Contribution ID: **48** Type: **Oral Presentation**

Performance estimation of deep learning methods for change detection on satellite images with a low-power GPU

Tuesday, 23 March 2021 15:30 (30 minutes)

In the last few years, Earth observation has known a significant growth due to both the increased number of satellite launched into orbit and the augmented data production capabilities provided by new sensors on board. However, processing this huge amount of data is becoming a crucial problem that require innovative solutions both on board, where the amount of mass memory storage is very limited, and on the ground stations, where data are often transmitted after long time due to the bottleneck effect resulting from the limited bandwidth.

In order to provide an optimization of the big data processing, two concurrent possible solutions are being investigated: transmitting to the ground station only a few selected data (containing interesting information) and exploiting heterogeneous computing on board the satellites, to speed up computational expensive operations of data analysis.

Change detection is an interesting task in the field of remote sensing, with many useful applications, from land cover studies to anomalies' observation (landslips, snowslides, wide firewoods, floods, oilspills into the sea, etc.). Many satellites like Sentinel-2 provide a full coverage of our planet every few days, but transmitting multispectral images of the same area multiple times within a small time interval might not be efficient for certain tasks. At the same time, the analysis of each image on ground requires a considerable amount of time and efforts that might be reduced if knowing in advance that some data do not provide additional information with respect to those acquired few days before. Therefore, the idea of comparing on board a new image with the older one corresponding to the same area on Earth can be a very powerful tool to both reduce the bottleneck effect and organize the analysis on the ground stations more efficiently by adding redundant data on a low-priority queue.

In this study, a deep learning approach is used to accomplish the change detection task on Sentinel-2 multispectral images. A pre-existing dataset focused on urban changes is exploited for training and validation purposes, with ground truths available in the form of binary change maps that provide pixel-wise target labels. Two different neural networks are tested. The first features an encoder-decoder structure to perform a segmentation of the two images of each pair and provide the exact location of each change happened in the processed area; for speed and computational load reasons, it was designed for the execution on the ground stations. The second, instead, is a classical convolutional neural network that aims at classifying each pair as hosting a considerable number of changes or not; therefore, its speed and smaller architecture satisfy the main requirements for the execution on board the satellite, exploiting dedicated hardware.

Finally, benchmark tests are also conducted on a low-power GPU, the NVIDIA Jetson AGX Xavier, to investigate throughput and speed results with both TensorFlow and NVIDIA TensorRT on this energy-efficient device. Indeed, the space scenario has inevitable constraints on the power consumption and energy efficiency of the instruments that can be used, and this platform shows important features that make it suitable for the installation on board the satellites in future missions.

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Session Classification: Earth & Environmental Sciences & Biodiversity Applications

Track Classification: Earth/Environmental Sciences & Biodiversity Applications