



Fuzzy Candlestick based Stock Market Trading System using Hammer Pattern

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Abstract: This paper proposes an easy model using which stock market forecasting can be performed. Researchers find stock markets as very dynamic and chaotic systems drawing their attention towards forecasting its movements. In this paper, a fuzzy approach is investigated for the famous candlestick method pinpointing on the Hammer formation. Modeling using fuzzy logic is done so that we can make the system understand, what we see as humans. The prediction of the future trend using the hammer candlestick technique is implemented using the fuzzy rule-base and fuzzy inference mechanism. For experimentation purpose the input for the proposed system is the real time daily and weekly data of NIFTY-50 index of National Stock Exchange of India.

Keywords: Forecasting, S&P CNX NIFTY 50, Fuzzy-logic, Fuzzy rule-base, Candlesticks, Fuzzy-candlesticks, Hammer pattern.

I. Introduction

The stock markets are sentiment driven markets. Human psychology plays an important part in deciding the market movements. Usually three types of sentiments are seen in the stock markets, namely bullish, neutral and bearish. The Bullish sentiment indicates that the buyers are more than sellers and the buyers are confident about the market, so they outnumber sellers causing the market prices to rise. The Bearish sentiment indicates that the sellers are more than buyers and the buyers are not very much confident about the market, so the sellers outnumber the buyers causing the market prices to fall. The Neutral sentiment indicates that neither buyers find enough confidence nor the sellers are aggressively selling, hence the market prices become range bounded around few points up and down. Market sentiments create momentum in the market, either bullish, bearish or neutral. The momentum remains in the market for few sessions from the day it originates.

In the following section we would try to understand the Japanese candlesticks and their meaning as they are very useful in identifying the market sentiment. In figure 1.1, the dark candle or dark filled candle indicates that the closing was lower than the opening, which means bearish sentiment. The white or hollow candle in figure 1.2, refers to a market that closes above the opening range, meaning bullish sentiment. The location of a candlestick pattern formed helps in determining the potential reversal of trend or sentiment in the market. When reversal patterns are found in top of an upward rally, it indicates possible turnaround of the market to bearish momentum. Similarly when reversal patterns are found at the bottom of a selloff rally, it indicates a possible reversal of the market sentiment to upwards momentum. It is important to identify the patterns formed by the candlesticks and interpret the meaning of them. The candlesticks not only represent the values but also reflect the sentiment of traders in the market. Figure 1.3 shows the hammer formation. The hammer can be recognized by three criteria: 1) The real body is at the upper end of the trading range, 2) A long lower shadow should be twice the height of the real body and 3) It should have no, or a very short, upper shadow. Figure 1.4 shows the same hammer but in inverted form. This formation has opposite implications as hammer.

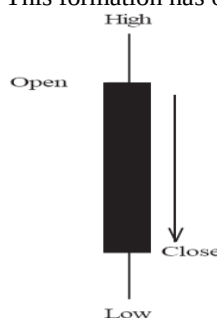


Figure 1.1:
Dark Candle

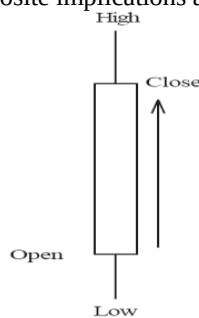


Figure 1.2:
White Candle



Figure 1.3:
Hammer

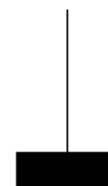


Figure 1.4:
Inverted Hammer

In the first phase of the development we fuzzify the candlestick representation of present day data which comprises of Open (OP), High (HI), Low (LO) and Close (CL) values of a day, using a combination of Z, Triangular and inverse Z functions. Here we also create the fuzzy models for the White and Black candles. Then in the second phase we develop a fuzzy model that could classify the fuzzy candles as Very-Small (VS), Small(SM), Big(BG) and Very-Big(VB). They represent the size of the candles. At every phase we develop Fuzzy-Rules. The accumulated Fuzzy-Rules from every phase would become the Fuzzy Rule-base. The Action Rule-base created from the Fuzzy Rule-base would guide us to decide the course of action whether to buy or sell.

In our experiments we fuzzified the candlesticks in such a way that we could identify the patterns formed and accordingly decide trading opportunities. The basic representations used are as follows:

X_i^j represents j value on the i^{th} trading session, where j represents any one of OP, HI, LO or CL values which are Open, High, Low or Close values respectively for the i^{th} day. $D_i^{j,k}$ represents distance between j & k values on the i^{th} trading session, where j & k can be any of the OP, HI, LO or CL values.

$$D_i^{j,k} \leq |X_i^j - X_i^k| \quad (1)$$

Example:

$$D_i^{OP,CL} \leq |X_i^{OP} - X_i^{CL}|$$

The R.H.S. in the example denotes the absolute (positive) value of the difference between Open (OP) and Close (CL) values on the i^{th} trading session which is assigned to the notation used in L.H.S of the equation (1). The fuzzy linguistic interpretations of the values of $D_i^{j,k}$ are as follows:

1. Very-Small abbreviated as **VS**.
2. Small abbreviated as **SM**.
3. Big abbreviated as **BG**.
4. Very-Big abbreviated as **VB**.

