Hyperspectral-based UAV imaging platform

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Abstract: Unmanned Aerial Vehicles (UAVs) are often employed as measuring/monitoring device: e.g., in precision agriculture (the need for observing the inter- and intra-variability in crops) or in infrastructure inspection (the need for detecting defects or faults that were not built as planned). In the EU ECSEL COMP4DRONES project (October 2019 - September 2022) we aim at inspecting of critical infrastructure such as (offshore) wind turbines and bridges with a specific emphasis on detecting corrosion. We focus on two main innovations: 1) the integration of hyperspectral sensing on a drone platform and 2) an improved software workflow to handle hyperspectral imagery captured in the field including improved data analytics in order to detect material degradation.

In terms of flying, specific challenges have to be addressed to have a safe flight, with the avoidance of environmental effects. Therefore, we have integrated and tested a first prototype of the hyperspectral payload on the Airobot Mapper drone (see Figure 1), which is a robust all-weather UAV platform including safety measures supporting BVLOS autonomous flights.

Figure 1: Prototype hyperspectral payload on Airobot Mapper.

The second iteration of the hyperspectral payload consists of a two hyperspectral sensors in the spectral range 480-860nm, a Jetson TX2 to enable onboard computation and 1TB of storage to collect spectral data during flight. In addition to the Airobot Mapper drone, we have done initial integration (both hardware and software) of this payload with a DJI M600 Pro drone as well. This integration was done to show the modular and flexible aspect of our payload and data acquisition software blocks: 1) firmware/acquisition software running on the payload/Jetson system (e.g., synchronization with GPS data and image pre-processing) and 2) ground controller software running on a tablet which is connected to a drone controller (e.g. controlling camera parameters and providing live preview).

The second innovation involves the hyperspectral imaging (HSI) processing pipeline for data-analytics, which consists of three main modules: pre-processing, (on-board) analysis and post-processing. Pre-processing includes demosaicking and several corrections such as radiometric, non-uniformity, reflectance, spectral (varying lighting conditions), etc. On-board analysis includes neural networks that exploit both spectral and spatial futures to identify the regions where corrosion appears. Figure 2 shows initial analysis results: the corroded parts (in yellow) can easily be distinguished from the non-corroded areas (in purple). We achieved a pixel-based accuracy of more than 80% using an intersection over union (IoU), a.k.a. the Jaccard index. The experiments also demonstrated that our algorithm detects corrosion from far distances (up to 10m) thus suitable for safe drone-based inspections. The off-board post-processing module will overlay the detected corrosion defects on the 3D model of the infrastructure, acquired via photogrammetry.

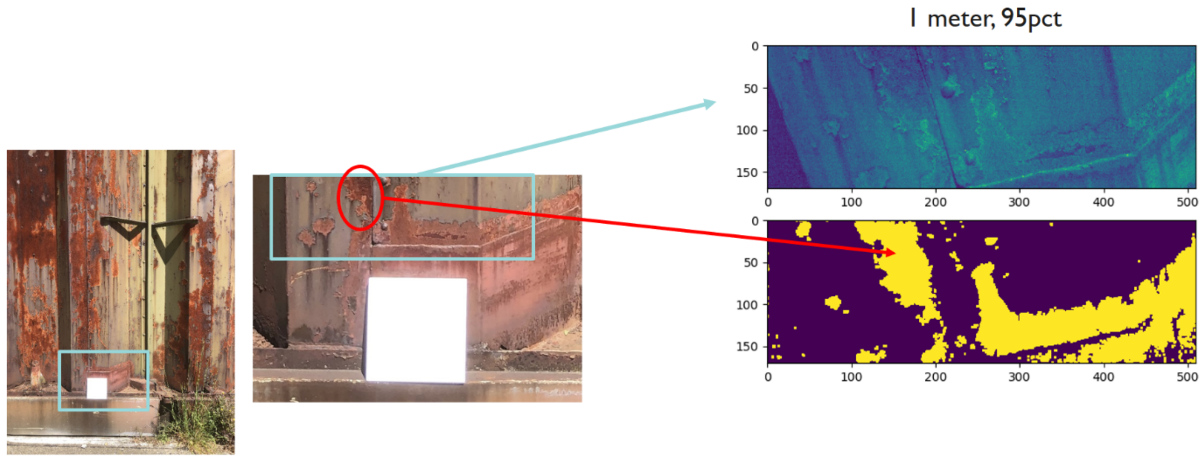

Figure 2: Our corrosion detection algorithm at 1 meter distance: purple denotes background, yellow denotes corrosion.

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