Use of LiDAR and Thermal Images for Bridge Deck Inspection

Ammad Khan, Abir Hadi, Kwanghee Won, and Mostafa Tazarv

Departments of Civil and Environmental Engineering, and Electrical Engineering & Computer Science

South Dakota State University

SOUTH DAKOTA STATE UNIVERSITY

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- National Center for Transportation Infrastructure Durability and Life Extension (TriDurLE)
- Center for Transformative Infrastructure Preservation and Sustainability (CTIPS)

TriDurLE

National Center for Transportation Infrastructure Durability & Life-Extension

CTIPS

Center for Transformative Infrastructure Preservation and Sustainability

USDOT Region 8 University Transportation Center

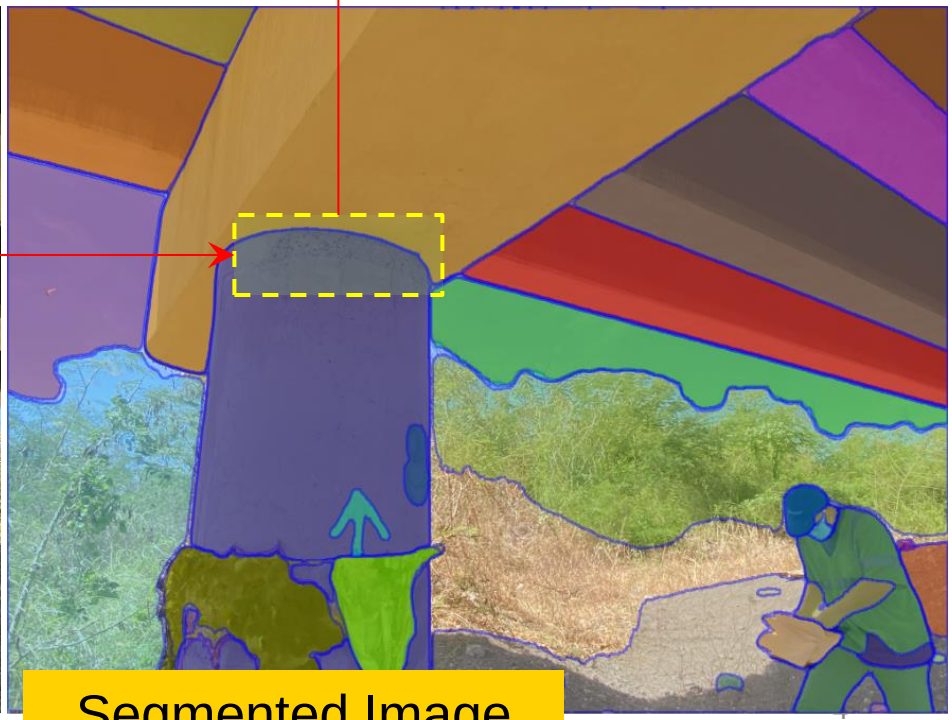
Project Goals and Objectives

The main goal of the study is to develop practical AI (**computer vision**) tools that help bridge inspectors with defect detection and quantification, and automate inspection reporting. The focus is on **bridge deck delamination**.

Computer Vision

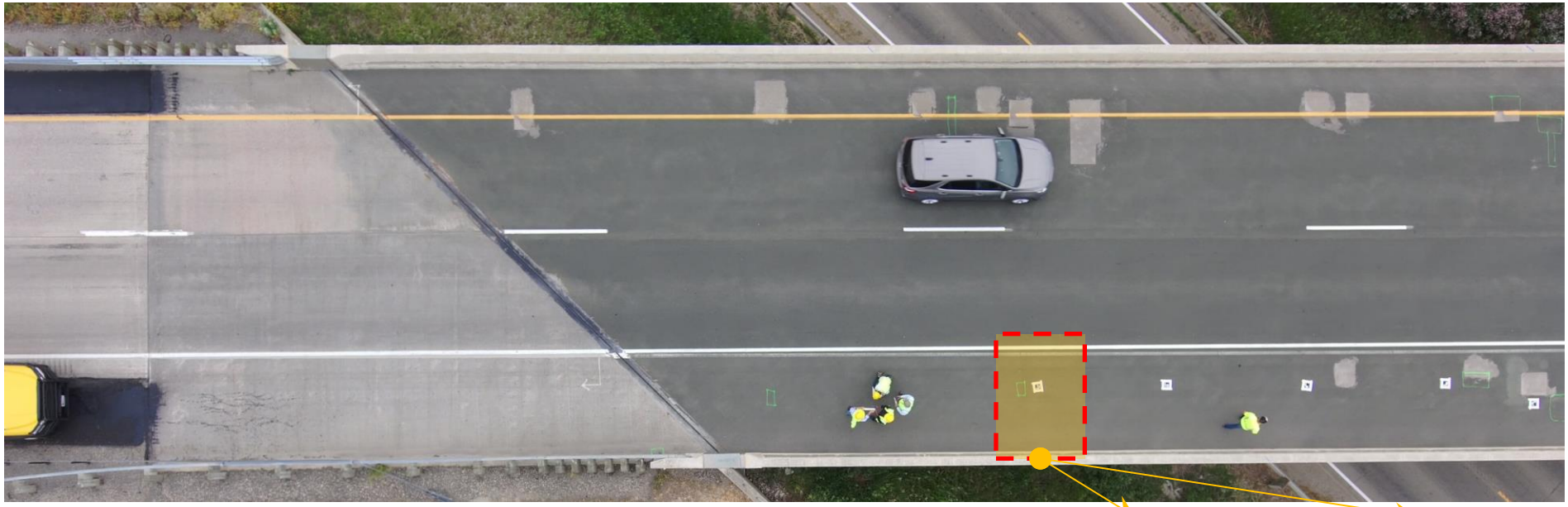
Computer vision (CV), a field of artificial intelligence (AI), enables computers to interpret and understand visual information from images and videos to make sense of their content.

