Detecting and characterizing corrosion on high voltage metallic towers using hyperspectral imaging

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Today, inspection and cleaning of high voltage towers is done by climbing the towers, which is time consuming, costly, and subjective. The aim of this study is to characterize different degrees of corrosion and subsequently the degree of material loss before the corrosion is scraped off using a completely non-destructive approach: hyperspectral imaging. This study summarizes the results of several analysis of metallic test samples with different corrosion degrees. The samples were collected from two metallic high voltage towers with 2 different coatings (green and silver coating) and were preliminarily labeled by Elia (Electricity provider in Belgium) into 3 main categories of big, medium, and small material loss in predefined frames. The more severe the corrosion is, the thinner the remaining metal plate and subsequently the bigger the material loss will be after scraping and cleaning the corrosion.
The scanning took place at VisionLab (UAntwerp, Belgium) with two different hyperspectral IMEC SnapScan cameras in the Visible-Near Infrared (VNIR, 470nm-900nm) and Shortwave Infrared (SWIR, 1,100nm-1,700nm). In a first step, the HSI data was analyzed to make a distinction between the different materials in the images (corrosion, coating, background) using a Support Vector Machine (SVM) classifier. In the second step, different degrees of corrosion were characterized on the samples at predefined frames. For this, we applied linear spectral unmixing using 3 different spectra (endmembers) for severe, moderate, and superficial corrosion respectively, from one of the samples with ground truth information (training data). Then, the unmixing model was applied to the rest of the samples and the severity of corrosion was evaluated on predefined frames. For samples without corrosion on the surface, we evaluated how healthy the coating is by using a spectral variability factor based on morphological changes on the coating surface. We defined a threshold of 5% of spectral variability for a healthy coating.
In total, 13 out of 15 green coated samples and 8 out of 9 silver coated samples were classified correctly (accuracy of 83.3% for 24 samples), when compared against the ground truth labels assigned by an expert of Elia, based on the manual assessment of the samples after the cleaning. The results showed that HSI VNIR data is more reliable for detecting corrosion, while the SWIR data is more sensitive to mineral changes and provided better characterization of the 3 different degrees of corrosions (Fig.1). As HSI is a surface-based technique, it cannot detect the corrosion behind the coating. The classification accuracy increased to 90.4% if only the 21 samples with corrosion damage on the surface were considered.
Even though HSI is limited to surface inspection, an accuracy above 90% was achieved without any destructive testing. Given the promising results of this feasibility study conducted in the laboratory, in future we will investigate the potential of HSI in field conditions for corrosion inspecting on high voltage towers in a fast, safe, less expensive and subjective manner, by employing hyperspectral cameras on drones and utilizing advanced Artificial Intelligence techniques.

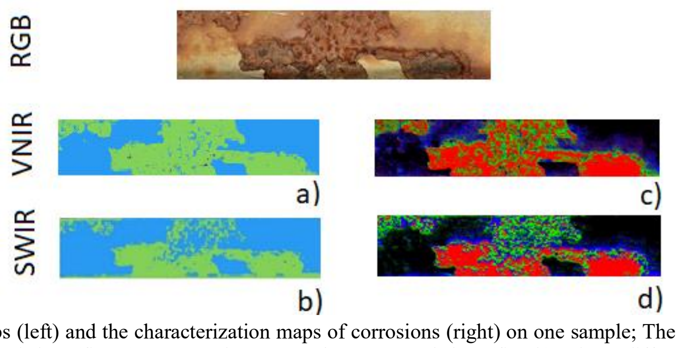

Figure 1. The classification maps (left) and the characterization maps of corrosions (right) on one sample; The corrosion (in green) is better detected with VNIR hyperspectral data (fig1.a) compared to SWIR hyperspectral data (fig1.b). The 3 different corrosions (severe in red, moderate in green, and superficial in dark blue) were better segmented using SWIR hyperspectral data (fig1.d) compared to VNIR hyperspectral data (fig1.c).