Android Application for Stock Market Prediction by Fuzzy Logic

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***Abstract*— Presently, firms in financial services sector like banking and insurance make profits by investing their clients' money in stock markets, the strategies for which are heavily infrastructure dependent and unknown outside the organization. This paper discusses the development of an android application which can be made available directly to the common investors from unorganized sector. The application uses rule based fuzzy logic [1, 2, 3, 4] for analyzing the direction of stock market movement. We report emulation on BlueStacks App Player [5].**

Keywords*— *Artificial Intelligence, Fuzzy logic, Fuzzy systems

I. INTRODUCTION

Post-liberalization activities have generated substantial interest amongst common masses to invest in securities and stock markets. Stock markets are a great means to generate wealth provided the investor has in-depth knowledge about its complex and unstable nature. The investor should be well aware of the factors that directly or indirectly affect the stock prices. For a beginner or an amateur willing to invest his money in securities, this may not be the case. This calls for an affordable technology supported application which can help such investors in making trading decisions.

Use of Fuzzy Logic and Artificial Intelligence Techniques [6, 7, 8] to predict the stock market movement can be very effective in such cases. Fuzzy logic has innate ability to model human understanding very efficiently in terms of linguistic variables. As opposed to strict boundaries in case of crisp sets - for example in binary logic where a given statement can either be completely true or completely false, fuzzy logic allows partial membership of a given input to multiple sets.

There are many financial indicators in stock market like Moving Average Convergence and Divergence (MACD), Consumer Confidence Index, Jobless Claims, Relative Strength Index (RSI) [9] etc. which may indicate different phenomena, for example- suppose that one of the indicators rises, which means that the market is bullish and the stocks of a certain company, if bought, can be profitable for the investor. But on the other hand, another indicator does not indicate the market as bullish as the previous one does. In such a situation, the decision of whether to buy stocks or sell them becomes a matter of confusion since there is no definite yes or no answer obtained from the analysis. Thus, fuzzy reasoning can be used in such cases where several factors act as different forces to push the decision of investment in different directions.

II. REQUIREMENT OF AN ANDROID APPLICATION

The investor spectrum characterization dictates the use of sophisticated high-tech infrastructure oriented organizations vis-à-vis limited meagre technology (or even no technology) dependent / supported investors. As mentioned previously, banking and financial institutions are quite often heavily infrastructure based as far as investments in securities is concerned. These facilities are inaccessible outside the organization and a lot of experienced investors with sophisticated tools are employed in investing the money.

In order to facilitate small unorganized sector investors, there is a need for affordable technology products for securities and stock market sector. While mobile apps provide an alternative to such a scenario, ease of use and trust in apps is of immense significance. Our investigations in this direction indicated that stock market prediction model based on fuzzy logic can be easily released on an android platform. Non-experts can have an easy and open domain access to such an application and they can use it to actively participate and contribute to the economic and financial dynamics. Simulation and modelling study of such an impact is one such key issue and authors are also investigating research issues associated with it. This paper focuses on development and deployment aspects of fuzzy logic based android mobile apps for use by larger cross section of society and android also enjoys tremendous popularity in Indian markets owing to its open-source nature, easy and powerful application development tools and availability of a large number of self learning tutorials on internet, where hundreds of apps are developed and distributed daily.

In addition, the speed of data communication has been on a constant rise and the telecommunication networks have evolved from 2G to 4G, offering ever increasing speeds at cheaper prices. In future, it is expected that this kind of an android application could be used anytime, anywhere and there would be guaranteed coverage at all places. This paper is organized as follows. Section III discusses fuzzy logic model and describes fuzzy rule set. Section IV describes issues related to Android API development.