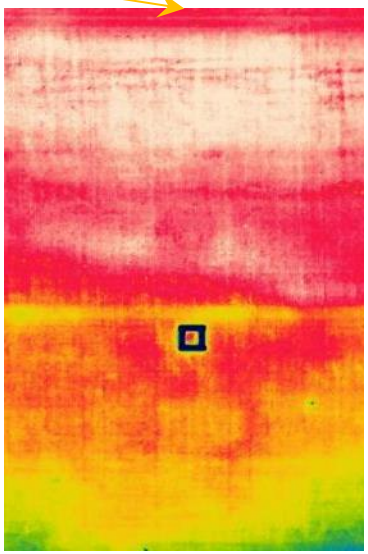
Original Image



Segmented Image

Bridge Inspection





Can we use new technologies to expedite bridge inspections?

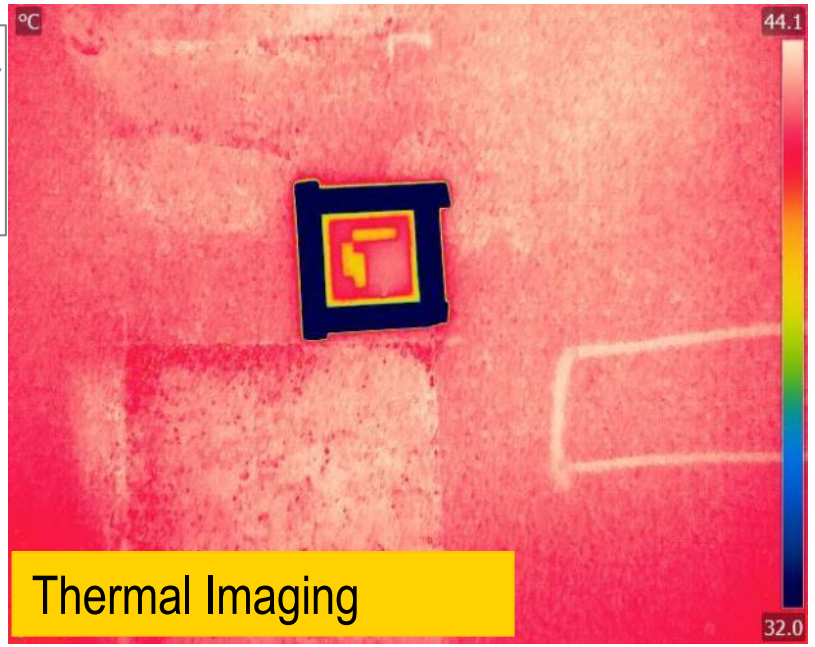
Proposed Solutions

for Delamination in Concrete Bridge Decks

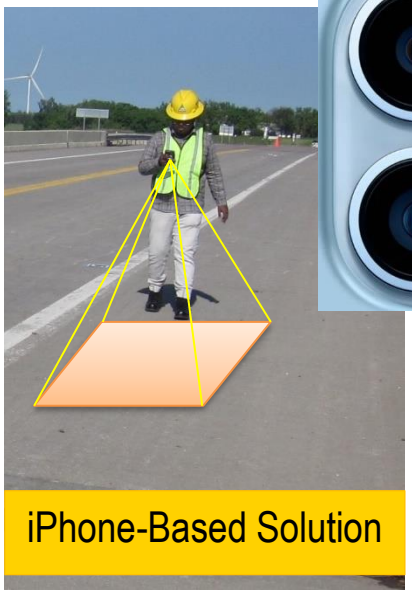
New Tools for Bridge Deck Inspection

Drone-Based Solution

DJI Mavic 3T



Thermal Imaging



iPhone-Based Solution

Lidar Camera

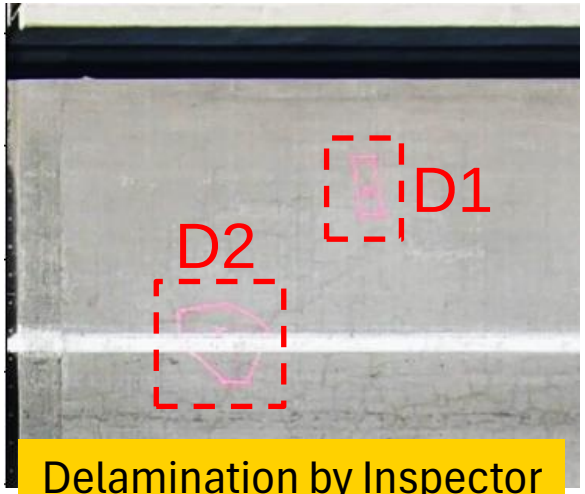
