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An Automated Stock Trading Auditing System Using Hybrid Adaptive Neuro-Fuzzy Inference System (ANFIS)

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ABSTRACT

This study presents a hybrid Adaptive Neuro-Fuzzy Inference System (ANFIS) that automates the audit of listed companies in a stock exchange. Software Methodology employed is object oriented and Model Base Engineering. Financial data collected from Nigeria Stock Exchange for 3 years was used as training set and 2016 financial data of listed companies as research test source data. The Model provides a profit or loss decision based on the evaluation of each listed company, testing and checking were used for validity test. The performance of listed companies for the year 2016 was obtained. Companies with minimal testing value 0.5 to 1 are healthy (profit) and companies with minimal testing value 0 to 0.4 are unhealthy (loss) to invest. The result shows that the prediction model is accurate and will enable investors know the right company that makes profit or loss to invest in. Proposed system performed better than TSFNN system with 86.32% accuracy using Root Mean Square Metrics. This technique was implemented in MATLAB.

Keywords: Adaptive Neuro-Fuzzy Inference System, Financial Data, Object-Oriented, Model Base Engineering

1. INTRODUCTION

Stock market is an exchange where security trading is conducted by professional stockbrokers. It brings stockholders together in company's shares trading, when the price is high, the demands also increases, price arrangements are dependent on supply and demand, where stocks are greatly sold, it reduces price (Venugopal, 2010). Stock markets are viable areas where companies and investors make huge profits, it give room for capital advancement and growth by trading shares Company's in a public market domain. It is regarded as an essential need for country's economic growth and improvement. Primary market are where new issues for securities are handled, and shares were bought directly from the company standpoint while secondary market handles current securities, where shares are bought and sold within stockbrokers. Stock exchanges have a trading base when instructions are communicated for accomplishment. Due to complexity of stock market financial data, soft computing techniques are being applied such as; fuzzy logic, machine learning, neural computing also known as automated system have made trading decision prevalent practice in major exchanges of the world.

The techniques developed within the computing nitty-gritties are unique in the appearance and performance. Soft computing was able to handle and capture imprecision, uncertainty, partial truth and approximation (Jin, 2016). Stock market is exploding at an alarming rate and hence prone to usual challenges of fraud or financial anomaly making many people to lose faith and hope in stock markets.
The analysis of the financial market always draws a lot of attention from investors and researchers. The trend of stock market is very complex and it is influenced by various factors. Before the age of computers, people traded stocks and commodities primarily on intuition. As the level of investing and trading grew, people searched for tools and methods that would increase their gains while minimizing their risk. Many of these techniques are used to preprocess raw data inputs, and their results are fed into models that the users use to derive their expected results.

2. RELATED WORKS

The Neuro- fuzzy based system approach learns the rules and membership functions from data. It is called an adaptive network because some, or all, of the nodes have parameters which affect the output of the nodes. These networks are learning a relationship between inputs and outputs (Hemath et al , 2012).
It uses a hybrid learning procedure for estimation of the premise and consequent (Jang 1993). The fuzzy neural network systems (Neuro-Fuzzy systems) combine the advantages of fuzzy logic systems and neural networks. The technique have become a very active subject in many scientific and engineering areas, such as, model reference control problems, Proportional Integral Derivative (PID) controller tuning and signal processing, (Lin & Lee,1991).

Neuro-fuzzy was used to predict their system and investigation shows that it performs well with various trading strategies involving the stock. They used historical data in prediction which spans through few days (Kumar et al., 2012). Adaptive Neuro-Fuzzy Infernce (ANFIS) was used to determine the best stock trend prediction model, results show that ANFIS clearly demonstrates the potential of Neuro-Fuzzy based modeling for financial market prediction (Atsalakis & Valavanis, 2009). Combining the concepts of fuzzy systems and artificial neural networks was suggested, the use of a hybrid adaptive network-based fuzzy inference system (ANFIS) to forecast the volatility of the Taiwan stock market(Chang *et al,* 2011). The authors indicated that the proposed model is superior to other methods with regard to error measures. Fuzzy logic and Neural Network approaches for predicting financial stock price are investigated by (Uduak & Udoinyang, 2015).