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III. FUZZY LOGIC MODEL FOR STOCK PREDICTION

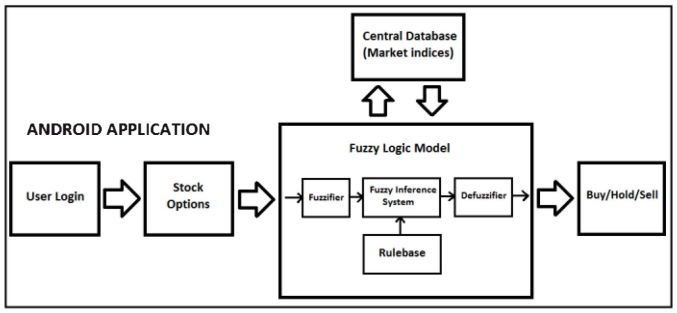

Fig. 1. Block diagram of a fuzzy logic system

Moving Average Convergence and Divergence (MACD) [10], Consumer Confidence Index (CCI) and Relative Strength Index (RSI) are selected as inputs to the fuzzifier. For this model, Triangular fuzzy membership function has been used.

A. Interpretation of Indices and Defining their Fuzzy Sets

1) Moving Average Convergence and Divergence (MACD): Moving Averages are calculated for smoothing out the price trends. They indicate the price movements with a lag. There are two types of moving average – Simple Moving Average (SMA) and Exponential Moving Average (EMA). SMA simply averages closing prices of the stock over past N number of periods. EMA, on the other hand gives more weight to current price of the stock. It is calculated as follows:

$$EMA_t = [\text{Current Price} \times \alpha] + [EMA_{t-1} \times (1- \alpha)] \quad (1)$$

Where $\alpha = 2 / (N+1)$

Typically, MACD is calculated by subtracting 26-day EMA from 12-day EMA. A 9 day EMA of the MACD is then again calculated which gives the "signal line". If MACD is above the signal line, it generates a buy signal and if MACD goes below the signal line, it generates a sell signal.

$$MACD = EMA_{12} - EMA_{26} \quad (2)$$

Fuzzy sets are made on (MACD-signal line) as follows:

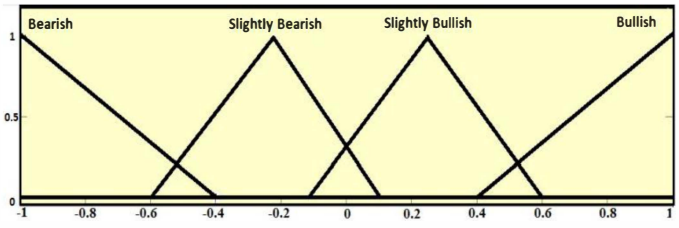

Fig. 2. (MACD-signal) line Fuzzy Sets

2) Consumer Confidence Index (CCI): CCI measures the overall consumer sentiment about the market, i.e. how optimistic are the consumers about the economy and financial markets in general. In India, personal consumption constitutes a major percentage of GDP. Thus CCI is an important market indicator. Here, we have selected BluFin [11] consumer confidence index for Indian stock market, which is a number between 0 and 100.

Fuzzy sets on CCI have been made as follows:

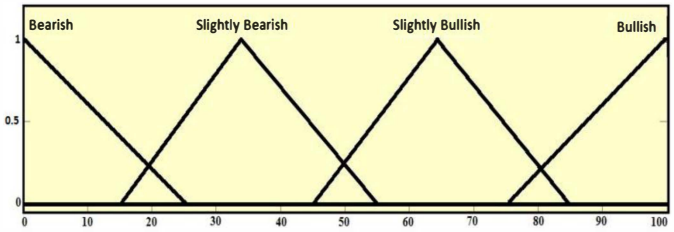

Fig. 3. CCI Fuzzy Sets

3) Relative Strength Index (RSI): RSI is used to determine whether a stock is overbought or oversold by comparing the value of recent gains and recent losses of a stock. RSI calculation is based on 14 periods

$$RSI = 100 - 100 / (1+RS^*) \quad (3)$$

$$RS^* = \text{Average Gain (AG)} / \text{Average loss (AL)} \quad (4)$$

$$AG = (\text{previous AG} \times 13 + \text{current Gain}) / 14 \quad (5)$$

$$AL = (\text{previous AL} \times 13 + \text{current Loss}) / 14 \quad (6)$$

RSI value ranges from 0 to 100. If RSI value approaches 30, it indicates that stock may be getting oversold and thus can be undervalued. If RSI value approaches 70, it indicates that the stock may be getting overvalued.