iPhone Lidar Imaging

AI-iPhone-Based Assessment

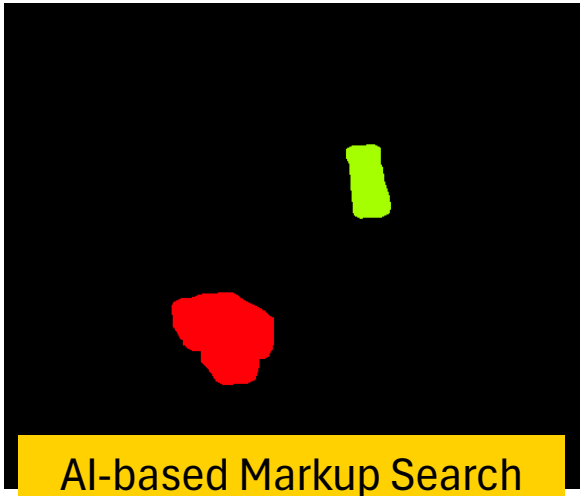
Delamination Annotation Detection

AI-iPhone Based Deck Inspection

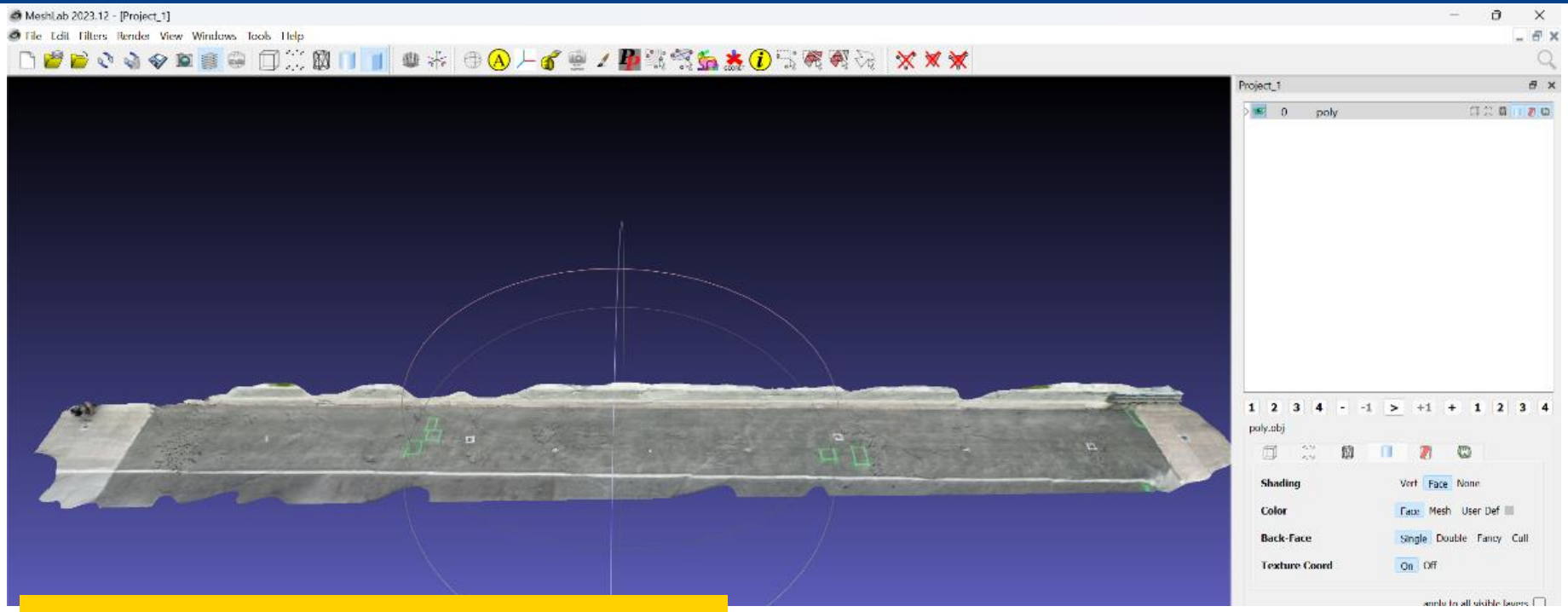
1. Allow inspectors to find delamination using conventional methods (e.g., chain drag) and paint the defected areas.
2. Use iPhone/iPad-LiDAR camera to scan the bridge deck.
3. Our program extracts a 2D map of the bridge deck and finds the inspector markups using AI.



