Tran-SET
Transportation Consortium of South-Central States

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Key Points

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$75,000

Funding Source(s):
Tran-SET
University of New Mexico

Total Project Cost:
$150,000

Development, Training, Education, and Implementation of Low-cost Sensing Technologies for Bridge Structural Health Monitoring (SHM)

Brief Project Description

This research project promotes the sustainability and resilience of transportation renewal and upgrade by developing cost-effective sensing technologies for structural health monitoring (SHM). These cost-effective new technologies are to be developed and applied towards the maintenance of the transportation infrastructure in metropolitan and rural areas. Examples of technologies that may be considered include Arduino, 3D printing, wireless smart sensors, drones, and Hololens.

Problem Statement

Today, freight transportation in North America is widely accepted to be the best in the world, carrying 40% of the US's freight tonnage. Data from the Association of American Railroads (AAR) estimated the cost of infrastructure expansion that was needed to match the 2007-2035 estimated growth was $148 billion (in 2007 dollars). Enhancing the assessment of civil infrastructure has many challenges, as it requires a wide range of temporal and spatial resolution and extensive field validation, and there is a dearth of effective data collection approaches to inform decisions. To help address this deficit the research team will identify, develop, and test technologies that enhance and inspector's ability to perform structural inspections using new technologies studied and developed by researchers that are of interest to infrastructure owners. We will focus, in particular, on proposing simple technology to monitor those railway and highway bridges with the greatest need for replacement. The effort is to maximize the transformational impact of the proposed cost-effective approach on the most important and urgent national infrastructure networks.

Currently, bridge inspection reports inform Maintenance, Repair, and Replacement (MRR) decisions within the entire network. Bridge inspections are required annually since 2010 as part as the bridge management program. Bridge inspections take time, cost money, and are often conducted in risky environments with limited access by inspectors. In addition, three significant challenges affect bridge inspections today: (1) bridge inspectors

need to visually evaluate all bridge structural elements and thereby are exposed to unsafe environments. This is a major challenge in tall and long steel bridges where elements are difficult to access; (2) Visual observations without measurements cannot quantify defects, and are in general subjective and depend on the experience of the inspector; (3) When infrastructure managers need to quantify the structural properties of bridges being inspected, a significant amount of money must be invested in equipment to collect objective data, such as timber testing equipment for timber bridges or non-destructive testing (NDT) equipment generally used by highly specialized companies.

To solve the aforementioned problem, this project seeks to increase the technical ability of the inspector, with an emphasis on using bridge assessment to inform bridge management decisions. A multi-disciplinary team from the University of New Mexico (UNM) will partner with the CN railway, NMDOT, and LANL to augment the human ability to measure the condition of the bridge under loads using low-cost sensors.

Objective

The proposed research equipment and analysis methods provide a means to augment the ability of inspectors to quantify bridge conditions and performance on site using low-cost sensors in collaboration with their inspection departments and needs.

Intended Implementation of Research

Technology Transfer

Knowledge about this research will be disseminated to these students and to all faculty and LANL staff participating in this summer school for the next two years. The CN railway will also disseminate knowledge generated from this research in collaboration with the PIs through their national and international events. The PIs will also lead the preparation of the workshop, coordinating with the Co-PI and the railway owners. In this workshop, regional high school science and math teachers will be invited to participate to broaden their experiences and abilities in developing low-cost sensing approaches that can be tested and developed in the first 12 months in collaboration with UNM. Collaborating with two national leading companies in the railroad industry, CN and BNSF, as well as LANL, provides an excellent opportunity for knowledge dissemination at different levels in higher education, but also in pre-college education in the region in New Mexico.

Education, Workforce Development, and Outreach

This grant will support the development of new sensing technologies generated by students enrolled in a suite of new STEM classes. The grant will fund one UNM graduate student to teach the new STEM courses related to fundamentals of transportation structures decay and deterioration; Arduino sensors for transportation infrastructure inspection; use of drones for structural inspections; and augmented reality tools (Hololens) to enhance infrastructure inspection. More specifically, the undergraduate and graduate students involved in this research will be exposed to cross-organizational working experiences, working side by side with the owners of infrastructure. By participating in this project, the students will be trained in railroad engineering, aerial robots, bridge inspections, industrial structures, augmented reality, electrical engineering, and signal processing. The professional exposure to a railroad company will better prepare students for future careers in industry. The students will receive training prior to visiting the railroad bridges, and will conduct quarterly presentations to industry partners which will serve to increase their training and preparation in the

engineering workforce. The active participation of the PI and Co-PIs will support student exposure to research that is strongly tied to innovation and entrepreneurship.

Anticipated Impacts/Benefits of Implementation

This research project will promote the sustainability and resilience of transportation renewal and upgrade by developing cost-effective technologies developed by students (including precollege and undergraduate students). These cost-effective new technologies will be developed and applied towards the maintenance of the transportation infrastructure in metropolitan and rural areas. Finally, this research in new technologies (Arduino, wireless smart sensors, drones, Hololens) will promote workforce development in the earliest stages of education in transportation engineering.

Weblinks:

- Tran-SET's website (http://transet.lsu.edu/completed-research/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1467524)