Increasing Bridge Durability and Service Life with LIDAR Enhanced Unmanned Aerial Systems (UAS)

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21STUNM04

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Lead Institution:

University of New Mexico

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Tran-SET

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Total Project Cost:

$ 100,000

Enabling the construction inspector of the future using Lidar-equipped UAS

The proposed research project will expand the positive results obtained in the past related to collecting rebar spacing in bridge construction using LiDAR. The research team will build up capabilities and adapt them to the technical demands imposed by COVID-19 of limited interaction by automatizing the LiDAR scanning using Unmanned Aerial Systems (UAS). This new technology is also called LiDAR-equipped UAS technology. The lack of quantitative measurements and location information during the bridge construction process results in personal human-based bridge inspections. Bridge owners and managers tasked with making major maintenance/repair decisions with inadequate funding and resources. It is appealing to develop a new construction inspection record with quantitative measures and geo-referenced locations in a holistic process that the owner can use in the entire life of the structure as a record of "as-built" rebar location. A new automatic bridge inspection method based on LiDAR and UAS is proposed to improve the efficiency, cost-effectiveness, and objectivity of these inspections while enhancing inspectors' safety. In this proposed project, an automated rebar layout detection algorithm will be developed to quickly extract quantitative rebar layout information (i.e., type, size, amount, and location) from the LiDAR data. This systematic method can also be used to inspect the bridge, by automatically segment the bridge elements from a 3D point cloud by using LiDAR-equipped UAS data collection and unsupervised machine learning techniques. The bridge construction information collected by LiDAR-equipped UAS technology with quantitative measures in conjunction with the 3D visualization can provide bridge managers with a transparent condition evaluation and one-stop decision-making support that can significantly ease repair planning/maintenance. The feasibility of this proposed research will be demonstrated using a bridge with the cooperation with NMDOT.

Problem Statement

Conventional inspection of bridge constructions, in general, is rather time-consuming and often cost expensive due to traffic closures and the need for special heavy vehicles such as under-bridge inspection units or other large lifting platforms. Visual inspection of the bridge construction process based on the non-equipped eye is the most commonly used method of reinforced concrete construction inspection. However, this method is subjective, costly, time-consuming, and may cause safety risks, such as falling or trying to reach far components. LiDAR-based methods are highly accurate and able to collect point clouds and enable measuremets to be collected with non-contact means and also faster. Bridge durability and service life depend heavily on the construction means and methods being closely monitored and tracked to be accounted for and known for future decisions of the agency. This requires a highly up-to-date and effective monitoring system for all critical constructions of bridges. A flexible and valuable tool such as Unmanned Aerial Systems (UAS) with special sensors like LiDAR scanner can be precious for carrying out the monitoring tasks. For this purpose, a low-cost system consisting in integrating LiDAR and UAS is proposed for this research project. In this project, the known LiDAR success from the past and the experience in adding sensors to UAS will be integrated with a new transportation durability emphasis: off the shelf LiDAR-UAS integration and validation for DOTs, with an emphasis on bridge structural quality inspection.

Objectives

The goal of this project is to use LiDAR-equipped UAS and build the appropriate software/hardware tools that will help enable the construction inspector of the future. More specifically, this research aims to:

1) Test if LiDAR-equipped UAS can collect reinforced concrete data in the field
2) Quantify the ability of LiDAR-equipped UAS during construction inspections
3) Identify challenges, both technical and from implementation, to use LiDAR-equipped UAS in NMDOT
4) Propose specifications that would inform how to use LiDAR-equipped UAS for construction inspection of reinforced concrete Construction.

Figure 1. LiDAR-equipped UAS

Intended Implementation of Research

This grant will support the development of STEM classes on LiDAR-equipped UAS and technology to inform of reinforcement layout during Construction. Also, students funded with this project will visit high schools and middle schools in New Mexico and introduce students to LiDAR during Construction. The PI will introduce LiDAR-equipped UAS to civil engineering students in the Summer Transportation Institute (STI) in 2021 if allowed with COVID and 2022. The risk-reward ratio of this research is low, because the quality of the collaborators will increase the impact of the research in two different department units at UNM. The strong partnership with the NMDOT will guarantee the high impact of this research. The collaboration with NMDOT will allow UNM students to collaborate with a different institution throughout the project, and more specifically to interact in conducting research outside of the state of New Mexico, broadening the impact for regional students.

Anticipated Impacts/Benefits of Implementation

This research will use the proposed monitoring technology to test the changes in transportation infrastructure inspection abilities during construction activities. The proposed research provides an innovative approach to intelligently augment the ability to assess infrastructure conditions (inspection) during Construction of bridges, which will be objectively monitored. The efficacy of the proposed system will be validated with the population of inspectors and managers of NMDOT. In this way, a new generation of inspectors will select the research developments that will allow them to conduct inexpensive, safer, and cost-effective construction inspections. Specific expected outcomes include, but are not be limited to, improving awareness of the value of new technologies for public safety and infrastructure resilience and sustainability.

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.