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Machine Learning Based Automated Trading Strategies for Indian Stock Market



Abstract: - Stock market is a very important and one of the main financial platforms for a country. It measures the growth of all financial components associated with the base of economy. Firms can raise capital through bonds, IPO, FPO etc. and investors can participate in this market. Different stock exchanges are regulatory bodies are responsible to regulate the system and provides the platform to the investors for the participation into market. In India investors participating in this marketplace over than 10 crores demat accounts. Investors analyses the fundamental, technical, price action and different research on the financial parameters of market or stocks before investing. This Machine Learning and Artificial Intelligence based proposed research provides an automated platform for the Indian investors to take decision about a strategy considering the different financial tools and price action. This research considering candlestick pattern and Exponential moving average (EMA) (10,50,100 and 200 EMAs) crossover together. Now a days large portfolio investors and different international financial intuitions such as Morgan Stanley, JP Morgan, Bank of America and the different domestic institutions such as LIC, SBI, HDFC mutual fund using different algo trading strategies for trading and investing.

Keywords: Exponential Moving Average (EMA), Simple Moving Average (EMA), Crossover, Automated Platform, Machine Learning (ML), Trading.

I. INTRODUCTION

The stock market is a marketplace where buyers and sellers can transact on publicly traded shares at particular times of the day. However, the main distinction between the two is that, whilst the latter enables you to trade a variety of financial securities, such as bonds, derivatives, currencies, etc., the former is only used to trade shares. “Buy low price, sell high price” is a strategy where the trader purchases the stock a low price and sells it a high price to complete a profitable transaction. Unfortunately, it is very difficult to determine if a stock price is low enough or high enough and hence, it is challenging to implement this strategy consistently. For this reason, traders consider other factors like moving averages, the business cycle and consumer sentiment.

Technical analysis is the research about the historical market data, mainly it considers price and volume of forecast of the future trends of the prices [3]. Technical indicator is a calculation of several parameters technical analysis which directs the trend of information of price forecasting. History based technical analysis oppose the long-held

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concept of Efficient Market Hypothesis (EMH). EMH describe that stock prices follow a random behaviour; it cannot be predicted through historical data. But one true fact is history repeats itself [9]. The exponential moving average is very simple technical indicator that very smoothly predict the future price of stock as well as it constantly updating its value. Though it is lagging indicator but future direction can be easily identified specially the crossovers. The exponential moving average is used to predict trends and when one exponential moving average crosses over another, it generates automated trading signals.

Trading strategy is a plan designed to execute a profitable return by going long i.e., buying a security or short i.e., selling a security in the stock market. Buy signal is generated or bullish crossover occurs if the shorter exponential moving average crosses to the upside longer exponential moving average. This is also known as a golden crossover. The sell signal or bearish crossover occurs if the shorter exponential moving average crosses to the down side the longer exponential moving average. This is known as a dead crossover. The bullish crossover or golden crossover is the indication that the market price will increase in the recent days, the trader/investors consider this as a signal to buy the share. The bearish crossover or dead crossover is the indication that the stock price will decrease in the next few days, and the trader/investor should sell the share

The Moving Average (MA) or Simple Moving Average (SMA) is calculated based on the past data. So SMA crossover strategy is very lagging indicator because it gives equal weightage to all the prices. But closer prices having higher priority or weightage over far on. Exponential Moving Average assign the different weightage to different price. Current price gets maximum weightage. This property makes the indicator very much less lagging.

Buy signal is generated or bullish crossover occurs if the shorter exponential moving average crosses to the upside longer exponential moving average. This is also known as a golden crossover. The sell signal or bearish crossover occurs if the shorter exponential moving average crosses to the down side the longer exponential moving average. This is known as a dead crossover [2]. The bullish crossover or golden crossover is the indication that the market price will increase in the recent days, the trader/investors consider this as a signal to buy the share. The bearish crossover or dead crossover is the indication that the stock price will decrease in the next few days, and the trader/investor should sell the share

As remedies of the short coming of the disadvantage of the moving average strategy, in this proposal exponential moving average along with machine learning approach is proposed. Through regression method, the exponential moving average crossover are predicted in respect of time thereby not only minimizing the lagging but also predicting the of trend reversal points that a trader can take profitable trades.

