CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-7031: Towards Efficient Prediction of Highway Friction on an Annual Basis on the Texas Network

Background

Maintaining good skid resistance on highways to ensure the safety of the public is a crucial task for state transportation agencies. Thus it is imperative to monitor the skid resistance of Texas' highways on a regular basis. However, equipment to measure skid resistance is highly inefficient due to the large volumes of water required to collect a few miles of skid data. Because of these limitations, TxDOT measures the skid resistance of approximately one-third of the state-maintained network on an annual basis. Researchers have attempted to estimate skid number based on texture for years with different degrees of success. However, recent developments at the University of Texas at Austin have demonstrated that macrotexture and microtexture measured in the field can be used to estimate skid number with a high degree of accuracy. This research project investigated the development of 1) a system to measure macro- and microtexture in the field at highway speeds and 2) a methodology to predict skid numbers for the entire Texas network on an annual basis.

What the Researchers Did

The researchers conducted a thorough analysis of texture, its effects on pavement friction, and the different testing methods to measure it. The basic principles that govern roadway friction, the main friction-generating mechanisms, and the different equipment used to measure pavement friction were also thoroughly investigated. Finally, they summarized the most promising developments in predicting skid data and using texture information found across the literature.

A new system for collecting high-definition texture and skid resistance data at speeds of 40 mph or higher was developed. This prototype eliminates uncertainty in the data collection process because both skid and texture are collected simultaneously on the same wheel path. The equipment has been proven to work at the same speed at which the locked wheel testers operate (50 mph), and the laser sensor used is powerful enough to capture the full spectrum of macrotexture and up to half of the first decade of microtexture. The researchers have written a list of specifications such that any sensor that meets those requirements can produce results similar to the ones obtained in this study. A complete user guide of how to operate the software developed to measure texture with the line laser sensor was also compiled. The prototype was used to survey texture and friction data from 29 different in-service pavement sections in Texas.

The research team developed stringent quality control criteria and an automated multi-step algorithm that processes both the texture and

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friction data. Multiple statistics to characterize pavement texture were computed and used to predict friction. Friction is a function of both texture and the type of pavement surface present, so the researchers used artificial intelligence (AI) models to accurately distinguish between different types of pavement surfaces. These surface predictions alongside texture statistics were then used to create a robust and accurate mathematical model to predict surface friction. The researchers made a detailed end-to-end video that explains the entire process from data collection to friction prediction.

What They Found

A cluster analysis indicated that within the 29 pavement sections surveyed, there were six clearly distinguishable pavement surfaces:

1) Chip seals with medium to low macrotexture (Grades 3, 4);
2) Chip seals with high macrotexture (Grade 5);
3) Dense coarse mixes (Types C, D);
4) Dense fine mixes (Type F or fine TOM);
5) Open friction coarse surfaces (PFC); and
6) Stone matrix asphalts (SMA).

The six pavement surfaces were reduced to four because, in terms of their surface texture interactions with friction, SMAs, dense fine mixes, and dense coarse mixes have statistically identical behaviors so were grouped together as "dense mix surfaces."

The AI classifier uses the following four statistics: cross-width variance (C_v), ten-point mean roughness (R_t), solidity factor (R_r), and two-point slope variance ($SV2$) to predict the pavement surface type with an overall accuracy of 94% in terms of the F1 Score. The classifier was trained, tested, and validated using over 20,000 different pavement profiles to avoid overfitting. The researchers developed a robust and accurate friction model by combining the pavement surface prediction with at least two texture statistics. A multiple regression model with dummy variables was the most efficient and accurate method of predicting friction. The model combined two texture statistics, skewness (R_s) and root mean square (RMS), and three dummy variables to represent the four pavement surfaces previously mentioned.

What This Means

The capability to accurately predict friction at a network level has significant safety implications for TxDOT. This type of information allows decision-makers to identify low-friction pavement sections within the network before they become accident hotspots, and thus schedule proactive maintenance as soon as friction levels are lower than the intervention level. This will result in a safer road network where the potential for wet weather accidents is mitigated as much as possible and the lives of many Texan drivers could be saved. In addition, the algorithms recommended by the research team are simple to interpret and to code into Pavement Analyst, allowing TxDOT to save time, money, and valuable resources by not having to send locked wheel testers on an annual basis to measure one-third of the network.

For More Information

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