Agent Application in the Stock Market

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Abstract

The stock market is a key market in any economy and financial forecast such as stock price prediction is a field receiving much attention both for research studies and commercial applications. Stock market forecasters are keen on developing a successful approach to predict stock prices even more accurately since there is motivation of gaining massive profits from trading shares by using well defined attractive strategies. This research project develops a stock price prediction model built using JADE environment. It is based on multi-agent architecture in order to harness the power of agents. This provides investors with predicted trend of share price by incorporating various correlated factors like economic, political, company outlook to traditional price over time, demand and supply in order to accurately forecast the stock price trend and thus, provide a buying or selling signal to traders. The Trend is determined by incorporating text processing in agents from live news sources. The model was tested and has proved to be a key

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tool for stockbrokers, novice traders and investment bankers since it is automated and more robust than traditional methods of price prediction.

Keywords: Agents, Stock Market, Prediction, Model, Text processing.

Introduction

Financial analysts, stock brokers, individuals and fund managers who trade in Nairobi Securities Exchange lack accurate models to enable them predict the future price of stocks and make decision of whether to buy, sell or hold in view of maximizing portfolio's and returns. It is noted by the Capital Markets Authority (2014) that choosing the company shares to invest in, is an intricate decision and the following are current methods in use: *Fundamental Analysis;* study the company's current management and position in the market and *Technical analysis,* which is purely based on charts to identify price trends the company's stock has and invest accordingly. The current observed trend is that the decision to buy is entirely for the client and sometimes some advice from the stock broker and investment bank. This has led to selection being made based on speculation with no supporting fundamentals to justify growth of a company's share price and a failure to look at the economic situation, the industry into which the company is trading in and strong points from the company like current management, market share and sustainability of profits. Therefore, use of automated tools is not mentioned in this market.

Also, most of the traders and investors apart from the large stock brokers and investment banks cannot afford the expensive algorithms and software's for prediction nor do they have relevant experience to make relevant, efficient predictions of future stock price. A survey on such a tool like market reckons may be out of reach of small investors with the full version

costing price at United States of America dollars (US$) 4997, which is equivalent to KES 429,742 at the rate of KES86 for US$ 1.

Objectives

The specific objectives of the study include the following:

i.   To assess the impact of using agent in stock price prediction;

ii.   To assess the agent based stock price prediction system;

iii. To use data generated from the system to evaluate stock price prediction;

iv.   To provide support for traders at the NSE on whether stock price is going up or down and thus, enable them decide to BUY, SELL or HOLD; and

v.   To provide a Graphical user interface for the User interaction and feedback.

Technology Description

Why Agents?

The most common method of prediction being currently used is Artificial Neural networks and they have proved successful. This does not mean they are perfect as they have downsides as Karl (2004) indicates, first, that it is the black-box-property. Relating one single outcome of a network to a specific internal decision (known as the credit assignment problem) is very difficult. Noisy data also reinforce the negative implications of establishing incorrect causalities, overtraining (or over fitting), which will harm generalization. Finally, a certain degree of knowledge in current subject is required because it is not trivial to assess relevance of chosen input series.

According to Jakob (2012), it is ideal to use a multi-agent simulation in that it can model complex interactions much more accurately and realistically than any static algorithm. Various static algorithms have been common in market prediction for years and some do generally well. These algorithms commonly work by taking a set of historical prices from the market and analyzing them by using different algorithms (running averages, high-low points, candlestick calculations) to produce a very short-term prediction on general rise or fall of stock prices. But the limitation of these algorithms is that they usually only predict a very short-term rise or fall (the next couple of price iterations, be that next few minutes, hours or days in that specific granularity), but do not predict actual price trend over a longer period (over more than a few trading session iterations).

Multi-Agent simulation uses the concept of many agents in a system to model various objects that contain interactions (for example, a financial market). On their own, these agents are relatively un-intelligent, governed only by a set of rules of interaction. But with introduction of many agents into the system, the rules of interaction form much more complex behaviors and patterns that are difficult and in many cases, impossible to model using conventional algorithms, for these rules of interaction for each agent are a subset of algorithms used for static prediction, as mentioned before. So what is actually observed in a multi-agent simulation is the result of the interaction of all various algorithms working together and competing against each other.

