Exploration of Machine Learning Approaches to Predict Pavement Performance

tech transfer summary

Machine learning software offers a viable approach to predicting a pavement condition index up to two years ahead.

Objective

The primary objective of this research was to develop and assess pavement condition index (PCI) predictive models for the years 2014 and 2015 based on the 2013 PCI values and other road characteristics during the 2013 calendar year. The study also factored in whether the road segment was resurfaced in 2014 or 2015.

Problem Statement

Acceptable pavement conditions are paramount to road safety, but determining PCI annually can be subjective and time-consuming. Advances in machine learning (ML) may make it possible to determine PCI without measuring road segments on a yearly basis.

Research Methodology

The research team refined its input variables and modeling methods over three years to provide the best predictors for determining PCI for 2014 and 2015 using 2013 data provided by the Iowa Department of Transportation for nearly 4,000 road segments that included portland cement, composite, and asphalt pavement types.

The research in 2015 and 2016 utilized JMP Pro software (version 12.1.0, 64-bit) from SAS Institute, Inc., to test a series of multiple regression models for the different pavement types. A total of 23 distress measures, including cracking types and patching, and 9 descriptive variables, such as average daily traffic, were considered as possible model inputs in 2015. The research was refined to 18 different road conditions and measures in 2016, with 11 used in the final predictions for PCI 2014 and 2015.

The analysis in 2017 utilized IBM's Watson Analytics, a machine learning software tool. Based on the research team's previous work, 21 relevant variables were included, and a separate analysis was performed for each of the three studied pavement types.

Key Findings

The results suggest that machine learning techniques are capable of modeling and predicting PCI for various pavement types and using a variety of input variables.

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MTC RESEARCH PROJECT TITLE
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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

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Other key findings include the following:

- The ML approach has an advantage over multiple linear regression models, which have been used in previous studies, because ML automatically accounts for nonlinear relationships.
- One of the key factors in predicting PCI for 2014 and 2015 is the PCI in 2013. Other key factors include International Roughness Index (IRI) for portland cement and composite pavement types and road resurfacing and average daily traffic for asphalt cement.
- For each pavement type, the variables that best predict PCI 2014 can differ from the variables that best predict PCI 2015. The key variables for predicting PCI also differ among the three pavement types.

Recommendations

Based on the potential for using machine learning to predict performance, the research team recommends repeating the analysis in the future with different data sets to ensure the software's generalizability and validity in its pavement condition index predictions.

Implementation Readiness and Benefits

The analysis using IBM's Watson Analytics reveals that an ML approach is a viable one for predicting PCI because it identifies the key input variables for three different pavement types: portland cement, composite, and asphalt cement.

Moreover, the analysis shows that it is possible to predict 2014 and 2015 PCI values using 2013 PCI readings, which eliminates the need to measure PCI every year.