Executive Summary, Research Readiness Level Assessment, and Technology Transfer

To Automate Detecting, Quantifying and Mapping of Delamination of Bridge Decks using Aerial Thermographic NDE

Research Objectives

There were three primary objectives in this project:
1) further validated the proposed airborne thermographic approach in detecting, quantifying, and mapping delamination in bridge decks by substantially expanding the pool of candidate bridge decks in the project, including asphalt decks.
2) identified the best timing and weather conditions for thermographic surveying through numerical simulations.
3) evaluated the feasibility and performance of machine learning methods automated for detection, quantification, and mapping of concrete deck delamination .

Research Benefits

Despite its limitations the proposed approach had some notable benefits:
1. Safe, low cost and easy to deploy
2. Highly Efficient
3. Accurate and Precise
4. Versatile

Background

Timely detection of delamination/debonding issues of concrete bridge decks is essential to the safety of transportation and to make informed maintenance decisions. Many NDE methods (such as GPR, impact echo, chain dragging, half-cell, acoustic, and thermography) have been developed to identify these subsurface defects. Each of the developed methods has its pros and cons in terms of cost, safety, accuracy, reliability, and operability. Most of these methods need to have traffic closure when conducting the detections, which can be a substantial burden and raise safety concerns for bridge users and DOTs. Therefore, delamination/debonding detection cannot be performed as often as necessary in order to have the most updated deck data for optimal decision making.

Conclusion

The goal of this project was to develop a UAV-based Arial thermographic method to detect and map the delamination on concrete bridge decks. Several image processing methods such as level-set and machine-learning were developed in this project. The developed method is high-efficient and low-cost and requires no-traffic-closure during the surveying process. The coring outcomes from four different concrete bride decks validated the performance of this developed method. The coring results suggested that this method outperformed several existing methods in detecting delamination in concrete bridge decks in terms of efficiency, accuracy, cost, and safety.

Principal Investigator

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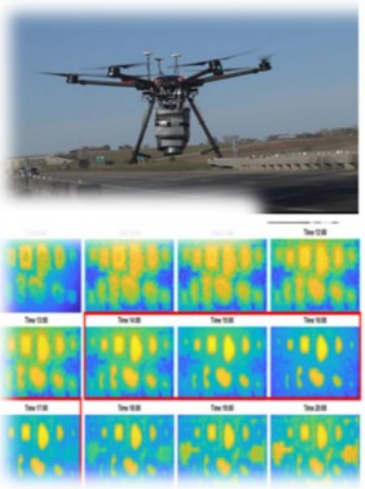
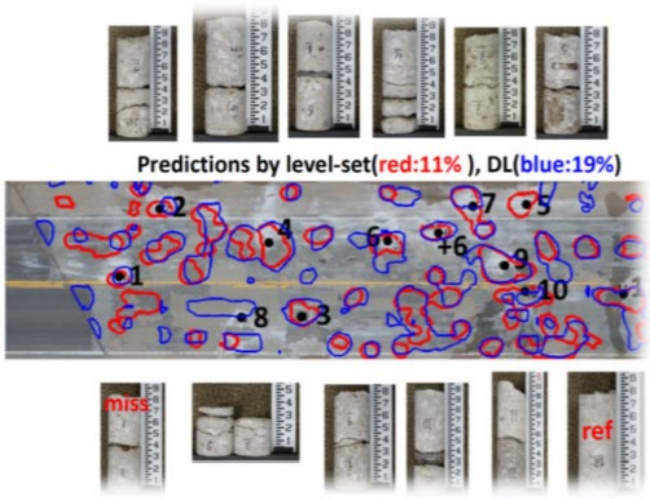
Jon Starr, Engineering Technology and UAS Program Leader





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Final report is available:
HERE

NDOT's Matrice 210 RTK Drone

NDOT Recommendations Based Off of Research Project

This research developed a UAV-based Arial thermographic method to detect and map the delamination on concrete bridge decks. The Department will start a validation of the UAV-based Arial thermographic method by the Department's Matrice 210 RTK Drone in coordination with Engineering Technologies within Business Technology Support Division (BTSD) Division and the Bridge Division forces to address the followings:

- To validate the proposed Aerial IRT approach in detecting, quantifying, and mapping delamination in bridge decks by using NDOT forces. The validation will answer some questions for the Department:
  - field survey planning, field survey operation, data acquisition, safety considerations, data flow, post-processing of image data, how long the process takes and accuracy of algorithms output compared to repaired sections.

- *As provided by Jon Starr and Fouad Jaber, Lead TAC Members*

Research Readiness Level (RRL) Assessment

Level 2: Applied Research/Proof Concept –
-Research/Technology developed by the study. Integration of components for the Department used proof of concept.

RRL 2

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Technology Transfer

Transportation Research Board (TRB) papers and Publications

- Cheng, C., Shang, Z., and Shen, Z. (2019). "Enhancing Bridge Deck Delamination Detection Based on Aerial Thermography through Grayscale Morphologic Reconstruction: A Case Study", TRB-2019 Annual Meeting, Jan. 13-17, Washington D.C. https://annualmeeting.mytrb.org/OnlineProgram/Details/11200

Journal Papers Submitted for Review and In Progress Journal Papers and Theses

- Cheng, Chongsheng, Shang, Zhexiong, Shen, Zhigang (2020) " Automatic delamination segmentation for bridge deck based on encoder-decoder deep learning through UAV-based thermography." ScienceDirect, NDT&E International, Volume 116. https://doi.org/10.1016/j.ndteint.2020.102341
- Cheng, Chongsheng, Shang, Zhexiong, Shen, Zhigang (2019) "Bridge deck delamination segmentation based on aerial thermography through regularized grayscale morphological reconstruction and gradient statistics" ScienceDirect, Infrared Physics & Technology, Volume 98. https://doi.org/10.1016/j.infrared.2019.03.018
- Cheng, Chongsheng, Shen, Zhigang (2020) "The application of gray-scale level-set method in segmentation of concrete deck delamination using infrared images" ScienceDirect, Construction and Building Materials, Volume 240. https://doi.org/10.1016/j.conbuildmat.2019.117974

This brief summarizes Project SPR-P1 (20) M109
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