Research Summary

Detecting Subsurface Voids in Roadways using UAS with Infrared Thermal Imaging

Research Need

The opening of soil voids below pavement caused by the failure of culverts and drainage piping creates a safety hazard. More accurate and cost-effective new non-destructive approaches are sought to inspect roadways.

Goals/Objectives

The study focuses on the experimental validation of rapid aerial infrared thermography (AIR_T) and unmanned aerial systems (UASs) for detecting soil voids and assessing the conditions of culverts and drainage piping underneath public roadways. Specific goals include:

- Determine the accuracy of IR imaging for field inspections to detect soil voids as a function of depth and to detect underground structures;
- Characterize the smallest size and severity of defects that can be detected with IR thermography;
- Define operational problems associated with its field deployment and suggest operating procedures to optimize the use of IR imaging on UAS platforms;
- Outperform currently used techniques such as visual inspection and GPR.

Methodology

The methods for this project include:

- Extensive literature review of UAS-IR inspection to determine limitations in detecting subsurface voids in roadways;
- Advanced laboratory testing campaign using handheld IR cameras to characterize the AIR_T system's capabilities to detect defects in a controlled environment (e. g., function of camera distance and tilt, depth, moisture content, light intensity, and temperature difference);
- Field and outdoor tests are used to validate the novel AIR_T in a real-world environment by using a UAS embedding a high resolution IR camera.

Key Findings

- Developed a framework based on Sparse Principal Component Thermography (S-PCT) to improve IRT detection
- Characterization of optimal sampling rate of IR images
- Possibility to determine the size of sub-pavement voids with 97% accuracy

Use of Findings

- MassDOT is provided with a promising system to monitor in-service roadways to extend their operational life while reducing traffic congestion and risks for the inspectors.
- Damages not that have not reached the surface of the road can be identified using IRT.
- Flying the UAS with camera perpedicular to the road surface or at an angle (e.g., 55-degree) provides similar results.
- When adjacent IR images are collected with 90% overlap, it is possible to inspect large portions of a roadway and stitch IR together to obtain large-area hortomosaics
- Inspection should be performed when the roadway starts to emit thermal energy after being heated for an extended time by the sun. For this reason, dusk or night inspections should be preferred.
- The presence of water on the road's surface (e.g., after heavy rain) makes it challenging to detect subsurface voids.

Project Information

This project was completed as part of the Massachusetts Department of Transportation (MassDOT) Research Program with funding from Federal Highway Administration (FHWA) State Planning and Research (SPR) funds.

Principal Investigators:
Alessandro Sabato, Ph.D.
Performing Organization:
University of Massachusetts Lowell
Project Champion:
Dr. Jeffrey DeCarlo and Mr. Jason L. Benoit
Project Start Date:
11/15/2020
Project Completion Date:
02/15/2022
MassDOT Research Project Number:
112754
Key Words:
culvert, infraredthermography, sinkhole, UAS

Research and Technology Transfer Section
MassDOT Office of Transportation Planning
Planning.Research@dot.state.ma.us

massDOT
Massachusetts Department of Transportation