Quest Journals
Journal of Software Engineering and Simulation
Volume 5 ~ Issue 1 (2019) pp: 49-55
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Multi-Agent Based Stock Market Prediction Using Ant Colony Optimization Technique

M. K. Ahmed[1], G. M. Wajiga[2] and N. V. Blamah[3]
[1]*Department of Mathematics, Gombe State University, Gombe, Nigeria*
[2] *Department of Computer Science, Modibbo Adama University of Technology, Yola, Nigeria*
[3] *Department of Computer Science, University of Jos, Plateau State, Nigeria*
Corresponding Author: M. K. Ahmed

ABSTRACT: *The stock market is one of the major institutions that contribute to the economic growth of many countries. Stock exchanges play an important role of channeling resources and building investment. Many works have been carried out in the capital market, which include agent – based approaches, stock market prediction using artificial neural network and machine learning approaches. However there is need to apply a meta-heuristic technique in order to get an optimal prediction from some of these techniques. In this work we employ Agent – based Ant Colony Optimization (ACO) where we obtained optimal prediction of the next day stock price of some selected companies listed in the Nigeria Stock Exchange. The results of our ACO Agent provide a better forecast than the other three initial strategies.*
KEYWORDS: *STOCK MARKET, MULTI-AGENT, ACO, PREDICTION*

R*eceived 20 May, 2019;* ***A****ccepted 03 June, 2019 © The author(s) 2019.*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

The capital market is a network of specialized financial institutions, series of mechanisms, processes and infrastructure that, in various ways, facilitate the bringing together of suppliers and users of medium to long-term capital for investment in socio-economic developmental projects. It embraces all the arrangements that facilitate the buying and selling of securities. The capital market has two segments, the Primary Market and the Secondary market. The primary market provides the avenue through which governments and corporate bodies raise fresh funds through the issuance of securities. It is otherwise known as the new issues market. Fresh funds can be raised through a combination of ways. These include public offers, rights issues and private placements. The secondary market provides investors the opportunity to buy or sell securities that were earlier issued in the primary market. The secondary market can be organized or unorganized. An organized market is a stock market with physical location, trading in designated (quoted) securities. Example of this is The Nigerian Stock Exchange. An unorganized market has no physical trading location but transactions are conducted mainly through telephone calls and the computer. It is called an Over-the-Counter-Market (OTC). The OTC trades mainly in unquoted securities. The distinguishing factor between the two segments is that in the primary market, the funds raised from investors go to the issuing entity, while in the secondary market; the proceeds from the transactions go to investors [1].

Nigerian stock market provides a major investment opportunity in country with the sole aim of improving the welfare of the citizen through wealth creation. The stock market has been identified as an institution that contributes to the economic growth of emerging economies, which also refers as a variable in explaining the economic growth in the most-developed ones. Stock exchanges play an increasingly important role, not only for channeling resources, but also for promoting reforms to modernize the financial sector legislation as is experienced in Nigeria and other emerging economies [1].

However despite the contributions of the stock market to the Nigerian economy, the market is still facing a lot of challenges which if not tackled, it will only affect the smooth running of the market but will also prevent the market from growing to reach its target stage so as to compete with other similar global markets. [8] Identify the challenges faced by individual investors in the course of their participation in the capital market which may be hindering the flow of funds to the market. A number of challenges ranging from inefficiencies of capital market operators, lack of information about quoted companies, the capital market crash, paucity of investible funds, low returns on investment, and lack of transparency in the market, among others were

identified. Also the findings of [5] reveals that there is an underutilization of the Stock Exchange market due to poor enlightenment campaign, and lack of transparency and accountability on the part of the operators of the market.

It is believed that Multi-Agent Systems (MAS) can be applicable in a stock market environment due to the characteristics of the problems in the domain as it is very possible that the knowledge required to solve a problem is spatially distributed in different locations, the solution of a problem involves the coordination of the effort of different individuals with different skills and functions. MAS are very suitable in distributed and homogeneous environment.

