Holistic Network-level Assessment of Pavement Flood Damages

Highlight | Dec. 2020

Project No. 19PLSU13

PI: Dr. Yong-Cheol Lee

Co.PI: Dr. Kunhee Choi

August. 2019

– February. 2021

Flood events frequently occur in United States, causing severe damages to roadway infrastructure. Current assessment of roadway flood damages is conducted through physical investigation such as core bores, which evaluates limited spots. To analyze network-level pavement inundation damage, this study utilizes the PMS (Pavement Management System) data, which contain information about pavements' distress over the years that enables researchers to find damage patterns for pavement deterioration in various flood occasions. Understanding the impact of flood on pavement allows practitioners to provide plans for roadway maintenance and rehabilitation against flood occurrences. This study investigates the effect of the Louisiana's 2016 and Texas 2017 flood events on pavement through analyzing the historical data and identifying the variation of distress scores. The study developed a prediction model to forecast pavement behaviors in flood-prone regions and identify the most vulnerable roadways to flood occurrences.

Background

Roadways can be easily inundated by flooding and currently, especially in region 6, numerous roadway sections are exposed to flood risk. Several roadways are frequently inundated with floodwater or the stork of debris, providing critical problems in providing the path for evacuation, assistance, and others. Most of flood damages on roadway pavement are not visible after floodwater recedes, therefore, a comprehensive investigation is required to estimate the impact of flood in short-term and long-term periods. current methods for evaluating roadway damages are time-consuming and labor-intensive. In addition, even though existing methods provide a detailed damage analysis of pavement in a particular location for a particular time period, there is still a large practical knowledge gap in understanding network-level roadway functional/structural damages before-and-after historic flooding as well as assessing flooding impacts on roadways over time. Since each roadway system encompasses several miles of interconnected networks between cities and States in Region 6, a holistic assessment of roadway damages after flooding events not only provides regional roadway damage patterns but also facilitates an integrated roadway recovery and maintenance plan. In addition, there is no previous effort to evaluate roadway damages by adopting the most accurate and latest flooding data. Unfortunately, a lack of holistic perspective and long-term investigation on roadway damages caused by floods has resulted in the absence of accurate maintenance cost prediction.

Project summary

This study aims to develop a holistic network-level assessment of flood impacts on pavement structures using the pavement distress data provided by state DOTs. The research focus area of the proposed study is developing and implementing a holistic network-level pavement damage assessment approach for enhancing durability and service life of transportation infrastructure in metropolitan and rural areas. In this study, the research team investigated the effect of flood on pavements through analyzing the variations in different distress types, using pavement historical data. In this analysis, the most flood-affected distress types were identified. The results of the analysis were used to create a machine learning-based prediction model that is able to forecast the pavement behavior in flood-prone regions.

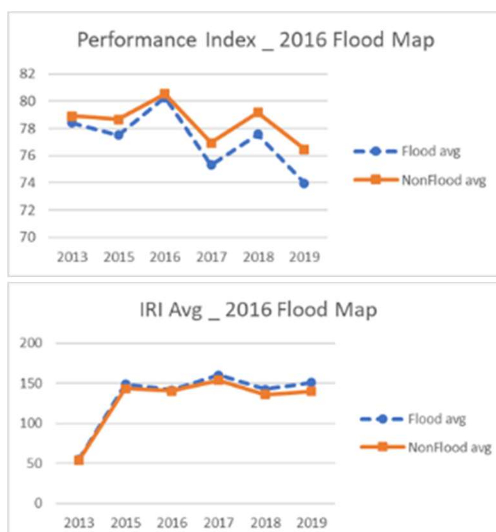

Figure 1. Analysis of the effect of flood on different distress types (left: the effect of flood on performance index, right: the effect of flood on IRI)

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Status update

The historical distress data were attained from the PMS database to be used for analysis and train data for the prediction model. However, one major challenge on PMS data was the records that indicated improvements in pavement condition over time without any treatment or maintenance. Although this issue was rectified by eliminating those records from the dataset, there were a large number of records to be eliminated. To improve the dataset, the attributes such as traffic data, project data (for identifying repaired roads), and flood data were used along with the distress data attained from the PMS. The following two different flood maps were used for this study; Louisiana 2016 estimated flood maps in ArcGIS and FEMA's High-risk Flood areas map. Several types of analyses such as clustering analysis, grouping analysis, etc. were conducted to understand the effect of flood on the pavement.

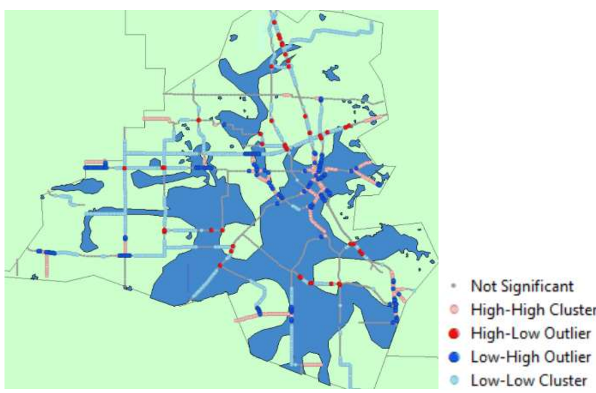

Figure 2. Clustering analysis according to variations in IRI in Lafayette parish

Two different machine learning algorithms, including Support Vector Machine (SVM) and XG Boost (XGB) were examined for developing the prediction model. The XGB classifier had the highest accuracy of near 80%.

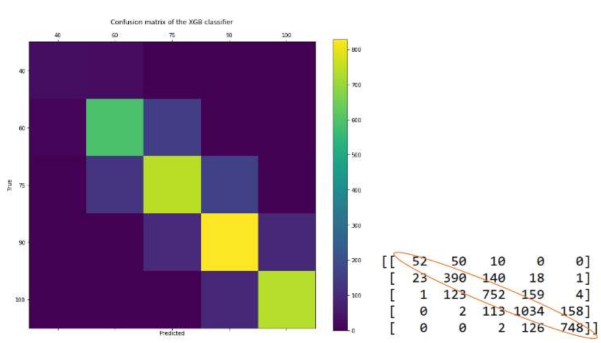

Figure 3. The confusion matrix of the developed XGB prediction model with 80% accuracy.

Impacts

The study showed what pavement distress types are affected by flood and which types are not significantly influenced. The pavement management data-based analysis showed the distress types such as random cracking, rutting, and roughness are affected by flood, while the flood does not affect pavement's faulting. The study also showed that the distress analysis results may differ using different sources of flood data. In addition, the research provided a prediction model to anticipate the performance of the pavements and facilitate identifying the most vulnerable roadways in a flooded area.

The prediction model provided in this research can be used by state practitioners to identify the most vulnerable roadways to flood hazards, and accordingly, prioritize the budget and resource allocations.

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