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AI-Based Bridge and Road Inspection Framework Using Drones

Hovannes Kulhandjian, PhD

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Introduction

There are over 590,000 bridges dispersed across the roadway network that stretches across the United States alone. Each bridge with a length of 20 feet or greater must be inspected at least once every 24 months, according to the Federal Highway Act (FHWA) of 1968. Each inspection must adhere to the National Bridge Inspection Standards' requirements (NBIS). A bridge inspection should uncover any severe structural flaws that need to be addressed, quantify the overall state of the bridge to prioritize capital needs, identify routine maintenance, and keep track of the bridge's history. Inspecting bridges is a time-consuming and expensive task. Traditional inspection methods necessitate a great deal of coordination, such as traffic control, and they put personnel in danger. There are several methods of routine bridge inspection currently used by specialists for detecting defects such as surface cracks or sub-surface delamination in infrastructure, including in-person visible inspection, thermal imaging inspection, ground penetrating radar (GPR), and acoustic inspection. Regardless of the technique, the current processes can potentially place workers in unsafe environments and require complex traffic lane-closure management, additional labor hours, and expensive equipment.

Study Methods

This research proposes an artificial intelligence (AI)-based framework for bridge and road inspection using drones with multiple sensors collecting capabilities. As it is not sufficient to conduct inspections using cameras alone, the research team utilized an infrared (IR) camera along with a high-resolution optical camera. In many instances, the IR camera can provide more details to the interior structural damages of a bridge or a road surface than an optical camera, which is more suitable for inspecting damages on the surface of a bridge. In addition, the drone inspection system is equipped with a minicomputer that runs Machine Learning algorithms to enable autonomous drone navigation and the taking of images of the bridge or the road structure whenever any damage is detected. The drone can self-operate and carry out the inspection process on its own using the developed AI algorithms.

The research team built the system on a Hexacopter that has a S550 Frame, a Pixhawk Flight Control, 920KV Motors, a global positioning system (GPS), and a transceiver. A Raspberry Pi 4B minicomputer was embedded in the drone to perform all the command and control as well as data gathering and implementing all the machine learning algorithms. A visible light camera and a high-resolution thermal infrared camera were installed on the drone and were used for gathering the camera images. The team developed several road navigation algorithms that are used to allow the drone to perform GPS-less navigation through the streets to inspect the road for potholes. After gathering sufficient data with the visible light camera and the IR camera, deep learning algorithms are used to train the machine learning models to detect potholes. Pre-trained machine learning algorithms are ported onto the Raspberry Pi to detect potholes in real time and record their location using GPS coordinates. This information can later be provided to the inspection authorities to fix the issues that exist on the roads. Experimentations were carried out on roads but not on bridges due to stricter regulations around flying a drone near a bridge.

The experimental results of this bridge and road inspection framework detected potholes with an average accuracy of 84.62% using the visible light camera and 95.12% using a thermal camera. This inspection framework can save a lot of time, money, and lives by automating and having drones conduct major inspection operations in place of humans.

Findings

After developing the bridge and road inspection framework, the research team conducted actual experimentation detecting potholes using the video camera and the IR thermal camera combined with machine learning algorithms. The developed system, using the trained machine learning algorithms, was able to successfully detect potholes and record the location of those potholes on the streets with high accuracy. The experimental results reveal the system can detect potholes with an average accuracy of 84.62% using a visible light camera and 95.12% using a thermal camera.

Policy/Practice Recommendations

The proposed AI-based drone inspection framework could be used by the US Department of Transportation to conduct routine inspections of bridges and roads autonomously with minimum manpower, which could save a great deal of time, money, manpower, and even lives as the inspectors often must risk themselves on the bridge to perform such inspections.

About the Author

Hovannes Kulhandjian, PhD

Dr. Kulhandjian has received five research grants from Fresno State Transportation Institute (FSTI), and he also received the Claude C. Laval III Award for Commercialization of Research, Innovation and Creativity 2021 as well as the Claude C. Laval Award for Innovative Technology and Research 2020 at Fresno State. In April 2021, as a Principal Investigator (PI), he received a grant from the Department of Defense (DOD) Research and Education Program for Historically Black Colleges and Universities and Minority-Serving Institutions (HBCU/MI) Equipment/Instrumentation, to establish a “Secure Communications and Embedded Systems Laboratory at California State University, Fresno”.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2226

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