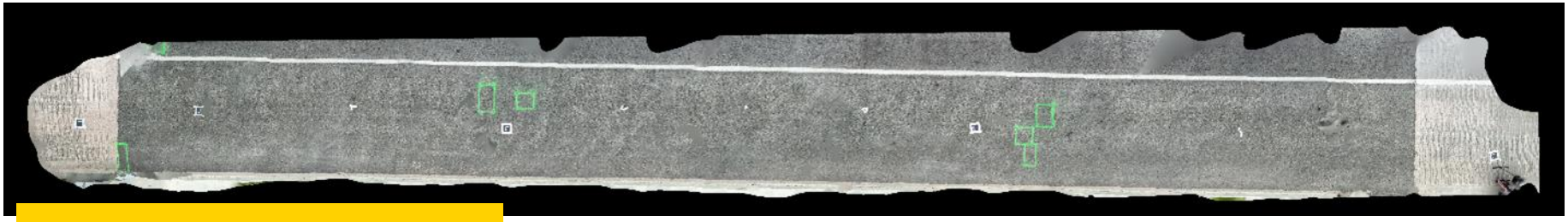
Delamination by Inspector


AI-based Markup Search with Condition State

3D Mesh to 2D Deck Map



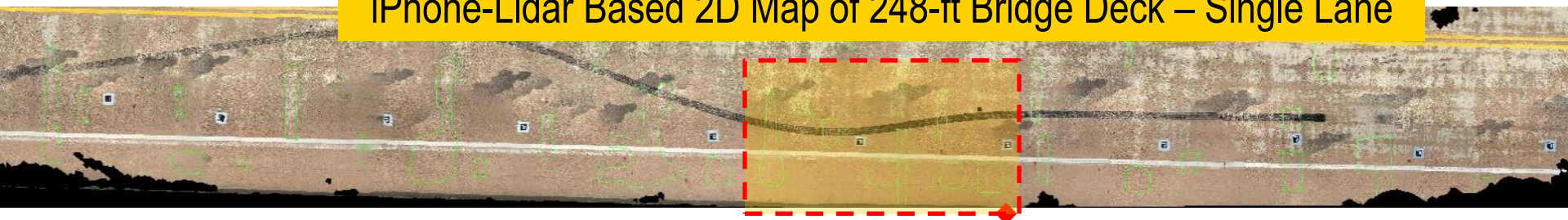
iPhone (PolyCam) Generated 3D Mesh



2D Map of Bridge Deck

AI Delamination Detection on 2D Deck Map

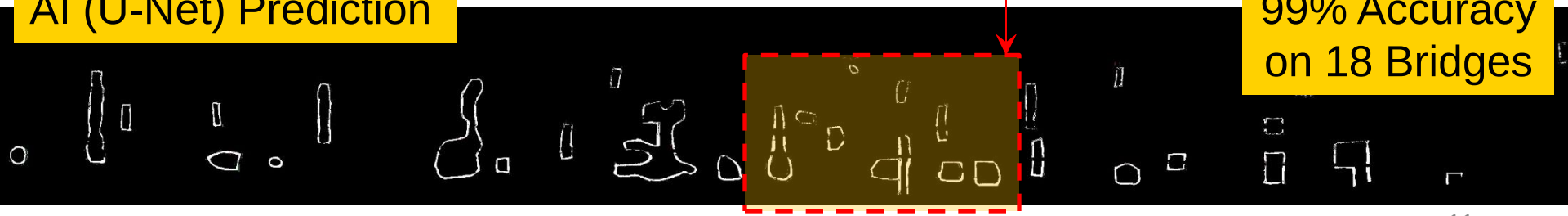
iPhone-Lidar Based 2D Map of 248-ft Bridge Deck – Single Lane