An agent is a computer system within an environment and with an autonomous behavior made for achieving the objectives that were set during its design [15]. A multi-agents system is a system that contains a set of agents that interact with communications protocols and are able to act on their environment. Different agents have different spheres of influence, mainly because of their control (or at least an influence) on different parts of the environment. In some cases, these spheres of influence my overlap which causes dependency of reports between the agents [15]

Agent-based systems technology has generated a lot of excitement in recent years because of its promise as a new paradigm for conceptualizing, designing, and implementing software systems. This promise is particularly attractive for creating software that operates in distributed and open environments such as the internet. Recently, the great majority of agent-based systems consist of a single agent. However, with technological advancement in the Agent-based systems and the increasing demand to address complex applications, the need for systems that consist of multiple agents which communicate in a peer-to-peer fashion are becoming apparent. This Multi-Agent based System can be used in different application areas such as e-commerce and distributed information systems.

Multi-agent systems are promising as models of organizations because they are based on the idea that most work in human organizations is done based on intelligence, communication, co-operation, negotiation, and massive parallel processing [7]. Therefore in this research MAS will be used as tool in solving the identified problems of the Nigerian Stock Market together with Ant Colony Optimization.

Ant colonies, and more generally social insect societies, are distributed systems that, in spite of the simplicity of their individuals, present a highly structured social organization. As a result of this organization, ant colonies can accomplish complex tasks that in some cases far exceed the individual capabilities of a single ant. The field of ‘‘ant algorithms’’ studies models derived from the observation of real ants’ behavior, and uses these models as a source of inspiration for the design of novel algorithms for the solution of optimization and distributed control problems [6].The problems face by stockbrokers and shareholders are checking for reliability and transparency of the market so as to take an effective decision (decision making). There is need for each broker to have a perception about the "reliability" of the other brokers so that the available information can assist the process of decision-making regarding to the investment. The system should also be able to make more specific decisions based on individual performance data of the companies participating in the stock market so that agent may choose to sell a company’s share and buy another if the first company is performing poorly while the second is on the rise, or in a more complex reasoning, where two companies are on the rise, but one company is more promising than another. So the agent chooses to sell shares of a company to raise capital, with the intention to purchase shares of the company that has a higher profit outlook. Looking at the stock market, its principles conform to that of a complex system. Stockbrokers lack other sources of correct information beside the financial report and audited account.

The aim of this research is to come up with a Multi-Agent Based System that enable Decision Maker Agents to forecast the next day stock price using both technical and fundamental analysis. After that, the ACO Agent will get the optimal prediction from the results obtained by the Decision Maker Agents so as to allow the Broker Agent trade using the optimal strategy

II. LITERATURE REVIEW

A Multi-Agent System (MAS) is a specific type of system that is made up of multiple intelligent agents that interact with each other to achieve certain objectives. These systems can be used to solve problems that are difficult or impossible for a monolithic or a single agent system to resolve [11].

When we are talking about agent and multi-agent system two levels are usually considered. The micro level refers to the agent itself. The agent definition, reactive and cognitive agents and their architecture are also considered in this level. While at macro level, agent communication languages, protocols communication between agents, coordination mechanism and negotiation are investigated [3]. Macro level has to do with multi-agent system not a single agent based system. Since MAS has to do with multiple agents communicating and cooperating together. [2] Explained the cooperation structure in multi-agent systems in which they divided the cooperation into complete structure and incomplete structure depending on the goal dividing.

Ant colonies, and more generally social insect societies, are distributed systems that, in spite of the simplicity of their individuals, present a highly structured social organization. As a result of this organization, ant colonies can accomplish complex tasks that in some cases far exceed the individual capabilities of a single ant. The field of ''ant algorithms'' studies models derived from the observation of real ants' behavior, and uses these models as a source of inspiration for the design of novel algorithms for the solution of optimization and distributed control problems [6].

