Novel Damage Index-Based Rapid Evaluation of Civil Infrastructure Subsurface Defects Using Thermography Analytics

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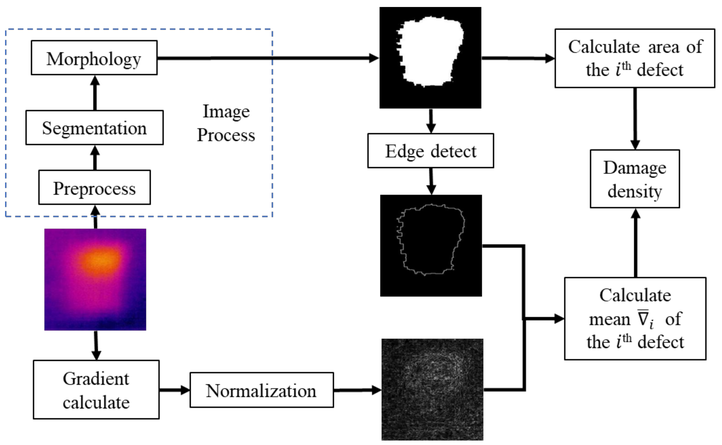
Introduction

Infrared Thermography (IRT) is an effective non-destructive testing method in the field of concrete pavement inspection. The method can be widely used for civil infrastructures, particularly bridge decks inspection.

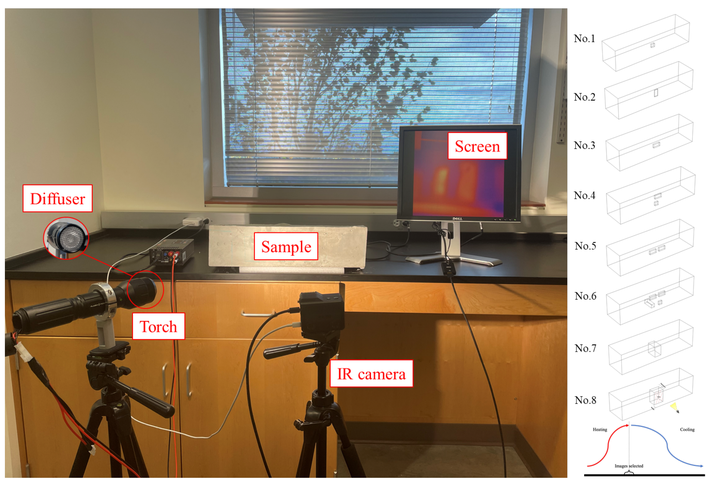
Most of researches are focused on the detectability of IRT rather than on the quantitative analysis of the damage condition in the detected civil infrastructures. Thus, we aimed to propose a novel damage index, **damage density**, which would depict the significance and distribution of subsurface defects in concrete both quantitatively and precisely through automatically thermography analysis.

Methodology

❖ **Damage density calculation framework**



❖ **Lab test set up and get the raw image**

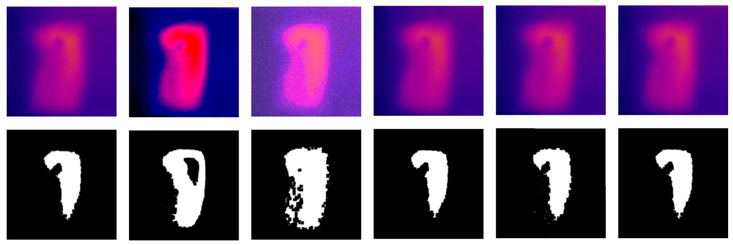


❖ **STEPS:**

- 8 specimens were modeled in lab with different shape of Styrofoam (substitute of air).
- An activate thermography was applied to capture the temperature change on the samples' surface.
- The subsurface delamination was segmented by comparing and applying different infrared thermal **image processing** methods.
- Based on the segmented image, the damage index was calculated through **edge detection** and **thermal image gradient map construction**.
- The relationship between the damage index and volume of defects was evaluated based on lab tests. This relationship can show the correlation between the damage index and damage condition of the infrastructure because the volume of defects is generally related to the damage intensity in the detected concrete sample.