II. BRIEF OVERVIEW OF MARKET

The Bombay Stock Exchange (BSE), India's oldest exchange, serves as the foundation of the country's stock market. Under a banyan tree in front of Mumbai's Town Hall, four Gujarati stockbrokers and one Parsi stockbroker joined forces to launch it in 1855. As the number of brokers steadily increased, a lot of adjustments occurred. The first set up relocated to Dalal Street in 1874, and in 1875 it adopted the name "The Native Share & Stock Brokers Association" to become an official corporation. The BSE was the first stock exchange to be acknowledged by the Central Government under the Securities Contracts Regulation Act starting in 1958. In 1980, the exchange moved back to the Phiroze Jeebhoy Towers on Dalal Street. The BSE team created the BSE SENSEX index to gauge the overall performance of the stock markets. Twenty-two other stock exchanges, including those in Mumbai and Ahmadabad, were established in the 20th century. When compared to any other country in the globe, our money market has had a process of development and practically unmatched expansion. When measured in terms of money raised in the market, the expansion of Indian securities expanded exponentially based on the number of stocks held, market value, number of traded volumes, daily total turnover, investor populations, and price indices of various stock sectors. As investors, issuers, and intermediaries' profiles changed dramatically over time, the market was frequently realigned. Thanks to the National Stock Exchange, the BSE has seen fundamental changes, such as a decrease in transaction costs, which have significantly improved efficiency, transparency, and safety. Currently, the Indian market can compete with any market in a developed nation on a variety of fronts. The stock market is a marketplace where investors can purchase and sell various stocks. Through a sequence of bids, the market determines the price of the day for each and every stock listed under it. The investor can offer to acquire a stock or to sell it for a specific price depending on market value. Buyers competed with one another to offer the best bid, or the greatest price as quoted, to buy a specific stock. Similar to this, sellers compete with one another for the stock

at the lowest price given. A trade is carried out when a match develops between the buyer and seller. The various group of tread brokers tell exchanges with high-speed computers about the entire process, which is automated. BSE has helped the Indian corporate sector flourish over the past 14 decades by giving it a productive platform for capital raising. The BSE is the world's top exchange in terms of the number of listed members, with close to 6000 listed businesses trading there.

III. SECURITIES EXCHANGE OF INDIA

From a country's stock market, one can determine how well its economy is doing. Essentially, it refers to the nation's financial status at the time. It is crucial to continue watching the stock market in order to improve the nation's economic situation and safeguard investors' rights. The Capital Issue (manage) Act of 1947 was implemented as a result, however it was unable to completely manage the market. In order to support this law, the Securities and Exchange Board of India (SEBI) was founded in 1992.

The following are a few of SEBI's listed functions:

Three key categories can be used to group SEBI's activities:

- Protective Purposes: To safeguard unethical market trade practises.

to confirm every investor in the stock market.

to provide investors with appropriate education regarding the securities industry.

to provide knowledge of the security market's code of conduct.

- Regulatory Functions: To regulate the share market's corporate strategy in order to register and control venture capital funds. To periodically conduct an audit of the stock markets the registration and regulation of credit rating agencies.

- Providing all intermediary personnel with effective training is one of the development functions. To support and promote self-governing organisations. Access to conduct research in support of the development of the shear market. To provide various information for the benefit of everyone working in the capital markets.

IV. DEPOSITORY PARTICIPANT

Depository Participant (DP) is referred to in India as the depository's agent (law). This organisation serves as a go-between for the market's investors and the depository. According to a mutual agreement reached between the two parties under the Act of Depositories, the operation between DPs and the depository is governed. Under the Subsection of 1A of the SEBI Act 12, DP is an organisation that collaborates with SEBI. A DP may only recommend depository-related services in accordance with this act after receiving a certificate of registration from SEBI. There are currently 288 DPs of NSDL and 563 DPs of CDSL registered with SEBI for the 2012 accounting period. A depository is a business that keeps investor securities certificates and facilitates trading in commodities, mutual funds, derivatives, shares, and debentures. On behalf of their clients, the intermediaries handle activities involving securities at the Depository. The term "Depositories Participants" refers to these middlemen. In India, there are essentially two different types of depositories. According to data collected up until January 2021, 1.7 million new Demat accounts were established; however, from September 2019, a little under 1.9 million new accounts have been opened each month. The overall number of Demat accounts in India as of January 2021 was 51.5 million, up from 35.9 million at the end of FY19 and 40.8 million at the end of FY20.

