Artificial Neural Network Approach to Predict the Traffic Flow during Neighborhood Hurricane and other Emergency Evacuation

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Abstract: In order to minimize the loss of life during a hurricane and other emergencies, it is important for a planned for evacuation. Neighborhood evacuation is one of the major issues in any emergency management planning. This study investigated the use of Artificial Neural Network (ANN) approach for hurricane evacuation using local streets with speed limits (less than 30 mph) in an urban setting. Using ANN with one hidden layer of 18 neurons and 1000 echos, evacuation through 9 streets was predicted.

1 Introduction

Hurricane and other emergency evacuation is an essential component of an emergency plan. Many researchers have studied about the major highway evacuations. It is more important to get to the major highways from local streets without congestion. Danistan and Vipulanadan (2009) developed a model to evacuate the neighborhood from local streets. Artificial neural network (ANN) is versatile tool for pattern recognition, offer efficient execution and modeling nonlinear relationships effectively. ANNs have recently gained a significant attention in many engineering fields. Neural networks also defined as "an information processing technology inspired by studies of the brain and nervous system". More number of neural network paradigms exists, but the most widely applied one is the back propagation. Typical structure of artificial neural network is shown in Fig. 1.

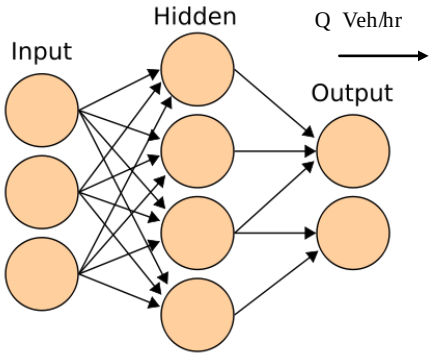

Fig.1. Typical structure of Artificial Neural Network

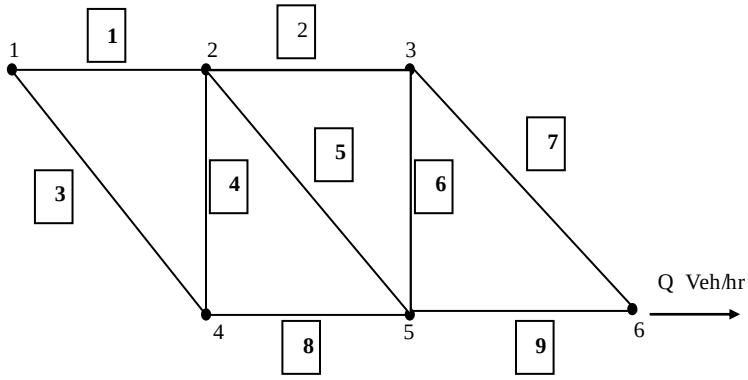

Fig.2. Typical road network (Danistan and Vipulanandan 2009)

2 Objectives

The objective of this study was to investigate the applicability of an artificial neural network to predict the evacuation along local streets with speed limits (back propagation) was used.

3 Modeling Background

Artificial neural networks are being used in many engineering applications. ANNs used to predict the traffic flow and traffic volume in Transportation engineering. Smith and Demetsky (1994) developed a back propagation model to predict the short-term traffic flow. Zheng and Lee (2006) used a combined neural network approach to predict the freeway traffic flow. Jin and Sun (2008) used neural network multitask learning to forecast the traffic flow. Huang and Ran (2003) used the neural network on traffic speed prediction under the adverse weather condition.

4 Modeling Concepts

The evacuation model used by Danistan and Vipulanandan (2009) was used to generate the data for this study. Generated data was used in the prediction. Total of 50 data sets was generated from the evacuation model. These 50 data sets, 30 were used for training and the remaining 20 were used for testing. Least mean square error (MSE) method was used to select the best network architecture. The widely used two transfer functions (sigmoid (Eq-1) and hyperbolic tangent (Eq-2)) were used for comparison.

