



# PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 41st cycle

**THEMATIC Research Field: AI FOR THE CLASSIFICATION/SEGMENTATION/OBJECT RECOGNITION OF CH DIGITAL DATA INTEGRATING IMAGES, 3D POINTS CLOUDS AND MULTISPECTRAL/HYPERSPECTRAL IMAGING**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1400.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research in this field**

The research is positioned within the domain of Cultural Heritage (CH), with a focus on reality-based surveying and data interpretation supported by Artificial Intelligence (AI) methodologies.

The increasing availability of high-resolution 3D data and advanced diagnostic information in the field of architectural heritage presents both a major opportunity and a significant challenge: how to effectively interpret, classify, and manage vast volumes of spatial data to support informed conservation strategies.

Within this context, the proposed research addresses the urgent need for intelligent and scalable methodologies capable of transforming raw 3D survey data into actionable knowledge. The motivation stems from the inherent complexity of monumental heritage, where traditional approaches to data management and analysis are no longer sufficient to meet contemporary demands for precision, scalability, and long-term monitoring. The primary objective is to develop a workflow that integrates multiple sources of digital data—including 3D point clouds derived from laser scanning and photogrammetry, digital



	<p>imagery, and diagnostic (multispectral and or hyperspectral) and material analysis datasets—within a unified framework. This integrated dataset will serve as the foundation for implementing AI-based techniques for multiscale object recognition, specifically designed to address the intricacies of complex architectural environments.</p> <p>The research aims to achieve the semantic classification of a complete 3D dataset of a monumental structure, from large-scale point cloud segmentation down to individual element decomposition and micro-surface feature detection. While the Milan Cathedral will serve as the main case study, additional heritage sites will be considered to test and validate the proposed methodologies. Using advanced computer vision and machine learning algorithms, the research will explore automated techniques for identifying, classifying, and spatially locating architectural elements based on both geometric (2D and 3D) and physical characteristics. A key goal is to support structural interpretation by integrating external survey data with theoretical principles and historical construction logic.</p> <p>The AI system will be capable of hypothesizing internal structural layouts based on external measurements and multimodal inputs. Special attention will be given to the detection of anomalies and degradation features, enabling a data-driven approach to condition assessment. This will involve building a dedicated training dataset for anomalies, linking deterioration patterns to specific geometric, environmental, and material conditions. In summary, the project aims to advance the field of digital heritage by combining artificial intelligence, high-resolution spatial data, and diagnostic insight into a coherent and replicable framework.</p>
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>The research will adopt a multidisciplinary methodology combining spatial data processing, artificial intelligence, and digital heritage practices. Core techniques will include the acquisition and preprocessing of 3D point clouds from</p>



	<p>laser scanning and photogrammetry, followed by alignment and optimization for large-scale architectural environments. Advanced methods for semantic segmentation and object recognition will be developed using machine learning and deep learning algorithms, trained on annotated datasets representing both architectural components and material degradation. A key innovation will be the use of semantic photogrammetry, integrating AI-based classification and segmentation workflows directly within photogrammetric processing environments. The project will also emphasize the integration of heterogeneous data sources—such as 2D diagnostic maps, historical documentation, and material analyses (multispectral or hyperspectral)—within a unified semantic framework. This will involve the creation of customized pipelines for multimodal data fusion, enabling the joint processing of geometric, physical, and historical information. To manage and explore complex spatial datasets, the research will develop interactive tools for point cloud manipulation, allowing users to select, annotate, and segment data within immersive environments, such as Mixed Reality (MR).</p> <p>These tools will also support user-in-the-loop validation of AI outputs, combining automated processing with expert input. This activity will be conducted in close collaboration with researchers specializing in MR applications in the cultural heritage field. In the domain of anomaly detection, both supervised and unsupervised learning techniques will be employed to identify surface irregularities, weathering, and deformations. A domain-specific training dataset will be compiled to correlate degradation types with material, geometric, and environmental parameters. Finally, rule-based reasoning and knowledge-driven inference systems will be explored to support hypothetical reconstruction of internal structural components, using external geometry and known construction logics. All techniques will be tested and validated through iterative prototyping and cross-case comparisons, ensuring robustness, scalability, and adaptability.</p>
Educational objectives	



	The project will train the PhD candidate in 3D spatial data processing, semantic photogrammetry, and real-time analysis of spatial and diagnostic datasets. Key skills include the application of AI and deep learning techniques for object classification, segmentation, and anomaly detection. The candidate will also learn to integrate heterogeneous data sources and develop interactive tools for immersive analysis.
<b>Job opportunities</b>	The research will open up career opportunities in the fields of digital heritage, architectural conservation, and applied AI for cultural assets. The candidate will acquire highly transferable skills relevant to research institutions, heritage authorities, tech companies, and design studios. Expertise in 3D spatial data, semantic processing, and immersive technologies is increasingly in demand. The project also prepares for roles in innovation-driven public or private sectors. Researchers completing this PhD will be well-positioned to lead digital innovation in the field of cultural heritage.
<b>Composition of the research group</b>	0 Full Professors 2 Associated Professors 0 Assistant Professors 4 PhD Students
<b>Name of the research directors</b>	Prof. Francesco Fassi, Prof. Cristiana Achille

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<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

<b>Stage and period abroad</b>
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<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	
<b>By number of months abroad</b>	0

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**Additional support:**

**Budget for the research activity (only for positions supported by scholarship):**total amount Euro 5.707,20 per student.

In detail:

- 1<sup>st</sup> year Euro 1.902,40
- 2<sup>nd</sup> year Euro 1.902,40
- 3<sup>rd</sup> year Euro 1.902,40

**Additional information about the organization and regulations of ABC-PhD programme can be found in the Regulations for the 41<sup>st</sup> Cycle of ABC-PhD:**download is available at link:  
<https://www.dottorato.polimi.it/en/phd-programmes>

**Additional information about ABC department and ABC-PhD programme:**available at link:  
<https://www.dabc.polimi.it/>

**Desk availability:**The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.