

Application of artificial neural networks with backpropagation technique in the financial data

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Abstract. The propensity of applying neural networks has been proliferated in multiple disciplines for research activities since the past recent decades because of its powerful control over regulatory parameters for pattern recognition and classification. It is also being widely applied for forecasting in the numerous divisions. Since financial data have been readily available due to the involvement of computers and computing systems in the stock market premises throughout the world, researchers have also developed numerous techniques and algorithms to analyze the data from this sector. In this paper, we have applied neural network with backpropagation technique to find the data pattern from finance section and prediction for stock values as well.

1. Introduction

The estimated amount of world stock market was about the US \$ 36.6 trillion in October 2008. The size of total world derivatives market was nearly \$791 trillion nominal or face value, which was 11 times of the entire world economy. Bombay Stock Exchange (BSE) was the first established stock market of Asia in 1875 with the earlier name as 'The Native Share & Stock Brokers' Association. It was the first stock exchange considered by the Government of India under the Securities Contracts (Regulation) Act 1956. It is also the first exchange in India and second in the world that secured in ISO 9001:2000 certifications. The S&P BSE Sensex is the popular equity index of BSE that is considered as India's most widely followed stock market benchmark index [1]. One other leading stock exchange in India is the National Stock Exchange (NSE) that starts functioning in 1994. It was the fourth largest agency by equity trading volume of the world in 2015. NSE had projected the electronic screen-based trading in 1994 and derivatives & Internet trading in 2000 [2].

The impact and applications of artificial neural networks have prevailed remarkably in the past recent years since it provides one of the most elegant data fit environments and numerous suggestive and predictive models with high flexibility. These models have been perceived as thoroughly efficacious in the domain of computational problem solving, classification, data compression, adaptive control, multi-sensor data fusion, forecasting, and noise filtering, etc. In this article, we have considered backpropagation technique for modeling some quantitative analysis and forecasting of data from the financial sector. The neural networks models can learn a function that maps input to output by applying weights to network connections and it can compare different techniques with multivariate discriminant analysis approach that may also improve the predictability of stock values and their performances [3]. It may also be applied to predict stock market returns, risks, and stocks ratings with help of fuzzy and probabilistic rules [4]. ANN can perform with a wide area of tasks in numerous fields of business, industry, and science [5]. It can also implement effective techniques for credit scoring [6], [7], [8], [9], and [10].

Many researchers have applied the concept of backpropagation from ANN in a different area of applications such as [11], [12], and [13] have applied the backpropagation algorithm to predict the online



monitoring, MRR, and surface roughness in the electro-discharge machining process. The authors in [14] have applied backpropagation neural network model for landslide susceptibility analyses. Researchers in [15] have compared random forest, support vector machine and back propagation neural network for electronic tongue data classification.

In the Section - 2, we have explained about the data source and the experimental setup with the considered variables. Section - 3 comprises the concept of ANN with backpropagation technique. Further, in the Section - 4, we have discussed the obtained results from our experimentations. Finally, we have concluded the paper in the Section - 5.

2. Experimentation

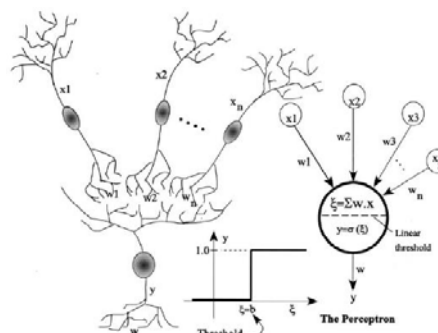
The data has been downloaded for the last 5-years Automobile from NSE from the website [16] for the stocks Ashok Leyland Limited, TATA Motors, Mahindra & Mahindra Limited, and Maruti Suzuki India Limited from 17/07/2012 to 17/07/2017 on the daily basis. All the programming and result analysis were performed on the MATLAB software from MathWorks.

We have considered four variables namely opening, high, low, and closing (OHLC) values for the considered stocks. First three variables have been used for the input the neural network model and the last variable is utilized for the prediction process. That is based on the first three variables, weight assignment process has been done and the mean squared error will be calculated with the help of output from the three variables and closing value of the stock for the same days.

3. Artificial Neural Networks

Artificial neural networks basically deal with the nodes and connectors. Nodes are analogous to natural neurons those receive signals through synapses situated on dendrites or membrane of the neurons which are connected through Axons as connectors. Synapses are analogous to weights of the inputs (Figure -1). When the strong enough signals, more than a certain threshold, are passed through axons, neurons would be activated. In the same way, other signals may be passed through other synapses, those may instigate other neurons.

