Short Term Road Traffic Flow Forecasting using Artificial Neural Network

V. Sumalatha, Manohar Dingari, C.Jayalakshmi

Abstract : In recent days, road traffic management and congestion control has become major problems in any busy junction in Hyderabad city. Hence short term traffic flow forecasting has gained greater importance in Intelligent Transport System(ITS). Artificial Neural Network(ANN) models have been fruitfully applied for classification and prediction of time series. In this paper, an attempt has been made to model and forecast short-term traffic flow at 6.no. junction in Amberpet, Hyderabad, Telangana state, India applying Neural Network models. The traffic data has been considered for peak hours in the morning for 8A.M to 12 Noon, for 5 days. Multilayer Perceptron (MLP) network model is used in this study. These results can be considered to monitor traffic signals and explore methods to avoid congestion at that junction.

Keywords: Traffic volume, Multilayer Perceptron, Artificial Neural Network, Intelligent Transport System, Forecasting.

I. INTRODUCTION

India is the most populated country in the world and one of the fastest developed country. The rapid growth of personal vehicles (cars and two wheelers) in addition to private and public transport(cabs, tucks and RTC buses etc..) result in huge traffic congestion in most of the cities in India. In recent years Intelligent Transport System(ITS) is being applied to reduce congestion. The prediction of short term traffic and future traffic conditions based on present and past traffic is a major component of Intelligent Transport System(ITS) applications. The importance of traffic flow forecasting for ITS has important applications such as development of traffic control strategies in Advanced Traffic Management Systems[4] and Advanced Traveler Information Systems[5].

Short term traffic flow forecasting involves predicting the traffic volume in the next time interval usually in the range of 5 minutes to 30 minutes. For this study we have considered 5days traffic data at 6 no. junction, Amberpet, Hyderabad, Telangana state, India. In any junction it is very important to forecast the short term traffic flow to design planning and operations of traffic signals and various traffic strategies. In

this paper an attempt was made to develop a short term traffic flow forecasting model using Artificial Neural Network (ANN).

An Artificial Neural Network(ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as brain, spinal cord process information. In this study MultiLayer Perceptron(MLP) network has been used for the prediction of short term traffic flow.

II. MATERIALS AND METHODS

A. Data collection and processing:

The data was taken from the office of Commissionarate, traffic, Hyderabad. The data set used in this study was collected from 6 no. junction, Amberpet, Hyderabad, Telangana state, India. Data was collected during 8:00 am to 12.:00 noon from 08-02-2019 to 12-02-2019. The data was given in the form of video captured by cc TV cameras fixed at the junction. Volume of each category was obtained by counting the vehicles manually. Data extraction was done in the intervals of 5 minutes for 4 directions. The data consists of number of vehicles passing in the junction in all directions. The vehicles has been divided into 3 categories; 1.Two wheeler vehicles (Bike, Scooter, etc..) , 2. Three and Four wheeler vehicles(Car, Auto, Jeep, Mini truck etc..) 3.Heavy vehicles (Bus, lorry, Truck, Tractor etc..). The observed data was collected for the peak period of 4 hours for 5 days gave, a sample of 240 data points. The basic Statistical characteristics of three categories of vehicles are presented in table1.

TABLE1. Statistical Characteristics of Traffic Volume

Statistic	Two wheeler	3 and 4 wheelers	Heavy vehicles
Minimum	240	140	14
Maximum	492	424	48
Mean	357.654	257.342	21.95
Standard deviation	59.196	55.396	6.358

In this study three input variables were considered(the frequency of each category of vehicles as one variable) to create a neural network model to forecast the future traffic. 80% of the data set i.e; 192 data points were considered for training and the remaining 20% (48 data points) were considered for testing.

B. Methodology

Neural networks have broad applicability to real world. Since, neural networks are best for identifying patterns or trends in data, they are well suited for prediction or forecasting needs.

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Multilayer perceptron (MLP) is most widely used network structure of Artificial Neural Network (ANN). Multilayer perceptron (MLP) is able to solve non linearly separable problems, a number of neurons connected in layers to build a Multilayer perceptron. Each of the perceptrons is used to identify small linearly separable sections of the inputs.