- Inspected 45 bridges
- 11,551 RGB photos

  (training 70,000)
- 40 lidar maps

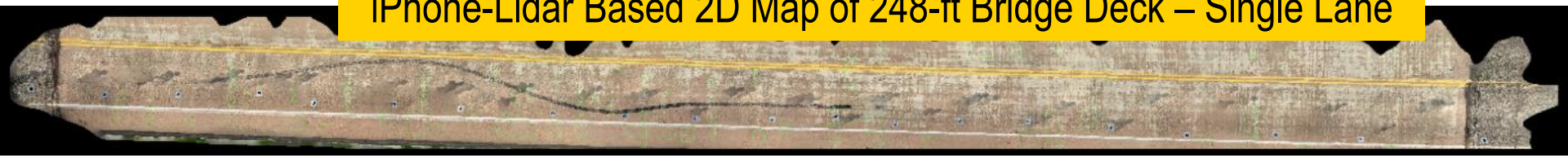
AI (U-Net) Prediction



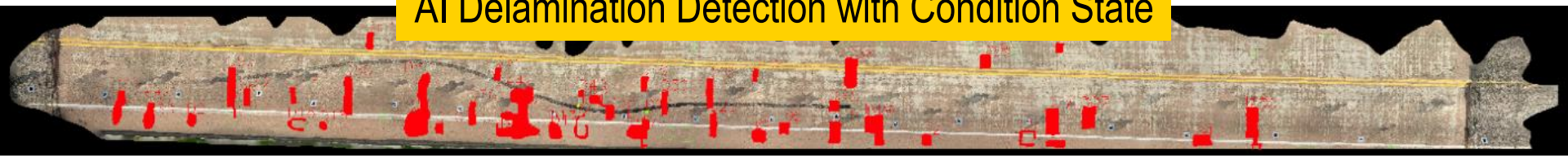
99% Accuracy on 18 Bridges

AI Delamination Detection with CS Estimation

iPhone-Lidar Based 2D Map of 248-ft Bridge Deck – Single Lane



AI Delamination Detection with Condition State



Proposed Condition States for Delamination in Concrete Decks

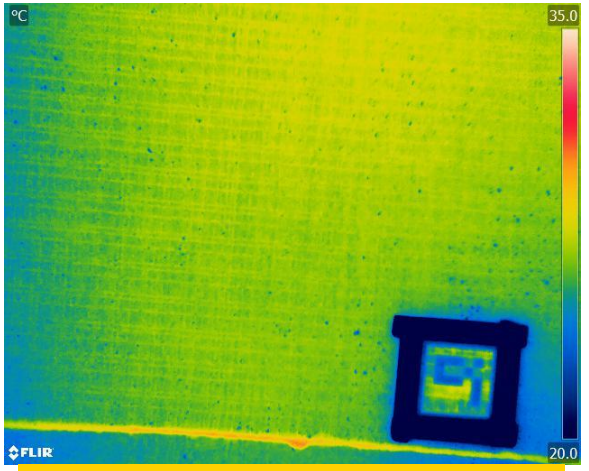
Defects	CS 1	CS 2	CS 3	CS 4
	Good	**Fair**	**Poor**	**Severe**
Delamination, Spall, or Patched Area (1080)	Defected area is less than or equal to 7 in^2 (45 cm^2)	Defected area is greater than 7 in^2 (45 cm^2) but less than 30 in^2 (195 cm^2)	Defected area is greater than 30 in^2 (195 cm^2) but less than 110 in^2 (710 cm^2)	Defected area is greater than 110 in^2 (710 cm^2)

AI-Drone-Based Assessment

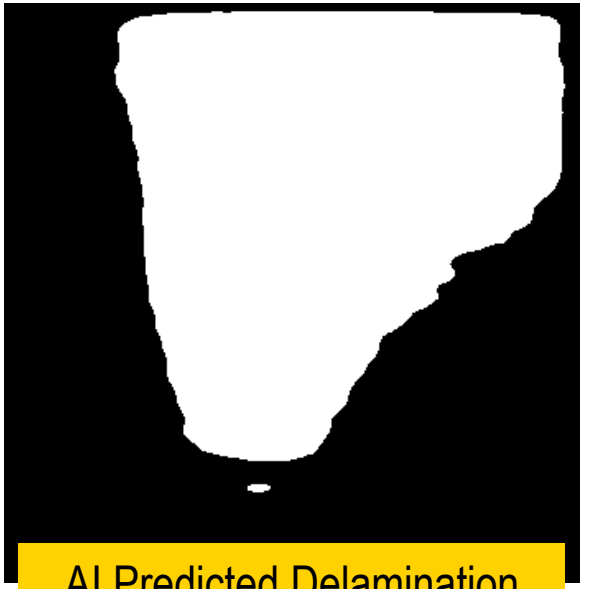
Fully Autonomous Delamination Detection

AI-Drone Based Bridge Deck Inspection

1. Fly drones that are equipped with RGB-thermal cameras. Scan the bridge deck.
2. Our AI software develops a 2D map of the bridge deck by stitching RGB images, overlays the thermal data on the top of RGB, and finds delamination automatically.



