a particular stock based on the perspective of today.

[10] In order to perform long-term stock price prediction Brownian motion model is developed using hyperparameters. When conducting the expected formulation of stock prices, a confidence level of 95% is determined. Initially the dataset is retrieved using the Pandas yahoo finance data reader by specifying the stock symbol of the particular stock which is required to be predicted. In order to specify the range of the time period the current date is fetched using **current=datetime.now ()** function. Along with current date and time details, **current.year-3** is used to specify the starting year of dataset and **current.Month** and **current.Day** are used to specify the latest time period which the particular stock related dataset needs to contain. The main parameter from the dataset- **"Adjust Close"** is mainly used to train the model. After the fetching process the data normalization is performed using logarithm function. On completing the normalization process the following calculations are generated- Mean, Standard deviation, Variance, Volatility and Drift value are calculated. The Brownian motion algorithm along with hyper parameter are applied in order to forecast the stock price after completing the previous computational step. In order to obtain meaningful representations using the Mat plot library a graph is plotted and saved in .PNG format in order to render and display in the portfolio management system once an investor/user requests the prediction results. Final graph generated using Brownian Motion algorithm on APPLE Inc (AAPL) stock Original stock price and Predicted Output is represented using the Fig 2.

For short term stock price prediction Deep learning Artificial Recurrent Neural Network (RNN) architecture based Long Short-Term Memory (LSTM) model is developed. On elaborating the process of prediction initially using an API driven end point data source named Tiingo is used to download the relevant stock related dataset in CSV format. Every dataset downloaded from Tiingo consists of information related to stock prices ranging from 2016 to present. Accordingly, the following attributes are provided from the dataset which are as follow-**symbol, date, close, high, low, open, volume, adjClose, adjHigh, adjLow, adjOpen, adjVolume, divCash and splitFactor.**As the main parameter **"close"** value of the concerned share is used to train the model. In next step the dataset is split as training data and test data in order to avoid overfitting. This will also help to determine the model generalization ability as well. After implementing the splitting process feature scaling process is implemented, since the LSTM is sensitive to the scale of data. Therefore, before model fitting the data are normalized using scikit-learn pre-processing package named **Min-Max Scaler** and NumPy. One of the advantages of feature scaling could be the increase of performance. Since LSTM expect all the data to be in one specific arrangement using NumPy the data are transformed in to 3D dimension array. Once all the above-mentioned steps are fulfilled the LSTM model could be build using the followings- **Keras** imports, **Sequential**-neural network initialization, **Dense**- to add a densely connected neural network layer, **LSTM**- to add a Long Short Term Memory layer. After importing the required modules, the model is compiled using popular optimizer named **adam** and the loss is set as **mean_squarred_error** in order to calculate the squared errors mean. Next the model will be fit to run 100 Epoch with the batch size of 64 and verbose 1. Epoch is specified here to define the number of times the learning algorithms would work on the entire training dataset. After completing the model compiling process the future stock prices could be predicted using the test data set. In here some of the actions performed earlier are conducted again such as transforming the new dataset using MinMaxScaler and reshaping the dataset. **Inverse_transform** function is used here to obtain the readable format of the stock prices after completing the predictions. Finally using **Matplotlib** predicted stock prices are visualized. LSTM model prediction developed to Microsoft Corporation (MSFT) stock is shown using the Figure**??** .

After completing the development and testing phases the entire project is hosted on Microsoft Azure platform (IaaS, PaaS) deployed and implemented on a virtual machine to ensure the platform performances are guaranteed during

Figure 2 : Apple Stock prediction using Brownian Motion Algorithm
Source: Author

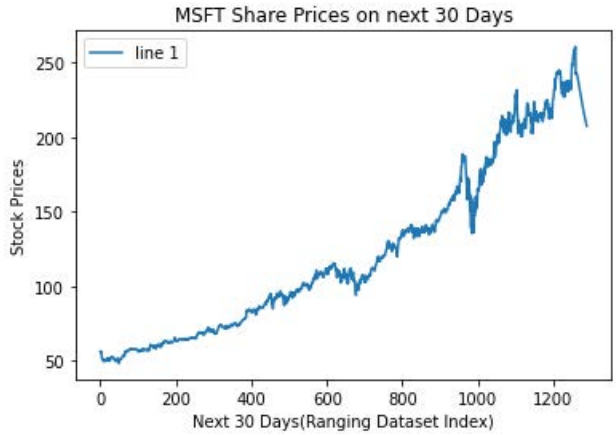

Figure 3 : MSFT Stock prediction using LSTM.
Source: Author

times when the workload is at peak. The finalized system architecture is represented using the Figure**??**.