Software Agent Technology

Software agent technology is a relatively new software engineering paradigm, a shift from the structured programming and object oriented programming approach that has been widely used in the traditional software engineering environment. In this new approach, agents are intelligent through reasoning, communication and interactions and they do most of the work. They are modeled in a way that corresponds to how humans understand

the world. Agents operate in environments in which they may have full or partial influence. These environments are usually non-deterministic with the effect that an agent cannot expect the same result each time it performs the same action.

According to Wooldridge and Jennings (1995), an agent is a computer system that is situated in some environment, and that is capable of an autonomous action in this environment in order to meet design objectives. A multi Agent system is one that consists of a number of agents, which interact with each other typically by exchanging messages through some computer network infrastructure. They achieve this through their ability to cooperate, coordinate and negotiate with each other.

Some common characteristics of software agents include (Wooldridge and Jennings, 1995) *Autonomy* - Agents must be able to operate without direct intervention by humans or other agents. *Reactive* - Agents must be able to react to changes in the environment in time for actions to be useful. *Pro-activeness* - Agents must be able to take initiative to act in their operating environment. *Social ability* - Agents participating in a multi-agent system must be able to communicate with each other in the system. *Mobility* – ability to move around network platforms. *Veracity* – Avoid communicating false information knowingly. *Benevolence* – conflicting goals. Always try to do what one is asked. *Rationality* – Acts in order to achieve its goals subject to beliefs. *Learning/Adaptation* – can improve performance over time. *Personality* – Have distinct personality – behavior, name, and role.

Text Processing

Text processing refers to the discipline of mechanizing creation or manipulation of electronic text. Text usually refers to all alphanumeric characters specified on the keyboard of the person performing the mechanization, but in general, text here means an abstraction layer that is

one layer above the standard character encoding of the target text. The term processing refers to automated (or mechanized) processing, as opposed to the same manipulation done manually. Text processing involves computer commands, which invoke content, content changes, and cursor movement, for example, to search and replace, format, generate a processed report of the content of, or filter a file or report of a text file.

The project utilizes Regular expressions, which are small computer language of their own and are developed with just as much discipline and care as people apply to writing any computer code. In particular, a complex regular expression is built up in smaller pieces in order to understand how each component of the regular expression works before adding further components.

Prediction

Khalid and colleagues (2013) indicate that recent research interests are intense in areas of future predictions of events/price movements as the traditional time series has proven difficult and inaccurate, which make it challenging and demanding. Researchers, businesspersons and investors who assume that future occurrence depends on present and past data are keen to identify the stock price prediction of movements in stock markets. One of the pillars of current financial theory is the Efficient Market Hypothesis (EMH), which assumes that prices in financial markets are based on rationale expectations of traders who are trying to maximize their expected utility. As a consequence, past information cannot help in predicting future prices and markets are assumed to be free of internal dynamics of their own. Van den Bergh and colleagues (n.d) further indicate that in such a setting, mathematical models of price movements in the markets are based on assumptions of homogeneity of traders (for example, traders are rational), equilibrium analysis and possession of all relevant information by traders. Any deviations from these idealized conditions are considered to

be exogenous effects or uncertainty (for example, noise).

Despite the EMH view, it has been suggested that empirical evidence regarding the price patterns observed in financial markets seem to indicate that the market have internal dynamics of their own.

Van den Bergh and co-workers (n.d) further indicate that one promising way of analyzing the internal dynamics of financial markets is use of agent-based approach. In recent years, agent-based approach to economic and financial analysis has grown into an important research field for developing an understanding of complex patterns and phenomena that are observed in the economic system. The agent based approach to the analysis of financial systems models, financial markets as evolutionary systems of competing bounded rational agents. The agents adapt, learn, and evolve in order to remain successful in their competition with other agents.