V. LITERATURE REVIEW

For stock market prediction most commonly and popular classifier is used is Artificial Neural Networks (ANN)[6]. But the problem associated is it suffer from over-fitting. That problem introduced in [11]. There uses Swarm Optimization (SO) and Least Square Support Vector Machine (LSSVM). In this model consider five indicators Relative Strength Index(RSI), Exponential Moving Average (EMA), Money Flow Index (MFI), Moving Average Convergence/Divergence (MACD) and Stochastic Oscillator(StO) along with some fundamental analysis and comparing with average volume. To select informative input features for several indicators there used Genetic Algorithms (GA).

Author in [7] introduced a prediction two stage scheme. In first stage user support vector regressor (SVR) and in second stage ANN with Random Forest (RF). The research proposed based on SMA, Stochastic K%, Stochastic D%, RSI, MACD. Whatever there uses some advanced indicators, but complexity as well as signal generation for trading is very poor.

Author in [3] proposed a data mining with historical data on stock market to assume the future. There used the decision tree method on historical data such as open, close low, high by author in [5] to predict the action to be taken next. In another study author [11] use RSI, Bollinger Bands (BB) Chaikin Money Flow (CMF) and SMA to generate signal for one day trading strategies. There uses of decision tree as classifier which gives very poor result. The model proposed by author in [9] consider wide range of indicators along with price based and volume-based overlays. Here also as classifier their uses of diction tree and neuro fuzzy system.

The candlestick generated based on open, close, low and high price of certain stock in some time period. In stock market trading candlestick is largely use as tool which indicates about the trends of market or stock. To predict next candle pattern current candle is very important and demand-supply can be easily understandable. In [17] author proposed automation method to predict candlestick based on Convolution Neural Network (CNN) classifier. A simple way to use time-series encoding methods. It converts 1D time-series data into a 2D matrix.

From the above literature survey, it can be concluded most of the authors using some predefine indicators and using machine learning based classifier which trading the system first and test for accuracy. Classifiers are generally decision tree, SVM or ANN based. 90% cases indicators are lagging gives the signal after happing. Two studies based on SMA based which is unweighted. This proposed methodology based on EMA, which is weighted and CNN based classifier will overcoming the shortcomings of existing methods.

VI. SIMPLE MOVING AVERAGE

Moving averages or simple moving averages are one of the core indicators in technical analysis, and there are a variety of different versions. SMA is very easy moving average to construct. It is simply the average price over the given *period*. This average is called as moving, reason is it is plotted in the chartbar by the bar, forming a moving average line that moves along the bar chart as the moving average value changes.

Simple moving average are often used to determine trend or direction of market or stock. If the Simple moving average is moving up, the trend is up. If the SMA is moving down, the trend is down. A 200-bar SMA is common proxy for the long-term trend. 50-bar SMAs are typically used to gauge the intermediate trend. Shorter period SMAs can be used to determine shorter term trends. SMAs are commonly used to smooth price data and technical indicators. The longer the period of the SMA, the smoother the result, but the more lag that is introduced between the SMA and the source. Price crossing SMA is often used to trigger trading signals. When prices cross above the SMA, you might want to go long or cover short; when they cross below the SMA, you might want to go short or exit long.

$$SMA = (A_1 + A_2 + A_3 + \dots + A_n) / n$$

where: A_n = the price of an asset at period n

n = the number of total periods



Figure 1 Simple Moving Average

VII. EXPONENTIAL MOVING AVERAGE CROSSOVER

The Moving Average (MA) or Simple Moving Average (SMA) crossover strategy is one of the well-known technical analysis tools used by trader or investors in stock markets. When the short-duration MA crosses above the long-duration MA, this means that average prices of the short time period are showing higher than those over the longer time period and the prices have a bullish momentum appearing [3].

$$MA = (A_1 + A_2 + \dots + A_n) / n \dots\dots\dots 7.1$$

where: A_n = Price of an asset at period n

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The Moving Average (MA) or Simple Moving Average (SMA) crossover strategy is very lacking indicator because it gives equal weightage to all the prices. But closer prices having higher priority or weightage over far on. Exponential Moving Average assign the different weightage to different price. Current price gets maximum weightage. This property makes the indicator very much less lagging.