A study of a knowledge based system for stock price prediction is carried out. They explore Trapezoidal membership function method and Sugeno-type fuzzy inference engine to optimize the estimated result. Our model utilizes the performance of artificial neural networks trained using back propagation and supervised learning methods respectively. The system is developed based on the selection of stock data history obtained from Nigerian Stock Exchange (NSE), which are studied and used in training the system. A computer simulation is designed to assist the experimental decision for the best control action. The experimental result shows that the model has such properties as fast convergence, high precision and strong function approximation ability. It has shown to perform well in the context of various trading strategies involving stocks. The application of hybridized soft computing techniques for automated stock market forecasting and trend analysis (Abraham et al, 2001). The predicted stock values are further fed to a neuro-fuzzy system to analyze the trend of the market. The forecasting and trend prediction results using the proposed hybrid system are promising, and the fuzzy set theory is a theory which can handle imprecise or linguistic information that actually probability theory cannot do properly (Zadeh, 1965).

3. METHODOLOGY

This study explores the use of object-oriented method/ recursive design and model based engineering. In Object Oriented Method/Recursive Design (OOM/RD) software development, are essentially technique that makes software generate an efficient result, and these processes applied to part of the main system that describes the functionality of the system in details (Ramirez et al, 2011). While Model-Based Software Engineering/Development approach, is particularly well suited for implementing dynamic systems which is very suitable for real-time applications. In a typical model-based technique, the software development process is directed towards a high-level executable model of the given system(s) (Stahl & Volter, 2013). It does not focus on the algorithmic or computing aspects of the system. (Basha et al, 2012).

3.1 Proposed System

The proposed system uses neural techniques i.e. it can learn continually which is very desirable for continual auditing of listed companies in the Nigerian Stock Exchange (NSE). It can make predictions into the future and automatically identify trends that may indicate an anomaly, which is an important feature of data analytics. Fuzzy Neural Network; is a combination of fuzzy and neural network in predicting audit opinion in Nigeria Stock Exchange. It also uses Adaptive Neuro-Fuzzy Inference System (ANFIS) to measure the performance of the system. The architecture of the system is presented in figure 1.