[4] gives behavior of each ant in nature, wander randomly at first, laying down a pheromone trail, if food is found, then return to the nest laying down a pheromone trail, if pheromone is found, with some increased probability follow the pheromone trail, once back at the nest, go out again in search of food. However, pheromones evaporate over time, such that unless they are reinforced by more ants, the pheromones will disappear.

MAX–MIN Ant System (MMAS) is another improvement over the original ant system and it is proposed by [16]. It introduces four main modifications with respect to ant system [10].

- Only the best ant adds pheromone trails i.e. either the ant that produced the best tour in the current iteration, or the best-so-far ant is allowed to deposit pheromone. But this may lead to a stagnation situation.
- Above defined situation can be modified by MMAS i.e. the minimum and maximum values of the pheromone are explicitly limited
- The pheromone trails are initialized to the upper pheromone trail limit, which, together with a small pheromone evaporation rate which increases the exploration of tours at the start of the search.
- Finally, in MMAS, pheromone trails are reinitialized each time the system approaches stagnation or when no improved tour has been generated for a certain number of consecutive iterations.

[12] Present a machine learning aided approach to evaluate the equity's future price over the long time. Their work is able to correctly predict whether some company's value will be 10% higher or not over the period of one year in 76.5% of cases. When it comes to prediction of the movement of the stock market, several studies have been conducted using machine learning algorithms such as support vector machine (SVM) and reinforcement learning. [13] Proposed a new prediction algorithm that exploits the temporal correlation among global stock markets and various financial products to predict the next-day stock trend with the aid of SVM. Numerical results indicate a prediction accuracy of 74.4% in NASDAQ, 76% in S&P500 and 77.6% in DJIA.

Prediction of stock price index movement is regarded as a challenging task of financial time series prediction. An accurate prediction of stock price movement may yield profits for investors. Due to the complexity of stock market data, development of efficient models for predicting is very difficult. [9] Attempted to develop two efficient models and compared their performances in predicting the direction of movement in the daily Istanbul Stock Exchange (ISE) National 100 Index. The models are based on two classification techniques, artificial neural networks (ANN) and support vector machines (SVM). Ten technical indicators were selected as inputs of the proposed models. The average prediction performance of the ANN model (75.74%) was found significantly better than that of the SVM model (71.52%).

To investigate the effect of market behaviour on stock prices, [17] traditional neural network algorithm may also fail to forecast the capital market accurately, since the initial weight of the random selection problem can be easily susceptible to inaccurate forecasting. Based on the idea of word vector in deep learning, the researchers demonstrated the concept of stock vector. The input is no longer a single index or single stock index, but multi-stock high-dimensional historical data. They propose the deep long-short term memory neural network (LSMN) with embedded layer to predict the stock market. In their model, the embedded layer to vectorize the data, in a bid to forecast the stock via long-short term memory neural network. Their results show that the deep long short term memory neural network with embedded layer is state-of-the-art in developing countries. Precisely, the accuracy of this model is 57.2% for the Shanghai A-shares composite index. Moreover, this is 52.4% for individual stocks.

Most of the reviewed literatures mainly simulate a stock market using only an Agent based approach or stock market prediction using artificial neural network in order to learn about companies that are performing well based on their financial information. However there is need to apply a meta-heuristic technique in order to get an optimal solution i.e the Agent may choose to buy shares from company with the most profitable shares.

III. EXPERIMENTAL SETUP AND ANALYSIS

Fifty day trading data for five randomly selected companies form various sectors were used. Closing price is used as the input parameter. Three method of stock market prediction were applied i.e. the fundamental analysis, technical analysis and regression analysis in order to obtain the fitted values. Optimization of strategy was done using Ant Colony Optimization (ACO) so as to get optimal prediction between the three trading strategies. R software was used in the analysis of the result.

