URBAN AND REGIONAL DEVELOPMENT

Ateneo/DIST - Innovative AI-based algorithms for Earth observation and emergency management through 3D data modeling

Funded By	Dipartimento DIST Politecnico di TORINO [P.iva/CF:00518460019] SPACE IT UP SOCIETA' CONSORTILE A RESPONSABILITA' LIMITATA [P.iva/CF:13087860014]
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Context of the research activity	The research project focuses on the development and application of advanced algorithms for processing 3D data derived from Earth observations. Specifically, the research aims to enhance response capabilities to environmental and extreme emergencies through automated processes for information extraction and analysis. This involves integrating machine learning and deep learning techniques with existing Earth observation systems, such as the Copernicus program and its contributing missions, as well as the upcoming national IRIDE constellation.
Objectives	The Ph.D. research project is part of the Space It Up program, with a particular focus on the Work Package dedicated to resilience against extreme events. The primary objective of the research is to develop innovative algorithms and procedures for the rapid and scalable processing of three-dimensional data, aimed at providing detailed and timely information about territories and infrastructures, thereby improving response capabilities in emergency scenarios. The ultimate goal of the research is to revolutionize the approach to geospatial data processing by integrating advanced 3D models and artificial intelligence to achieve a deeper and more immediate understanding of critical situations. The research will be structured into several lines of intervention. A key area will focus on the development of advanced algorithms based on artificial intelligence for the direct analysis of three-dimensional data, such as point clouds and meshes. The application of deep learning to these models will enable the automation of recognition and classification processes for objects of interest, including buildings, critical infrastructures, and vegetation. Furthermore, algorithms will be developed to detect structural and environmental anomalies, which are essential for emergency management. The goal is to maximize the accuracy of information extraction while significantly reducing processing times. Another crucial aspect of the research will involve the automation and scalability of processes. The implementation of automated procedures for processing large volumes of data will leverage cloud infrastructure and distributed

Objectives	computing systems to handle complex analyses within reduced timeframes. This approach will support critical applications, such as real-time monitoring of extreme events and the planning of operational responses. The technological infrastructure employed will ensure high processing capacity, enabling the integration of data from various sources with speed and efficiency. A further focus will be dedicated to the integration of multi-temporal data, aiming to analyze and interpret datasets collected at different times to monitor territorial changes and improve predictive capabilities. The techniques developed will make it possible to track the evolution of natural or human-induced phenomena, offering decision-support tools for sustainable land management and resource planning. The dynamic integration of heterogeneous data, combined with the power of artificial intelligence, will provide a fundamental added value to ensure reliable and timely results. The overall goal of the project is to combine algorithmic innovation with three-dimensional modeling technologies to significantly improve the quality and speed of information derived from Earth observation data. The entire research process will be driven by the need to automate workflows, minimizing reliance on manual checks and prioritizing fully automated approaches controlled by artificial intelligence algorithms. This will enable successful responses to challenges related to emergency management, enhancing the resilience of territories and the response capacity of the involved institutions.

Skills and competencies for the development of the activity	The ideal candidate should have a strong background in programming, with particular expertise in Python, PyTorch, or other advanced tools for developing deep learning models. A solid understanding of machine learning and computer vision is essential, with a specific focus on the processing of geospatial data and three-dimensional models. The candidate should also demonstrate proficiency in 3D data processing, including techniques for analyzing and classifying point clouds and meshes, as well as practical experience in implementing algorithms for processing large datasets (big data) using cloud infrastructures. A key requirement is a strong knowledge of Earth observation, including an understanding of major satellite data acquisition systems and their applications. The candidate must be able to integrate this knowledge with technical expertise to develop innovative solutions and contribute to scientific advancements within the project context. The ability to work in an interdisciplinary environment and apply advanced technological tools to address complex problems related to land management and emergency response is considered a valuable asset.