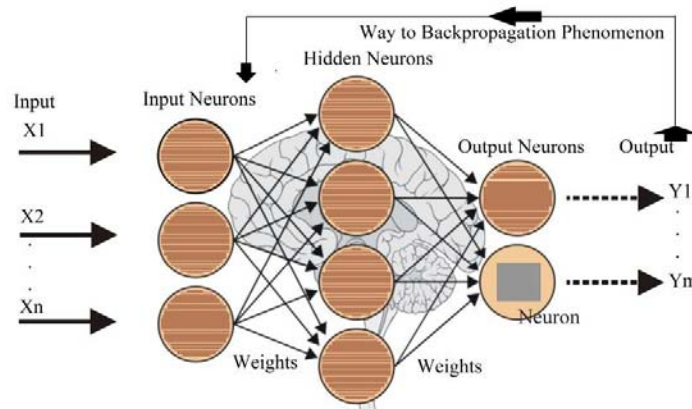
Figure 1. The Neural Network analogous with Natural neurons



Natural neurons are highly abstracted in the reference of the artificial neural network as a working model that comprises inputs like synapses, multiplied by weights as the strength of respective signals, and then calculated by a mathematical function that regulates the activation of neurons. Neurons are situated in layers those work collectively. In the same way, the processing of neural networks model performs at different levels, called as hidden layers, with same or different mathematical functions (Figure -2). The artificial neural network combines artificial neurons to operate as information processing. The development of neural networks is based on different architectures which may comprise different

activation functions and learning algorithms. Each type may have its different input-output characteristics and hence they could be applied for different specific purposes.

Figure 2. The Neural Network with hidden layers



3.1. Backpropagation neural network

Backpropagation neural network (BPNN) is a concept of re-framing the obtained output towards the desired output. The output neurons are again connected back to the input neurons in the BPNN system to train the network by modifying the weights according to the obtained error in such a way that desired output relationship is eventually realized (Figure -2). In the Figure -3, a schematic sketch of BPNN (represented in a darker shade of line) has been drawn comprising n input neurons, r output neurons, and a single hidden layer with m neurons. In a model of ANN, a number of hidden layers play a crucial role for determining the rate of convergence during the period of parameters training for a given number of neurons at input and output layers [3]. In this paper, the constructed ANN model, input nodes have a transfer function of identity, and the hidden and output layers have the activation functions as sigmoid $S(\cdot)$ and linear respectively.

The functioning input to j^{th} hidden node is given by the following formula

$$y_i(x) = \sum_{i=1}^n W1_{ji} x_i + b1_j \quad (1)$$

where $W1_{ji}$ is the applied weight between i^{th} input neuron and j^{th} hidden node. The resultant function of j^{th} hidden neuron is given by

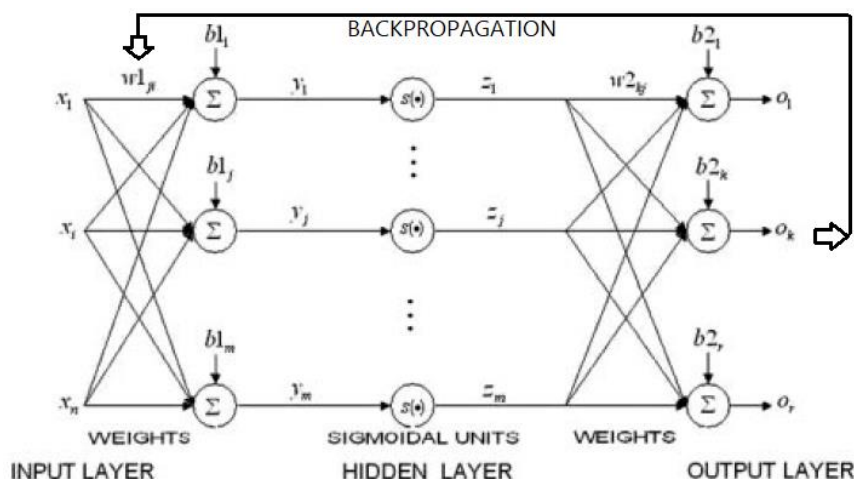
$$z_j(x) = \frac{1}{1 + \exp(-y_j(x))} \quad (2)$$

On the basis of given input vector x , the output $o_k(x)$ of the k^{th} output neuron is given by the weighted sum of the outputs of the hidden neurons and the bias weights of the k^{th} output neuron, as the following formula

$$o_k(x) = \sum W2_{kj} + b2_k \quad (3)$$

where W_{kj} is the applied weight between j^{th} hidden and k^{th} output neurons and b_{2k} is the biased weight at the k^{th} output neuron.

