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RESEARCH ARTICLE

Accurate Forecasting Prediction of Foreign Exchange Rate Using Neural Network Algorithms: A STUDY

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Abstract— Data mining is a form of knowledge discovery essential for solving problems in a specific domain. Classification is a technique used for discovering classes of unknown data. Several major kinds of classification method including decision tree induction, Bayesian networks, k-nearest neighbour classifier, case-based reasoning, genetic algorithm, fuzzy logic techniques and neural networks etc. A neural network is a massively parallel distributed processor that has a natural propensity for storing experimental knowledge and making it available for use. Artificial Neural Networks [ANN] are nonlinear information processing devices which are built from interconnected elementary processing devices called neurons. The goal of this study is to find the efficiency of the existing artificial neural network algorithm on forecasting foreign exchange rate. Back propagation Algorithm, Hidden Markov Model, recurrent neural networks are the algorithms selected for the study. The back propagation algorithm gives finite accuracy in foreign exchange rate.

Key Terms: - Back propagation Algorithm; Hidden Markov Model; Recurrent Neural Networks; Artificial Neural Networks

I. INTRODUCTION

Artificial Neural Network is an information processing paradigm that is inspired by the way of biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements working in union to solve specific problems. An ANN is configured for a specific application, such as pattern recognition or data classification through a learning process. An ANN characterized by its architecture, training or learning and activation function.

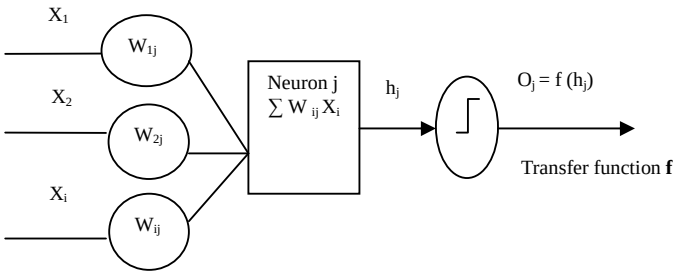

Fig 1: Network architecture of ANN

A neuron may be divided into three parts for analysis purpose. First, the input connections, second the summing and activation functions and lastly, the output connections as shown in the fig 1. A neuron is connected to other neurons in artificial neural network and process the information it receives from them. No limit to the amount of connections a neuron may receive information from. The weights are used to regulate the information that a neuron receives from others. When a neuron receives information from other neurons, each portion of information is multiplied by a weight with a value between -1 and +1, which allows the neuron to judge how important the information it receives from its input neurons is. These weights are essential to the way a network works and is trained: in a reality, training a network means modifying all the weights and regulating information flow to ensure output follows the given criteria, for instance, minimization of root mean squared error or moving average error.

A. Summing and Activation Functions

Summing and activation functions are the second part of a neuron. The information sent to the neuron and multiplied by corresponding weights is added together and used as a parameter within an activation function. A neuron becomes activated when it detects electrical signals from the neurons it is connected to in biological context [7].If these signals are sufficient, the neuron will become activated or excited. it will send electrical signals to the neurons connected to it. There many activation functions used in ANN literature, but we will discuss the one that is identity function with a domain of $(-\infty, \infty)$ and a range of (-1, 1):

$$F(x) = x \text{ for all } x$$

B. Output Connections

Once the activation function returns a matching value for the summed inputs, these values are sent to the neurons that use the current neuron as an input. This process repeats again, with the current neuron's output being summed with others, and more activation functions accepting the sum of these inputs [2]. It can only be ignored is if the current neuron is an output neuron. After which the summed inputs and normalized sum is sent as an output and not processed again. Neural networks are also more noise tolerant, having the ability to learn complex systems with incomplete and corrupted data. In addition, they are more flexible, having the capability to learn dynamic systems through a retraining process using new data patterns [12].

The foreign exchange market is a decentralized market where the money exchanged totals approximately one billion dollars each day. Banks and other market makers send their exchange rates to certain companies that disseminate this information to subscribers. Exchange rates actually have two components, the bid price and the ask price. The bid price is the highest price at which the market maker is willing to buy the currency, while the ask price is the lowest price at which the market maker is willing to sell the currency to trade a currency, a dealer will call a market maker request the current quote, and decide whether or not to place a trade [11]. Foreign exchange rates are amongst the most important economic indices in the international monetary markets. The forecasting of them poses many theoretical and experimental challenges given the abandonment of the field exchange rates, the implementation of the floating exchange rate system in the 1970s and foreign exchange rates are affected by many highly correlated economic, political and even psychological factors. The interaction of these factors is in a very complex fashion [1]. Therefore, to forecast the changes of foreign exchange rates is generally very difficult. Technical and fundamental analyses are the basic and major forecasting methodologies which are in popular use in financial forecasting. Like many other economic time series, foreign exchange market has its own trend, cycle, season and irregularity. Thus to identify, model, extrapolate and recombine these patterns and to give foreign exchange market (Forex) forecasting is the major challenge. Well-trained

ANNs can predict complex biological patterns, structures, or functions of newly discovered sequences. The foreign exchange market not only has known inputs and outputs but is also affected by external information causing uncertainty.