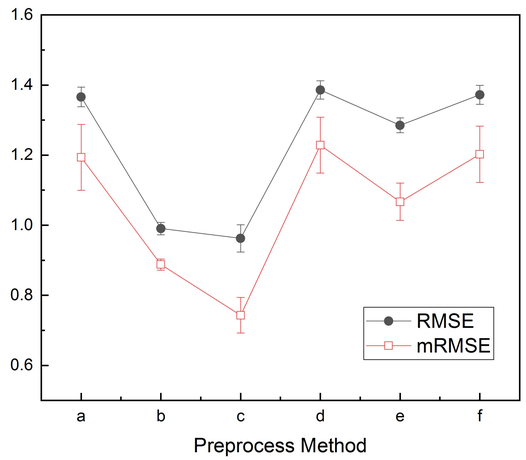
Results

❖ **Image process**



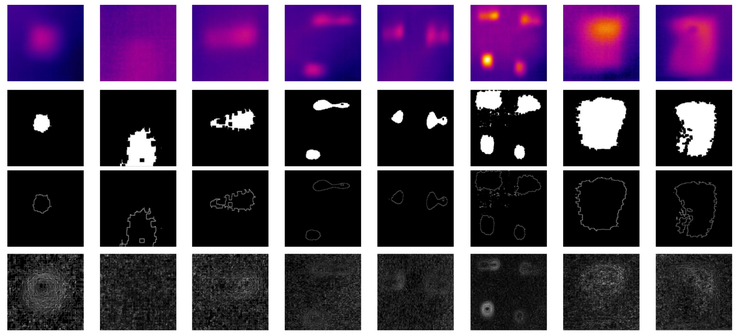
(a) (b) (c) (d) (e) (f)

The results of preprocessing and binarized images: (a) Raw image; (b) Contrast adjustment**; (c) Histogram equalization;** (d) Mean filter; (e) Log filter; (f) Gaussian filter.

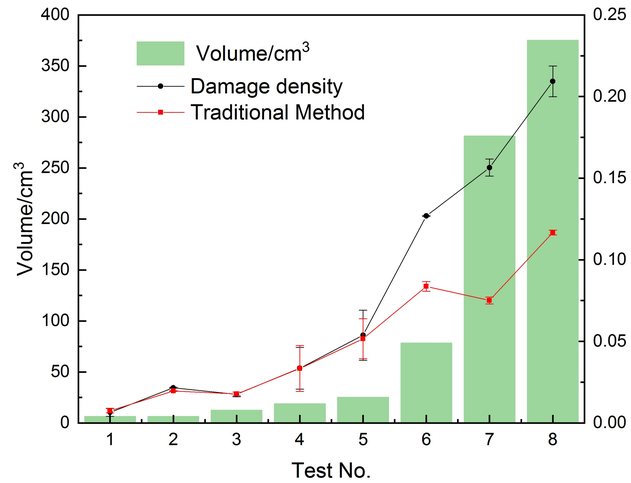


The mRMSE and RMSE of Histogram equalization is the lowest among all the image processing methods. It will be chosen as our main method.

❖ **Damage density**



Each column represents a single test to calculate the damage density index.



The relationship between damage density and volume of subsurface voids as the volume represents the damage condition and intensity of an infrastructure.

Conclusion and Future Study

❖ **Conclusion**

- A damage index-based method for quick evaluation using thermography analytics was proposed to improve the utility and interpretability of the IRT, leading to automated analysis and quantitative evaluation.
- Five image preprocessing methods were compared to optimize the performance of the whole framework. Histogram equalization was selected as the best preprocessing method in IRT procedure.
- Damage density has a positive linear relationship with total volumes of the subsurface voids in the detecting area compared to traditional image segmentation methods.

❖ **Future work**

- A drone is being designing to hold the IR camera and torches so that the engineers could do detection work safely and quickly.