Transportation Consortium of South Central States

Decision-Making Tool for Road Preventive Maintenance Using Vehicle Vibration Data

Key Points

Project Number:
18PLSU08

Start Date:
03/15/2018

End Date:
09/15/2019

Principal Investigator(s):
Jing Du
Texas A&M University
dujing@tamu.edu
Chao Wang
Louisiana State University
chaowang@lsu.edu

Lead Institution:
Texas A&M University

Funds Requested to UTC:
$50,000

Funding Source(s):
Tran-SET
Texas A&M University
Louisiana State University

Total Project Cost:
$100,002

Brief Project Description

To overcome the foreseeable challenges in system-level road pavement preventive maintenance decision-making, this study aims to test a framework that maps pavement surface conditions based on running vehicles' vibration data (via sensors built in most smartphones), and optimizes the preventive maintenance plans based on the deterioration modeling of the road system (urban level). This study will advance our knowledge about preserving existing road infrastructure through calculated preventive maintenance. The findings will enable the development of an automatic and economic road condition evaluation method by monitoring the vibration patterns of the running vehicles on the road.

Problem Statement

America's aging infrastructure systems are facing a significant challenge due to the limited renovation funding. The most cost-effective strategy to improve the overall conditions of America's road infrastructure is through preventive maintenance, i.e., a planned treatment to an existing roadway system and its appurtenances before deficiencies develop. However, making robust preventive maintenance decisions on a relatively large section of roads can be a nontrivial task, due to various factors that need to be considered in the calculation. Even in a small area, different sections of a road can be in varying and changing conditions. Decision makers must be able to identify the critical sections, predict the temporal deterioration of each and every section of the roads, and ultimately distribute limited resources in a holistic way to optimize the long-term performance of the entire system, instead of local sections. It requires large amounts of high quality live data about the pavement surface conditions, and a near real-time decision-making system (and optimization algorithm) that processes and analyzes the dynamic data.

Objectives

This study aims to test a framework that maps pavement surface conditions and optimizes the preventive maintenance plans based on the deterioration modeling of the road system. The technical objectives include to:

- Understand the statistical relationship between vehicle vibration (monitored by smartphone accelerator sensors) and pavement damages;
- Investigate deterioration modeling of the road system with vehicle vibration data;
- Test algorithms that optimize preventive maintenance plans for the overall performance of the entire system in the long term.

Intended Implementation of Research

Workforce Development

This study will support two graduate students in research activities – and involve at least 20 undergraduate students. The research team will collaborate with Texas A&M University (TAMU) College of Education and Human Development (EHM) to create workshop sessions about preventive maintenance decision making.

Education

New short course modules will be developed that construction, engineering, and computer science faculty members could incorporate into their syllabi. Furthermore, rather than simply involve students in research, this study will foster personal and professional success through mentored research experiences; each undergraduate student worker will be paired with a graduate student member to help the student develop essential research skills.

Outreach

The research team will work with San Antonio Northside ISD Construction Careers Academy (CCA) to organize a summer camp for Hispanic students who are interested in STEM fields. Additionally, in collaboration with TAMU EHM, students will create road maintenance planning games; teacher training manuals and workshop sessions will be made available to faculty who want to incorporate the games in their curriculum. The research team will also work with Kenilworth Science and Technology Middle School and participate in their mentorship program.

Anticipated Impacts/Benefits of Implementation

This study will advance knowledge about preserving existing road infrastructure through calculated preventive maintenance. The findings will enable the development of an automatic and economic road condition evaluation method by monitoring the vibration patterns of the running vehicles on the road. Decision makers will be able to develop precise road deterioration models to predict the temporal change of conditions. The set of deterioration models will ultimately help optimize the preventive maintenance activities to preserve the functional condition of the road system at the minimum cost. The large amount of empirical data collected in this study will help build the holistic view of road infrastructure system in the selected areas. The maintenance decision-making will be driven by the system science of all interdependent factors instead of local optimization.

Weblinks:

- Trna-SET's website (http://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1505367)