II. RELATED WORK

Different methods are used in Foreign Exchange Rates prediction. These methods are distinguishable from each other by what they hold to be constant into the future. The Hidden Markov Model (HMM) approach basically is used to predict the hidden relationship between inputs and outputs, and has been one of the most attractive research areas in the field of information systems [9]. This approach can be used in simulating the foreign exchange market by taking a small subset of known information to reduce the effect of this uncertainty and noise. For ex: according to hidden. Markov models are unstable to be taken in as a trading tool on foreign exchange data with too many factors influencing the results [10]. The HMMs attempt to generate or predict an output signal given a model. HMMs according to does not improve results as one might have expected. The HMMs attempt to generate or predict an output signal given a model and investigated the stability of robustness of alternative novel Neural Network architectures when applied to the task of forecasting and trading the Euro/ Dollar (EUR/USD) for exchange rate using the European Central Bank (ECB) fixing series with only auto regressive terms as inputs. Also, according to, Artificial Neural Networks (ANNs) are mathematical models simulating the learning and decision making processes of the human brain. The foreign exchange market, unlike the stock market is an over the counter market, that is built by a number of different banks. The participants of the foreign exchange market can be roughly divided into the central bank, commercial banks, non-bank financial entities, commercial companies and retail traders. The central bank has a significant influence in the foreign exchange markets by virtue of their role in controlling the countries' money supply, inflation, and/or interest rates [6]. ANNs were originally developed to model human brain function. ANNs are parameterized graphical models consisting of networks with three prime architectures: recurrent, feed-forward and layered. Artificial neural networks have proven to be efficient and profitable in forecasting financial time series [5]. In particular recurrent networks in which activity patterns pass through the network more than once before they generate an output pattern can learn extremely complex sequences. Three recurrent architectures are compared in terms of prediction accuracy of futures forecast for Deutsche mark currency [3]. A trading strategy is then devised and optimized. The profitability of the trading strategy, taking into account transaction costs is shown for the different architectures and conducted a survey on the use of neural networks in business application that contains a list of works covering bankruptcy prediction. It focuses on portfolio optimization and short term equity forecasting that mentioned the varying degree that ANN has the capability to forecast financial markets. Novel flexible model called neuron coefficient smooth transition auto regression (NCSTAR), an ANN to test for and model the nonlinearities in monthly exchange rates. Traditionally, statistical models such as Box-Jenkins models dominate the time series forecasting which suggested that the relationship between neural networks and conventional statistical approaches for time series forecasting are complementary and also indicated that traditional statistical techniques for forecasting have reached their limitation in applications with nonlinearities in the data set such as stock indices[4]. Neural Network technology has seen many application areas in business especially when the problem domain involves classification, recognition and predictions, according to a survey research conducted by more than 127 neural network business applications had been published in international journals up to September, 1994. The number rose to 213 after a year .said that the multilayer feed forwards are one of the most important and most popular classes of ANNs in real world applications [9]. A multilayer Perceptron has three distinctive characteristics:

- The model of each neuron in the network includes usually a non-linear activation function, sigmoid or hyperbolic.
- The network contains one or more layers of hidden neurons that are not part of the input or output of the network to learn complex and highly nonlinear tasks by extracting progressively more meaningful features from the input patterns.
- The network exhibits a high degree or connectivity from one layer to the next one.

III. HIDDEN MARKOV MODEL (HMM)

The Hidden Markov Model (HMM) is a variant of a finite state machine having a set of hidden states Q, an output alphabet (observations), O, transition probabilities, A, output (emission) probabilities, B, and initial state probabilities, Π. The current state is not observable instead; each state produces an output with a certain probability (B). Usually the states, Q, and outputs, O, are understood, so an HMM is said to be a triple, (A, B, Π). Hidden states Q = {qi; i = 1. . . N}.Transition probabilities: A = {aij = P (qj at t +1 | qi at t)}

Where,

P (a | b) = conditional probability of a given b,

t = 1. . . T = time, and qi in Q.

Informally, A is the probability that the next state is qj, given that the current state is qi.

Observations (symbols) O = {ok}, k = 1. . . M.

Emission probabilities B = {bik = bi (ok) = P (ok | qi)}

Informally, B is the probability that the output is ok, given that the current state is qi.

The Initial state probabilities

Π = {pi = P (qi at t = 1)}.