Figure 3. A Schematic Sketch of an ANN System



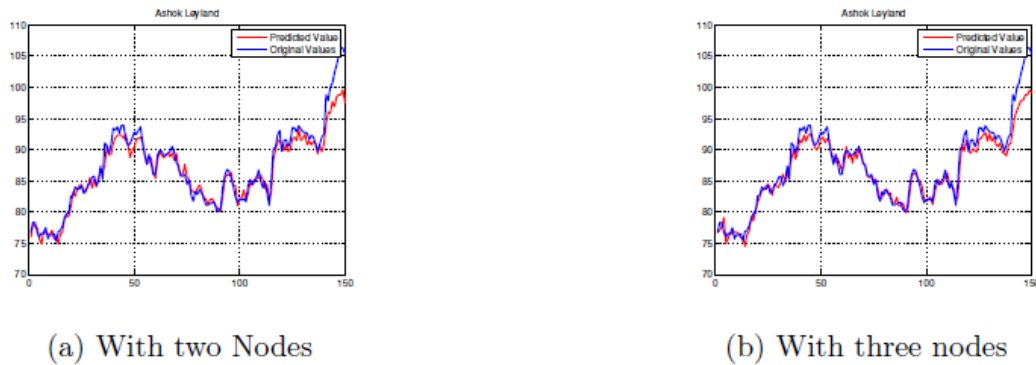
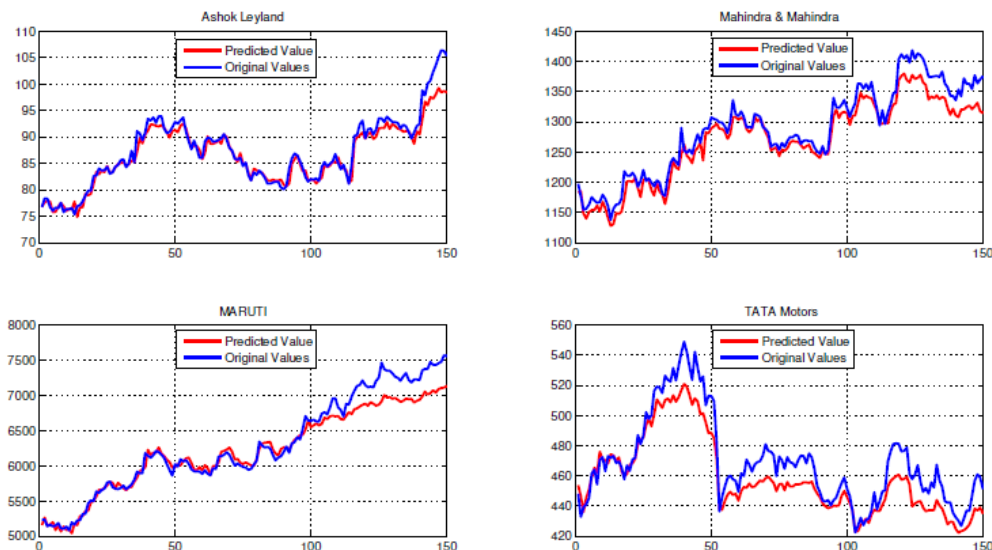
The learning process of BPNN follows the iterative steps by generating some outputs based on their running state of its synoptic weights whereas at the initial stage the weights had been considered randomly. The output is compared with the desired output and based on the mean squared error (MSE) calculations; the weights are modified iteratively until the threshold is achieved with the backpropagation technique. Of course, the weight changes are performed to reduce the error signals. After crossing the threshold, it is said that, now our model has learned enough and ready to perform the real modeling and forecasting. It is true that the network or model will never perform with the exact desired output but since its characteristics are asymptotic, it may reach quite close to the real scenario.

4. Result Discussion

A number of hidden layers in the neural network model has been allotted only one while the numbers of neurons in the hidden layer are varied to perform the result analysis in a different manner. We have allotted 2, 3, and 4 nodes at the hidden layer for analyzing the results. For 2 and 3 nodes at the hidden layer, we have calculated and presented graphs in the Figure - 4 for the stock ASHOK LEYLAND only. The same way can be followed by the other stocks. For 4 nodes in the hidden layer, we have compared all the stocks and shown the results in Figure - 5. Some difference can definitely be observed even though there are very slight differences in the graphs with changing the number of nodes in the hidden layer. There are other internal regulatory parameters to control the training of the ANN model.

