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BRINGING BARE SOIL DETECTION ON-BOARD INTUITION-1 THROUGH EXPLOITING DATA-LEVEL DIGITAL TWINS

Abstract

The nature of activity in the agricultural sector has changed over the years due to the growth of the population and the increase in its demand for food, fiber and fuel. The limited availability of agricultural land requires targeted management of resource production and leads to the increasing adoption of precision agriculture approaches. This requires the assessment of soil quality, its hydration, fertilizer content, and the impact of seasonality of ecosystems, which translate into crop yields. Satellite imaging brings enormous scalability in this context, if a satellite captured multi- or hyperspectral imagery (MSI and HSI) that allows us to perform non-invasive in-orbit soil analysis. This helps also reduce the amount of data to transfer back to Earth – instead of sending large-size HSI, we can transmit the extracted soil parameters only. Precise detection of the agricultural area corresponding to the soil in such imagery is important due to the possibility of reducing the amount of data for further processing, to extract various soil parameters, such as potassium, phosphorus pentoxide, magnesium or pH. The detection of the bare soil areas in the MSI and HSI data can be based on the investigation of various vegetation indices (which can later be used to estimate soil parameters or crop yields as well). The use of a multitude of available bands enables soil detection using sensors with different spectral ranges. However, such bands may not be available in real sensors that will fly on-board a satellite. In this paper, we present our approach toward building an algorithm for bare soil detection from HSI which will be captured on-board Intuition-1 – a satellite mission designed to observe the Earth using a hyperspectral instrument and an on-board computing unit capable of processing data using artificial intelligence. We will discuss our approach toward simulating on-board acquisition conditions that we expect to meet once the satellite is in orbit – we exploit data-level digital twins to transform airborne HSI into such imagery (here, we can simulate e.g., different atmospheric conditions). Finally, we will present our quantitative and qualitative approach

(the latter including various visualizations of airborne and simulated imagery, alongside the extracted maps of spectral indices) toward assessing the capabilities of the bare soil detection algorithms in the case of very limited ground truth data. It is of note that the algorithms must be resource-frugal, and should be possible to run in a hardware-constrained execution environment.