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$$EMA = Price(t) \times k + EMA(y) \times (1 - k) \dots\dots\dots 7.2$$

Where t = today

y = yesterday

N = number of days in EMA

$$k = 2 \div (N + 1) \dots\dots\dots 7.3$$

Using what is known as moving average crossovers, trading rules are frequently defined in this way. Moving averages are often calculated using the asset's price rather than returns. A definition of the moving average crossover is:

$$\hat{y}_t^{f,s} = \frac{1}{f} \sum_{i=0}^{f-1} y_{t-i} - \frac{1}{s} \sum_{i=0}^{s-1} y_{t-i} = \hat{y}_t^f - \hat{y}_t^s \dots\dots\dots 7.4$$

The concept is based on using two moving averages—one rapid, denoted by y f t, and one slow, denoted by y s t—where f denotes an upward trend and y f t y s t denotes a downward trend. Therefore, the general trading rule is to purchase an asset when the moving averages cross y f t > y s t and to short an asset when y f t < y s t. The approach as shown in the introduction is one of the most fundamental trading indicators.

Which trends the indicator detects will depend on the smoothing parameters f,s that are used. Return signature plots are used to facilitate this operation, which is further discussed in method . These charts show the relative weights that the feature has given historical returns. Such plots are created by deriving a function that yields the weights. Expressing the price at a time t, the weights allocated to observations can be obtained under the assumption of log prices.

$$y_{t-n} = y_t - \sum_{i=0}^{n-1} r_{t-i} \dots\dots\dots 7.5$$

Expressing the summation yields a pattern

$$y_{t-n} = \begin{cases} y_t & \text{if } n = 0 \\ y_t - r_t & \text{if } n = 1 \\ y_t - r_t - r_{t-1} & \text{if } n = 2 \\ \vdots & \end{cases} \dots\dots\dots 7.6$$

By taking the sum of the emerging pattern an equivalent expression to that can be written as:

$$\hat{y}_t^n = \frac{1}{n} \sum_{i=0}^{n-1} r_{t-i} = y_t - \sum_{i=1}^{n-1} \frac{n-i}{n} r_{t+1-i} \dots\dots\dots 7.7$$

Now an expression of moving average crossover can be calculated.

$$\hat{y}_t^{f,s} = \hat{y}_t^f - \hat{y}_t^s = \left[y_t - \sum_{i=1}^{f-1} \frac{f-i}{f} r_{t+1-i} \right] - \left[y_t - \sum_{i=1}^{s-1} \frac{s-i}{s} r_{t+1-i} \right] = \sum_{i=1}^{s-1} \frac{s-i}{s} r_{t+1-i} - \sum_{i=1}^{f-1} \frac{f-i}{f} r_{t+1-i} \dots\dots\dots 7.8$$

From equation one can draw the conclude that the moving average crossover of logarithmic prices consists of Exponentially weighted previous returns. The trend expression can be simplified as

$$\hat{y}_t^{f,s} = \sum_{i=1}^{s-1} w_i r_{t+1-i} \dots\dots\dots 7.9$$

Where the weights can be derived as:

$$w_i = \begin{cases} \frac{i}{f} - \frac{i}{s} & \text{for } 1 \leq i \leq f-1 \\ 1 - \frac{i}{s} & \text{for } f \leq i \leq s-1 \end{cases} \dots\dots\dots 7.10$$

The formula is of relevance when realizing how the weighing changes with different combinations of f and s. For easier comparison of different pairs of s and f the weights are standardise by the sum of the weights:

$$\sum_{i=1}^{f-1} \left(\frac{i}{f} - \frac{i}{s} \right) + \sum_{i=f}^{s+f-1} \left(1 - \frac{i}{s} \right) = \sum_{i=1}^{f-1} \frac{i}{f} + \sum_{i=k}^{s+f-1} 1 - \sum_{i=1}^{s-1} = \frac{1}{2}(f-1) + s - \frac{1}{2}(s-1) = \frac{1}{2}(s-f) \dots\dots\dots 7.11$$

The normalised weights can be derived as:

$$w_i = \begin{cases} \frac{2}{(s-f)} \frac{i}{f} - \frac{i}{s} & \text{for } 1 \leq i \leq f-1 \\ \frac{2}{(s-f)} - \frac{i}{s} & \text{for } f \leq i \leq s-1 \end{cases} \dots\dots\dots 7.12$$

Fig 2, shows the exponential moving average crossover for nifty 50 index. This is also applicable for any stocks. It considers hour time frame i.e., each candle representing one hour. Within the time duration of Feb 26th to April 13th 2023 two crossover generated

First signal is for on 10th march 2023 a dead crossover or bearish crossover or sell signal occurs, the shorter exponential moving average crosses to the down side the longer exponential moving average. Another in 2nd April

2023 a golden crossover or the bullish crossover or buy is the indication that the market price will increase in the recent days, the trader/investors consider this as a signal to buy the share.