Fuzzy sets on RSI are as follows:

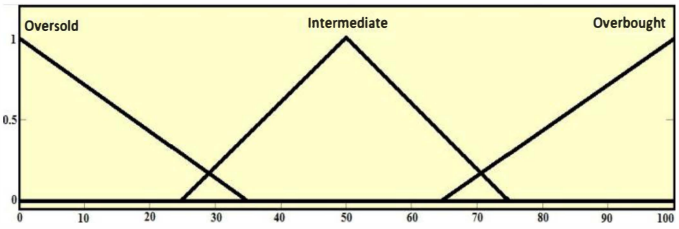

Fig. 4. RSI Fuzzy Sets

3) Decision: The output is the percentage buy recommendation, classified as Strong Sell, Sell, Hold, Buy and Strong Buy.

Fuzzy sets on output are as follows:

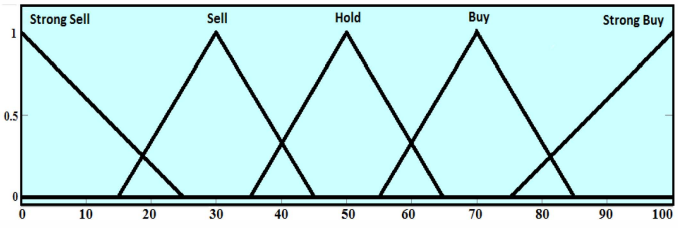

Fig. 5. Decision Fuzzy Sets using CCI, RSI and MACD for 3 Input – 1 Output system

B. Fuzzy Logic Rules:

For testing purposes, the following fuzzy logic rules were formed:

TABLE I. FUZZY LOGIC RULES

(IF) MACD	(IF) CCI	(IF) RSI	(THEN) DECISION
Bearish	Bearish	Overbought	Sell
Bearish	Bearish	Intermediate	Sell
Bearish	Bearish	Oversold	Strong Sell
Bearish	Slightly Bearish	Overbought	Sell
Bearish	Slightly Bearish	Intermediate	Sell
Bearish	Slightly Bearish	Oversold	Strong Sell
Bearish	Slightly Bullish	Overbought	Buy
Bearish	Slightly Bullish	Intermediate	Hold
Bearish	Slightly Bullish	Oversold	Sell
Bearish	Bullish	Overbought	Buy
Bearish	Bullish	Intermediate	Hold
Bearish	Bullish	Oversold	Sell
Slightly Bearish	Bearish	Overbought	Sell
Slightly Bearish	Bearish	Intermediate	Sell
Slightly Bearish	Bearish	Oversold	Strong Sell
Slightly Bearish	Slightly Bearish	Overbought	Hold
Slightly Bearish	Slightly Bearish	Intermediate	Sell
Slightly Bearish	Slightly Bearish	Oversold	Strong Sell
Slightly Bearish	Slightly Bullish	Overbought	Buy
Slightly Bearish	Slightly Bullish	Intermediate	Hold
Slightly Bearish	Slightly Bullish	Oversold	Sell
Slightly Bearish	Bullish	Overbought	Buy
Slightly Bearish	Bullish	Intermediate	Hold
Slightly Bearish	Bullish	Oversold	Sell
Slightly Bullish	Bearish	Overbought	Buy
Slightly Bullish	Bearish	Intermediate	Hold
Slightly Bullish	Bearish	Oversold	Sell
Slightly Bullish	Slightly Bearish	Overbought	Buy
Slightly Bullish	Slightly Bearish	Intermediate	Hold
Slightly Bullish	Slightly Bearish	Oversold	Sell
Slightly Bullish	Slightly Bullish	Overbought	Strong Buy
Slightly Bullish	Slightly Bullish	Intermediate	Buy
Slightly Bullish	Slightly Bullish	Oversold	Hold
Slightly Bullish	Bullish	Overbought	Strong Buy
Slightly Bullish	Bullish	Intermediate	Buy
Slightly Bullish	Bullish	Oversold	Hold
Bullish	Bearish	Overbought	Buy
Bullish	Bearish	Intermediate	Hold
Bullish	Bearish	Oversold	Sell
Bullish	Slightly Bearish	Overbought	Buy
Bullish	Slightly Bearish	Intermediate	Hold
Bullish	Slightly Bearish	Oversold	Sell
Bullish	Slightly Bullish	Overbought	Strong Buy
Bullish	Slightly Bullish	Intermediate	Buy
Bullish	Slightly Bullish	Oversold	Hold
Bullish	Bullish	Overbought	Strong Buy
Bullish	Bullish	Intermediate	Buy
Bullish	Bullish	Oversold	Hold

