Air Traffic Forecasting Using Artificial Neural Networks

Manohar Dingari, D. Mallikarjuna Reddy, V. Sumalatha

Abstract: In recent years civil aviation transportation has developed rapidly in India. For any air carrier it is important to know the future demand of air passengers (air traffic) to provide proper air space resources. In this paper we focused on forecasting the air passengers traveling by Air India domestic flights by using Artificial Neural Networks (ANN). For this the data has been considered as the number of passengers traveled monthly during January 2012 to December 2018 by Air India domestic flights. Artificial Neural Network models have found many applications in classification and prediction of time series. Multi-Layer Perceptron (MLP) architecture is used in this study with feed forwarded back propagation algorithm. Sigmoid function is used as activation function.

Index Terms: Activation function, Air traffic, Artificial Neural Networks, Back Propagation, Forecasting, Multi-Layer Perceptron, sigmoid function.

1. INTRODUCTION

In India air transport is fastest growing service sector, people continuously travel to distinct locations within a country and worldwide for various reasons. It is important to any air carrier to know the future demand of air passengers to provide proper air spaces resources in order to maintain certain standards and good will of the particular air carrier. Hence the analysis and forecasting of air traffic (air passengers) has got the importance in civil aviation department which helps them to develop operating strategies regarding air space resources. In this study the data of the number of passengers travelled by Air India domestic flights during January 2012 to December 2018 has been considered. To this data Artificial Neural Networks (ANN) have been applied to develop a model and forecast the future air traffic. Ann Artificial Neural Networks (ANN) is an information processing pattern that is inspired by the way biological nervous systems like spinal cord, brain process the information. In this study, Multi-Layer Perceptron (MLP) architecture with feed forwarded back propagation algorithm has been applied.

2 MATERIALS AND METHODS

2.1 Data

The data has been taken from the Directorate General of Civil Aviation (DGCA) website. The data refer to the number of passengers travelling monthly by Air India on scheduled Domestic services for the years January 2012 to December 2018. There are 84 months in this duration, so the data has 84 observations. Each observation refers to the number of passengers travelled by Air India on that month. Basic statistics of the data are presented in table1.

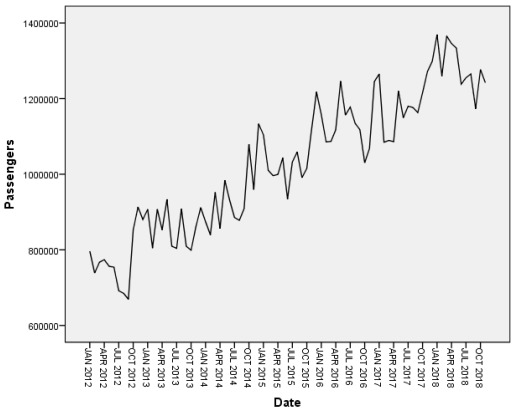

Figure 1. *Graphical Representation of the Data.*

TABLE1.
STATISTICAL CHARACTERISTICS OF AIR TRAFFIC

Statistic	Value
Minimum	669342
Maximum	1372904
Mean	1032337
Standard deviation	186066.2
Skewness	-0.09117512
Kurtosis	1.923432

To create Neural Network model to forecast the future air traffic, 70% of the data set was considered for training and rest of 30% of the data was considered for testing.

2.2 Methodology

Artificial Neural Network (ANN) has wider applications to real world problems. They are well suited for pattern recognition and classification. Artificial Neural Networks got greater importance in time series analysis and forecasting. The neural network aims to learn to recognize patterns in a given data. After the neural network trained on given data set, it detects similar pattern in future data to make predictions [2]. Multi-Layer perceptron (MLP) is most widely used network structure of Artificial Neural Network in time series analysis. A Multi-Layer perceptron is a class of feed forward Artificial Neural Network. A Multi-Layer perceptron consists of at least 3 layers

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of nodes: an Input layer, an output layer and 1 or more hidden layers [8]. Input layer receives the signal, output layer makes a decision or prediction about the input and input and in between those two, an arbitrary number of hidden layers that are the true computational engine of the Multi-Layer perceptron.

