ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DET - Self-supervised deep learning architectures for multi-application edge-AI on board satellites

Funded By	Dipartimento DET
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Context of the research activity	The topic of this scholarship is Edge-AI for satellite systems. The actitivy is performed in the framework of a project recentlòy funded by the Italian Space Agency, for the design and implementation of a multi-application image processign system to be run onboard an Earth observation satellite.
Objectives	Edge-AI is motivated by various factors. In recent years, machine learning, particularly deep learning, has made significant advancements, enabling the extraction of information from data and images with excellent precision. Onboard satellite image analysis allows for the "selection" of images of interest to transmit to the ground station (for example, avoiding the transmission of those with an excessively high percentage of cloud cover). Moreover, it is possible to detect events of interest and report them to the ground station with very low latency, making early warning systems for potentially dangerous events such as fires and floods possible. However, several factors have so far limited the adoption of Edge-AI on satellites, such as issues related to the use of FPGAs for implementing machine learning methods, the energy consumption of accelerators for scientific computation, and the limited availability of annotated data. The Edge-AI system to be developed is based on an innovative architecture built upon deep neural networks that seamlessly integrate with existing onboard processing systems. It is designed for satellites equipped with optical, panchromatic, and/or multi- or hyperspectral payloads. The architecture relies on computing the semantic representation of the acquired image (feature extractor), which is shared among all applications. The feature extractor is trained independently of the specific application through self-supervised learning techniques. The representation obtained from the feature extractor is utilized by various applications that leverage the image representation to extract information of interest. Three applications will be considered during the project: 1) image segmentation for the identification of regions of interest, 2) fire detection, and

	3) flood detection. These applications were chosen because they represent practical use cases of interest where it is crucial for the ground station to receive information with very low latency. This makes it necessary to extract information directly onboard the satellite, enabling the generation of early warnings for potentially dangerous events. It is also anticipated that applications can be updated from the ground in case their onboard execution occurs in a reprogrammable part of the hardware.

Skills and competencies for the development of the activity	Prospective candidtes should have at least 6 months of experience in the design and implementation of deep neural networks. Specific experience with deep learning for satellite imaging applications will be considered a plus.