

A NEW SHORT-TERM TRAFFIC PREDICTION AND INCIDENT DETECTION SYSTEM ON I-4: VOLUMES I & II

PROBLEM STATEMENT

Volume I: The propagation of traffic congestion on the transportation infrastructure of our society has become a major concern for motorists and transportation officials. Travel time is an indirect measure of the travel cost and is strongly perceived by travelers. A key element for an effective on-line Advanced Traveler Information System (ATMIS) is the ability to predict traffic congestion with reasonable accuracy. Predictive information is used in traffic diversion because drivers' travel decisions are affected by future traffic conditions expected to be in effect when they reach downstream sections of the highway network on-route to their destinations. Forecasting traffic parameters requires a model that can process past values of the parameters and then dynamically respond to changing conditions on the network.

Volume II: Non-recurrent freeway congestion has increased substantially, adversely impacting traffic conditions by causing excessive delays, queue backups, reduced safety, and increased air pollution. Most developed incident detection algorithms have not yet shown the anticipated level of success required for on-line implementation. Therefore, the need for fast, accurate detection of incidents to facilitate quick response and immediate dispatch of emergency services is still pressing. Unlike traditional incident detection algorithms that compare individual occupancy, speed or volume values at successive loop detector stations, pattern recognition models have the ability to learn how to recognize traffic patterns with certain characteristics. Recently, Fuzzy ART (Adaptive Resonance Theory) has been introduced as an artificial neural network model.

OBJECTIVES

Volume I: Short-term traffic prediction on I-4.

1. Use different decay factors, such as half normal and exponential function.
2. Use additional traffic variables (e.g., occupancy as well as speed).
3. Test the off-line prediction model using more incident-free days.
4. Implement and evaluate the on-line real time traffic prediction model.

Volume II: Short-term traffic prediction on I-4.

1. Use different decay factors such as half normal and exponential function.
2. Collect a new set of incident and loop detector data on I-4.
3. Develop new software to process the data and train the proposed Artificial Neural Networks (ANN) models.
4. Split the data set into two subsets: one for training and the other for testing.
5. Train the proposed ANN models using the training data subset.

6. Evaluate the performance of the trained models using incident detection performance measures.
7. Test the proposed models off-line using the testing data subset.
8. Conduct the on-line testing of the new trained models by incorporating a new module into the existing on-line module.

FINDINGS

Volume I: An intelligent infrastructure is driven by information technology to collect, process, and disseminate real-time traffic information to travelers in order to improve traffic operations and safety. Such information will provide travelers with projected travel times at the pre-trip stage and en-route. One methodology for building forecasts of traffic parameters is the non-linear time series approach, which was previously applied in the off-line traffic prediction model developed in an earlier research project conducted for FDOT.

The real time on-line traffic prediction module developed in this project was used to conduct a comprehensive sensitivity analysis of the effect of various factors on the performance of the model. Several factors were considered, resulting in a wide range of prediction errors. The effects of the following variables were studied: Prediction Horizon, Prediction Step, Rolling Horizon, Rolling Step, Predicted Period, Traffic Direction, and Observed Speed. The performance of the traffic prediction model was evaluated using the following measures: Absolute Error and Relative Error. The following factors were found to have a significant effect on the model performance at a 5% confidence level: Observed Speed, Prediction Period, Traffic Direction, Prediction Horizon, and Prediction Step.

Volume II: Unlike traditional incident detection algorithms, pattern recognition techniques, such as artificial neural networks, have the ability to learn how to recognize traffic patterns based on their unique characteristics. Fuzzy ART is a clustering algorithm that has the ability to map traffic patterns to a set of categories. Incident traffic patterns are mapped to similar clusters according to their common characteristics.

Volume II presents the results of training and testing the Fuzzy ART network for the application of automatic freeway incident detection. The performance envelopes of the DR-FAR (Detection Rate-False Alarm Rate) relationship were the basis for assessing the performance of the algorithm. For performance improvement, a persistence period and a persistence factor were introduced to reduce the false alarm rate. The effect of the persistence factor was not significant for values in the range between 1 and 4. Performance was evaluated under a variety of scenarios to address the impact of certain factors (i.e., the vigilance parameter, the temporal pattern size, and the type of traffic parameter) on the overall algorithm performance. The results showed that the performance could be significantly improved by increasing the value of the vigilance parameter ($p=0.95$) and the temporal pattern size. Results based on speed patterns outperformed those based on occupancy patterns. However, the combination of occupancy and speed has resulted in the highest performance. A comparative evaluation of the Fuzzy ART algorithm and the California algorithm versions 7 and 8 was presented.

CONCLUSIONS

Volume I: This part of the study presents the research and development efforts to improve and validate

the time-series, short-term traffic prediction model on 1-4. The traffic prediction system was developed as a stand-alone module using MS Visual Basic 6.0. The developed module is capable of running in both off-line and on-line modes. Extensive testing using the developed module was also conducted to explore the impact of the model parameters and the traffic conditions on the performance of the model. Researchers found that the model performed very well except under heavy traffic congestion, due primarily to the rapid change in and instability of traffic conditions.

Researchers identified several factors and parameters that had a significant impact on the performance of the model. However, model performance during congested conditions may be further improved by incorporating historical traffic information. This approach will result in a hybrid model that predicts traffic conditions using historical data and the most recent data, which will improve the accuracy of prediction.

Volume II: This part of the study presents the results of training and testing the Fuzzy ART network for the application of automatic freeway incident detection. The research has demonstrated the potential of applying the artificial neural networks for automated detection of incidents on freeways using the existing loop detector data. The performance of the Fuzzy ART algorithm showed a constant increase in the detection rate of up to nearly 88% at relatively low values of FAR. The results of the Fuzzy ART network suggest that the combination of occupancy and speed in the representation of the traffic pattern leads to better performance. The additional information is more likely to make incident patterns more distinguishable from incident-like patterns. Research results suggested that increasing the temporal size of the traffic pattern leads to better results.

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