Conceptual Model

The multi-agent system will be able to provide an output that informs the trader/broker whether to buy, sell or hold on to a share. The conceptual model of the agent has the following agents and a database: Political Environment Scan agent, Company Environment scan agent, Economic environmental scan agent and Control Agent.
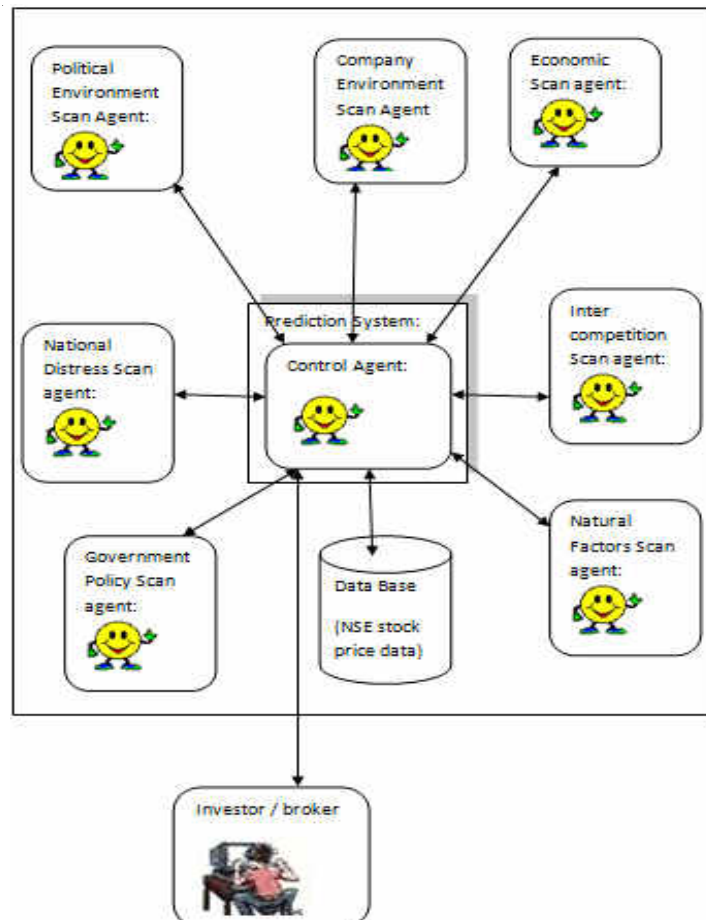
Fig. 1: *The Conceptual Model*

Methodology

There are a variety of methodologies for developing multi-agent systems. This system utilizes the PASSI methodology.

The PASSI Methodology (Italy)

Process for agent society's specification and implementation (PASSI) Process for agent society's specification and implementation (PASSI) is a step by step requirement to code methodology for designing and developing multi-agent societies integrating design models and concepts from both object-oriented software engineering and MAS, using unified modeling language (UML) notation.

PASSI evolved out of theoretical studies and experiments in the development of embedded robotics applications.

The PASSI methodology brings a particular rich development lifecycle that spans initial requirements through deployment and, in addition, emphasizes on the social model of agent based systems.
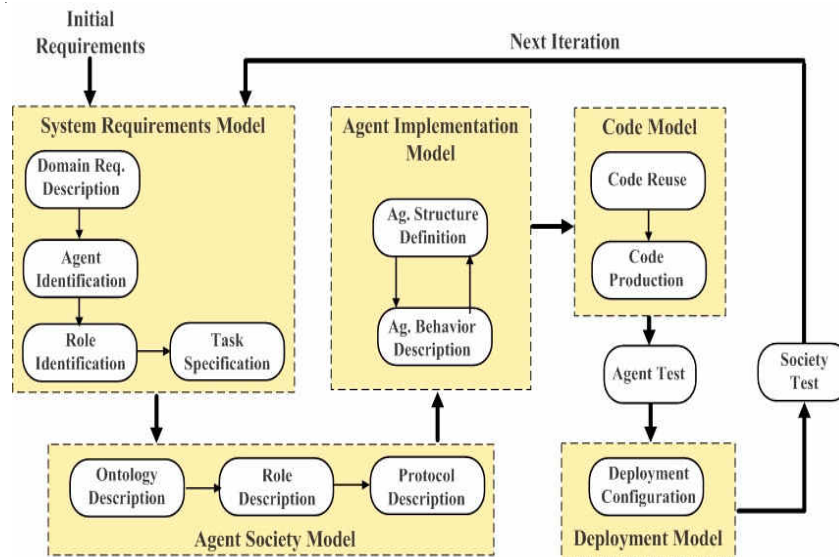

