DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

Geotechnical/ Structures

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Project Title: Development of Autonomous Drone Inspection for Bridge Maintenance

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Task Manager:

Colman Cronin
Senior TE
colman.cronin@dot.ca.gov

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

Development of Autonomous Drone Inspection for Bridge Maintenance

This project aimed to design, develop, and implement autonomous drone-based inspection and damage assessment of bridges.

WHAT WAS THE NEED?

Bridge inspections involve assessing the condition of various structural components to ensure safety and integrity. Manual inspections, traditionally conducted by trained engineers, focus on identifying defects such as cracks, corrosion, spalling, and other signs of deterioration. These inspections rely heavily on visual observations and require capturing detailed imagery for accurate assessment.

Drones have emerged as a promising technology to enhance the efficiency, accuracy, and safety of bridge inspections. However, current drone-based approaches are still heavily reliant on manual piloting and are often not optimized for the specific requirements of structural condition assessment. The integration of autonomy into drone inspection workflows has the potential to address these limitations and better align with California Department of Transportation (Caltrans') operational needs.

WHAT WAS OUR GOAL?

The goal of the research task was to design, develop, and demonstrate autonomous drone-based inspection and damage assessment of bridges.

WHAT DID WE DO?

The University of California, Berkeley (UC Berkeley) researchers proposed a research methodology that involved developing a prototype drone that could be pre-programmed with pre-determined flight paths in a simulator and testing of the autonomous flight of the drone in a laboratory setting first and subsequently at two bridges. The workflow involved developing an interface in the open-source simulator Blender platform that allows users to specify inspection viewpoints on a bridge model. These specifications can be inputted into the drone prototype which is capable of autonomously executing these predefined viewpoints.

The inspection workflow requires a digital model of the bridge and a navigation map. To build the digital model, aerial images were captured manually by a piloted drone. The images were processed using commercial 3D photogrammetry software for 3D reconstruction of a mesh model. Figure 1 below shows the proposed inspection workflow. The result is a high-fidelity textured mesh model of the bridges. In addition to the mesh model, a navigation map was also needed for the drone. The bridge mapper module developed by the research team generates this map using simultaneous localization and mapping (SLAM), implemented via the RTAB-Map package in the drone's software stack.

Once the mission plan and viewpoints were uploaded, the drone executed the inspection flights autonomously. Manual interventions were limited to takeoff, landing, and issuing commands to proceed to the next viewpoint, all performed under operator supervision for safety. During the autonomous portion of the flight, the drone employed a local collision-avoidance planner to compute trajectories, navigate the environment, and capture the required images.

WHAT WAS THE OUTCOME?

After the drone executed the pre-programmed flight paths at the test bridges, a visual comparison was performed to confirm that the rendered and captured views were well aligned. The drone captured images closely matched the expected viewpoints, as previewed using rendered images from the virtual bridge models. This validated the proposed inspection workflow for real-world autonomous bridge inspections.

WHAT IS THE BENEFIT?

Autonomous drone-based inspection and damage assessment of bridges could result in more efficient and complete condition evaluation of bridges during regular and damage inspections. The increased amount and timeliness of the condition data could enable stakeholders to make more informed and timely decisions.

LEARN MORE

Video demonstrations of the prototype autonomous drone at the UC Berkeley Richmond Field Lab (Big Press bldg.) and at the two test bridges are as follows:

https://berkeley.app.box.com/s/f9ge0m9lq5c16j4ze-1j3vjkccft4ui4k (Big Press),
https://berkeley.box.com/s/7iwcqt2lyphjhprajvt3y-5b9lr755a7s (Bridge 1, 20 0019Y
https://berkeley.box.com/s/dbvb4618o3y5puoqhy-e89hrxna2jh52d (Bridge2, 33 0046Y).

Final Report link is forthcoming and will be found in link below once it is available: https://dot.ca.gov/programs/research-innovation-system-information/research-final-reports

IMAGES

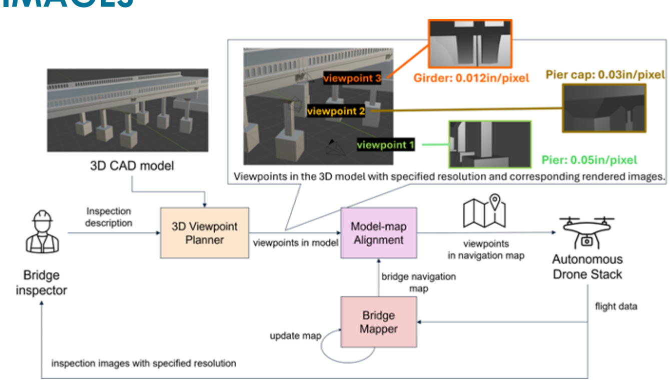

Image 1: Proposed inspection workflow