An automated system for inspecting rock faces and detecting potential rock falls using machine learning

Developing a simple and effective analysis method to identify unstable rocks prior to a rockfall

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$100,000

Rock falls are a danger to everyone at locations near steep rock cuts, including the South-Central states of Region 6. On September 13, 1988, a rock fall occurred 50 miles north of Santa Fe, NM, killing 5 and injuring 14. Beyond the fatalities and injuries, rock falls result in property damage, traffic delays, and road closures. Moreover, rehabilitation of transportation infrastructure after a rock fall is costly. For example, a rock fall in June of 2015 along Interstate 35 resulted in road closure for seven weeks while the Oklahoma Department of Transportation stabilized the rock face and moved 14,000 tons of fallen rock away to a local quarry for an estimated $2M. Within the last year, there have been 3 rockslides on Loop 360 near Austin, Texas that resulted in many road closures and property damage. A potentially beneficial way to reduce rock fall hazards is to detect and move rocks that are prone to fall by manually inspecting and scaling existing exposed rock surfaces. Trained crews access the rock faces often by rappelling over the edge from above or via portable lifts - and use pry-bars to strike the rock. The sound and feel of striking the rock are used to identify loose rocks that are then scaled. Rock inspection and scaling risky to the workers. It is also costly, time-consuming, and labor intensive. Furthermore, roads must be closed, and traffic is diverted. A significant limitation of current inspection practice is that the results from striking the rock face is subjective as it is operator dependent. Further, the method is not conducive to recording data to allow for monitoring subtle changes in rock block response over time.

Problem Statement

To address the shortcomings of manual rock face inspections, an automatic system for rock face inspection has been proposed. An automated tap hammer will be designed, developed, tested, and validated to become a tool for striking rock face surfaces and recording the resulting reflected waveforms with a microphone. The response of the rock to the hammer tap will be interpreted in terms of rock stability. A similar system has been developed for remote inspection of bridges. It has been demonstrated that an automatic tap testing device can collect the acoustic impact response of concrete bridges automatically, and that data can be used with machine learning classification methods to identify different structural states (i.e., damaged vs. non-damaged). We will adapt and modify this technology to design a new tap testing hammer that can be used in identifying loose rock blocks on rock faces associated with transportation infrastructure. Beyond reducing the risks and costs of manual inspections, more efficient data will be collected. In addition, inspections can be repeated at the same location.

Objectives

The objective of the research is to establish an automatic system for identifying blocks of rock that are prone to rock fall. Rock falls threaten the safety of residents, drivers, and transportation infrastructure at locations adjacent to steep rock cuts, including the South-Central states of Region 6. Furthermore, rehabilitation of transportation infrastructure after rock falls is costly. A principal means to mitigate rock fall hazards is to examine and remove rocks that are prone to fall by manually inspecting and scaling exposed rock surfaces. Trained crews access the rock faces - by rappelling over the edge from above or via portable lifts - and use pry-bars to hit the rock. The sound and feel of striking the rock are used to identify loose rocks that are then scaled.

Intended Implementation of Research

Workforce Development: This will be achieved directly by training graduate, undergraduate, and high school students interested in pursuing a career in STEM or Transportation Engineering career.

Education: This task supports the federal initiative to build the next generation of transportation

professionals to meet the demands of the rapidly changing 21st-century transportation system and its rehabilitations practices.

Outreach: Technical articles, posters, and presentations will be delivered at national and local conferences and symposia such as ASCE, Transportation Research Board, NMDOT, and Tran-SET.

Figure 1: Rock fall mitigation Otero County, New Mexico

Anticipated Impacts/Benefits of Implementation

The assessment of this technology and the potential to lead to safer rock face inspections with data for machine learning for analysis. The main deliverables from this study are:

(1) A final report containing the problem description, proposed solution, data, procedures, and recommendations.

(2) Webinars to disseminate the findings of this study to a national audience via American Society of Civil Engineers (ASCE).

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.