Fig. 2: *Phases of PASSI Methodology (Massimo, 2005)*

Systems Requirements Model

Systems Requirements Model contains the following activities as described in the PASSI methodology. It is a model of the system requirements in terms of agency and purpose. It is made of the following four phases:

♦ Domain requirements description, A functional description of the system using convectional use case diagrams.

♦ Agent identification, The phase of attribution of responsibilities to agents, represented as stereotyped UML packages.

♦ Roles identification, A series of sequence diagrams exploring the responsibilities of each agent through role-specific scenarios.

♦ Task Specification, Specification of the capabilities of each agent with activity diagrams.

Agent Society Model

Agent Society Model entails a model of the social interactions and dependencies among agents involved in the solution. Developing this model involves three phases.

♦ Ontology specification; Use of class diagrams and OCL constraints to describe the knowledge ascribed to individual agents and their communications.

♦ Role description: Class diagrams are used to show roles played by agents, tasks involved, communication capabilities and inter-agent dependencies.

♦ Protocol description; Use of sequence diagrams to specify the grammar of each pragmatic communication protocol in terms of speech-act per formatives.

Agent Implementation Model
Agent Implementation Model is a classical model of the solution architecture in terms of classes and methods.

♦ Agent structure definition: produces agent overview diagrams showing the internal structure of solution agent classes.
♦ Agent behavior description: It encompasses activity diagrams describing the behavior of individual agents.

Code Model
This stage of the methodology involves the following:

♦ Code production: write the code to implement the agents.
♦ Code Reuse: Since agents are similar, reuse previously produced code to make implement more agents.

The initial Agent test will occur after this is complete.

Deployment Model
This is the final stage in the PASSI methodology and involves deployment and configuration.
   A society test will occur after the deployment is successful.
   The methodology is a lifecycle kind of methodology and if the result agent model is not ideal, the process can be iterated through again to achieve a perfect model.

Development

System Design

The Process for Agent Societies Specification and Implementation (PASSI) is a step by step requirement to code methodology for designing and

developing multi-agent societies integrating design models and concepts from both OO software engineering, and artificial intelligence approaches using UML notations.

The system was designed guided by the PASSI methodology. This methodology brings a particular rich development lifecycle that spans initial requirements through deployment and in addition, emphasizes on the social model of agent based systems.

System Requirements Model
This contains the following activities as described in the PASSI methodology. The Domain requirements including the functional description of the system using use case diagrams and actual agent identification including their roles and task specification will be done in this stage.