(The above table does not imply that the rules are absolute. They have only been used for testing purposes and can be changed as per requirements)
For example:

If MACD is **Bullish** and CCI is **Bullish** and RSI is O**verbought** *Then* OUTPUT is **Strong Buy**

C. Algorithm for Writing a Fuzzy Logic Code:

The program for implementation of fuzzy logic makes use of Linked Lists. In order to improve the accuracy of the decision, several other indicators can also be used as inputs and fuzzy sets can be defined on them as and when required. Also, the number of fuzzy sets in each input can also be varied depending upon the level of precision needed. These two reasons justify the use of Linked Lists in the code.

Input fuzzy sets, output fuzzy sets and rulebase have been defined initially as a Structure in C. Since the focus of the paper is on common investor from unorganized sector, our interactions indicated that the algorithm description should be simple and comprehensible by professionals from different domains. Accordingly, we describe the algorithm for the code in an unconventional manner and is as follows:

1. Define Input, Output and Rulebase structures

```
typedef struct input
{
   char fuzzyset;
   int a,b,c;
   float value;
   struct input *next;
}input;

typedef struct rulebase
{

   char if_part[10];
   char then_part;
   char operation;
   float fir_value;
   struct rulebase *next;
}rulebase;
```

Fig. 6. Input and Rulebase Structure

2. Define a function (piecewise triangular, in this case) for finding out the values of membership function at a given crisp input

3. Create a separate linked list for each input (MACD, CCI and RSI), where a node of the linked list contains the following information – fuzzy set name, values of coordinates used for determining the equation of the membership function and the value of membership function (at a particular input)

4. Create a separate linked list for the output (DECISION), where a node of the linked list contains the following information – fuzzy set name, values of coordinates used for determining the equation of the membership function and the value of membership function

5. Create another linked list for Rulebase, where each node corresponds to one rule, and contains the fuzzy linguistic

variables in "if-parts" and "then-parts" and also the variable for storing the firing strength of that rule

6. Input the current values of MACD, CCI AND RSI. For every index, traverse the corresponding linked list and calculate the values of membership function for each fuzzy set of the index and store the values in the respective nodes

7. Traverse the linked list for rulebase and calculate the firing strength of each rule in the rulebase using the values of membership function and store the values in the respective nodes

8. Calculate the value of output membership function for every output fuzzy set using firing strength of each rule (assuming all the possible combinations of rules are accounted for and each fuzzy set of the output appears at least once)

9. Defuzzify and obtain a crisp output using any of the following defuzzification methods – Centroid Method, Bisector Method, MOM (Mean of Maximum), SOM (Smallest of Maximum) and LOM (Largest of Maximum).

IV. ANDROID API

For developing an android application, Android SDK downloaded from https://developer.android.com is used. ADT plug-in for Eclipse and use of the SDK Manager facilitated easy program development.