C_i represents the colour of the candlestick on the i^{th} day, which can be either Black or White. When X_i^{CL} is lower than X_i^{OP} then the colour is black (Figure 1.1) and vice-versa for white (Figure 1.2). T_i represents trading sentiment on i^{th} day. The fuzzy linguistic interpretations of the values of T_i are as follows:

1. Bearish (when sellers are in control and making the market go down) abbreviated as **BR**.
2. Bullish (when buyers are in control and making the market go up) abbreviated as **BL**.

F_i represents type of candlestick formation occurred on i^{th} day. In this paper it would be the Hammer and Inverted Hammer formation.

II. Literature Review

Nison, 1991 first introduced Japanese candlestick concepts to the western world, and the researchers got ideas to model Japanese candlesticks using fuzzy logic [4]. Bigalow, 2002 identified that with its 400 years of development, the Candlestick methodology got its major refinement in the mid-1700s. Japanese candlestick modeling is a very cognitive task which involves a lot of experience and intuition to rightly judge the meaning of the patterns formed [1].

Zadeh *et al.*, 1975 introduced fuzzy logic and demonstrated, how it can be used to model approximate reasoning that the human beings use in day to day life. The authors also proposed fuzzy modeling of human cognition. This created a new wave of how computer systems could be used to model human behavior and learning [8].

Taking further the research on stock market forecasting (Hon Leon and Liu, 2006) proposed a method of modeling Japanese candlesticks using fuzzy logic which was further improved (Dong and Wan, 2009) proposed a fuzzification subsystem consists of three parts: short term price breakout, short term exchange volume change and long term price trend, which can be used to predict market movements but the system needed optimization as the market nature is very chaotic [3] [2].

Othman and Schneider, 2010 proposed a fuzzy logic based decision making system that was used to develop an algorithm based on fuzzy rules to provide recommendation for selling and buying stock. It was concluded that the fuzzy rules needed optimization for better results [5]. Roy *et al.*, 2012 proposed the use of Japanese candlestick's engulfing pattern to trade the market and successfully developed a fuzzy model to do so as the results were promising [7]. Paranjape and Deshpande, 2013 proposed a stock market portfolio recommender system based on Association Rule Mining which used correlation of stock price action with sector performance as criteria for forecasting [6].

III. Fuzzification Process

The Membership function $\mu(D_i^{j,k})$ will be used to determine the distance between j and k values in the i^{th} day of the trade (Equation (1)). Figure 3.1 shows the representation of Fuzzy Membership function $\mu(D_i^{j,k})$ to interpret the values denoted by $D_i^{j,k}$, it is a combination of Z, Triangular and inverse Z functions. On the x-axis are the crisp values and on the y-axis is the membership grade ranging from 0 to 1.

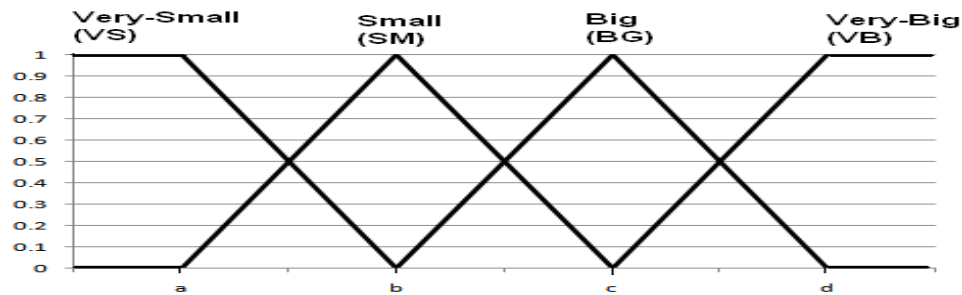


Figure 3.1: Membership function $\mu(D_i^j k)$

$$\mu_{VS}(D_i^j k) = \begin{cases} 1 & , D_i^j k \leq a \\ \frac{b-D_i^j k}{b-a} & , a < D_i^j k < b \\ 0 & , D_i^j k \geq b \end{cases} \quad \dots\dots\dots(2)$$