Outputs of the perceptrons are combined into another perceptron to produce the final output. The architecture of the Multi Layer Perceptron includes the neurons are arranged into an input layer an output layer and one or more hidden layers.
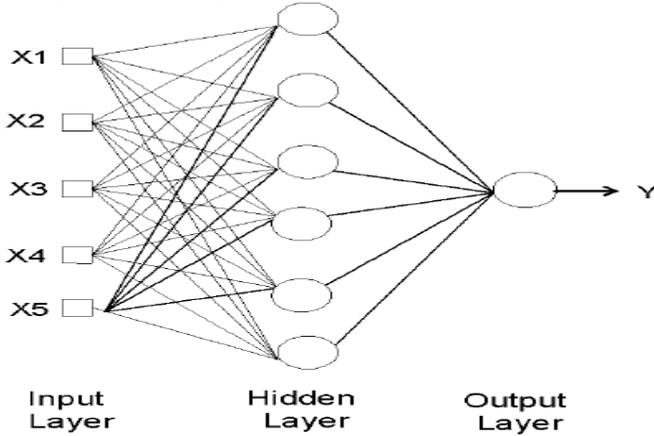

Fig. 1. . Picture of Multilayer Perceptron Network.

MultiLayer Perceptron uses the "back propagation rule" which calculates an error function for each input and back propagates the error from one layer to the previous one. The weights for a particular node are adjusted indirect proportion to the error in the units to which it is connected. An activation function is applied to the weighted sum of the inputs of a neuron to produce the output. In this study we used sigmoid function as activation function.

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

The MLP learning algorithm using the back propagation rule includes initialize 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: $\delta_{pj} = k O_{pj}(1 - O_{pj})(t_{pj} - O_{pj})$

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

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 jth 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

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

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

where y_i is the activity level of the jth unit in the top layer and d_j is the desired output of the jth unit.

III. DEVELOPING BEST MODEL

In this study, MLP network has been used for the prediction of short term traffic flow. For development of ANN model, 240 data points have been taken, each of which contained 3 categories of vehicles (2 wheeler, 3\4 wheeler, Heavy vehicles). These three categories were considered as input variables, and one hidden layer was considered. Different Artificial Neural Network(ANN) models have been developed on the training data set. In the present study RMSE, 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 5 i.e., neural network with 5 hidden neurons has minimum Root Mean Square Error (RMSE), Mean Absolute Error (MAE) values. Hence it is used to forecast the future values.

Table2.Different Neural Network models' RMSE, MAE values.

Model	Hidden layer	Hidden neurons	Two wheelers	Three/ Four wheelers	Heavy vehicles
M1	1	1	RMSE 21.367	22.174	3.243
			MAE 11.106	11.347	1.941
M2	1	2	RMSE 21.251	22.095	3.224
			MAE 10.850	11.220	1.917
M3	1	3	RMSE 21.145	22.091	3.220
			MAE 10.595	10.996	1.913
M4	1	4	RMSE 21.144	22.081	3.218
			MAE 10.591	10.693	1.912
M5	1	5	RMSE 21.111	22.063	3.20
			MAE 10.510	10.643	1.910

IV. GRAPHICAL PRESENTATION OF RESULTS

The plots of observed number of vehicles against predicted number of vehicles through the developed model, for the training data set, is presented in figure 2, figure3 and figure 4, below, for two wheeler, three / four wheeler and heavy vehicles, respectively.
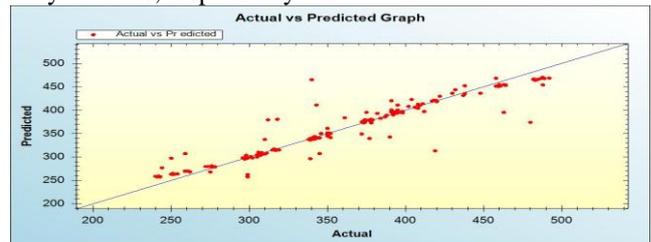

Fig. 2. Plot of Actual Versus Predicted Traffic Flow for Two Wheeler Vehicles
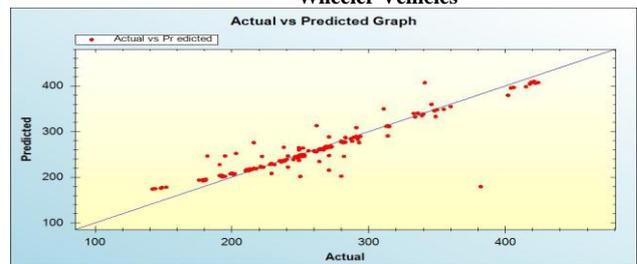