We have plotted the graph for prediction of about last six months data. As per the reference of the data pattern, we can also observe that, in the period of six months, the best increment has been achieved by Maruti, Mahindra & Mahindra, and Ashok Leyland while TATA Motors did not attain any remarkable escalation.

The data may be provided in two ways to the model: sliding window and increasing window manner. In the sliding window manner, the most recent data will be added and the oldest data would be truncated, while in the increasing window system, the data length would be increasing continuously with the addition of most recent data. We have followed here the sliding window manner. The other approach can also be followed in the same manner with a slight change in the codes followed in the same manner with a slight change in the codes.

Figure 4. Data Analysis for the stock Ashok Leyland**Figure 5. Forecasting with 4-neurons at the hidden layer**

5. Conclusion and Future Scope

The wide applicability of artificial neural network in the numerous areas has motivated us to analyze it here with the financial data; however, so many researchers have already applied this technique in the same area also. But there are different ways to follow this technique. It has mentioned in the result discussion that on which way we have developed and followed the model. With the graph in the same section, we can observe that the neural network model has followed a similar pattern as the original values of the data.

As it is obvious that the future scope of this modeling is highly applicable, and may be improved with the introduction of other mathematical functions and approaches for which we shall be continuously working. The researchers in data analysis and forecasting in the financial section have been quite ubiquitous from past recent decades and will definitely be achieving the new summits in future.

References

- [1] <http://www.bseindia.com/static/about/introduction.aspx?expandable=0> 14/Aug/2017, 11:00AM.
- [2] https://www.nseindia.com/global/content/about_us/about_us.htm 14/Aug/2017, 11:10AM.
- [3] Youngohc Y and George S 1991 Proceedings of the IEEE International Conference on Neural networks, 156-162.
- [4] Wong F S Wang P Z Goh T H and Quek B K 1992 *Financial Analysts Journal*, **48**(1), 47-52.
- [5] Widrow B Rumelhart D E Lehr M A 1994 Neural networks: Applications in industry, business and science *Communications of the ACM* **37** (3), 93105.
- [6] Piramuthu S 1999 Financial credit-risk evaluation with neural and neurofuzzy systems *European Journal of Operational Research*, **112**.
- [7] Wu C and Wang X M 2000 A neural network approach for analyzing small business lending decisions *Review of Quantitative Finance and Accounting*, **15**.
- [8] Atiya A 2001 Bankruptcy prediction for credit risk using neural networks: A survey and new results *IEEE Transactions on Neural Networks*, **12**(4).
- [9] Pang S Wang Y and Bai Y 2002 Credit scoring model based on neural network *In Proceedings of the first international conference on machine learning and cybernetics*.
- [10] Rong-Zhou L Su-Lin P and Jian-Min X 2002 Neural network credit-risk evaluation model based on back-propagation algorithm. *In Proceedings of the first international conference on machine learning and cybernetics*.
- [11] Panda D K and Bhoi R K 2005 Artificial neural network prediction of material removal rate in electro discharge machining. *Material Manufacturing Processes*, **20**(4), 645-672.
- [12] Markopoulos A P Manolakos D E and Vaxevanidis N M 2008 Artificial neural network models for the prediction of surface roughness in electrical discharge machining. *Journal of Intelligent Manufacturing*, **19**(3), 283-292. DOI: 10.1007/s10845-008-0081-9.
- [13] Kao J Y and Tarn Y S 1997 A neural network approach for the on-line monitoring of the electrical discharge machining process. *Journal of Material Process and Technology*, **69**, 112-119.
- [14] Biswajeet P Saro L Manfred F B 2010 A GIS-based back-propagation neural-network model and its cross-application and validation for landslide susceptibility analyses *Computers Environment and Urban Systems* **34**, 216-235.
- [15] Miao L Mingjun W Jun W and Duo L 2013 Comparison of random forest, support vector machine and back propagation neural network for electronic tongue data classification: Application to the recognition of orange beverage and Chinese vinegar *Sensors and Actuators B*, **117**, 970-980.
- [16] Yahoo Finance, <https://in.finance.yahoo.com/lookup> 17/07/2017, 12:15 PM.