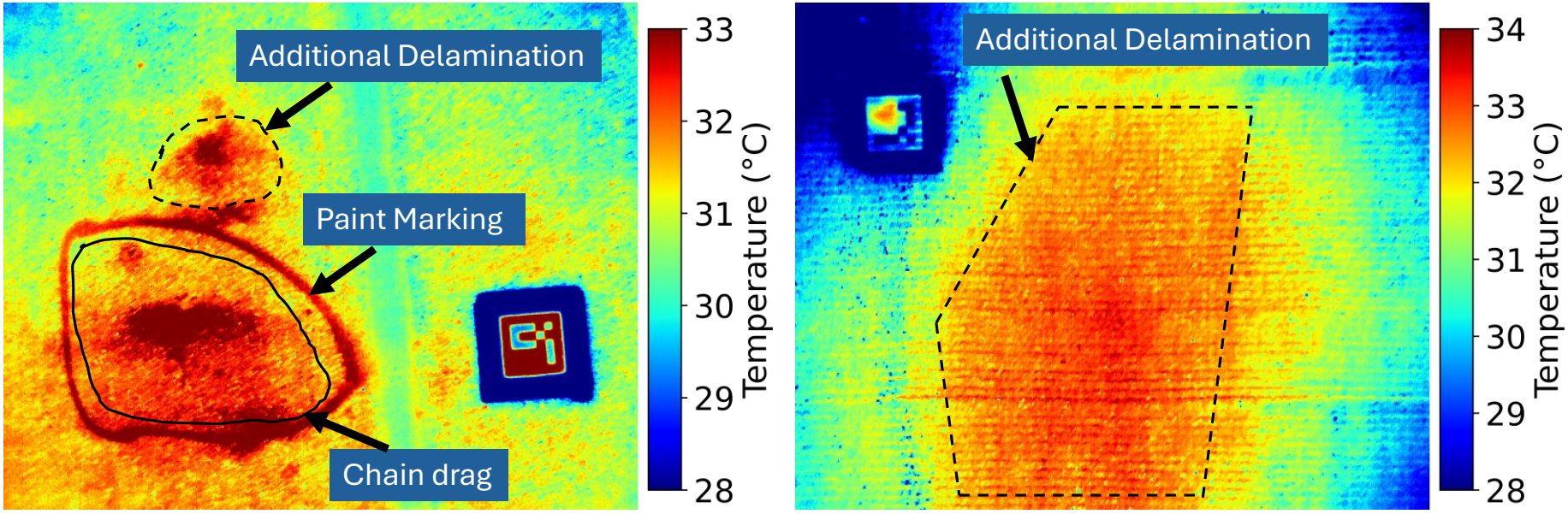
Thermal Image



AI Predicted Delamination

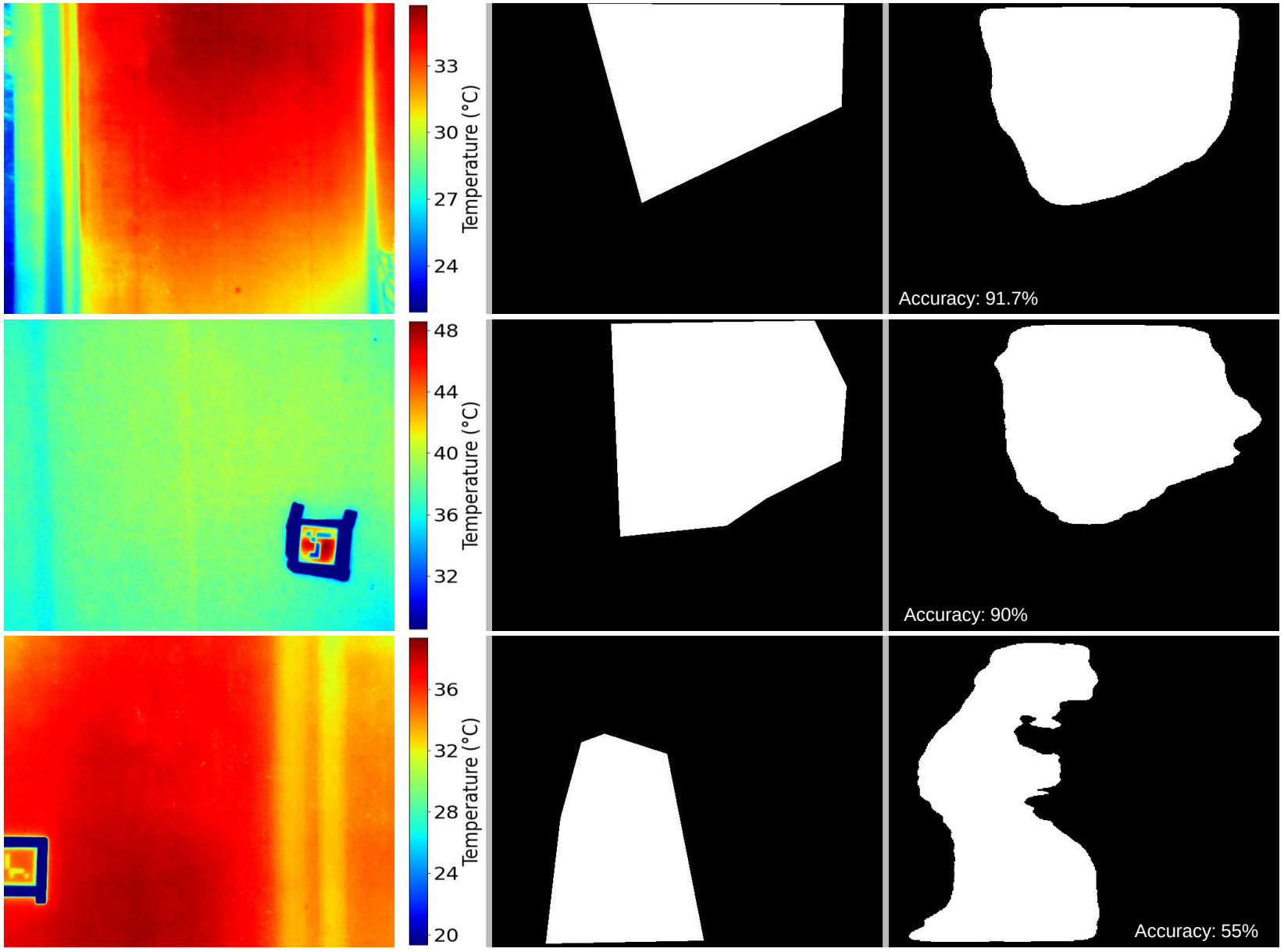
Thermal Data Training

- Inspected more than 45 bridges.
- Obtained more than 2,000 thermal images. Data was augmented to 5,000 for training, saved 400 images for evaluation. Used U-Net.



