Development of Distress Index Prediction Models for Rehabilitation Treatments in Louisiana Using Advance Machine Learning Techniques

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Principal Inverstigator(s):

Momen R. Mousa

Louisiana State University

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Louisiana State University

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Developing distress index prediction models using machine learning

Over time, new pavements deteriorate under the combined effects of traffic loading and the environment, no matter how well-designed or constructed. In general, maintenance and rehabilitation activities are employed to slow down or reset the rate of pavement deterioration. Rehabilitation activities are those activities conducted to repair portions of an existing pavement to reset the deterioration rate. The objective of this study is to utilize advanced machine learning techniques to develop and validate distress index prediction models for rehabilitation treatments in Louisiana. CatBoosT is a recently developed machine learning algorithm that is widely recognized among the computer science community for its robustness in handling high multi-collinearity and high dimensionality of large datasets. No such algorithm has been employed in previous studies to model the pavement performance. Therefore, this study will investigate the effectiveness of CatBoost in modeling pavement performance in Louisiana. It is expected that the developed models will assist transportation agencies in South-Central U.S enhance their pavement asset management practices and make better economic and defensible decisions on pavement treatment selection.

Problem Statement

LaDOTD currently uses a distress index prediction model for every distress index for every pavement family (pavement families are defined based on the pavement type and highway classification). All the distress index prediction models currently used by LaDOTD are based on at least 6 years of data collected at 2-year intervals. These models are only function of the pavement age and follow different transformation functions (polynomial, power, exponential and linear). Although these distress index prediction models are important to LaDOTD as they directly impact the year a pavement section is selected for repair, they are debatable in terms of accuracy. This is because these "parametric models" have a certain basic statistical structure, specific assumptions, and certain relationships between the input and output variables. When using this "parametric" approach, the adopted datasets generally suffer from high dimensionality [data has many variables] and high multicollinearity [two or more predictor variables are highly correlated]. This violates some imperative assumptions such as independence of the input variables for parametric methods, and therefore, the statistical power of the developed models is weakened and unpredictable variance is encountered rendering the prediction by these models unreliable. For these reasons, most of the developed distress index prediction models (including LaDOTD models) were limited to a limited number of variables such as pavement age, pavement type, and highway class neglecting other significant variables such as the traffic level, rehabilitation and maintenance history, pre-treatment pavement conditions (condition of the original pavement before rehabilitation), pavement thickness, etc. As a result of this shortcoming, a previous study in Louisiana indicated that most of the models used by LaDOTD usually overpredict the distress indices. This is a critical issue as it affects maintenance and rehabilitation decisions and may result in inadequate allocation of maintenance and rehabilitation funds. Therefore, it is necessary to utilize a "non-parametric machine learning algorithm," which is robust against high dimensionality and high multi-collinearity to develop new updated distress index prediction models for rehabilitation treatments in Louisiana and to ensure that correct maintenance and rehabilitation decisions are made.

Objectives

The main objective of this research study is to utilize advanced machine learning techniques to develop and validate distress index prediction models for rehabilitation treatments in Louisiana. CatBoosT is a recently developed machine learning algorithm that is widely recognized among the computer science community for its robustness in handling high multi-collinearity and high dimensionality of large datasets. No such algorithm has been employed in previous studies to model the pavement performance. Therefore, this study will investigate the effectiveness of

CatBoost in modeling pavement performance of rehabilitation treatments in Louisiana.

Intended Implementation of Research

Workforce Development, Education, and Outreach: This research project will provide funding to one master student at Louisiana State University. This will help recruit and train future leaders in the Transportation Sector. The research team will also prepare educational materials on the new models developed in this study. These educational materials will be shared and disseminated to government entities and the industry. Results of this work will be also presented at national conferences such as TRB and ASCE.

Anticipated Impacts/Benefits of Implementation

The research team will utilize the results of the technical phase to develop an Excelbased spreadsheet tool that automates the utilization of the proposed machine learning models. This tool, which will be implementation-ready, can be utilized by the DOTs to make more economic and defensible decisions on future rehabilitation activities. The developed tool would be complemented with a standalone user guide, along with a proposed evaluation plan to track the implementation progress of the tool.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.