Developing an android application requires the developer to write mainly the following files:

1. .xml file: Used for defining different user interfaces in XML

2. .java file: The main program which is responsible for running different activities (every screen in the application with a user interface is an activity) [12].

Instead of writing an XML file, one can directly make use of graphical layout tool in Eclipse, as illustrated in Figure (7).

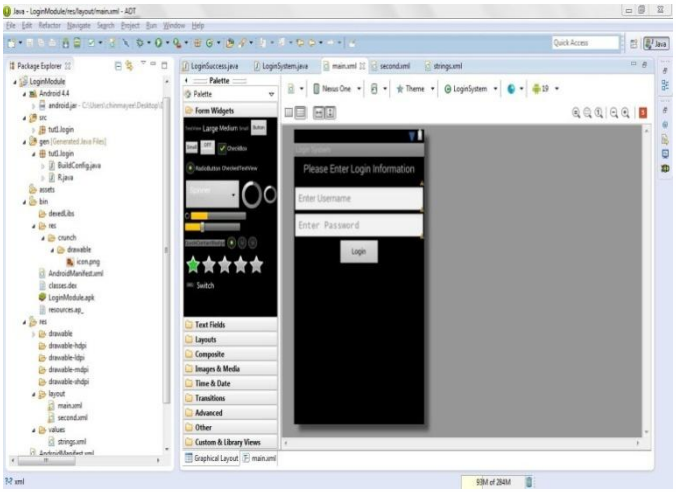

Fig. 7. Android API

While an android application can be tested on an inbuilt emulator in Eclipse, we opted for testing on BlueStacks App Player which provided faster and hassle-free emulation as compared to the inbuilt Eclipse emulator. Figure (8) depicts emulation on BlueStacks.

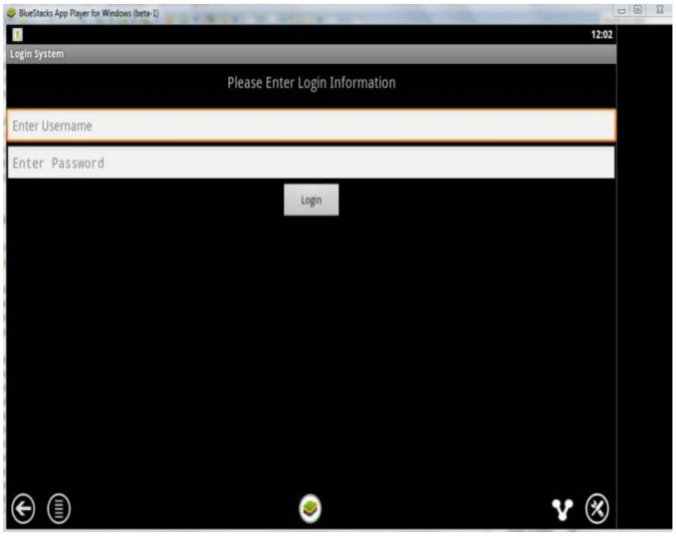

Fig. 8. Emulation on BlueStacks

V. CONCLUSION AND FUTURE WORK

The paper demonstrates the method of predicting stock market movement using Fuzzy Logic based apps for android mobile platform. This model gives practical results as the success ratio of this model has been experimentally found to be approximately 70%. This estimate is based on historical data of stock prices and market indices (www.investexcel.net). The market index values were inputted to the fuzzy logic system and buy, sell or hold decisions were compared against the actual prices to see if the decision was correct.

This project prototype has qualified for Third Prize in NES (Natarajan Education Society) Innovation Awards 2013-14 [13]. Since the project is being promoted for commercialization, the full code has not been provided here.

Future work includes modification of this model using Artificial Neural Networks and designing a Neuro-Fuzzy system, in which the advantages of both types of artificial intelligence techniques can be harnessed.

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