Promoting Research and Innovation for Cultural Heritage in Cyprus through the CONNECTING Infrastructure Project

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Abstract. The "Research and Innovation Knowledge Centre for Engineering in Heritage" project, in short CONNECTING, aims to establish a knowledge centre equipped with advanced sensors and platforms such as Vertical Take-off and Landing (VTOL) drones, cameras, LiDAR systems, laser scanners, and various other sensors to support research on cultural heritage sites and monuments, both on land and underwater. The knowledge centre will serve as a hub for supporting local research in Cyprus dealing with cultural heritage. The project brings together a multidisciplinary team involving experts from the domains of geomatics, civil engineers, Information, Communication and Technology (ICT)experts, archaeologists, and heritage managers. This collaborative effort will enable the selection of appropriate methods, techniques, and tools to support heritage sites, management, and preservation. The project will also develop a cloud Data Centre to store and share evidence, results, services, and products. This paper serves as an introduction to the scope and objectives of the project, while it also outlines the infrastructure that is expected to be acquired and hosted at the Cyprus University of Technology premises.

Keywords: Cultural Heritage, Documentation, Remote Sensors, UAV, Earth Observation, Underwater Object Detection.

1 Introduction

The thematic priority of the CONNECTING project is closely connected with the Smart Specialisation Strategy of Cyprus (S3Cy). The S3Cy aims to facilitate the future sustainable development of the country by leveraging its unique characteristics and research ecosystem (Fig. 1). The final report of S3Cy emphasizes the significance of cultural heritage as a central pillar for the country's future development. It highlights the

interaction of cultural heritage with other disciplines, such as tourism - a significant economic revenue stream for Cyprus - and ICT.

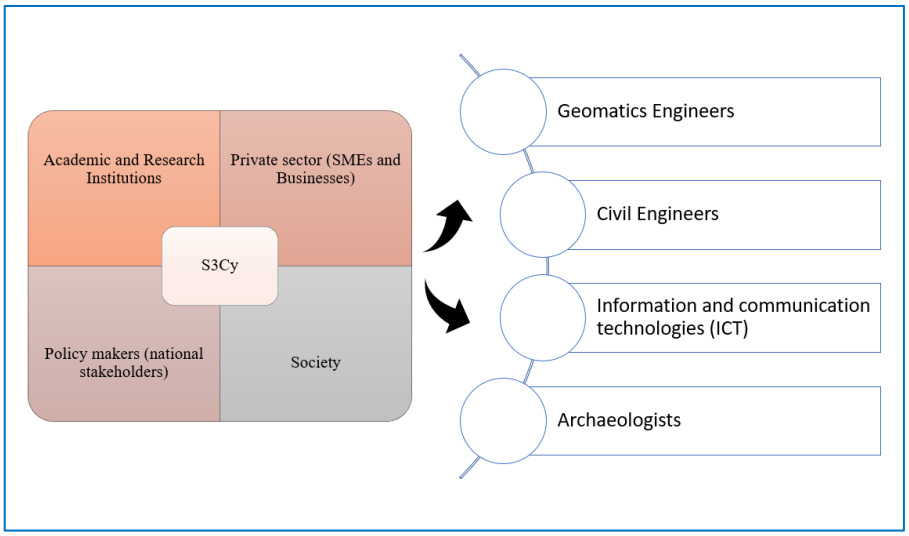

Fig. 1. The CONNECTING project's links with the Smart Specialisation Strategy of Cyprus

The CONNECTING project aligns with the European Commission's vision to establish a collaborative European cloud for cultural heritage by 2025. This initiative aims to facilitate extensive collaboration between cultural heritage professionals across the EU using advanced digital tools to preserve European cultural treasures through a digital infrastructure. The project aims to foster cooperation between the partners and stakeholders of the local research and innovation (R&I) ecosystem, leveraging targeted coordination and support actions (CSA). The project involves academic laboratories at the Cyprus University of Technology (CUT), the Archaeological Research Unit of the University of Cyprus (UCY), and the private sector (Infralabs). The project's development of a multidisciplinary knowledge center, unique in its thematic domain at a national level, is anticipated to support strategic goals defined by the Department of Antiquities of Cyprus (DoA), the single responsible authority in Cyprus for all monuments and sites. Additionally, the knowledge, expertise, and infrastructure gained, could be utilized to support needs beyond the cultural heritage sector, such as mapping and cartographic purposes. The project's actions are backed by wider society involvement, including the UNESCO Chair of Digital Heritage, bridging the collaboration gap between academia, stakeholders, society, and the private/business sector.