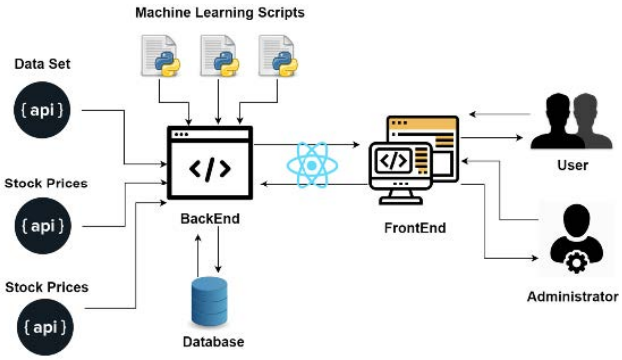

Figure 4 : System Architecture
Source: Author

V RESULTS AND DISCUSSION

A comprehensive system testing, and evaluation was conducted to verify the results/output of the finally developed system. System testing and user acceptance testing are conducted on the 95% completed system by the author as well as from the higher officials of CSE. The Fig 5. provides the results of the test conducted on each and every functional component which is developed in the system using manual as well as automation testing mechanisms (e.g.- Selenium and Katalan Studio tools). The sole purpose of system testing, and evaluation is to ensure the reliability of the system and the appropriate arrangement of newly developed functionalities.

On deeply evaluating the stock price prediction module, it was identified that the accuracy rates of the Long Short-Term Model (LSTM) and Brownian Motion algorithm-based stock price prediction model are more than 85% when these models are used to forecast the future stock prices. According to the testing conducted on different types of Stocks using the Brownian motion algorithm-based model the differences are as follows, On Microsoft Corporation (MSFT) stock the difference between the original stock price and predicted stock price was 4.88%. When evaluating the model on Nike Inc (NKE) stock the difference between the original stock price and predicted stock price was 12.1%. On APPLE Inc (AAPL) stock the difference between the original stock price and predicted stock price was 18.51%. It can be concluded that when different types of stocks are tested using the Brownian motion algorithm-based model, the difference between the original stock price and predicted stock price value of these stocks varies based on the type of the stock. Moreover, based on the outcomes of these tests, it is evident that the accuracy rate of Brownian Motion algorithm-based stock price prediction model is generally more than 80%.

Functional Requirements	Pass/Fail	Score
Investor/User		
Login and Sign-up Function	Pass	98%
Live and summarized stock market transaction dashboard	Pass	97%
Summary report generated in PDF format	Pass	95%
Delivery of E-mail and SMS-text notifications on profits and losses incurred	Pass	92%
Ability of adding and removing stocks from portfolio	Pass	100%
Informative analysis of a particular share using Candle stick chart	Pass	100%
Wish Stock list feature	Pass	96%
Future Stock prices prediction using line graph representations, provided on each share based on user selection	Pass	97%
Ability to modify user/investor account related details	Pass	97%
Administrator		
Detailed analytics on the investors/users who are currently enrolled with the platform	Pass	95%
Ability to obtain an overview of currently logged and active users	Pass	95%
Ability to create new users and update personal information of existing users	Pass	98%

Figure 5 : Test Case Results
Source: Author

VI CONCLUSION

In conclusion, it can be stated that throughout the study a highly interactive, fully functional portfolio management system has been developed. Its specialty is marked by its abilities to engage in thorough analysis of the market and to predict the future stock values. The system would be beneficial for the highly engaged investors to actively participate in the stock market transactions with high volumes of investments at low risk levels and obtain maximum possible returns from the investments. Higher levels of investor participation on stock market activities would ultimately leads to achieve the goals and objectives of the CSE. Accordingly, this would contribute to boost the overall volume of market transactions and ultimately contribute to improve the country's GDP (Gross Domestic Production) in mid and long terms.

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