Hyperspectral Imaging Analysis of Steel Corrosion

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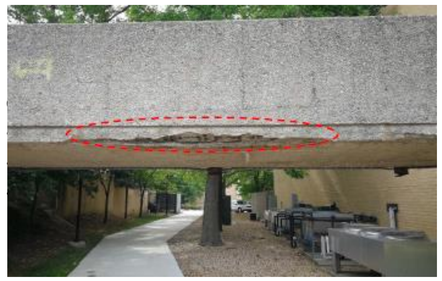
INTRODUCTION

Steel reinforcement corrosion is one the most common causes of bridge deterioration. There is significant increase of number of deteriorating and aging bridges. For example, in USA, according to the 2017 ASCE, there is approximately 54% of 614387 bridges aged more than 40 years old. The conventional visual inspection is usually conducted on bridges each two years period. However, this method can only provide qualitative results which are highly influenced by inspectors' errors and inconsistency. Hyperspectral imaging (HSI) technique mounted on unmanned aerial vehicle can provide more reliable and quantitative results with more remote and safe operations. HSI can be used to characterize the physical and chemical features in bridges such as concrete cracking and steel corrosion respectively.



Bridge deterioration

METHODS

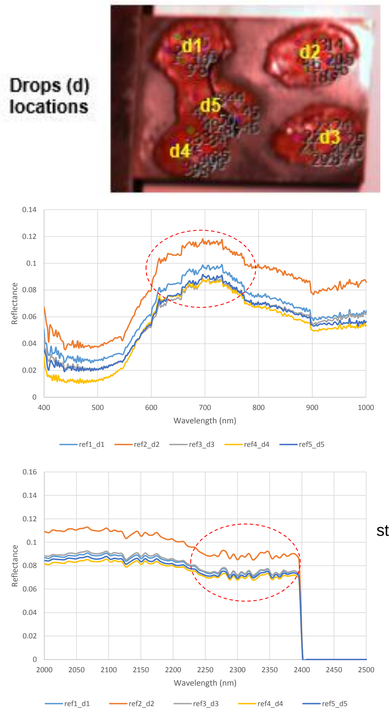
Hyperspectral imaging technique is based on reflection of light from an object surface such as concrete or steel placed at a given distance from camera. HSI camera moves perpendicular to the scanned object and each pixel in the image is represented by spectrum of wavelength range depending of the type of camera used (In INSPIRE Center: 400-2500nm was used). The spectral analysis is used to evaluate the physical and chemical properties of the scanned members (e.g. concrete or steel) from distinctive signatures on the spectrum. Machine learning can be used to extract interesting signatures or features and classify the structural conditions from a reference imagery.

In this study, a co-aligned dual VNIR-SWIR HSI camera was used to scan square steel samples of 2.5 inch long X 2.5 inch wide X 0.5 inch thick and 3.0 inch long X 3.0 inch wide X 0.5 inch thick placed at distance of 3.0 feet from the setup camera. The camera has resolution of 1~2 pixel from VNIR (400-1000 nm) and 1~3 from SWIR (900-2500 nm).

PRELIMINARY RESULTS

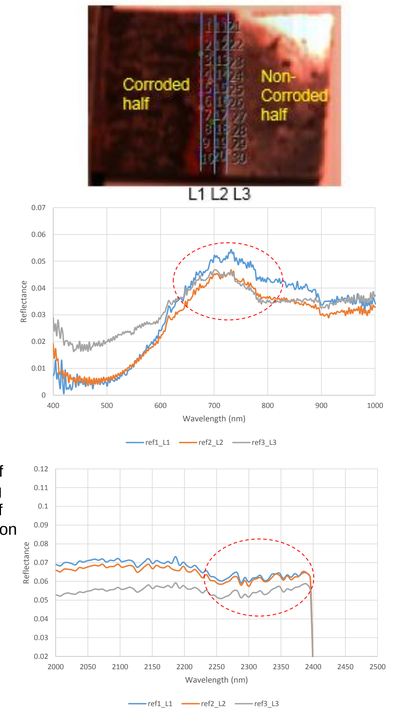
Steel samples were corroded using two mechanisms of half immersion of some samples and applied droplets on other samples' surfaces. NaCl solution concentrations of 18 g of NaCl in 500 ml of tap water and 36 g of NaCl in 500 ml of tap water were used during corrosion process.

Samples preparation



Average reflectance of pitting corrosion locations on a steel sample surface after 71 days (1704hr) of applied drops of 36g of NaCl solution

Regions of interesting features of steel corrosion



Average reflectance of transitional zone between the corroded and non-corroded half of a steel sample after 71 days (1704hr) of immersion in 18g of NaCl solution

CONCLUSIONS

- HSI can be used to obtain reflectance spectrum containing distinctive features or signatures to characterize and evaluate the physical and chemical properties of steel such as steel fatigue and corrosion.
- The classification models can be developed to predict and evaluate conditions for structural health monitoring of steel bridges

FUTURE PLAN

- HSI classification models for steel corrosion products evaluation will be developed based on training dataset and verified by validation dataset.
- Correlation between the distinctive features on reflectance spectra to the steel mass loss due to corrosion and 3D laser scanning images (using NextEngine 3D scanner) of corroded samples will be further studied.

REFERENCE

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