Domain Description Phase
This is a function description of the system composed of a hierarchical series of use case diagrams. Scenarios of use case diagrams are explained using the sequence diagrams. We utilized the scenario described in the statement of the problem in order to highlight analysis of the stock price predictor system.
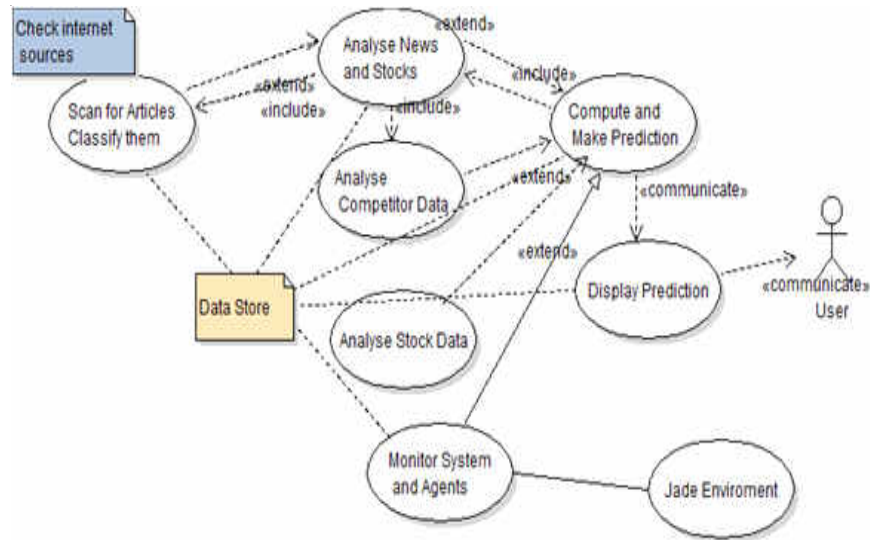
Fig. 3: *A Domain Requirements Description Diagram*

Agent Identification Phase

This involves attribution of responsibilities to agents represented as stereo typed UML packages. In MAS, it is more reasonable to locate required behaviors into units of responsibility from the start and thus this phase. Agent identification starts from use of case diagram above and is packaged as a functional composition from the previous phase.
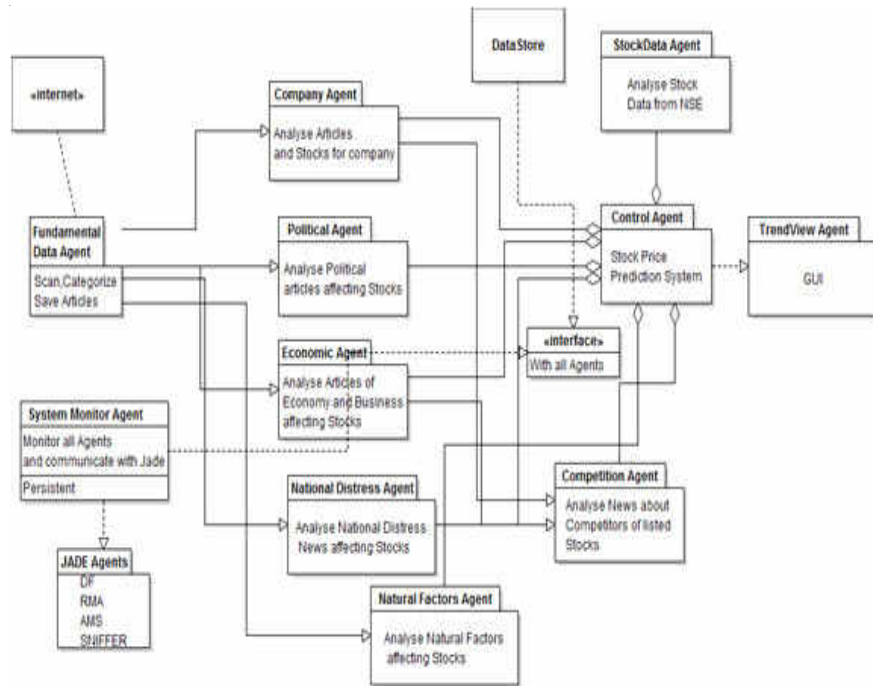
Fig. 4: *A Block Diagram of System Role Identification Phase*

