Efficient, Low-cost Bridge Cracking Detection and Quantification Using Deep-learning and UAV Images

Collecting visual bridge data through the use of drones and smart imaging

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$90,165

Many bridges in Louisiana and the United States are working under serious degradation conditions where dangerous cracking can occur. To ensure structural integrity and public security, bridges in the US must be inspected and rated every two years. Currently, this biannual assessment is mostly implemented using slow, costly manual visual inspection methods. Furthermore, it is challenging to detect cracks in out-of-reach parts of bridges, (e.g., top of bridge tower, cables, mid-span of the bridge girders, etc). It is possible there are undetected cracks during inspection, which might cause bridge to collapse when the undetected damage on load-bearing members becomes too high. One example is the I-35 Bridge that collapsed in Minneapolis in 2007. As unmanned aerial vehicles (UAVs) have become more popular, researchers started to use them to collect visual data from unreachable places. Especially for bridges, UAVs can quickly fly to desired locations to take images and videos. Hence, it is promising to incorporate this deep learning method with UAV images to develop an automatic crack damage identification method.

Problem Statement

Advances in image processing techniques have provided an automatic visual monitoring system that conveys structural damage through image or video processing. This method does not require expensive sensors and is less dependent on labor work and expert experience compared to preexisting manual inspection methods. Many image processing techniques have been proposed including the generative adversarial network, convolutional neural network (CNN), seeded region growing algorithm, and edge detection. Recently, vision-based crack identification has been investigated and received more research attention and thus requires further testing and analysis.

Objectives

The goal of the study is to develop an efficient, economical deep learning-based groundwork to detect and quantify cracks on bridges using computer vision-based technique. The Convolutional Neural Networks (CNN) deep learning method is powerful in extracting and learning image features and will be used to identify cracks in images. Specific research activities include: (1) extensive collection of images from the Internet with subsequent categorization into five classes (intact surfaces, cracks, multiple joints and edges, single joint or edge, etc.); (2) collection of images of target structures with a UAV (example shown below); (3) development of a deep CNN model using collected images and their augmentation; and (4) identification of cracks using the learned deep learning model. The outcomes of this project will enable automatic crack damage detection and cost-effective quantification of bridge key components. The methodology is expected to expedite crack damage identification for other transportation infrastructures, e.g. pavement and traffic sign structures.

Figure 1: The phantom 4 DJ drone in the PI's lab

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 and Outreach: This research project will directly involve undergraduate and graduate students to prepare the next generation entering the workforce in this field. In addition, demonstrations will be presented to practitioners at local DOTDs to show them to implement bridge cracking detection using the proposed methodology.

Anticipated Impacts/Benefits of Implementation

The developed computer vision- and deep learning-based framework will enable automatic crack identification of bridges and other infrastructures. This will significantly improve the inspection efficiency and reduce the huge costs on bridge inspection and maintenance in U.S.

The main deliverables from this study are: (1) a report containing the problem description, objective(s), scope, methodology, results, conclusions, and recommendations (2) journal publications and presentations to be given at national conferences.

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.