$$\mu_{SM}(D_i^j k) = \begin{cases} 1 & , D_i^j k = b \\ \frac{D_i^j k - a}{b-a} & , b > D_i^j k > a \\ \frac{c-D_i^j k}{c-b} & , c > D_i^j k > b \\ 0 & , a \geq D_i^j k \geq c \end{cases} \quad \dots\dots\dots(3)$$

$$\mu_{BG}(D_i^j k) = \begin{cases} 1 & , D_i^j k = c \\ \frac{D_i^j k - b}{c-b} & , c > D_i^j k > b \\ \frac{d-D_i^j k}{d-c} & , d > D_i^j k > c \\ 0 & , b \geq D_i^j k \geq d \end{cases} \quad \dots\dots\dots(4)$$

$$\mu_{VB}(D_i^j k) = \begin{cases} 1 & , D_i^j k \geq d \\ \frac{D_i^j k - c}{d-c} & , d > D_i^j k > c \\ 0 & , D_i^j k \leq c \end{cases} \quad \dots\dots\dots(5)$$

We propose the following fuzzy sets:

- $\mu_{VS}(x)$, to represent Very Small candle size.
- $\mu_{SM}(x)$ to represent Small candle size.
- $\mu_{BG}(x)$ to represent Big candle size.
- $\mu_{VB}(x)$ to represent Very Big candle size.

Here 'x' represents the simple numeric difference between any set of OP, HI, LO and CL values.

IV. Fuzzy Rule-base Formation

Using the available information now we can develop a fuzzy rule-base to assist our decision to buy or sell.

Fuzzy Rule-Base Formation

1) Fuzzy-Rule for determining Distance $D_i^j k$:

Rule-D1: IF $\mu_{VS}(D_i^j k) > 0.5$ then $D_i^j k$ is VERY-SMALL (VS).

Rule-D2: IF $\mu_{SM}(D_i^j k) > 0.5$ then $D_i^j k$ is SMALL (SM).

Rule-D3: IF $\mu_{BG}(D_i^j k) > 0.5$ then $D_i^j k$ is BIG (BG).

Rule-D4: IF $\mu_{VB}(D_i^j k) > 0.5$ then $D_i^j k$ is VERY-BIG (VB).

2) Fuzzy-Rule for Candlestick colour C_i :

Rule-C1: IF $X_i^{OP} > X_i^{CL}$ THEN C_i IS BLACK.

Rule-C2: IF $X_i^{OP} < X_i^{CL}$ THEN C_i IS WHITE.

3) Fuzzy-Rule for Trading Sentiment T_i :

Rule-T1: IF $X_{i-1}^{CL} > X_{i-2}^{CL}$ AND $X_i^{CL} > X_{i-1}^{CL}$ THEN T_i IS BULLISH.

Rule-T2: IF $X_{i-1}^{CL} < X_{i-2}^{CL}$ AND $X_i^{CL} < X_{i-1}^{CL}$ THEN T_i IS BEARISH.

4) Fuzzy-Rule to identify Hammer and Inverted Hammer pattern formation F_i :

Rule-F1: IF (D_i^{HICL} IS VS OR D_i^{OPHI} IS VS) AND round (D_i^{HILO} / D_i^{OPCL}) = 3 THEN F_i IS HAMMER

Rule-F2: IF (D_i^{OPLO} IS VS OR D_i^{LOCL} IS VS) AND round (D_i^{HILO} / D_i^{OPCL}) = 3 THEN F_i IS INVERTED-HAMMER

From the exercises done above we can now form an Action Rule-Base to decide upon when to initiate BUY and SELL positions taking the help of rules created in the Fuzzy Rule-Base.

Action Rule-Base or the inference mechanism, to decide when to initiate BUY and SELL positions, taking the help of Fuzzy Rule-Base.

Rule-BS1: IF **Rule-T2** is True AND **Rule-F1** is True THEN BUY.

Rule-BS2: IF **Rule-T1** is True AND **Rule-F1** is True THEN SELL.

Rule-BS3: IF **Rule-T1** is True AND **Rule-F1** is True THEN SELL.

V. Results and Discussion

For experimental purpose the daily and weekly NIFTY index values were used. Table 5.1 represents weekly and table 5.3 represents the daily Open, High, Low and Close values of NIFTY index.