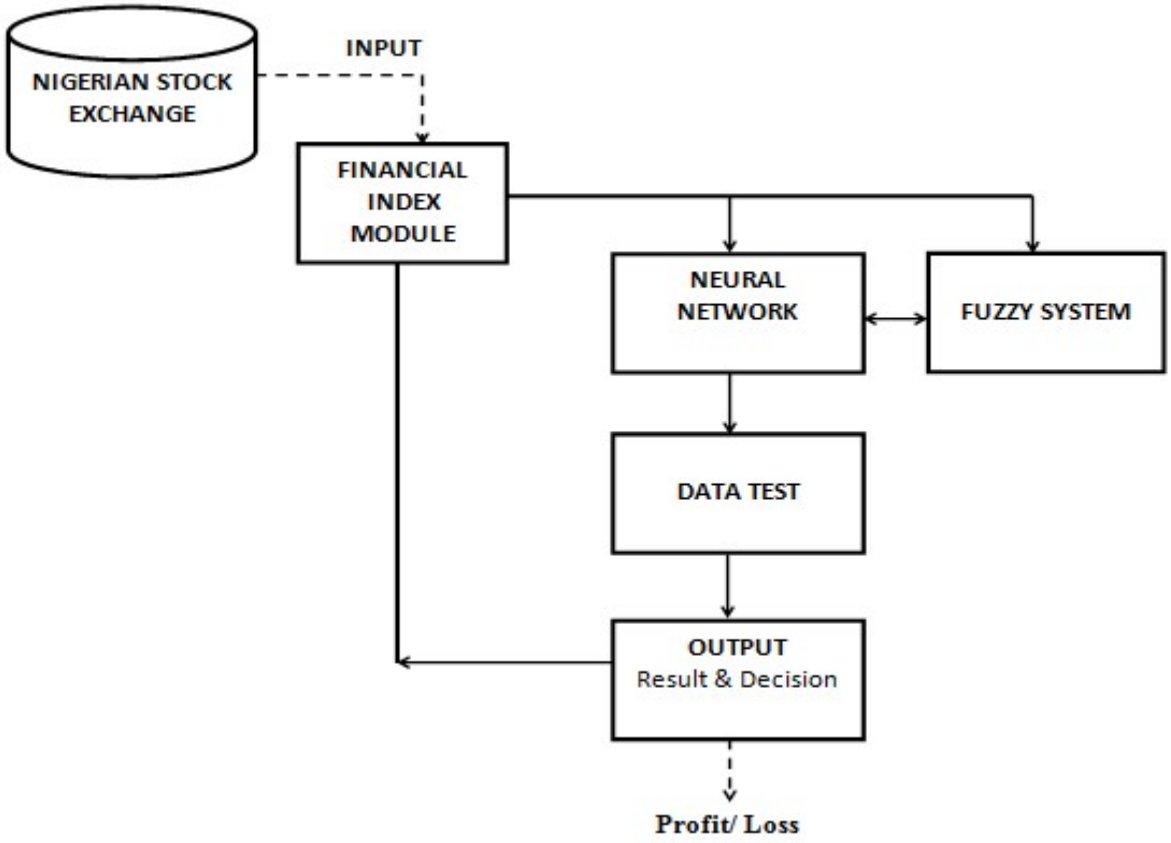

Figure 1: Design of the Proposed System

Financial index Module
Financial indexes data gotten from Nigeria Stock Exchange (NSE) serves as input to the system. In financial indexes, auditors look for patterns, trends and other factors that may be present in capital investment (stock market). These patterns and trends may be able to effectively predict stocks' future performances hence can be used to make a profit and loss decision. These financial indexes include: Net Current Assets, Total Assets, Net Worth, Turn Over, Profit Before Tax, Profit After Tax, Taxes and Retained Earnings.

Neural Network
The Neural Network learns the financial indexes data analysis variables that have the tendency to fluctuate within a period of time. Financial indexes data goes to the Neural Network; these indexes are inputs to the system to produce decision.

Fuzzy System
Fuzzy theory attempts to mimic human reasoning in its use of approximate information and uncertainty to generate decisions. Fuzzification transforms the financial indexes to fuzzy values using membership functions. These membership functions are chosen based on the intuitive meaning obtained from the auditing.

Data Test
The data test module is used to check the performance of the system against the trained data. The data gotten from the NSE were trained with the proposed technique and tested to know the performance of the listed companies.

Output (Result & Decision)
The output of the system shows decision of the listed companies which can be profit or loss. Companies with minimal testing value 0.5 to 1 are healthy (profit) and companies with minimal testing value 0 to 0.4 and unhealthy (loss).

3.2 Use-case Diagram
The use case diagram is used to gain understanding on how the proposed Automated Fuzzy Neural Stock-Exchange Auditing tool may operate in reality. It identifies, clarify and organize system requirements. Its diagram is as shown in Figure 2. They contain all system activities that have significance to the users.

