Project Summary

Texas Department of Transportation

0-5141: Development of Freeway Traffic Time Prediction Capability in Conjunction with Detector Coverage Analysis

Background

Dynamic message signs (DMS) provide full public value only when predicted travel time information is integrated into the message. The research conducted in this project led to innovative travel time prediction tools, accurate for a range of traffic conditions and detector coverage scenarios. A deeper understanding of the relationship between sensor coverage and the quality of freeway travel time forecasts resulted from this research also.

What the Researchers Did

To accomplish the purpose of the project, the following tasks were undertaken:

1. Investigated the performance and features of existing algorithms deployed in the U.S. and Europe.
2. Conducted a detailed review of existing travel time prediction models available in the literature and identified the advantages and disadvantages of each type of model.
3. Based on the conducted review, identified some potential prediction models for evaluation.
4. Developed and calibrated advanced prediction models that complement and enhance existing capabilities.
5. Tested newly developed models utilizing simulated and field data.
6. Developed an understanding of the relationship between existing and proposed travel time prediction algorithms and detector deployment characteristics.
7. Determined detection data coverage requirements, given a prediction accuracy requirement.
8. Identified challenges and issues that may arise during the real-time deployment of the proposed models in a traffic management center (TMC), providing recommendations to overcome the same.
9. Developed software tools to implement travel time prediction models, display the corresponding forecasts, and visualize traffic sensor data.

Research Performed by:

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Project Completed:
8-31-07

What They Found

Two innovative travel time prediction models were developed through this project. The first model combines the advantages of statistical forecasting techniques and traffic simulation models. The integrated simulation and statistical analysis-based model predicts the traffic flows entering the freeway network by means of a Time Series Model. The forecasted inputs are then utilized to run a Cell Transmission Model simulation, from which travel times are obtained. The forecasted travel times account for the evolving dynamics of traffic flow. The proposed model is computationally efficient and can be executed in a standard personal computer, as long as data is available. The calibration and validation experiments conducted to test the model confirmed its adequacy and robustness. Tests performed using simulated data suggest that high accuracies in travel time forecasts are possible for a wide range of traffic conditions. The numerical experiments conducted on field data showed the same trend when the necessary data filtering steps were accomplished.

The second model developed for this project is a generalized N-Curve method, which computes travel times based on the comparison of the cumulative count of vehicles entering and exiting the freeway segment. The generalized version can account for the presence of on-ramps and off-ramps. The model testing, accomplished mainly via simulated data, suggests that the methodology has a very good performance for low and medium traffic demand. The model performance was found to deteriorate slightly during heavy traffic conditions.

An optimization-based framework was developed to analyze the impact of detector location along the freeway section. The numerical experiments conducted using such tools suggest that the location of detectors does influence the model performance and highlight the importance of locating sensors close to merge/diverge sections. Additional numerical testing indicates that the optimal detector placement resulting from the proposed optimization process is fairly robust with respect to changes in demand patterns. The latter suggests that the model can be used to gain insights regarding the number and approximate location of detectors bound to result in better travel time predictions. An analysis of the issues involved in integration of the model with the TMC and real-time deployment was conducted and recommendations were provided.

What This Means

Two novel innovative travel time prediction methodologies accounting for the spatial and temporal evolution of congestion in freeway sections were developed. The prediction models use only traffic counts, which are the most widely available form of data, and are computationally efficient. The fact that the proposed models are robust under a wide range of traffic conditions makes them appropriate for real-time deployment at virtually any location. The study of possible implementation issues revealed the need for special attention in sensor data pre-processing and transfer in order to take full advantage of the models' potential.

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