New England University Transportation Center Final Report

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The main objective of the study was to explore the applicability of using principles from the field of *Intelligent Adaptive Control* for the on-line management and control of transportation systems. *Intelligent adaptive control* is an emerging multi-disciplinary field that encompasses the computational procedures of Fuzzy Logic, Artificial Neural Networks, and Genetic Algorithms. The goal of intelligent control is to design robust and learning controllers operating in an uncertain environment with very limited mathematical knowledge of the controlled process principles, which makes it quite applicable to the control of transportation systems.

The project developed Artificial Neural Network (ANN) models for predicting *experienced* travel time, under transient conditions and in the presence of incidents. *Experienced* travel time, which refers to the travel time drivers actually experience, is different from *current* travel times, especially under transient conditions. While *current* travel times are typically readily available from Intelligent Transportation Systems (ITS) equipment, *experienced* travel times are only available after a driver has completed his/her trip, and hence a predictive model needs to be developed to estimate such times. The development of these ANN models is critical for the development of predictive, adaptive control strategies.

Using simulation, the data required for training the ANN were generated. Several trials were made to "optimize" the architecture of the ANN to improve the quality of the networks' predictions. Separate models were developed for freeway sections, and for arterial streets. Computational experiments were also performed to investigate the impact on the quality of the ANN models' predictions of several factors, including; (1) the time lag in the input data set; (2) the type of input data used to train the network; and (3) the temporal resolution of the input data set.

Evaluation results show that, with the correct input and network parameters, ANN are capable of predicting reasonable values for experienced travel time. This was the case for both freeways as well as arterials. For freeways, the followings were among the main conclusions of the study:

(1) The Multi-layer Perceptron (MLP) of ANN using time-lagged input data is capable of predicting experienced travel times in the presence of incidents;

(2) Increasing the percentage of data corresponding to time periods influenced by incidents helps in improving the ability of a trained ANN to predict experienced travel times in the presence of incidents;

(3) Varying the time lag incorporated into the input data set had no statistically significant difference on the performance of the ANN

(4) For the freeway case, the best ANN performance was achieved by using either speed or both speed and incident data

(5) In general, no statistically significant difference in the accuracy of the predictions resulted when traffic condition information recorded by the loop detector in the left-lane was used instead of the right-lane detector.

For arterial experienced travel time prediction, the following conclusions were made:

(1) ANNs are quite capable of predicting experienced travel time along arterials from detectors' output. For the case study considered, it was possible to achieve average prediction errors as low as 8.35%, even under queue spillback conditions.

(2) The quality of experienced travel time predictions made by dynamic ANNs, such as the Jordan/Elman topology, are slightly superior to those produced by a time-lagged MLP topology; and

(3) Loop detectors can be strategically located to achieve reasonable accuracy levels in predicting experienced travel times with speed data only.