Figure 2 Exponential Moving Average Crossover in Daily Timeframe for Nifty50 Index

Fig 3, shows the exponential moving average crossover for nifty HDFC bank. This is also applicable for any other stocks. It considers hour time frame i.e., each candle stick representing one hour. Within the time duration of April 3rd to May 22nd 2023 two crossover generated

First signal is for on 3rd April 2023 a dead crossover or bearish crossover or sell signal generated, the shorter exponential moving average (10 EMA and 50 EMA) crosses to the down side the longer exponential moving average (100 EMA and 200 EMA). Another in 22nd May 2023 a golden crossover or the bullish crossover or buy is generated that the market price of HDFC Bank will increase in the recent days, the trader/investors consider this as a signal to buy the share of HDFC Bank.



Figure. 3 Exponential Moving Average Crossover in Daily Timeframe for HDFC bank equity

VIII. PROPOSED METHOD

This proposes research proposes the use of Machine Learning on moving averages of closing price of candle. The proposed model uses the concept of regression on the candle moving average to predict the moving average crossover ahead in time and generate buy and sell signal accordingly.

The study taken the traces on live National Stock Exchange (NSE) index data Nifty 50 data. It can be also and much more applicable for individual stocks and traced with historical data of Reliance Industries, HDFC bank, TCS and Infosys. The proposed research will be developed on historical data and tested on live data available in NSE website The method will includes the data pre-processing includes to finding the 4 moving averages, the data set contains 6 columns date/time price EMA10, MA50, EMA100, EMA200.

Time frame is very important for the investment period. Generally, 5 min or 15 min consider for intraday trading. 30 min and 1 hr or daily for mid time of one week to one month. Weekly and monthly time frame for long term investment. Regression based algorithm is trained by long- and short-term exponential moving averages. From the trained time period upcoming moving averages will be calculated for next few candles.

The output of the proposed model is three clustered.

Class 1: Bullish sentiment or buy signal generated, candle and check the trends to cross short term EMA crosses long term EMA then buy signal generated. Such as if 10Days EMA crosses 50D EMA, 100D EMA or 200D EMA buy signal generated

Class 2: on the other hand, if higher moving average of higher time frame crosses lower time frame moving average from up to down sell signal is generated

Class 3: If no possibility of crossover generation returns no trade zone. This either consolidation or distribution.

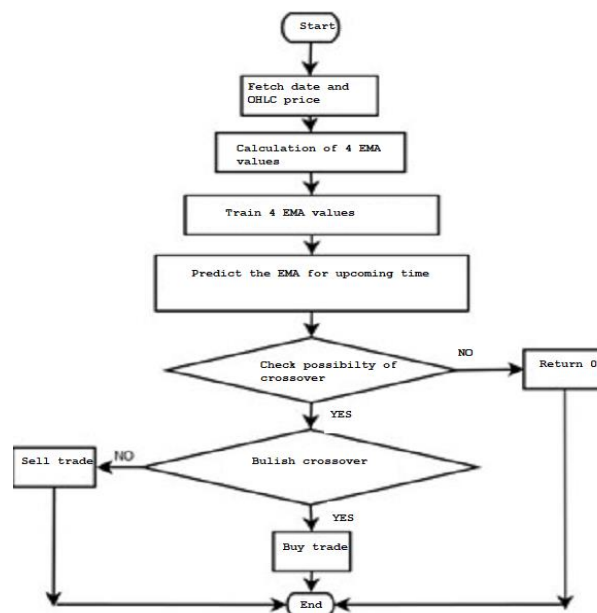


Figure 3. Flow diagram for proposed model

IX. METHODOLOGY:

1. Exponential Moving Average Crossover

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$$\text{EMA} = \text{Price}(t) \times k + \text{EMA}(y) \times (1 - k)$$

Where t=today

y=yesterday

N=number of days in EMA

$$k = 2 \div (N + 1)$$

2. *Confusion Matrix:*

The performance of the classifier is evaluated by confusion matrix. Actual class is represented by each row of confusion matrix and column indicates the predicted class by the classifier. The bisection or intersection of the predicted and actual class represent are the number of corrected classier outputs of the model designed. So, the diagonal of the matrix represents all true positive.

