Analytical study on Air India Traffic Using Artificial Neural Networks

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Abstract: In the past few years, Artificial Neural Networks (ANNs) have become more popular as a revolutionary approach to forecasting the time series. The present paper discusses Artificial Neural Networks to forecast air traffic. In this study, we developed an Artificial Neural Network (ANN) model to predict the air traffic of Air India by using a Multi-Layer Perceptron network. For this, we have considered the number of passengers traveling monthly in different seasons from January 2012 to December 2019 by air India domestic flights. The results provided through the model were entirely satisfactory.

1. Introduction
In the fore studies, various stochastic models and exponential smoothing models have been discussed to analyze and forecast air traffic. In recent times Artificial Neural Networks (ANNs) have gradually more popular as a revolutionary approach to forecasting the time series. The present paper discusses Artificial Neural Networks to forecast air traffic. The field of Neural Network was established before the invention of computers, but Neural Network limitations are contemporary evolution. In 1943 the elemental artificial neuron was invented by Warren McCulloch, neurophysiologist [1]. Subsequently, artificial neurons were proposed by Hebbian [2] and perceptron [3]. The single-layer networks, which are called perceptron's, were introduced by Frank Rosenblatt [4]. Neural Network solves the problem by different approach than conventional computers [5]. Neural Network exercise instruction alike as human brain exercises [6]. The ANN comprises an immense amount of inter-linked neurons, which are the processing elements they work parallel in solving a particular problem. ANN is the processing of information patterns influenced by how organic neurological schemes like the spinal cord and brain exercise the information. Artificial Neural Network (ANN) has broader applications to real-world problems [7]. They are well suited for structure identification and categorization. ANNs got greater prominence in the analysis of time series as well as forecasting [8]. The ANN aims to pursue to identify structures in a given set. Afterward, the NN trained on a given data set detects a similar pattern in future data to make predictions (Mohie El-Din et al., 2017) [9].

Additionally, the study presents ANN application challenges, contributions, compare performances, and critiques methods. The study covers many ANN techniques applications in various disciplines, including computing, science, engineering, medicine, environmental, agriculture, mining, technology, climate, business, arts, and nanotechnology, etc. The study found that neural-network models such as feedforward and feedback propagation artificial neural networks are performing better in its application to human problems. Therefore, we proposed feedback propagation ANN models for research focus
based on data analysis like accuracy. Moreover, we recommend that instead of applying a single method, future research can focus on combining ANN models into one network-wide application. ANNs' full applications can be evaluated concerning data analysis factors such as accuracy, processing speed, latency, performance, fault tolerance, volume, scalability, and convergence [10].

2. Experimental Program

2.1. Materials and Methods

Air passengers' data for the years 2012 to 2018 indicates the number of passengers itinerant monthly by Air India on planned Domestic services, which explored in the introduction. The data had taken from the official DGCA (Director General of Civil Aviation) website. The monthly traveling data of air passengers by Air India has been deliberated. Table 1. Illustrate the number of Passengers traveled monthly by AIR INDIA Scheduled Domestic Flights from January 2012 to December 2018.