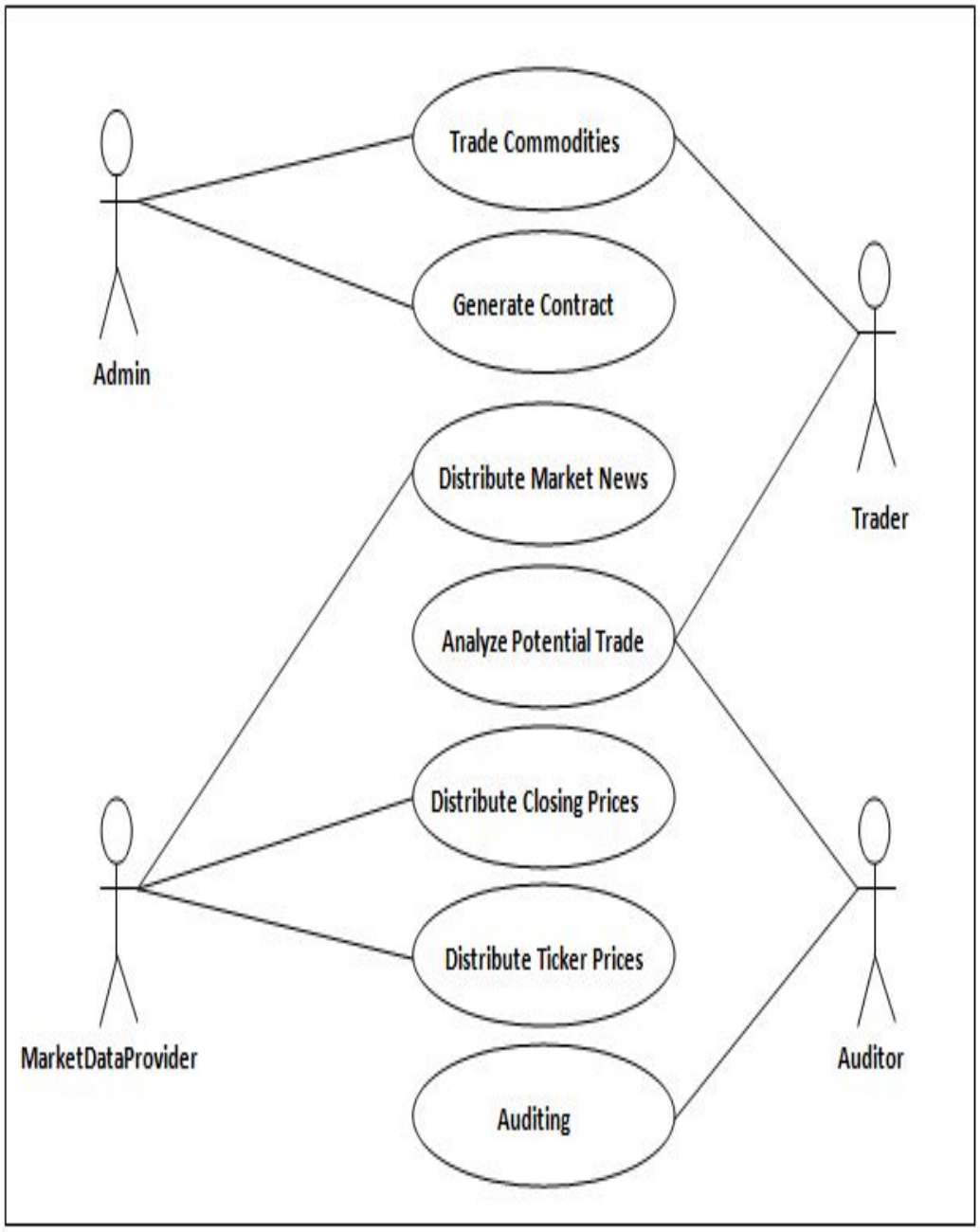

Figure 2: Use-case Diagram

The use-case model has four actors:

Admin: Initiate contract, trade commodities
Trader: Trade commodities and analyze potential trade
Auditor: Analyze potential trade and auditing
Market Data Provider: Distribute market news, distribute closing prices and distribute ticker prices.

3.3 ANFIS Architecture

The ANFIS network (multilayer model) consist of N units of x_i (i=1,2,3...N) ,the hidden layer consist of P processing entities of k_m (m=1,2,3..P) and one output layer *y* as shown in figure 4.