Accuracy: Evaluation of the classification model is represented by the metric. It is evaluated by the ratio of prediction correctly and total number of testings.

$$\text{Accuracy} = (\text{TP} + \text{TN}) / n$$

Where n is total testing process.

TP is total number of true positive and TN is true negative.

Precision:

Accuracy of the positive prediction of the classifier is represented by precision.

$$\text{Precision} = \text{TP} / (\text{TP} + \text{FP})$$

Where TP is total number of true positive and FP is total number of false positive

Recall: Recall is an important parameter to measure sensitivity or true positive rate. It is represented by positive instances evaluated by classifier.

$$\text{Precision} = \text{TP} / (\text{TP} + \text{FN})$$

Where TP is total number of true positive and FN is total number of false negative.

FI score:

It is the combination of recall and precision in single parameter. FI is harmonic mean of recall and precision

$$\text{FI} = 2 \times (\text{Precision} \times \text{recall}) / (\text{precision} + \text{recall})$$

Regression:

Regression is used to for training 4 EMAs and predict the direction of EMA crossover

X. RESULT:

Confusion matrix of HDFC bank shows in table1. The accuracy is measured of the model is approximately 83.63%.

Another case study is taken for the Nifty50 index which is shows in table2. It is similarly working for index and ETF also. The accuracy is measured of the model is approximately 83.84%.

The third case study on reliance industries ltd. Which is shown in table 3. The accuracy is measured of the model is approximately 83.77%.

Table 4 represent relative performance of above case studies for the proposed model HDFC bank, Nifty 50 index and Reliance Industries Ltd.

Buying and selling signal for that is dead crossover golden crossover also shown in fig 3. In figure clearly shown buy call after that a good movement is appearing in chart. Similarly happening for sell call also. Image shows live prediction for HDFC bank.

Table1 Confusion matrix for HDFC bank

Predicted/Actual	Actual sell trade	Actual no trade	Actual buy trade
Predicted sell trade	455	289	7
Predicted no trade	254	5747	212
Predicted buy trade	11	487	234

Table2 Confusion matrix for Nifty 50 index

Predicted/Actual	Actual sell trade	Actual no trade	Actual buy trade
Predicted sell trade	503	331	6
Predicted no trade	244	5630	208
Predicted buy trade	9	432	248

Table3 Confusion matrix for Reliance Industries Ltd.

Predicted/Actual	Actual sell trade	Actual no trade	Actual buy trade
Predicted sell trade	377	257	7
Predicted no trade	234	5234	199
Predicted buy trade	10	423	221

Table4 Performance compares between existing and proposed system

	Existing System	Proposed System
HDFC bank	81.76	83.63
Nifty 50	82.02	83.84
Reliance Industries Ltd.	81.92	83.77

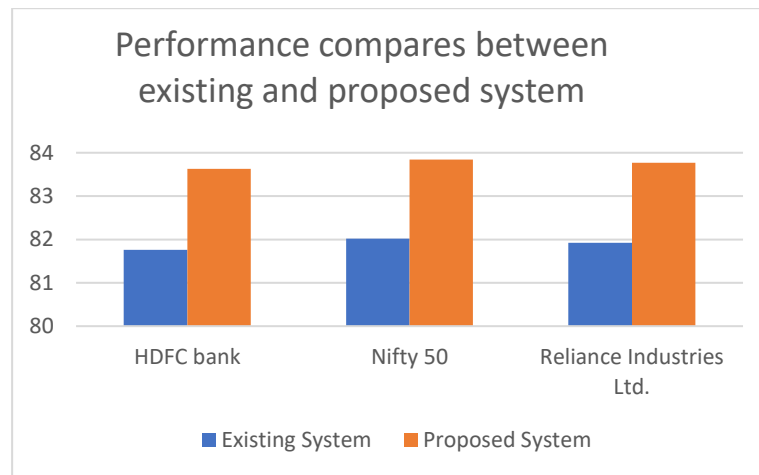


Figure 5 Performance compares between existing and proposed system graphically

XI. CONCLUSION:

It is very important to take right decision in right time. To take the trading decisions generally traders using indicator based. Like about almost indicators are lagging, that means signal generated after occurring. This moving average based automated system using exponentials data which is based on future movement possibilities and direction of the EMA.

The accuracy of the proposed model is very high in compare to another existing model. This model generates both buy and sell signal for index and securities also which gives both directional profit to the traders.

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