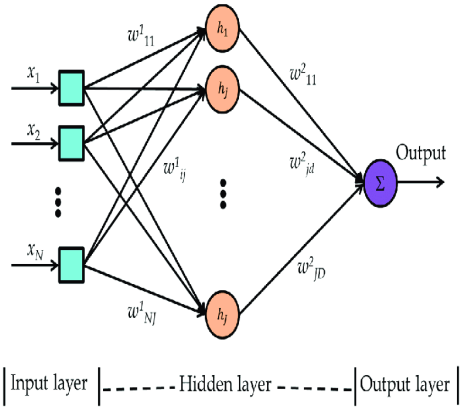

Fig 2. *Picture of MultiLayer Perceptron network.*

Multi-Layer perceptron uses a supervised learning technique called back propagation for training. Back propagation is an important mathematical tool for improving the accuracy of predictions in data mining and machine learning. A neural network propagates the signal of the input data forward through its parameters towards the moment of decision, and then back propagates information about the error, inverse through the network, so that it can alter the parameters. This happens step by step

- The network makes a guess about data using its parameters.
- The network's error is measured with a loss function.
- The error is back propagated to adjust the wrong headed parameters.

Back propagation takes the error associated with a wrong guess by a neural network, and uses that error to adjust the neural l networks parameters in the direction of less error. The weights for a particular node are adjusted in direct proportion to the connected units of the node. Output is produced by applying an activation function to the weighted sum of inputs of a neuron. Sigmoid function used as activation function in this study.

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

The MLP learning algorithm using the back propagation rule includes initialise weights (to small random values) and transfer function and adjust weights by starting from output layer and working backwards.

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

Where $W_{ij}(t)$ represents the weights from node i to node j at time t,

η is a gain term and δ_{pj} is an error term for pattern p on node j (where the sum is over the k nodes in the following layer)

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

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

A unit in the output layer determines its activity by following a 2- step procedure.

Step1: It computes the total weighted input X_j using the formula $X_j = \sum_i y_i W_{ij}$

Where y_i is the activity level of the j[th] unit in the previous layer.

Step2: Calculate the activity y_j using sigmoid function of the total weighted input once the activities of all output units have been determined, the network computes the error E

$$y_j = \frac{1}{1+e^{-x_j}}$$

$$E = \frac{1}{2} \Sigma (y_i - d_i)^2$$

Where y_i is the activity level of the j[th] unit in the top layer and d_i is the desired output of the j[th] unit.

3 DEVELOPING BEST MODEL

In this paper, MLP network has been used for the prediction of air traffic flow. For development of ANN model, 84 months data points regarding number of passengers travelled by Air India domestic services have been taken. Air traffic was considered as input variable, and one hidden layer was considered. Different Artificial Neural Network (ANN) models have been developed on the training data set. In the present study ERROR, RMSE and MAE values were used to evaluate the performance of the model and predicted results. The specification of all the models has been presented in table2. It was observed that model 3 i.e., neural network with 3 hidden neurons has minimum Error, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) values. Hence it is used to forecast the future air traffic.

TABLE 2.
DIFFERENT NEURAL NETWORK MODELS' ERROR, RMSE AND MAE VALUES.

Model	Hidden layer	Hiddenn eurons	ERROR	RMSE	MAE
M1	1	1	0.30861	74236.0496	60658.9795
M2	1	2	0.30757	74130.2889	60590.8331
M3	1	3	0.30756	74101.2399	60528.7820

4 GRAPHICAL PRESENTATION OF RESULTS

The plots of actual traffic and predicted traffic of air passengers by the developed model, for the training data set, and also residuals are presented in figure 3 and figure 4 below respectively.