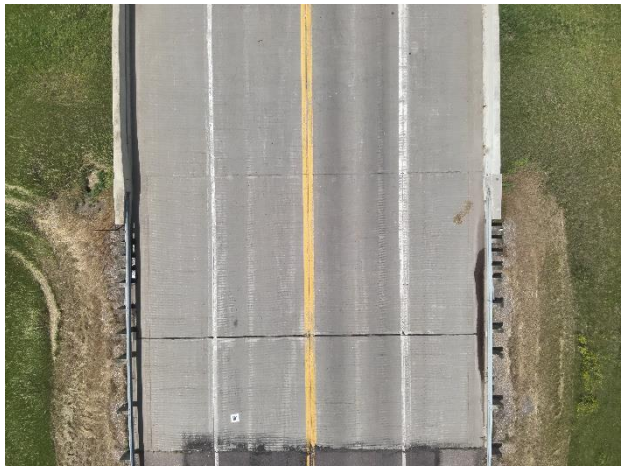
Sample of Thermal Data with Inspector-found Delamination and Additional that were missed

AI Predicted Delamination from Thermal Data

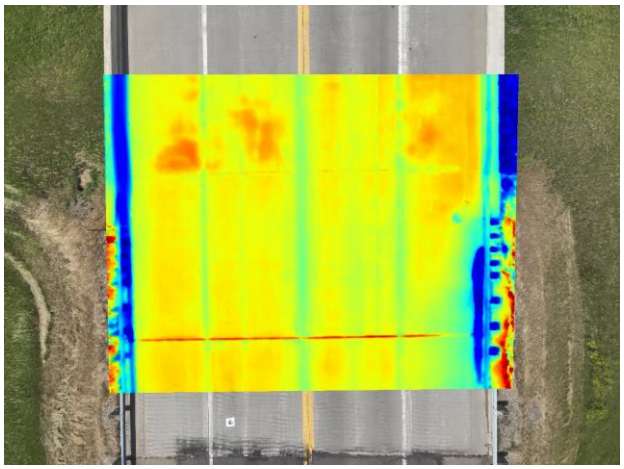


86% Accuracy over 400 images

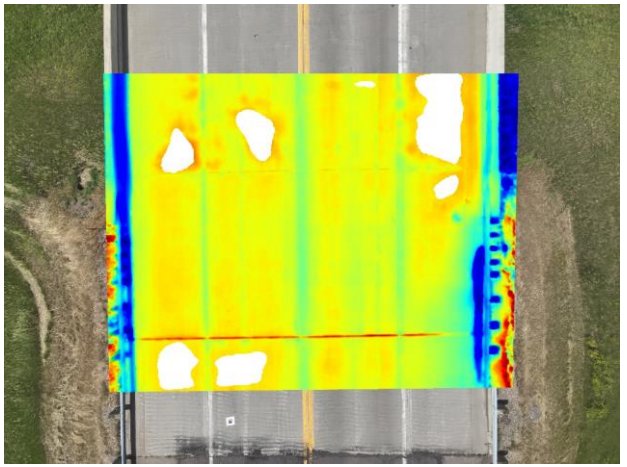
AI-Drone Based Bridge Deck Inspection



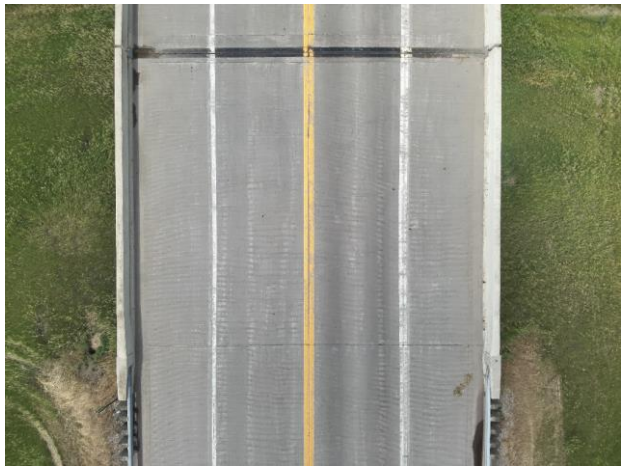
RGB Image

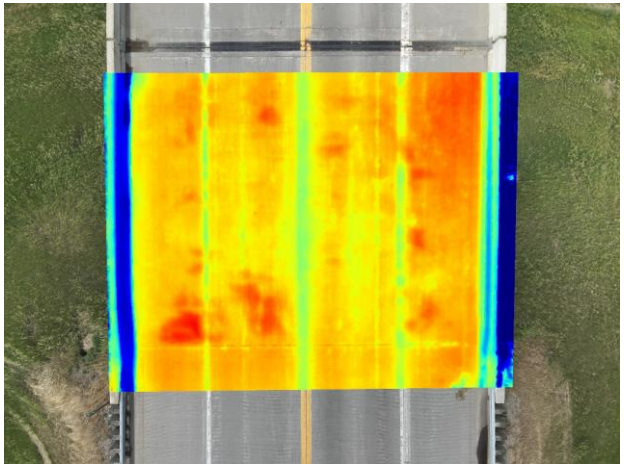


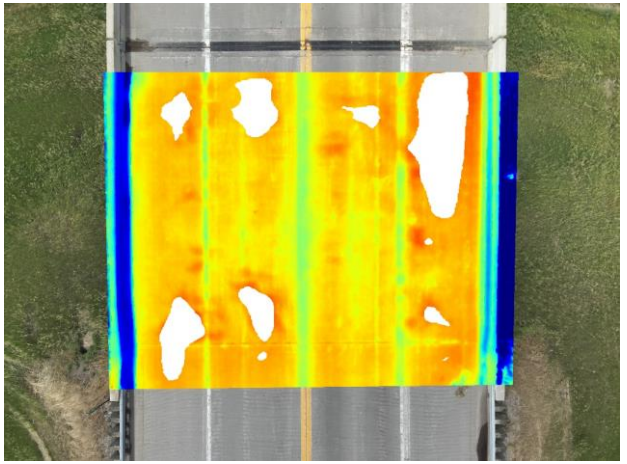
Thermal over RGB Image



AI Predicted Delamination







White Areas are delaminated concrete by AI

AI-Drone Based Inspection for Whole Deck

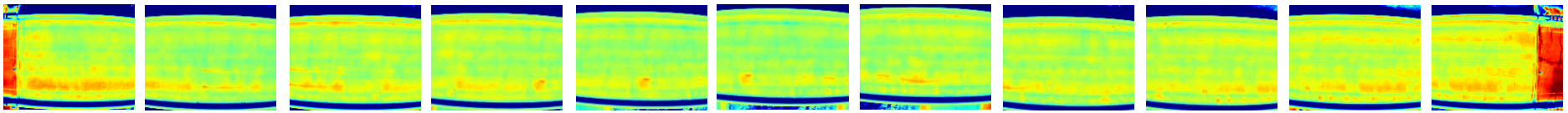
- Highway overpass
- Bridge Length = 293 ft