The model is characterized by the complete set of parameters:

Λ = {A, B, Π}

Using the Hidden Markov Model, the accuracy for the Foreign exchange rate forecasting model can be calculated as:

$$\text{HFERFM Accuracy Forecast} = \frac{\sigma(qv) - \sigma(av)}{\sigma(av)} * 100$$

Where standard deviation is

$$\sigma = \sqrt{E(X - \mu)^2}$$

And the Mean Square error is

$$\text{MSE} = \frac{(\sum FE)}{N-1}$$

Where the FE is forecast error and can be calculated as difference between actual value and predicted value. The task is to have minimal value of MSE.

IV. MULTILAYER PERCEPTRON NETWORKS

Multilayer Perceptron [MLP] networks are an important class of neural networks. The network consists of a set of sensory units that constitute the input layer and one or more hidden layer of computing nodes. The input signal passes through the network in the forward direction. The multilayer Perceptron are used with supervised learning and have led to successful back propagation algorithm. In MLP networks there exists a non-linear activation function. The widely used non-linear activation function is logistic sigmoid function. The MLP network also has the various layers of hidden neurons. The hidden neurons make the MLP network activity for highly complex tasks. The layers of the network are connected by synaptic weights. The MLP thus has a high computational efficiency. The MLP networks are usually fully connected networks. There are various multilayer Perceptron networks which includes Back propagation network, Radial basis function network etc.

1. Back Propagation Algorithm

The back-propagation (BP) algorithm is a generalization of the delta rule that works for networks with hidden layers. It is by far the most popular and most widely used learning algorithm by ANN researchers. Its popularity is due to its simplicity in design and implementation.

The algorithm for the back propagation is as follows:

(i) Perform the forward propagation phase for an input pattern and calculate the output error.

(ii) Change all weight values of each weight matrix using the formula

Weight (new) = weight (old) + learning rate * output error * output (neuron i) *
Output (neuron I + 1) * (1 – output (neurons i+1))

(iii) Go back to step 1.

(iv) The algorithm ends, if all output patterns match their target patterns.

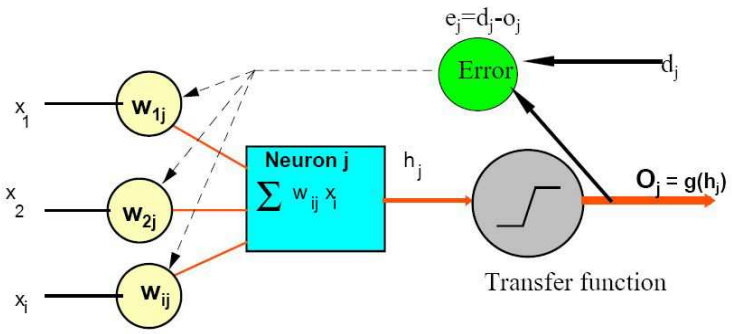

Fig: 2 Back-propagation of errors for a single neuron J

When Back Propagation algorithm is used for weight change, the state of the system is doing gradient descent; moving in the direction opposite to the largest local slope on the performance surface. That is, the weights are being updated in a downward direction. The back propagation algorithm is general, widely used and not complex, for raining multilayer feed forward networks.

Using the Back Propagation algorithm, the accuracy for artificial neural network foreign exchange rate forecasting model can be calculated as:

$$\text{AFERFM Accuracy Forecast} = \frac{\sigma(pv) - \sigma(av)}{\sigma(av)} * 100$$

V. RECURRENT NEURAL NETWORKS

Recurrent neural networks(RNN) in which the input layers activity patterns pass through the network more than once before generating a new output pattern can learn extremely complex temporal patterns. Several researchers have confirmed the superiority of RNN over feed forward networks when performing non-linear time series prediction [8]. Recurrent architecture proves to be superior to the windowing technique of overlapping snapshots of data, which is used with standard back propagation. In fact by introducing time lagged model components, RNNs may respond to the same input pattern in a different way at different times, depending on the sequence of inputs.

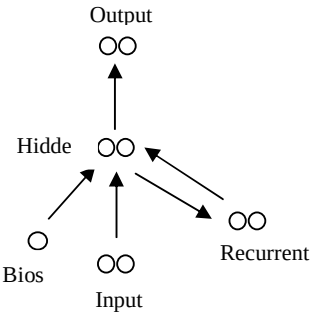

Fig 3: Recurrent Network Architecture

The tests were performed with three variations of RNNs. They belong to the RNN family known as local feedback networks, where only local connections are activated. The rationale is that instead of learning with complex, fully connected recurrent architectures, redundant connections should be eliminated in order to significantly increase the networks generalization capability.

VI. CONCLUSION

This paper has compared three different neural network algorithms to predict the accuracy on foreign currency exchange rate, forecasting using Neural Network Algorithms. Because of back propagation algorithm is used with AFERFM, which gives the 11.3 percentages more accurate than the HFERFM. So the ability of back propagation algorithm is very high in predicting the foreign exchange rate forecasting model. In future research the accuracy of error function used by the back propagation algorithm will be improved.

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