3.1 Decision Maker Agent 1 (Fundamental Ant Agent)

The strategy of fundamental analysis is to compare the theoretical stock price with the market and then to see if the price is devalued or over-valued as shown in equation 4.1.

$$r = \frac{p_{*_i} - p_{t-1}}{p_{t-1}} \quad \ldots\ldots\ldots\ldots\ldots 4.1$$

Where p_{*i} represents the theoretical stock price, Pt−1 is the actual stock price on phase t-1. The value of r may be positive or negative. p_{*i} is the average of the stock price during the phases.

When it is positive then the stock price is appreciate by that value while if it is negative then the stock is going to depreciate by the value also.

While table 3.1 shows the respective performance evaluation.

Table 3.1: Performance Evaluation of Fundamental Analysis strategy

ACCESS	
MAPE	**1.26**
MAD	**14.94**
RMSE	**0.45**

3.2 Decision maker Agent 2 (Regression Agent)

The Regression Agent uses Simple Regression Model (SRM) for the modelling. The original model in which the data was fitted is shown in equation 3.2 below:

$y_i = B_0 + B_1 x_i \ldots\ldots\ldots\ldots 3.2$

Where y_i is the stock price for the ith day, x_i is the ith day, B_0, B_1, are the constants.

$\hat{y}_i = B_0 + B_1 x + e \ldots\ldots\ldots 3.3$

The equation 3.3 shows the model that was use in generating the fitted values i.e the predicted values. While table 3.2 shows the respective performance evaluation.

Table 3.2: Performance Evaluation of Regression Analysis strategy

ACCESS	
MAPE	**3.10**
MAD	**36.73**
RMSE	**0.18**

3.3 Decision maker Agent 3 (Technical Analysis Agent)

The technical analysis was done using five (5) days moving average in order to get the corresponding predicted stock prices for the various stocks under study. While table 3.3 shows the respective performance evaluation.

Table 3.3: Performance Evaluation of Technical Analysis strategy

ACCESS	
MAPE	**1.46**
MAD	**17.62**
RMSE	**0.05**

3.4 Decision Maker Agent 4 (Optimizing Agent)

The strategy that is applied to come up with the optimized prediction using Ant Colony Optimization is as follows:

a. All Prediction Agent (Decision Makers) will forecast the stock price using their respective strategy.

b. The $AGENT_{AB}$ with the lowest absolute difference between the actual value and the predicted value will update the pheromone.
c. As a result of updating the pheromone, the $AGENT_{AB}$ strategy will be adopted for the next day trading.
d. Step 2 and 3 will be repeated till the end of the forecasting process.
e. Broker Agent will trade using the Optimized decision (ACO) agent.

3.4.1 ACO Prediction Algorithm Based on MAX MIN Ant System

AB is the agent with highest accuracy i.e Agent with least absolute difference between the actual price and the predicted value.

Start
DS ← InitializeDataSet
strategy_list ← [ ]
while (|AB| >DS) do
τ← InitializePheromones
i ←1
RuleBest ←$AGENT_{AB}$
while (trading does not close for the day) do
$AGENT_{AB}$ UpdatePheromones
∀ Ant Add RuleBase to Strategy
rulei ←LocalRule + RuleBest
Trade using LocalRule + RuleBest
if (f (rulei) > f (rulebest))
rulebest ← rulei
end-if
i ← i + 1
end-while
end-while
end-procedure

Table 3.4 shows the respective performance evaluation.

Table 3.4: Performance Evaluation of ACO Agent

MAPE	**1.23**
MAD	14.90
RMSE	0.5

IV. DISCUSSION OF RESULTS AND CONCLUSION

The major emphasis of this research is to forecast the stock prices using the various strategies and to come up with the most optimal prediction using Ant Colony Optimization technique that will provide a more accurate prediction than the other initial strategies. The optimal solution was obtained from the three strategies in which Agent (Ant) will the least absolute difference update the pheromone to forecast the next day stock price. From the analysis, the Mean Absolute Percentage Error (MAPE) and Mean Absolute Deviation (MAD) of our ACO Agent is lower than that of all the three strategies. Hence it can be concluded that, the optimal prediction of our ACO Agent provides a better forecast than the three initial strategies. The time series graphs for the various strategies are shown in the figure 4.1, 4.2, 4.3 and 4.4.