Agent Society Model

This stage includes modeling of social interactions of agents and their dependencies by describing their knowledge and communications that is ontology, also the role description and protocol description by utilizing sequence diagrams.
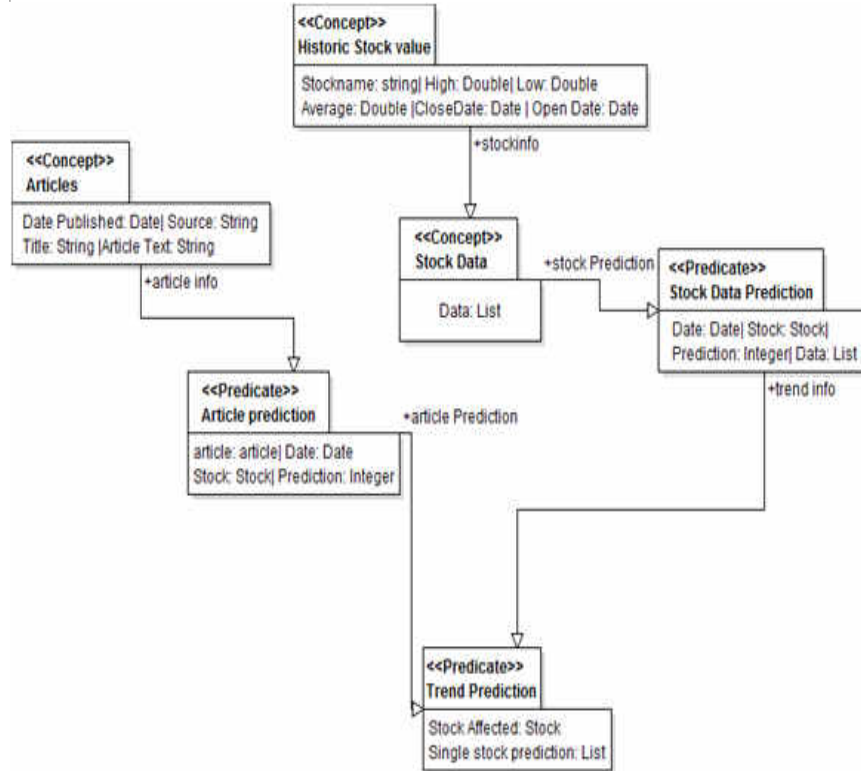
Ontology Description Phase

Fig. 5: *Domain Ontology Diagram*

If agents are to communicate in a way that makes sense for them, they must share the same language, vocabularies and protocols. By following FIPA standards, JADE already supports a certain degree of commonality. This includes description of knowledge ascribed to individual agents and their communication.

Agent Implementation Model

Here, the agent structure definition includes overview diagram and agent behavior description of individual agents.

♦ both subservice client and Database server

Agent Code and Deployment Model

This stage involves actual code production and reuse for similar agents. Thereafter, deployment and configuration takes place. A society test occurs after deployment is successful.

Development Tools

The following tools were used in development of the system.

♦ Java net beans integrated development environment 8.0 was installed on a 64bit Microsoft windows 7 laptop and libraries of JADE, JSON and all other necessary libraries included.

♦ Java Runtime environment 1.7 was also installed

♦ Adobe Dreamweaver was used in web development

♦ WAMP server 2.5 with Mysql was used for the Database

Implementation

Implementation of the agent based price prediction system was done through use of Java Agent Development Framework (JADE). The framework facilitates development of complete agent-based applications by means of a runtime environment implementing the life-cycle support features required by agents, the core logic of agents themselves and a rich

suite of graphical tools. Its written completely in java and thus, it enjoys a huge set of language features and third-party libraries thereby offering a rich set of abstractions and allowing development of Jade-multi-agent systems with relatively minimal expertise in agent theory.

Validation

The model was validated using live data from the NSE to check whether it is able to capture the intended objectives. Any noted variations were investigated and corrected to ensure accuracy of the model.

   A number of investors and stock brokers filled an evaluation form for inference of results from test conducted in order to show whether or not the research project was successful and any possible future works.