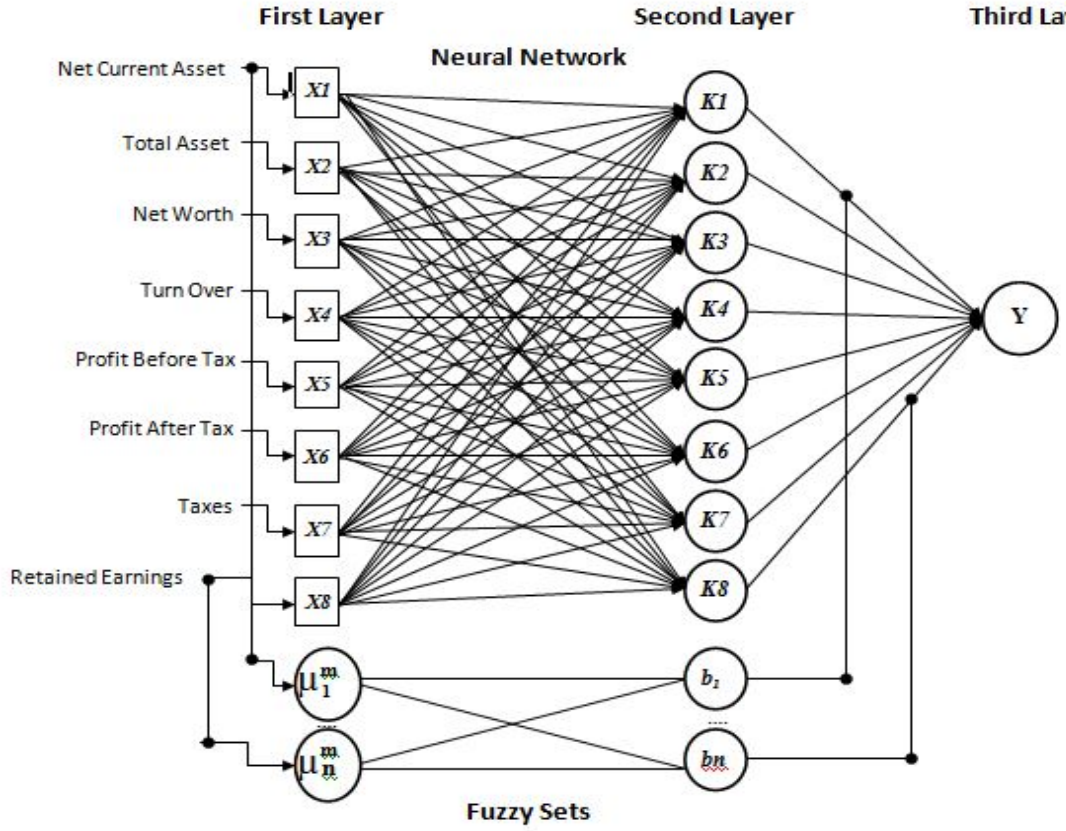

Figure 3 ANFIS model

The first layer is input layer. Set input value X = (x_1, x_2, ...,x_i)

In the model, n = 8 refers to number of indexes that influence audit opinion. (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) refers to Net Current Asset, Total Assets, Net worth, Turnover, Profit Before Tax, Tax, Profit After Tax, Retained Earnings.

The neural network has an input layer, an output layer, with one or more hidden layers in between the input and output layer.

The input layer consists of eight inputs (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8). Each node in the input layer has a signal X_i as network input, multiplied by a weight value between the input layer and the hidden layer. The training steps involved in network are as follows;

Initialize the input, output and weight of each neuron. Here,(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) are financial indexes which are inputs of the network and y output of the network. In each node k_i the hidden layer receives the signal ln(k_i) according to:

$X_i = \sum_{i=1}^{N} X_i W$ - - - - - - - - - (1)

Then passed through the sigmoid activation function:

$f(X) = \frac{2}{(1+\exp(-X_i))}$)=2/(1+exp-X_i) -1 - - - - - (2)

f(x) is a linear function of y and y being the output of the system.

The second layer is the subordinate function layer. Vectors from the input layer are transferred through this layer to the corresponding membership function for membership degree calculation and fuzzy processing.

Gauss function μ_i^m is used in this membership function as shown;

$\mu_i^m = \exp(-(x_i - k_i^m)/b_i^m$ - - - - - - - - - (3)

Which aim at calculating the input vectors fitness of fuzzy rules. In which, (i = 1, 2, ..., l) indicates the i fuzzy implication condition sentence.

Where

μ_i^m is the membership function value of the *i* financial indexes in the *m* sample company

k_i^m is the center value of the membership function of the *i* financial indexes in the *m* sample company.

b_i^m is the width of the membership function of the *i* financial indexes in the *m* sample company.

For our hybridized approach we identified 8 input variables to train the network using financial indexes.

The output for the model could be presented in the functional form as:

$y = g\left[\sum_{m=0}^{P} W_{md}\, g\left(\sum_{i=0}^{N} W_{im} X_i\right)\right]$ - - - - - - - - - (4)

This calculates the weighted sum of each fuzzy rule and the prediction output value of audit opinion in this model.

Where,

W_m is the connection weights between input units and hidden processing units,

W_{md} is the connection weights between hidden processing units and the output unit.

Y is the output of the system given decision either profit or loss.

Algorithm for the Neural Network

(1) Define the output
(2) Choose the appropriate network architecture and algorithm.
(3) Determine the input data and preprocess if necessary.
(4) Choose appropriate learning function.
(5) Choose the appropriate network structure.
(6) Perform the training and testing for each cycle.
(7) If the network produces acceptable results for all cycles, perform step 8 else perform step 5 to try other appropriate network structures else perform step 4 to try with other learning algorithm else perform step 3 to add or remove from input set.
(8) Finish - record the results.