The hub aims to enhance research excellence and support future research and innovation collaborations within the region and the broader European context. The knowledge center is expected to accommodate a critical mass of high-level researchers, while attracting well-trained young researchers who can effectively utilize the research

infrastructures and propel the consortium to the forefront of relevant research. The project will take all necessary actions to ensure effective infrastructure sharing with the wider society. It will also include educational activities for both undergraduate and postgraduate students and PhD candidates, providing targeted skills during the project's demonstration actions.

2 The aim

The general objectives of the project are presented below.

- The CONNECTING knowledge centre aims to serve as a research hub for the consortium partners and supporters. These entities will collaborate to achieve the two R&I demonstration activities outlined in the project. Actions will include best practices for detecting, monitoring, documenting, and analyzing heritage sites on land and underwater.
- The consortium also aims to comply with the "Strategic Infrastructures" research call regulations and the ERA priority for infrastructure openness. A secure and privacy-preserving cloud data center will host, process, and share project information with specific restrictions for sensitive data.
- The project is expected to enhance research excellence and innovation capacity in geomatics, ICT, archaeology, and civil engineering in heritage. The equipment claimed by CONNECTING will be demonstrated and disseminated through targeted actions. Stakeholders from the private sector and wider society will be engaged, and the infrastructure will be accessible to the local R&I ecosystem, supporting national priorities for open science practices.
- An additional objective of CONECTING is to create a critical mass of researchers in cutting-edge sectors to generate job opportunities for young scientists. Aim for a team of five well-trained researchers at the R&I knowledge center by project end, with potential for further research opportunities from competitive funds.
- CONNECTING also seeks to attract highly skilled researchers to Cyprus by announcing new job openings in geomatics, archaeology, ICT, and civil engineering for heritage-related projects. The proposed infrastructure and interconnected Data Centre, along with targeted skill development activities, will likely capture high-level researchers' attention.
- CONNECTING will ultimately promote effective national research collaboration supported by the partners of the project. This aims to foster synergies in the local R&I ecosystem through two targeted demonstrations on land and underwater, executed collaboratively by the project's end.

3 Proposed Research Infrastructure Gains

The CONNECTING consortium will be outfitted with cutting-edge ground-based terrestrial laser scanners and sensors to monitor the stability of monuments and sites, as

well as low-altitude active and passive sensors such as LiDAR, RGB, and multi- and hyperspectral drone sensors. These tools are designed for quick and precise assessments, generating high-resolution thematic maps, and creating 3D representations of landscapes and urban areas. They bridge the observation gap between satellite and ground-based data and can also be utilized for underwater applications. An overview of the proposed infrastructure to be acquired is depicted in Fig. 2.

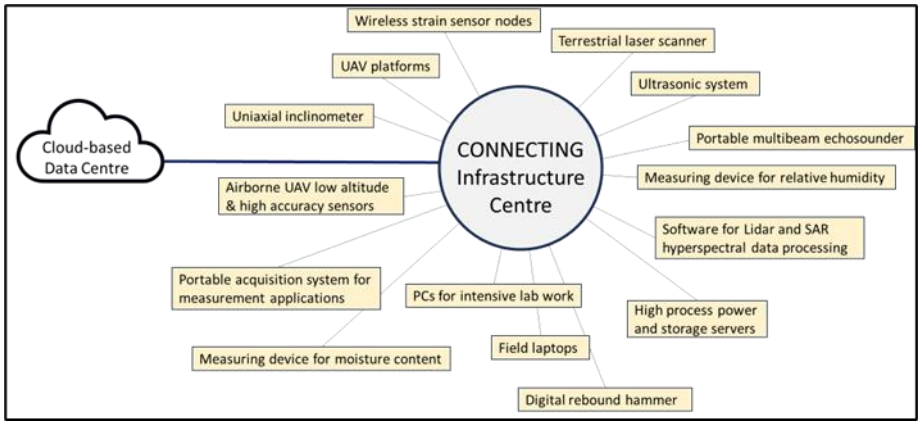

Fig. 2. Proposed research infrastructure of the CONNECTING project

3.1 UAV Platforms (VTOL Quadcopter)

This platform offers extended endurance, thanks to long flight times and weatherproof capabilities. In addition, it integrates advanced AI capabilities with directional sensing and positioning sensors. The proposed drone is engineered to meet all new EASA standards by combining intelligence with high performance and exceptional reliability. The system comes equipped with all necessary components for immediate deployment, including intelligent batteries, a battery station, a specially designed controller, and more. Furthermore, it features an advanced RTK high-precision GNSS receiver that supports all major global satellite navigation systems, delivering real-time differential corrections to generate centimeter-level positioning data for improved accuracy in 2D and 3D mapping.

