URBAN AND REGIONAL DEVELOPMENT

AMMIN/DIST - Multi-source urban digital twins: from space to street-level intelligence

Funded By	Dipartimento DIST Politecnico di TORINO [P.iva/CF:00518460019]
Supervisor	BOCCARDO PIERO - piero.boccardo@polito.it
Contact	BOCCARDO PIERO - piero.boccardo@polito.it
Context of the research activity	This PhD research focuses on the development of urban digital twins through the integration of multi-scale geospatial data, including satellite, aerial, UAV, MMS and IoT sources. It aims to design interoperable workflows for data fusion, 3D reconstruction and dynamic monitoring, supporting advanced analysis and decision-making for resilient and sustainable urban environments.
	The proposed PhD research is situated within the domain of geomatics, Earth Observation (EO), and spatial data science, with a specific focus on the development and implementation of urban digital twins (UDTs) as advanced tools for monitoring, analysis, and decision support in complex urban environments. The research aims to address the growing need for integrated, data-driven frameworks capable of representing cities as dynamic, multi-layered systems, where physical, environmental, and infrastructural processes can be continuously observed and simulated. The core objective of the research is to design and validate a scalable methodological framework for the creation of urban digital twins based on the integration of heterogeneous, multi-source geospatial data. These data include satellite imagery (Copernicus and other EO missions), aerial surveys, UAV-based acquisitions, Mobile Mapping Systems (MMS), and in situ data streams from IoT sensors. The research will investigate how these datasets, characterized by different spatial and temporal resolutions, can be harmonized and fused into coherent digital representations of the urban environment. A key aspect of the work will be the development of interoperable data models and workflows for 3D reconstruction and semantic enrichment of urban features, including buildings, infrastructure, and environmental components. Particular attention will be devoted to the extraction and integration of high-resolution geometric and radiometric information from point clouds and imagery, enabling the creation of accurate and analysis-ready digital models. These models will be designed to support both static representations and dynamic updates, allowing the digital twin to evolve over time.

Objectives	Another major objective is the integration of real-time and near-real-time data streams, particularly from IoT systems, to enable continuous monitoring of urban processes. This will include the design of data pipelines and system architectures capable of handling large volumes of data, ensuring interoperability (e.g., OGC standards) and compliance with FAIR data principles. The resulting digital twin environment will support advanced analytical capabilities, including scenario simulation, anomaly detection, and predictive modelling. The research will also explore the application of urban digital twins in key domains such as risk and emergency management, infrastructure monitoring, and urban resilience. In this context, the digital twin will be used as a platform to assess the impact of environmental hazards, monitor critical assets, and support decision-making processes. The integration of multi-scale EO data with local high-resolution datasets will be investigated as a means to bridge the gap between global observation systems and local operational needs. From a methodological perspective, the research will combine approaches from geomatics, computer vision, machine learning, and spatial analysis. It will evaluate different techniques for data fusion, feature extraction, and model integration, with the goal of identifying solutions that balance accuracy, scalability, and computational efficiency. Experimental validation will be conducted through case studies in urban environments, where the proposed framework will be tested against real-world datasets and use cases. Although the research is primarily academic in nature, it is strongly oriented toward applied outcomes and potential collaboration with public institutions and industry stakeholders involved in geospatial technologies, urban planning, and smart city initiatives. Such collaboration may support access to data, validation of methodologies, and transfer of results into operational contexts.

Skills and competencies for the development of the activity	The candidate should have a background in geomatics, GIS, or spatial data science, with experience in thesis work or research activities related to Earth Observation, 3D data processing, or urban analysis. Skills in geospatial data handling, programming (e.g. Python), and familiarity with remote sensing or point cloud processing are highly desirable, together with motivation toward applied research in urban digital twins.