Performance of Artificial Neural Network for Traffic Flow Prediction

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Abstract: The prediction of traffic flow plays an important part in Intelligent Transportation System (ITS). It plays a vital role in functioning of various ITS components such as in-vehicle route guidance systems (RGS), advanced traveller information systems (ATIS) and advanced traffic management systems (ATMS). Due to the non-linear and stochastic characteristic of traffic flow, it is difficult to predict traffic flow accurately. In this paper, back propagation algorithm is applied to predict traffic flow conditions on a section of freeway in Chennai. The results clearly demonstrate the effectiveness of using the back propagation algorithm for traffic flow prediction thereby improving the prediction accuracy.

Keywords: Intelligent Transportation Systems (ITS), Traffic Flow Prediction, Artificial Neural Network (ANN)

I. INTRODUCTION

With the accelerating process of urbanization, traffic congestion has become a problem which seriously affects the life of urban citizens. It leads to delays, decreasing flow rate, higher fuel consumption and thus has negative environmental effects. It greatly reduces the efficiency of the transportation infrastructure and inhibits the development of urban economics. If only relying on the construction of hardware facilities of roadway to solve traffic problems, the effect will be very limited. Therefore, it is necessary to construct the Intelligent Transportation Systems (ITS) to perform real-time traffic control and dynamic traffic management, which serves to alleviate traffic congestions in metropolitans and to enhance the transportation efficiency.

Traffic control and management needs accurate estimation and prediction of traffic variables. Traffic flow prediction is an essential part of transportation planning, traffic control and monitoring for the successful implementation of ITS. Short-term traffic flow prediction, which is to determine the traffic flow in the next time interval usually in the range of ten minutes to half an hour, is one of the important problems in the research area of ITS. It has the potential to improve traffic conditions and reduce travel delays by facilitating better utilisation of available capacity.

Traffic patterns are often recurrent, and therefore predictable, as evidenced by numerous empirical studies in the literature. A considerable amount of effort has been expended on short-term traffic flow forecasting and some models are proposed, such as random walk, historical average, time series models (including ARIMA, seasonal ARIMA), Kalman filter theory, neural network approaches, nonparametric methods, simulation models, local regression models and layered models known as the ATHENA model and the KARIMA model [1]-[6]. However, although researchers have declared their validities and efficiencies, survey suggests that there is no technique that clearly outperforms the other techniques. It is almost universally agreed in the forecasting literature that no single method is the best in every situation. Numerous researchers have demonstrated that if we combine several models for prediction then it results in improvement of prediction accuracy as compared to performance of individual model.

In this paper, short term traffic flow prediction model is proposed. The sample data is provided by IIT, Chennai which is recorded for 7 days of mid-block segment. The details about the sensor used for data recording are also elaborated.

II. DATA COLLECTION

Generally traffic flow data include several means such as travel speed, queue lengths, queue length ratio, and number of arriving vehicles per cycle. In this paper, we make only mention of traffic flow count. The data were collected from the IIT, Chennai. The freeway was selected, which is equipped with TIRTL (The Infrared Traffic Logger). The data were reported after some time intervals and includes velocity, speed, vehicle classification and axle details. The data were analysed over a continuous 24-hour period for six consecutive days starting from April 7, 2014 Monday to April 12, 2014, Saturday. After extracting the specific detector data from the whole set, an extensive data reduction and quality control process was carried out to identify and correct any discrepancies in the data. After this data reduction, the data were aggregated into 5 min interval and processed.

In the current scenario we have used two techniques for the forecasting – forecasting using direct data and forecasting using sub-sampled data (data sampled at 5
minutes interval). The data plot is as provided in the figure 1 below.

![Data Samples](image1)

**Figure 1. Data Samples**

The samples obtained were a total of 24 hours * 60 mins / 5 = 288 using sub-sampling time of 5 minutes. These are used to forecast the traffic flow count for every 15 minutes. Therefore forecast plots are available at every 15 minutes interval.

### III. ARTIFICIAL NEURAL NETWORK

Artificial neural network (ANN) is a computing technique, which can be trained to learn a complex relationship in a data set. ANN model, with its learning capabilities, is suitable for solving complex problems like prediction of traffic parameters. In this study a multi-layer feed forward neural network with back propagation algorithm was used. Back propagation is a supervised learning algorithm that provides a method to adjust the weights in a multi-layer network of connected processing units. Back propagation performs a gradient descend in the weight space to minimize the error at the outputs. This is done by calculating the error function for each input pattern and then back propagating the error from one layer to the previous one. The weights of a node are adjusted in direct proportion to the error in the units to which it is connected.

Any of the measures of error such as the sum of the mean square error can be used for this purpose.

\[ w_{ij}(t+1) = w_{ij}(t) + \eta \delta_j x'_j \]

Where, \( w_{ij}(t) \) = weight of the connection between the node i and node j at time t, \( x'_j \) = either output from node j or the input to the network, \( \eta \) = gain term

And \( \delta \) = error term for node j

### IV. SIMULATION RESULTS

To evaluate the forecasting performance of the model, ANN with 10 and 20 neurons in hidden layer were used. The ANN was trained using back propagation method and the MSE was used as the performance parameter.

The ANN used with the 20 neurons took up 18035 epochs to get trained as compared to the one with 10 hidden neurons took only 6873 epochs.

The performance of the ANN with 10 hidden neurons is as provided in figure 2 given below:

![ANN 10 model performance](image2)

**Fig 2 : ANN 10 model performance**

The ANN 20 performs better than the ANN 10 and its performance is as below:

![ANN 20 model performance](image3)

**Fig 3 : ANN 20 model performance**

### V. CONCLUSION

Finally we can reach a conclusion that the proposed model, ie. ANN with 20 neurons in the hidden layer proved to be superior due to its learning capabilities. This success can be attributed to the sub-sampling approach which is advantageous as it provides more training samples with the same data.
REFERENCES