| Sno. | Month/Year | Passengers | Sno. | Month/Year | Passengers | Sno. | Month/Year | Passengers |
|------|------------|------------|------|------------|------------|------|------------|------------|
| 1    | Jan-12     | 796467     | 29   | May-14     | 983898     | 57   | Sep-16     | 1117959    |
| 2    | Feb-12     | 738710     | 30   | Jun-14     | 931132     | 58   | Oct-16     | 1030490    |
| 3    | Mar-12     | 767293     | 31   | Jul-14     | 885447     | 59   | Nov-16     | 1068768    |
| 4    | Apr-12     | 773982     | 32   | Aug-14     | 878178     | 60   | Dec-16     | 1245063    |
| 5    | May-12     | 756425     | 33   | Sep-14     | 909531     | 61   | Jan-17     | 1265046    |
| 6    | Jun-12     | 754231     | 34   | Oct-14     | 1079368    | 62   | Feb-17     | 1084609    |
| 7    | Aug-12     | 684959     | 35   | Nov-14     | 959403     | 63   | Mar-17     | 1089418    |
| 8    | Jul-12     | 691686     | 36   | Dec-14     | 1133456    | 64   | Apr-17     | 1086116    |
| 9    | Sep-12     | 669342     | 37   | Jan-15     | 1104361    | 65   | May-17     | 1219997    |
| 10   | Oct-12     | 852892     | 38   | Feb-15     | 1010005    | 66   | Jun-17     | 1149333    |
| 11   | Nov-12     | 913426     | 39   | Mar-15     | 996246     | 67   | Jul-17     | 1179933    |
| 12   | Dec-12     | 880300     | 40   | Apr-15     | 999526     | 68   | Aug-17     | 1176397    |
| 13   | Jan-13     | 907261     | 41   | May-15     | 1043708    | 69   | Sep-17     | 1163026    |
| 14   | Feb-13     | 804577     | 42   | Jun-15     | 934155     | 70   | Oct-17     | 1216153    |
| 15   | Mar-13     | 907432     | 43   | Jul-15     | 1032276    | 71   | Nov-17     | 1271612    |
| 16   | Apr-13     | 852743     | 44   | Aug-15     | 1058866    | 72   | Dec-17     | 1298442    |
| 17   | May-13     | 933573     | 45   | Sep-15     | 990986     | 73   | Jan-18     | 1369342    |
| 18   | Jun-13     | 809681     | 46   | Oct-15     | 1015358    | 74   | Feb-18     | 1259379    |
| 19   | Jul-13     | 803943     | 47   | Nov-15     | 1119595    | 75   | Mar-18     | 1365653    |
| 20   | Aug-13     | 908224     | 48   | Dec-15     | 1217671    | 76   | Apr-18     | 1345592    |
| 21   | Sep-13     | 809330     | 49   | Jan-16     | 1157645    | 77   | May-18     | 1333851    |
| 22   | Oct-13     | 799041     | 50   | Feb-16     | 1085634    | 78   | Jun-18     | 1238131    |
| 23   | Nov-13     | 861128     | 51   | Mar-16     | 1086743    | 79   | Jul-18     | 1255241    |
| 24   | Dec-13     | 911763     | 52   | Apr-16     | 1117795    | 80   | Aug-18     | 1265214    |
| 25   | Jan-14     | 874549     | 53   | May-16     | 1246137    | 81   | Sep-18     | 1173238    |
| 26   | Feb-14     | 839258     | 54   | Jun-16     | 1156490    | 82   | Oct-18     | 1276807    |
| 27   | Mar-14     | 951993     | 55   | Jul-16     | 1177504    | 83   | Nov-18     | 1242223    |
| 28   | Apr-14     | 856146     | 56   | Aug-16     | 1134913    | 84   | Dec-18     | 1372904    |

(Source: Official Website of DGCA, http://www.dgca.nic.in)
2.2. Multi-Layer Perceptron
MLP is the most extensively used network structure of Artificial Neural Network in time series analysis, and it is a class of feed-forward Artificial Neural Network [11]. An MLP incorporates not less than three layers of nodes: one Input layer, one output layer, as well as one or higher hidden layers [12] (Masters T, 1983). The input layer acquires the action. The output layer creates a resolution or projection on the inserted data and allaying those two, a discretionary number of hidden layers, which are the Multi-Layer perceptron’s accurate reckoning mechanism. MLP implements a supervised studying course of action called backpropagation to train. Backpropagation is a prominent mathematical kit to upgrade the precision of projections in machine learning and data mining. ANN cultivates the action of the inserted data further along with its parameters in the direction of the instant of the resolution, after that back propagates instruction on the error, inverse by way of a network, with this it will revise the parameters. It arises in stages
• Network creates speculation on data based on the parameters.
• Error of network is enumerated using loss function.
• This error is backpropagated to regulate the erroneous specified parameters.