- Bridge Width = 44 ft.

RGB-to-Thermal Images Stitching

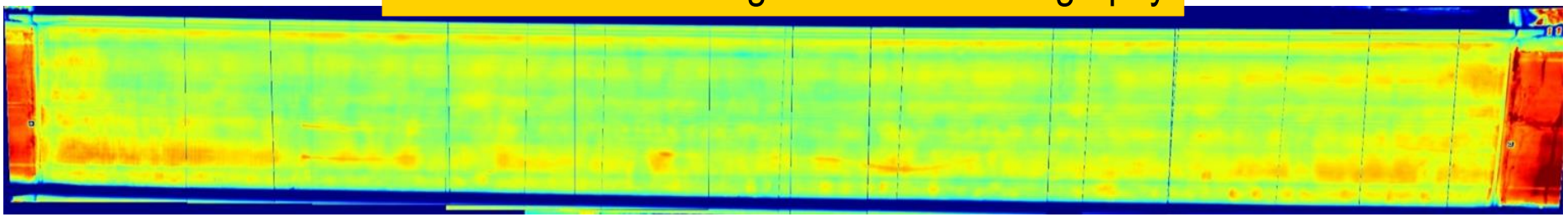
11 RGB Images at 50-ft Height

RGB Stitched Image (4208 x 809 pixels)

11 Thermal Images



Thermal Stitched Image based on Homography



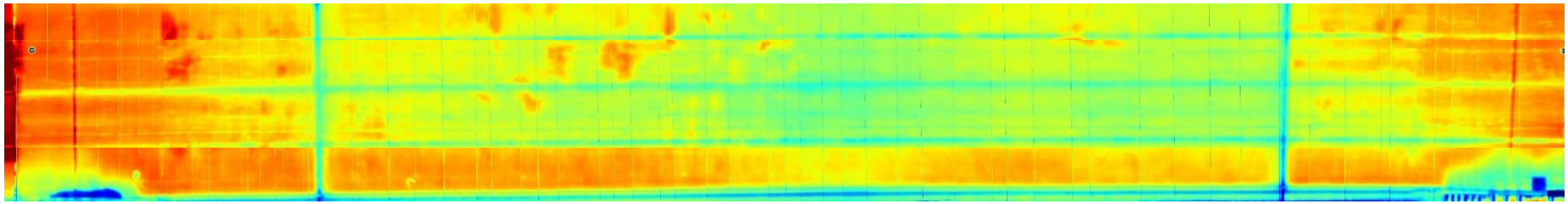
AI Predicted Delamination on Full Length

Vaulted Abutment

RGB Stitched Image

Vaulted Abutment

Thermal Stitched Image based on Homography



AI Predicted Delamination

Questions?

Mostafa Tazarv, PhD, PE,
Associate Professor
Department of Civil and Environmental Engineering
South Dakota State University
Tel: (605) 688-6526, Fax: (605) 688-6476
Mostafa.tazarv@sdstate.edu
https://sites.google.com/view/mostafa-tazarv