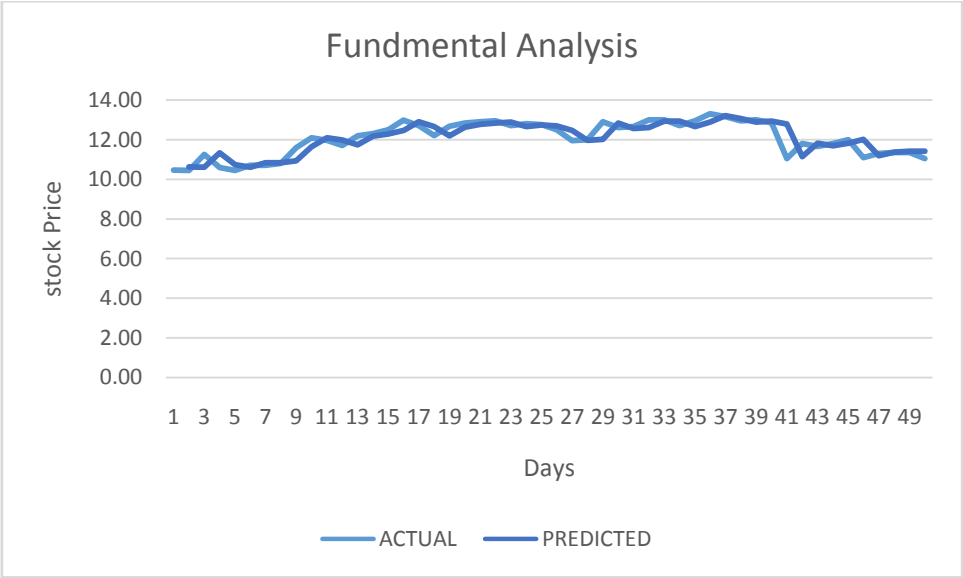

Figure 4.1: Stock prediction using Fundamental Analysis

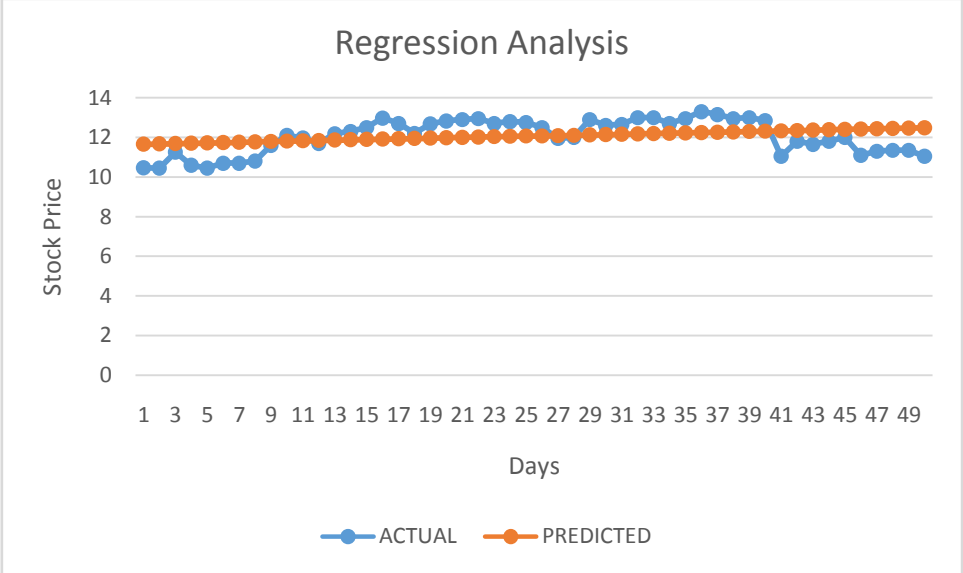

Figure 4.2: Stock Prediction using Regression Analysis

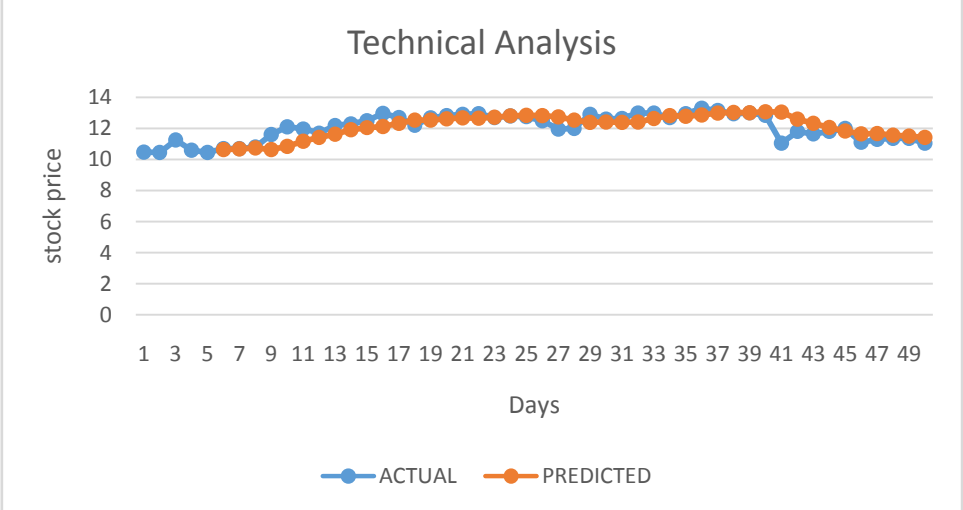

Figure 4.3: Stock Prediction using Technical Analysis

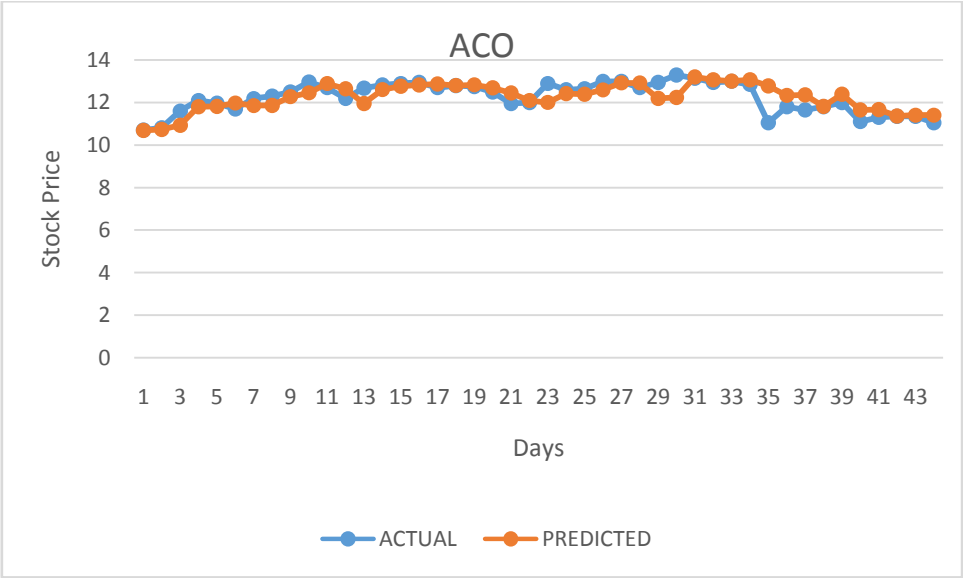

Figure 4.4: Optimal Prediction using ACO

V. FUTURE WORK

In our future work, we intend to increase the number of our prediction strategies using machine learning algorithms like Artificial Neural Network and Deep Learning. When the result is obtained, then we employ our ACO Agent to get the overall optimal result from all the strategies.