3.2 Airborne UAV Low Altitude & High Accuracy Sensors (Lidar, mapping RGB, Hyperspectral)

The sensor package comprises a high-performance surveying payload tailored to map 2D and 3D infrastructures. It is specifically designed to minimize distortions in open spaces. The package also includes an aerial LiDAR payload capable of generating highly detailed 3D point clouds of features that may not be visible in 2D mapping. Moreover, it is equipped with a drone-specific hyperspectral camera that can live-

stream real-time data to the remote-control during flight. This camera can capture RGB and HSI images simultaneously and is equipped with a built-in GPU for additional pre-processing. Lastly, the package automatically processes overview images to evaluate correct exposure settings and depict acquired spatial and spectral information.

3.3 High Process Power and Storage Servers

We require a high-performance computer capable of processing a wide range of data gathered from both airborne and ground sensors. It should handle dense 2D and 3D geoinformation, including dense 3D point clouds and hypercubes. Employing parallel data processing will enhance computing performance and enable complex calculations, ensuring efficient, reliable, and prompt operation of advanced applications in line with user needs and expectations. A Storage Server will also be necessary to store the project's data and applications. These servers will serve as repositories for data and applications, offering rapid and dependable access to large volumes of data over a shared network or the Internet. The server will also house the cloud Data Centre.
Researchers will have access to PCs for processing data and running intensive spatial calculations for 2D or 3D data analysis. Additionally, field laptops will be utilized as ground control stations during drone data acquisition, using specially designed software. Ground Control Stations (GCS) enable UAV operators to communicate with and control the drone and its payloads. This can be achieved by setting parameters for autonomous operation or by directly controlling the UAV.

3.4 Software for Process Lidar and SAR and Hyperspectral Data

The processing of 3D point clouds from aerial or ground lidar systems, as well as the integration of design and as-built models, requires specific software. This software creates and visualizes point clouds in a meaningful way, and can produce high-quality videos, screenshots, and orthophotos. It also enables annotation, measurement, and virtual environment tours, along with the extraction of floor plans and elevations from point clouds. Additionally, efficient software for hyperspectral and SAR imaging is essential for accurately processing hyperspectral images under variable lighting conditions.

3.5 Terrestrial Laser Scanner

The terrestrial laser scanner (TLS) as a ground-based alternative to airborne LIDAR for indoor terrain and landscape mapping. Terrestrial laser scanners, a relatively recent innovation, provide high-resolution mapping for deformation measurements, quality control, topographical surveying, and cultural heritage monitoring.

4 Discussion

CONNECTING project pathways to impact involves supporting emerging multidisciplinary needs for monitoring, documenting, analyzing, and preserving cultural heritage sites on land and underwater. The project results include know-how in data collection and integration in cultural heritage, implementing a cloud Data Centre, developing geospatial fusion techniques, and creating databases and datasets of cultural heritage sites. Additionally, the project aims to implement security measures, establish guidelines for standards, and train researchers. A Communication, Dissemination, and Exploitation plan will support the project outcomes. The project will focus on reaching academia, the research community, professionals, private industry, stakeholders, public authorities, and the public interested in innovative technologies, research, cultural heritage, and schools. The outcomes will showcase the potential of the infrastructure, making it open to external users and potential collaborators. New technologies for heritage documentation have the potential to impact a range of economic, social, and technological developments.

Indeed, the Knowledge Centre for Cultural Heritage will be closely linked to the Smart Specialisation Strategy of Cyprus (S3CY) for the country's sustainable development. Using new technologies for heritage documentation will increase public awareness and appreciation of cultural heritage and facilitate knowledge sharing and cultural exchange. The impact of technological development involves connecting cloud data centers and demonstrating new technology for cultural heritage documentation. This can drive innovation in fields like computer vision, machine learning, and robotics, leading to new tools and software creation. These technologies also can support new applications in urban planning, architecture, and geospatial analysis. The project's use of new technologies for cultural heritage documentation can drive economic growth in tourism, conservation, and cultural heritage management. Accurate documentation of heritage sites can attract more visitors, increase tourism revenue, and stimulate investment in restoration and conservation efforts. The project also aims to promote the development of new technologies for heritage documentation, creating opportunities for businesses to develop and market new products and services like virtual tours and online education programs.

The CONNECTING project can have a positive environmental impact by reducing the need for on-site visits and traditional surveying methods, which generate carbon emissions. The CONNECTING knowledge center will minimize travel and support remote data collection, while innovative technologies for heritage documentation can help reduce the carbon footprint of conservation and research efforts.

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