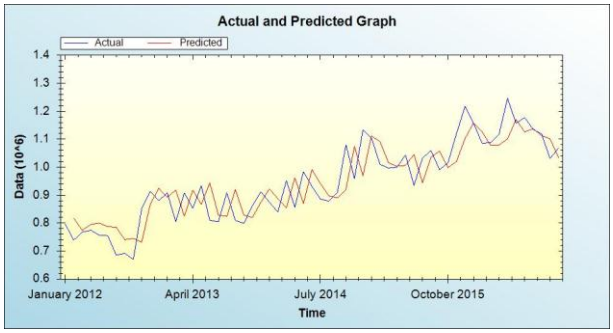

Fig 3: *Plot of Actual and Predicted air Traffic (training)*

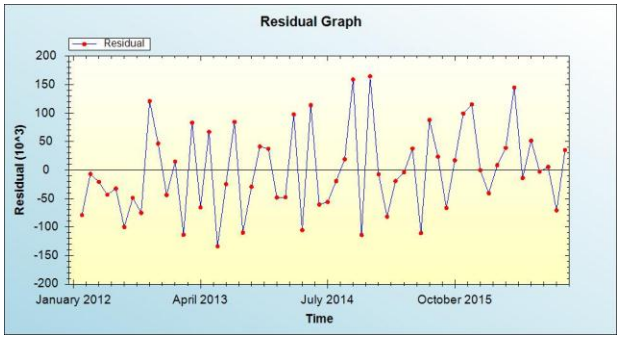

Fig 4: *Plot of Residuals (training)*

The plots of actual traffic and predicted traffic of air passengers by the developed model, for the testing data set, and also residuals are presented in figure 5 and figure 6 below respectively which show the adequacy of the model obtained by training data set.

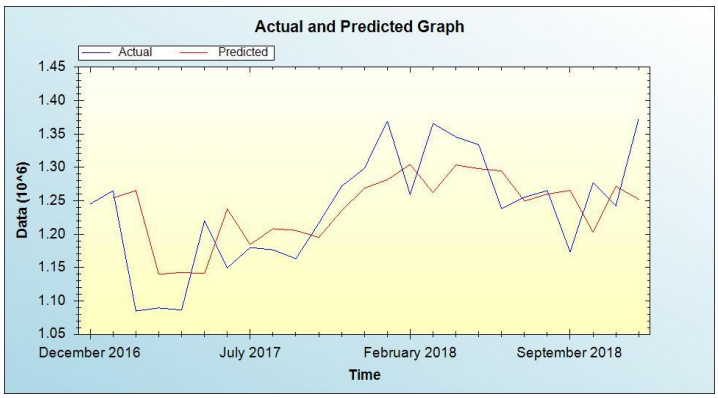

Fig 5: *Plot of Actual and Predicted Air Traffic (testing)*

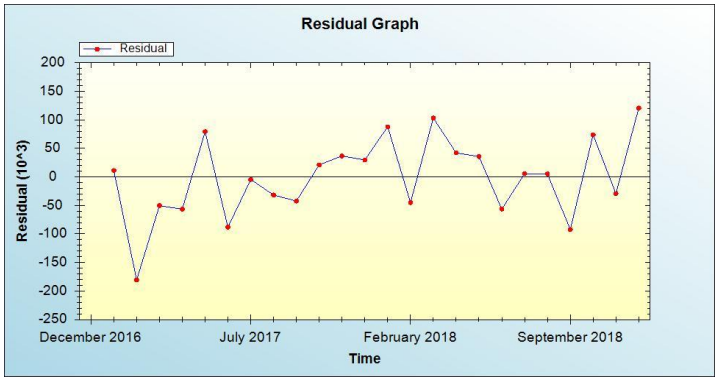

Fig 6: *Plot of Residuals (testing)*

5 FORECASTING

Model 3 has been proven as best model for this data, forecasts have been computed by using the model for 12 months of 2019.

TABLE 3.
FORECAST BY USING ANN MODEL

Month	Forecast
Jan-19	1305150
Feb-19	1284166
Mar-19	1275003
Apr-19	1270536
May-19	1268252
Jun-19	1267057
Jul-19	1266424
Aug-19	1266087
Sep-19	1265907
Oct-19	1265811
Nov-19	1265759
Dec-19	1265732

6 CONCLUSION

In this study we developed and presented an Artificial Neural Network (ANN) model for forecasting air traffic of Air India domestic Services by using Multi Layer Perceptron (MLP) network. The results exhibited by the model were quite satisfactory. This study is helpful to Air India to revise their services.

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