Results

Prototype Testing

The system testing was conducted and the following screen shots of running system captured.
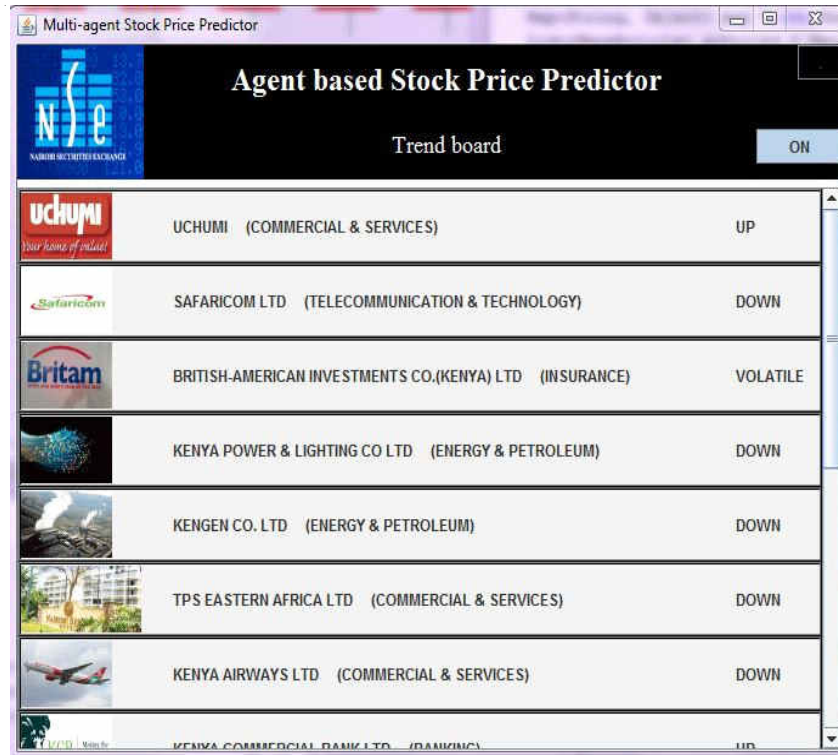
Fig. 6: *Trend Board Indicating Prediction*

A group of Users including Expert stock brokers and Investment Bankers, Analysts and Novice Traders were used in validation and the following results were gathered:

Table 1: *Summary Test Results*

System Usability	poor	Satisfactory	good	very good	excellent
How is The GUI	0	0	4	2	4
Stock Information Placement	0	1	3	3	3
Ease of use and learning	0	0	3	3	4
User Alerts	0	1	3	4	2
System Functionality	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Automated Article Review	0	0	0	2	8
Automated Prediction	0	0	4	3	3
System Performance	Very Dissatisfied	Dissatisfied	Neither	Satisfied	Very Satisfied
Level of Satisfaction	1	2	0	4	3
Level of Confidence	0	2	2	2	4
Opportunity for more profits	0	1	1	3	5

From the tests conducted by random sample of users, the system can be incorporated into an everyday tool for stock brokers and investors to use to predict the movement of stocks rather than manually reading through all possible news articles and trying to identify the trend on their own.

The System shows efficiency in use of multi agent's stock price prediction rather than reliance on technical analysis and fundamental analysis and thus, improved profitability as well as return on investment.

Conclusion

In the study, multi agents were used in the stock and financial services sector, which is a key area in any economy. Most Traders and Stock Brokers have to read through news articles about various stocks that are

trading in order to identify factors that positively or negatively affect the stock price then they can choose a trading strategy in order to place orders or publish shares to sell.

With use of the stock price prediction, it is evident that the model is a useful tool for stockbrokers and agents and even novice traders who would then need not only rely on the traditional methods to be able to identify the trend of prices at the NSE, but also have instant quick update of current trend and with pointer to what caused the trend. Then it makes it much easier to follow up using their individual trading strategies.

Recommendations

Due to possible litigations and legal hurdles, the Current Model is only registered with one news website source where it sources articles published in the website and further permission on web scraping pages from live news sources needs to be sort to enable the Fundamental agents, which is the crawler agent access to multiple articles from multiple news sources and enable better analysis by the other agents. Since the Agents are designed to keep retrieving news articles continuously, the brokers and investors would have a rich pool of prediction information and keep insight into the stock price and easily make more profits, make their work easier and give a return on investment to their clients.

Further Works

An area that requires further use of the Agents is to provide actual trading on identified stocks, which is possible once the NSE accepts algorithmic trading that is currently not available.

Identification of more phrases, keyword and sentiment that enable better prediction trend needs to be done. This collection will keep growing as more articles are reviewed.

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