Fig. 3. Plot of Actual Versus Predicted Traffic Flow for Three/Four Wheeler Vehicles.
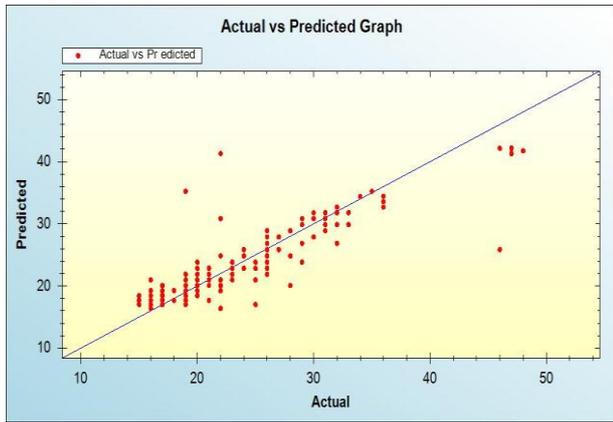
Fig. 4. Plot of actual versus predicted traffic flow for heavy vehicles

The plots of observed number of vehicles and predicted number of vehicles of the developed model, for the testing data set, is presented in figure 5, figure 6 and figure 7, below, for two wheeler, three\ four wheeler and heavy vehicles respectively which shows the adequacy of the model obtained by training data set.
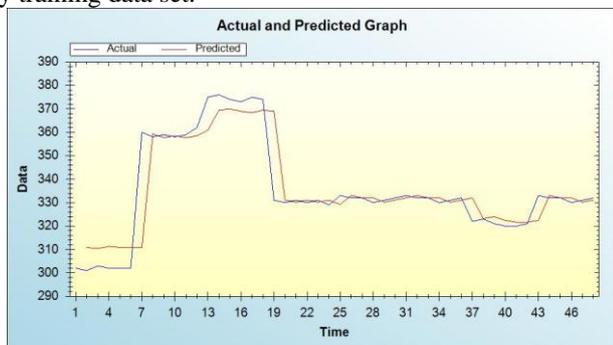

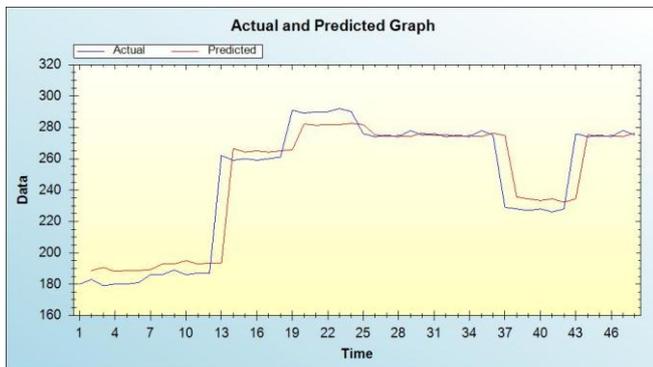**Fig. 5. Plot of Actual and Predicted Traffic Flow for Two Wheeler Vehicles (Testing Data Set)**

Fig. 6. Plot of Actual and Predicted Traffic Flow for Three/Four Wheeler Vehicles (Testing Data Set)
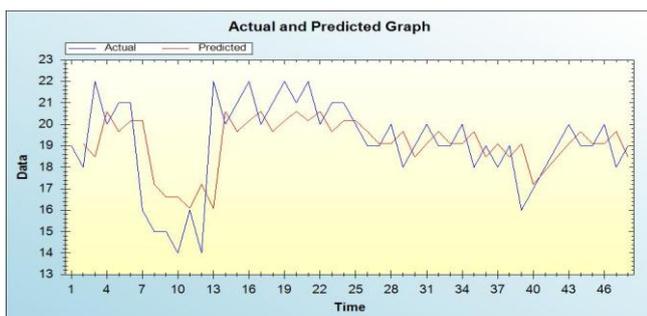

Fig. 7. Plot of Actual and Predicted Traffic Flow for Heavy Vehicles (Testing Data Set).

V. CONCLUSION

In this study we developed and presented an Artificial Neural Network (ANN) model for forecasting short term traffic volume in a busy junction (6.No junction in Amberpet) using Multi Layer Perceptron (MLP) network. The results exhibited by the model were quite satisfactory. This study is useful in Intelligent Transport System (ITS) where short term traffic flow forecasting is focused.

Future study: Time Series models and Markovian models are also to be applied to the same data set to forecast the short term traffic flow. We wish to apply Time Series models and Markovian models also to the same data set and compare them. Similar study can also be taken up other busy junctions or bottle neck traffic points in Hyderabad city and similar analysis can be carried out.

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