Sigmoid function: ——— ---------- Eq – (1)

Hyperbolic function: ——— ---------- Eq – (2)

5 Results and Analysis

A typical neighborhood network (Fig. 2) was studied to predict the flow rate on a typical road network (total of 6 junction and 9 streets (links). There were Q vehicles to be evacuated from location #1 to location #6. The speed was limited to 30 mph. The length of the all the streets (link) were assumed to be 2 miles.

Upstream Traffic flow at junction #1 was taken as input, each link (street) had its own outputs, Links 1 to 9 have their flows (q_i) and velocities (v_i) as output. Hence input was taken as one neuron, hidden layer was taken as 18, and output taken as 18. Learning rule was taken as momentum, momentum was taken as 0.7. MSE variations with epochs are shown in Fig.3 and in Table 1. ANN architecture for current study is shown in Fig.4.

Table 1. MSE variation with transfer function

Network	MSE	
	Sigmoid	Hyperbolic Tangent
Network # 1	9.277×10^{-3}	7.191×10^{-5}

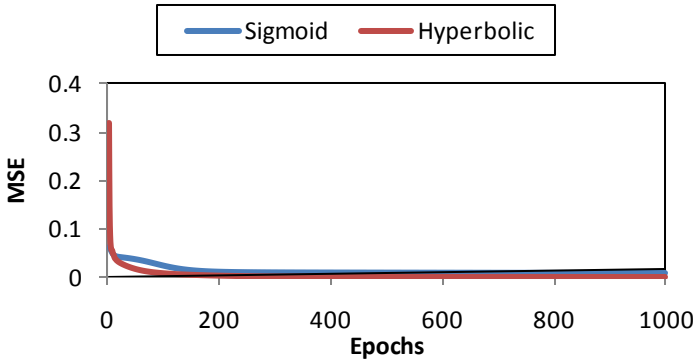

Fig. 3. Variation of MSE with number of epochs

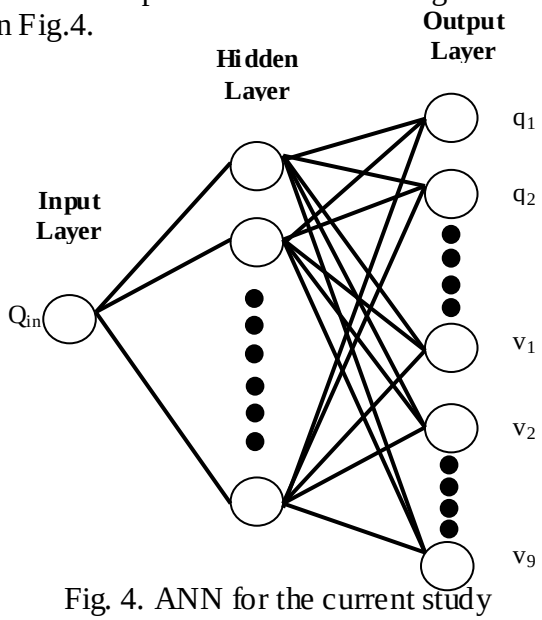

Fig. 4. ANN for the current study

6 Conclusions

ANN using the multilayer perception network was used to model the complex traffic flow pattern. Hyperbolic Tangent transfer function gave the best results based on the minimum MSE.

7 Acknowledgements

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8 References

Danistan, J. and Vipulanandan, C. (2009), "Traffic Flow Simulation Model for Neighborhood Hurricane Evacuation", THC-IT conference proceedings, University of Houston.

Jin, F., and Sun, S. (2008), "Neural Network Multitask Learning for Traffic Flow Forecasting", International Joint Conference on Neural Networks (IJCNN), pp. 1987-1901.

Huang, S.H., and Ran, B. (2003), "An application of Neural Network on Traffic speed prediction under Adverse Weather condition", TRB Annual Meeting.