REFERENCES

[1]. A, Abiola, and H. Okodua, The Role of the Nigerian Stock Market In Achieving Vision 2020. Lagos Journal of Banking, Finance & Economic Issues,Vol. 2 No. 1, 2008.
[2]. A. Al-Jumaily, and M. Al-Jaafreh, Multi-Agent System Concepts Theory and Application Phases: University of Technology Sydney Australia, InTech,2006.
[3]. A. M. Batista, Marietto, M. B., Botelho, W.T., Kobayashi, G., Alves, B. P., S. D.Castro, and T. L. Ruas, Principles of Agent-Oriented Programming: Centre of Mathematics, Computation and Cognition, Federal University of ABC (UFABC) Brazil, InTech, 2010.
[4]. C. Blum, Ant Colony Optimization: Introduction and Recent Trends: Science Direct, Physics of Life Review 353-373, 2005.
[5]. M. E. Chijioke, The Impact of Capital Market on The Nigerian Economy with Emphasis on the Role of the Nigerian Stock Exchange (Master's Thesis), 2011.
[6]. M. Dorigo, and T. Stutzle, Ant Colony Optimizatio:. London: A Bradford Book, The MIT Press, Cambridge, Massachusetts, 2004
[7]. H.W.M. Gazendam, Theories about architectures and performance of multi-agent systems. In: III European Congress of Psychology. Tampere, Finnland, 1993.
[8]. N. R. Ikeobi, Challenges Faced by Individual Investors in the Nigerian CapitalMarket. European Journal of Business and Management. Vol.7, No.23, 2015
[9]. Y. Kara, M. A. Boyacioglu, and O. K. Baykan, Predicting direction of stock price index movement using artificial neural networks and support vector machines: The sample of the Istanbul Stock Exchange. Expert Systems with Applications. Elsevier, 2011.
[10]. S. Katiyar, I. Nasiruddin, and A. Ansari, Ant Colony Optimization: A Tutorial Review. National Conference on Advances in Power and Control, At Faculty of Engineering and Technology, Manav Rachna International University, Faridabad, Haryana, 2015.
[11]. L.Rodriguez, E. Insfran, and L. Cernuzzi, Requirements Modeling for Multi-Agent Systems: ISSI Research Group, Department of Information Systems and Computation, Universidad Politécnica de Valencia, Camino de Vera s/n 46022, Valencia, InTech, 2012
[12]. N. Milosevic, Equity Forecast: Predicting Long Term Stock Price Movement using Machine Learning. Journal of Economics Library Volume 3(2), 2016
[13]. S. Shen, H. Jiang, and T. Zhang, Stock Market Forecasting Using Machine Learning Algorithms .Citeseer, 2016
[14]. M. Wooldridge, An Introduction to Multi-Agent Systems. Wiley & Sons, 2002
[15]. Wooldridge, J. M. (1999). Intelligent agents, Multiagent Systems: a Modern Approach to Distributed Artificial Intelligence. Wiley & Sons.
[16]. T. Stützle, and H.H. Hoosb, MAX–MIN Ant System: Future Generation Computer Systems, 16 (2000) 889–914, 2000.
[17]. Pang. X, Zhou. Y, Wang. P, Lin, W and Chang, V. Stock Market Prediction based on Deep Long Short Term Memory Neural Network In Proceedings of the 3rd International Conference on Complexity, Future Information Systems and Risk (COMPLEXIS 2018), pages 102-108.

M. K. Ahmed" Multi-Agent Based Stock Market Prediction Using Ant Colony Optimization Technique" Quest Journals Journal Of Software Engineering And Simulation, Vol. 05, No. 01, 2019, Pp. 49-55