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Author: Dr. Jakub Nalepa
KP Labs, Poland

Mr. Piotr Kuligowski
KP Labs, Poland
Mr. Michal Gumiela
KP Labs, Poland
Mr. Marcin Drobik
KP Labs, Poland
Mr. Maciej Nowak
KP Labs, Poland

LEOPARD: A NEW CHAPTER IN ON-BOARD DEEP LEARNING-POWERED ANALYSIS OF HYPERSPECTRAL IMAGERY

Abstract

Hyperspectral imaging has become a mature technology which brings exciting possibilities in various Earth observation applications in a plethora of fields, including precision agriculture, forestry, event detection and tracking, and more. However, high dimensionality is an important obstacle in its effective transfer from a satellite back to Earth for further processing. To tackle it and enable faster adoption of the hyperspectral technology in practice, the on-board data processing has become critical, as it allows to substantially reduce the data dimensionality before transferring it, and to extract value from raw data. In this talk, we present Leopard – a CubeSat standard compliant Data Processing Unit which enables mission designers to apply Artificial Intelligence solutions in space. It was designed to support capturing, managing and processing of hyperspectral image data in orbit. Leopard redefines the current approach to remote sensing – instead of sending huge, unprocessed sets of data to ground stations, Leopard can exploit Deep Neural Networks to process data on board, and therefore only sends the most important insights to the ground. By reducing the time and cost of data transfer and processing, it enables the practitioners to focus on a rapid response to any detected phenomena. Leopard is integrated with a powerful FPGA to accelerate execution of deep learning algorithms and has a throughput of up to 3 Tera Operations Per Second. Importantly, several hardware and software measures protect the computer against the influence of radiation. With its small size (1U form factor), wide voltage range and universal interfaces, it is compatible with most CubeSats platforms. Its scalable and customizable architecture makes it possible to create larger and more powerful versions dedicated to bigger platforms as well. Leopard will be utilized by the Intuition-1 satellite, coupled with a 150-band hyperspectral sensor to perform on-board image analysis. Although hyperspectral images capture a large number of contiguous spectral bands at each pixel which effectively characterize the underlying materials, their utilization in the emerging applications remains challenging, especially in the context of supervised learning – acquiring high-quality and representative ground-truth information is extremely costly, time-consuming, user-dependent and hardly reproducible. In this talk, we present the current approaches toward dealing with the issue of lacking ground-truth datasets and show how data augmentation and transfer learning can help build well-generalizing deep learning-powered techniques. Finally, we show how unsupervised learning, which does not require ground truth at all, can be used in real-life remote-sensing scenarios.