PhD programme in Earth, Environmental and Resources Sciences

Instructor(s)	Leopoldo Repola, DiSTAR - UNINA
Course Title	3D Digital Twin — The Virtual as a Method for the Analysis of Cultural Landscapes
Total Number of Hours	12
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Course Description

This doctoral course explores the intersection of digital technologies and cultural heritage, equipping students with both the theoretical foundations and practical skills required for the three-dimensional documentation and analysis of archaeological and landscape contexts.

The course begins by examining the core principles underpinning the use of digital tools in the production, management, and representation of geospatial data, with particular emphasis on the concept of the Digital Twin as an analytical and interpretive framework. Students will then gain a systematic understanding of the principal surveying technologies currently employed in terrestrial, marine, and coastal environments, including 3D laser scanning systems and drone-based photogrammetric platforms.

A central component of the course is a field session at the archaeological site of Cumae, where students will engage directly with professional-grade instrumentation — the Riegl VZ400 laser scanner and the DJI Matrice 300 drone — to carry out real-world digitisation activities. This experience is complemented by dedicated laboratory sessions focused on point cloud processing, textured model generation, CAD data extraction, and GIS integration.

Relevance for Doctoral Researchers

The course addresses a growing methodological demand within the geosciences, where three-dimensional digital documentation is becoming an essential tool for the survey, monitoring, and analysis of complex geological and geomorphological environments. The ability to acquire, process, and interpret high-resolution 3D spatial data is increasingly relevant across a broad spectrum of geological research, from the structural characterisation of rock formations and coastal erosion monitoring to the documentation of stratigraphic sequences and landslide-prone terrain.

By integrating theoretical foundations with hands-on fieldwork and laboratory data processing, the course equips doctoral students in geology with a transferable and up-to-date methodological skill set. The techniques covered — including terrestrial and airborne laser scanning, drone photogrammetry, point cloud analysis, and GIS integration — are directly applicable to research challenges in engineering geology, geohazard assessment, palaeoenvironmental reconstruction, and the study of landscape evolution over time.

Course Contents

1. **3D Digital Twin: The Virtual as a Method for the Analysis of Cultural Landscapes**
   a. This module introduces the founding principles of disciplines concerned with the application of digital technologies to the production, management, and representation of three-dimensional geospatial data. *(2 hours)*

2. **Technologies for Terrestrial, Marine, and Coastal Three-Dimensional Survey**
   a. A comprehensive overview of laser scanning and photogrammetric devices and methodologies for the three-dimensional survey of both large-scale and site-specific contexts. Topics include 3D laser scanning systems and drone-based photogrammetric platforms. *(2 hours)*

3. **Field Lesson at the Archaeological Site of Cumae**
   a. Hands-on three-dimensional digitisation activities conducted on-site, employing the Riegl VZ400 time-of-flight laser scanner and the DJI Matrice 300 drone. Sessions will cover point cloud acquisition and the pre-processing of three-dimensional models. *(4 hours)*

4. **Laboratory Activities**
   a. Processing and management of data acquired at the Cumae archaeological site, including point cloud filtering and the generation of textured polygonal models. Additional activities cover the extraction of CAD data for integration into GIS platforms, as well as data analysis and visualisation workflows. *(4 hours)*

Learning Outcomes

- Upon successful completion of the course, doctoral students will be able to:
- Understand the theoretical framework underpinning the use of digital twins and three-dimensional geospatial technologies in geological and geomorphological research contexts.
- Select and operate professional-grade survey instrumentation, including terrestrial time-of-flight laser scanners and drone-based photogrammetric systems, in both field and coastal environments.
- Plan and execute three-dimensional digitisation campaigns in complex geological settings, applying appropriate methodologies for data acquisition at varying spatial scales.
- Process and manage large geospatial datasets, including point cloud filtering, textured polygonal model generation, and the extraction of CAD-compatible data.
- Integrate three-dimensional survey outputs into GIS platforms for spatial analysis, visualisation, and interpretation in support of geological research objectives.
- Apply acquired competencies to a range of geological research challenges, including structural geology, geohazard assessment, monitoring, stratigraphic documentation, and landscape evolution studies.

Teaching Format

Lectures, practical exercises, workshops.

Essential Bibliography

- REPOLA L., (2023). **Extraction of constructive geometries from numerical models. The city walls in the Hattusa Gorge**. In: DisegnareCon, Volume 16, Number 30, October 2023, ARCHITECTURAL AND ARCHAEOLOGICAL HERITAGE. ISSN 1828-5961, DOI: 10.20365/disegnarecon.30.2023.10

- REPOLA L., VARRIALE G., ILACQUA S., LETIZIA M.A., (2025). **Cumae Archeological Site - Processes and Technologies for the Analysis and Monitoring of Anthropogenic Cavities**. In: Heritage, 2025, 8, 199, doi.org/10.3390/heritage8060199
- REPOLA L., VARRIALE G., MARAZZI M., VINCENZO M., SCHACHNER A., (2025). **Survey and Analysis of Hieroglyphic Inscriptions in the Postern of Yerkapı–Ḫattuša**. In: Heritage, 2025, 8, 321, doi.org/ 10.3390/heritage8080321
- REPOLA L., (2025). **3D digitization of the Sirkeli rock reliefs**. In: Königsbilder, Libationskuhlen und Steinbau, a cura di: Mirko Novák und Deniz Yaşin. Harrassowitz Verlag. Wiesbaden, pp. 78-92, Reihen DOI 10.13173/9783447122849
- REPOLA L., VARRIALE G, ILACQUA S., DI MARTIRE D., PAGANO F., LETIZIA M.A., (2025). **Cuma. Space information modelling**. In: 3D Modeling & BIM 2025 – Proliferazioni, a cura di: T. Empler, A. Caldarone, A. Fusinetti. Alghero, pp.266-278, ISBN 9788899586591

Assessment Method

In-class discussion and active participation.