Training are done using the financial indexes set as input element: X= {Net Current Asset, Total Assets, Net worth, Turnover, Profit Before Tax, Tax, Profit After Tax, Retained Earnings}.

Table 1 Minimal training and testing values for Year 2016 Automated Auditing System

S/N	LISTED COMPANIES	Actual Value	Predicted Value	Training Error	Minimal training RMSE	Testing Error	Minimal testing RMSE
1	ACCESS	739223936	739223941.8	72437186.3682	0.7244	72343957.2146	0.7234
2	FCMB	616251054	616251057	38062242.8855	0.3806	37991384.1302	0.3799
3	DIAMOND	642439909	642439914.5	69272955.1403	0.6927	69207558.7636	0.6921
4	FIDELITY	620073525	620073528.6	45066136.3049	0.4507	45008252.7728	0.4501
5	UBN	654081150	654081156.9	85946801.0664	0.8595	85928299.8354	0.8593
6	UNITY	705501252	705501258.9	86321685.5142	0.8632	86316696.7583	0.8632
7	WEMA	582220355	582220356.7	21837095.2149	0.2184	21819822.1607	0.2182

4. RESULT AND DISCUSSIONS

4.1 Results

Training was carried out in MatLab using 8 financial indexes of listed companies in Nigeria Stock Market as shown in Appendix A.1. Tranining is successful if the number of input and output defined in the training field are equal to the number of input and output data loaded to the system, else training failed. Training stop when the training line gets to the Epochs (100) as used in this sample. In ANFIS editor. Before training can be initiated, data must be in a matrix form,where the first colum consist of input data and last column consist of output data, then training can be initiated .You can test the performance of system against the checking data. Training error is the real error, but one can test the performance of system against either testing or checking data. To check the performance of the listed companies, testing error was used as shown in Table 1.The Results show that companies whose minimal training and minimal testing values ranging from 0 to 0.4 are vulnerable in 2016.

Table 2 Result of Stock Market Auditing System

S/N	LISTED COMPANIES	FUZZY OUTPUT
1	ACCESS	0.7
2	FCMB	0.3
3	DIAMOND	0.6
4	FIDELITY	0.4
5	UBN	0.8
6	UNITY	0.8
7	WEMA	0.2

Table 3 Interpretation of Result

S/N	LISTED COMPANIES	FUZZY OUTPUT	DECISION
1	ACCESS	0.7	Profit
2	FCMB	0.3	Loss
3	DIAMOND	0.6	Profit
4	FIDELITY	0.4	Loss
5	UBN	0.8	Profit
6	UNITY	0.8	Profit
7	WEMA	0.2	Loss