2.3. Backpropagation Algorithm
Backpropagation captures the error related to erroneous speculation via neural networks, as well as utilizes the error to regulate the parameters of neural networks in the track of minimum error. The weights for a specific node are altered in direct proportion to the connected units of the node. By applying an activation function to the weighted sum of inputs of a neuron, Output is produced. The activation function employed in this investigation is the sigmoid function represents the Equation (1).

$$Sigmoid\ function: \ \frac{1}{1+e^{-x}} \quad (1)$$

The Back-propagation rule of the Multi-Layer Perceptron learning algorithm includes starting weights are usually small random values and transfer function and adjust weights by starting from the output layer and working backward.

$$W_{ij}(t+1) = W_{ij}(t) + \eta \delta_{pj} O_{pj} \quad (2)$$

Equation (2) is used to measure the aggregate input to the neuron. The $W_{ij}(t)$ function represents the weights from the ith node to node jth node at time t, $\eta$ is an expansion term, and $\delta_{pj}$ is an error term for the pattern p and the jth node. In Equation (3) and (4), the sum is over the k nodes in the following input and output layer units.

For output layer units: $\delta_{pj} = kO_{pj}(1 - O_{pj}) \ (t_{pj} - O_{pj}) \quad (3)$

For hidden layer units: $\delta_{pj} = kO_{pj}(1 - O_{pj}) \ \Sigma \delta_{pk}W_{jk} \quad (4)$

A component in the output layer directs its activity by ensuing a 2-step procedure.

**Step1:** It measures the total weighted input $X(j)$ using the formula
Where, $y_i$ is the activity level in the previous layer of the $j^{th}$ unit.

**Step2:** From equation (5), calculate the activity $y_j$ of the total weighted input, the activities of all output units have been determined at once, the network computes the error $E$ by using the Equation (6).

$$y_j = \frac{1}{1+e^{-x_j}}$$  \hspace{1cm} (5)

$$E = \frac{1}{2} \sum (y_i - d_i)^2$$  \hspace{1cm} (6)

In Equation (6), $y_i$ indicates the activity intensity of the $j^{th}$ element in the peak layer, and $d_j$ indicates the expected result of the $j^{th}$ element.

### 3. Numerical Results and Discussion

In the investigation, Multi-Layer Perceptron (MLP) network was chosen for the prediction of air traffic flow. For expanding the Artificial Neural Network (ANN) model, 84 months of data concerning the number of passengers traveled by Air India domestic services have been taken. Air traffic was considered as the input variable, and one hidden layer and output layer. Various Artificial Neural Network (ANN) models have been developed on the data set. In this study, ERROR, MSE, RMSE, and MAE values have been used to estimate the performance of the model and predicted the results. The specification of the models has been presented in table 2. It can be observed from table 2 that model 3, i.e., a neural network with three hidden neurons has minimum Error, Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE) values. Therefore, it is used to predict future air traffic.

**Table 2.** Different Neural Network models' ERROR, MSE, RMSE, and MAE values of Air India.

| Model | Hidden layer | Hidden neurons | ERROR     | MSE                  | RMSE       | MAE          |
|-------|--------------|----------------|-----------|----------------------|-------------|--------------|
| M1    | 1            | 1              | 0.31842   | 5917114685.869600    | 76922.7839  | 64112.5062   |
| M2    | 1            | 2              | 0.31776   | 5903147003.622080    | 76831.9400  | 63991.8400   |
| M3    | 1            | 3              | 0.31696   | 5887281357.835080    | 76728.6215  | 63805.4018   |

From table 1, actual data of the number of passengers traveled monthly by air India scheduled domestic flights during January 2012 to December 2018 and predicted the number of passengers calculated by model 3 had been presented in Fig. 2. the representation of Original air traffic and Predicted air traffic data had been presented in Fig. 3. It is shown that there is a positive correlation between the actual and predicted traffic data. Fig. 4. Shown the Residual graph of the number of passengers traveled monthly by air India during the year Jan 2012 to Dec 2018.
4. Conclusions

In this study, we offered an Artificial Neural Network (ANN) model for predicting air traffic of Air India by using a Multi-Layer Perceptron (MLP) network. The results revealed by the model remained satisfactory. For Air India, the ANN architecture with one input layer, one hidden layer carrying three hidden neurons, and one output layer has been identified as the best model. For Indigo, the ANN architecture with one input layer, one hidden layer carrying four hidden neurons as well as one output layer has been identified as the best model. This kind of Analytical study is helpful for air carriers to revise their services.

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