Table 5.1:
Weekly values of NIFTY index

DATE	OPEN	HIGH	LOW	CLOSE
28-Jun-13	5638.05	5852.95	5566.25	5842.2
05-Jul-13	5834.1	5904.35	5760.4	5887.9
19-Jul-13	5991.2	6066.85	5901.95	6029.2
26-Jul-13	6009.75	6093.35	5869.5	5886.2
02-Aug-13	5869.95	5886	5649	5677.9

Table 5.2:
Hammer and Inverted Hammer

Date	HMR	IHMR
28-Jun-13	0	0
05-Jul-13	0	0
19-Jul-13	1	0
26-Jul-13	0	0
02-Aug-13	0	0

Table 5.3:
Daily values of NIFTY index

Sr.No.	DATE	OPEN	HIGH	LOW	CLOSE
1	11-05-2010	5191.25	5191.25	5122	5132.95
2	12-05-2010	5131.3	5174.4	5088.25	5150.2
3	13-05-2010	5185.5	5218	5165.4	5178.15
4	14-05-2010	5163.2	5202	5058.2	5083.65
5	17-05-2010	5017.7	5074.8	4962.2	5058.05

Table 5.4:
Hammer and Inverted Hammer

Sr.No.	HMR	IHMR
1	0	0
2	0	0
3	0	1
4	0	0
5	0	0

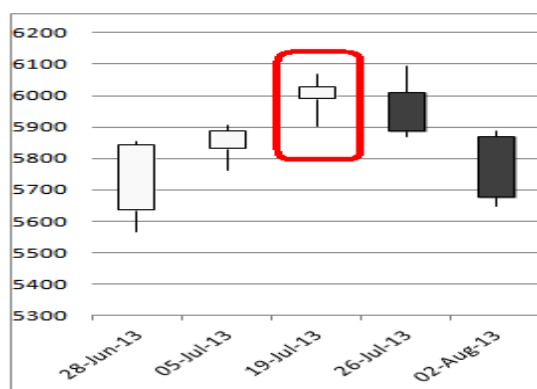


Figure 5.1: Candlestick chart of Table-5.1

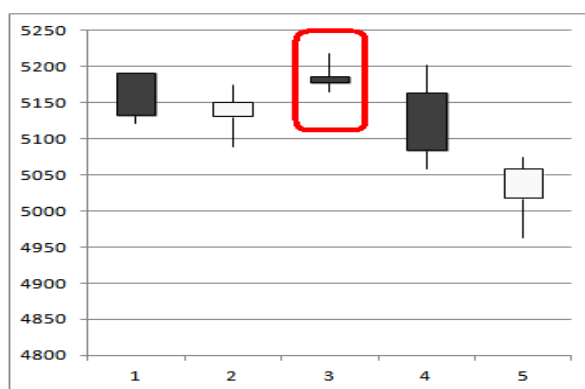


Figure 5.2: Candlestick chart of Table-5.3

Figures 5.1 and 5.2 show the candlestick representation of the values presented in tables 5.1 and 5.3 respectively. In figure 5.1 the x-axis represents the trading day (date) and the y-axis represents the Nifty-50 index value range. In figure 5.2 the x-axis represents the trading sessions in days (1,2,...) and y-axis represents the Nifty-50 index value range. The colored rounded box in figure 5.1 shows the Hammer formation and in figure 5.2 shows the Inverted Hammer formation. The table 5.2 represents the output of our system that successfully identified the Hammer formation on the third day, highlighted as 1 under HMR column. The table 5.4 represents the output of our system that successfully identified the Inverted Hammer formation on the third day, highlighted as 1 under IHMR column.

According to the identified formations our trading system would successfully generate buy and sell signals. For the formation identified from table 5.1 our trading system generated a sell signal on the 3rd session which actualized in consecutive two sessions and from table 5.3 our trading system generated a sell signal on 3rd session which actualized in coming two sessions.

This kind of experiments were performed in different time frames like hourly, daily, weekly and monthly settings and achieved successful results. The experiments were further performed with data of different set of years and achieved successful results.

VI. Conclusion

The experimentations were done with the proposed model and it was found that the system could identify the Hammer and Inverted Hammer patterns. Also the system generated successful trading signals using the action rule-base. For experimental purpose the weekly and daily NIFTY index values of five consecutive sessions were used and plotted candlestick charts for it. The developed model made the system understand the patterns and the proposed system took the decision whether to create a buy or sell position.

In the proposed system at every phase Fuzzy-Rules are developed. The accumulated Fuzzy-Rules from every phase become the Fuzzy Rule-base. This Fuzzy-Rule-base assisting the Action Rule-base guides it to decide the course of action whether to buy or sell. The methodology can be enhanced to predict the long term future trends. The proposed model is simple and easy to develop which can effectively identify the present trend and also help in predicting the immediate future trend. There is an ample scope of improvement and researchers can creatively use this model for trend identification and enhance it for further trend prediction.

The proposed future work in this context can be in finding methods or models that can help in forecasting exact values of how much points the market would move up or down in future. Also an expert system could be built by combining various techniques so that traders can use it for trading purpose and researchers can use it in forecasting other types of data.

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