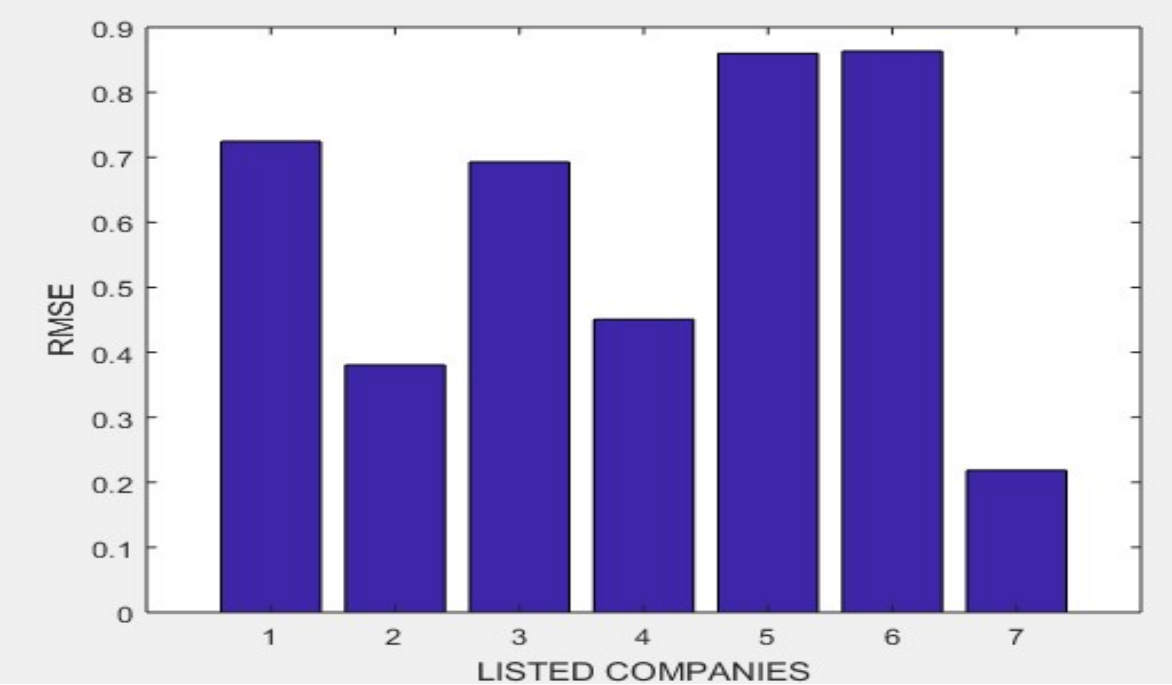

Figure 4 Root Mean Square of Listed Companies

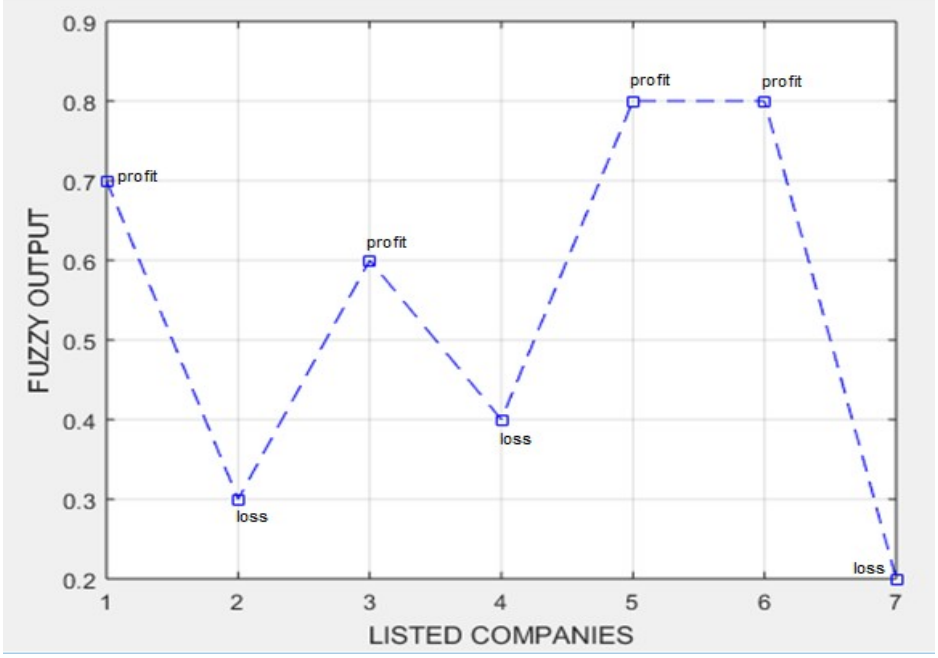

Figure 5 Performance of Listed Companies

4.2 Discussion

We have used the financial statement of ACCESS BANK PLC, DIAMOND BANK, FCMB, FIDELITY, UBN, UNITY and WEMA. For these companies, we have the index for 2016. So, we have generated index datasets for the stated companies. In the ANFIS, the node number of input is 8 and 1 are set as output element of the prediction model represent profit and loss, and the output element nodes is 1. Take 9 as the number of the hidden layer nodes and pick out 9 groups coefficient from T0 to T9, then the central value of fuzzy membership function *k* and width of fuzzy membership function *b* are obtained randomly. Set Epochs (Number of iterations) as 100 iterations and Tolerance (error) at 0, form a ANFIS model of 8-9-1 structure (8 inputs, 9 hidden layer and 1 output) to predict audit opinion. Training effect came out as shown in Appendix A.1. The training error is 0.0091.The node number of input is 8, 1 is set as output element of the prediction model represent a decision profit or loss.

