0-4946: Dynamic Traffic Flow Modeling for Incident Detection and Short-Term Congestion Prediction

Background

Historically, freeway traffic management software has been designed to allow operators to react to incidents and congestion after they have already occurred. While reacting to unexpected events will always remain a critical part of freeway operations, freeway operators need to proactively manage traffic on the freeway to minimize the impact of events or even possibly prevent them from occurring in the first place.

The purpose of this research project was to produce a tool that the Texas Department of Transportation (TxDOT) can implement in freeway management centers that will allow use of traffic detector information currently being generated in TxDOT freeway management systems. An effective tool would enable personnel to make real-time, short-term predictions of when and where incidents and congestion are likely to occur on the freeway network. The idea was to combine roadway network modeling, traffic flow simulation, statistical regression and prediction methodologies, and archived real-time traffic sensor information to forecast when and where:
- traffic conditions were likely to produce an incident, and
- platoons of traffic would merge together to create congestion on the freeway.

What the Researchers Did

As part of a two-year project, the researchers examined several different methodologies and techniques for identifying and predicting when and where incidents are likely to occur on the freeway system by comparing traffic detector data from known incident conditions. The researchers also examined several different techniques for predicting traffic flow parameters 15 to 30 minutes into the future based on current and historical traffic flow conditions. The researchers integrated several of these approaches into a prototype tool that TxDOT could potentially implement in its freeway management centers to predict potential incident conditions and short-term congestion. The researchers then conducted a proof-of-concept demonstration of the of the prototype tool in the TTI TransLink® Research Center Laboratory using a hardware-in-the-loop simulation of Loop 1 in Austin, Texas.

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What They Found

In this research project, researchers examined several strategies and techniques of developing short-term forecasts (i.e., up to 15 minutes into the future) of where traffic congestion and incidents were likely to form on a freeway network using real-time traffic and weather information. As part of this research, they developed and incorporated four prediction models for forecasting when and where incidents and traffic congestion were likely to occur. The first model, the Cumulative Flow Forecast Mode, used traffic condition data from two adjacent detector stations to forecast the flow in process level of service and delay in flow level of service over a span of 15 minutes in the designated target section of the freeway. The Speed-Density Forecast Model, which uses standard moving average techniques to forecast traffic conditions, developed 15-minute forecasts of traffic conditions at a single detector station based on observed historical trends. In the Incident Prediction Model, researchers developed a model to predict the probability that an incident would occur, the probability that the incident would be a collision, and a hazard score for a given station in the designated target section of the freeway based on current weather and traffic flow conditions. The Crash Potential Model applied standard accident rate forecasting techniques to predict the likelihood that current and forecast traffic conditions might result in a collision.

All four models were then integrated in a prototype tool called the Dynamic Congestion and Incident Prediction System (DCIPS). The DCIPS was designed to be installed in a TxDOT Traffic Management Center (TMC) connected in real-time to the System Control Unit, which provides one-minute volume, speed, and occupancy information collected from detector stations on the freeway. The DCIPS uses this information along with current visibility and weather data to develop a forecast of locations where incidents and congestion are likely to occur. The prototype tool was tested in a hardware-in-the-loop simulation environment in the TTI TransLink® Research Center laboratory.

What This Means

Historical data can be a valuable resource to TMC operators. This project showed that historical traffic condition information, coupled with information from other sources such as weather information, can be used to generate models that forecast short-term traffic conditions. By tying these models to real-time traffic and weather information conditions, operators can use these models to identify where incidents and congestion have the potential to occur based on the current travel conditions. Because these models are highly dependent upon having good-quality data to start with, TxDOT needs to take extraordinary steps to ensure the quality of its freeway management traffic data.

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