The testing of audit system is basically closed with the Average testing error is 0.0090 as shown in figure Appendix A.2. Both testing and checking are used for validation. Testing shows the Average Mean Square Error (ARMSE). ARMSE is the means RMSE obtained at each iteration. We used it to validate our model because it gives information on the speed of convergence towards the optimal solution. The number of listed companies is 7, Root Mean Square Error, Minimal training RMSE, Training Error, Average testing error and Minimal testing RMSE for each of the listed company are shown in table 1 and the graph in Figure 5.

Table 2 shows the result of stock market auditing system for the year 2016. Table consists of listed companies and fuzzy output. Interpretation of fuzzy output is done in Table 3. Fuzzy output membership value for loss ranges from 0 to 0.4 and profit ranges from 0.5 to 1.Companies with fuzzy output value 0.5 to 1 is healthy to invest, and companies with minimal testing value 0 to 0.4 are unhealthy to invest. The fuzzy output values indicate that UNITY, UBN, ACCESS, and DIAMOND are perfectly healthy for investment and the rest are unhealthy to invest. In Figure 6, line graph was plotted in MATLAB utilizing the interpreted result in Table 3. X-axis shows the listed companies and y-axis shows the fuzzy output. ANFIS Model studied in this research has 86.32% accuracy. So the model owns good generalization ability.

4.3 Comparison Evaluation

Proposed system performed better than existing system with 86.32% accuracy .Hence, ANFIS produces better result than TSFNN as shown in Table 4.

System		Accuracy	Training Error	Epochs
Existing System	Audit option of listed companies: A Takagi-Sugeno fuzzy neural network based study by (Heng-shu, 2017)	80%	0.08	100
Proposed System		86.32%	0.0091	100

5. CONCLUSION

Predicting the audit opinion of Nigeria stock market return is important and of great interest because successful prediction of financial indexes may promise attractive benefits. ANFIS is presented in the research by applying a financial index as a consequent to predict the audit opinion of listed company in stock market. The results for the prediction are validated through evaluation metrics root mean square error used to estimate the accuracy and improve audit efficiency. We have applied ANFIS in predicting the audit opinion of listed companies in Nigeria Stock Exchange.

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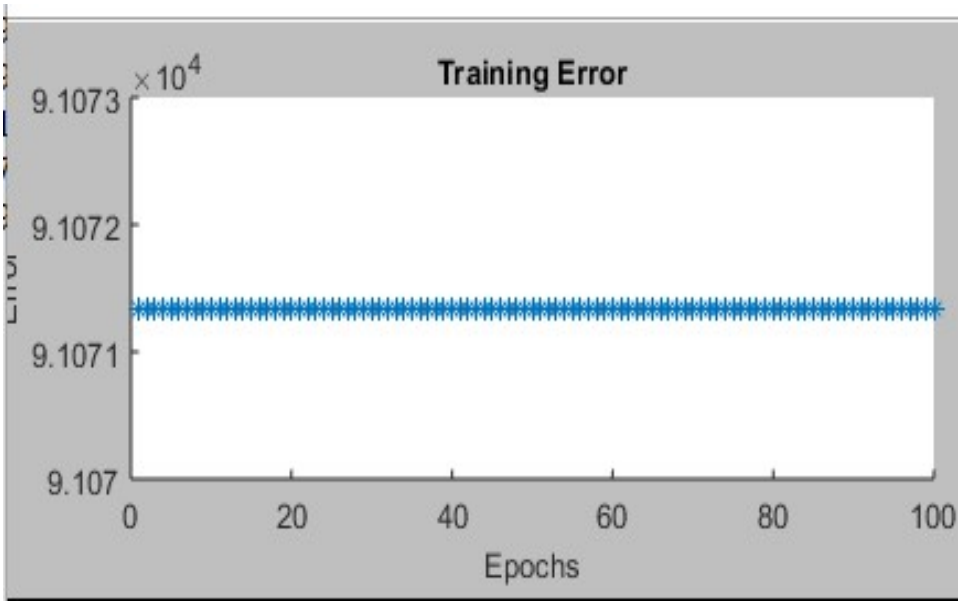
APPENDIX A.1

Training Error



Appendix A.2
Testing Error