On the design and development of new technologies to detect damages in cultural heritage assets

Long abstract

Introduction:

Europe's Cultural Heritage (CH) is a rich and diverse melting pot of traditions, monuments and communities where we have boiled our identity, well-being and sense of belonging. Nonetheless, in recent years, we have witnessed a series of natural and human-induced disasters that threaten it.

As stated by the European Commission in the report on *strengthening cultural heritage resilience for climate change* (2022), creating effective policies for safeguarding CH is complicated as there are no coherent methodologies for obtaining reliable information, quantitative data or deep knowledge about the decay and loss of cultural heritage. Indeed, the different formats for storing and visualising such data and the lack of a clear workflow hinder the collaborative work between different technical teams, the efforts to integrate incomplete and disparate data and the sharing of CH knowledge with end users (e.g., museums, guides) and citizens. Improving cultural heritage resilience to climate change and anthropogenic hazards requires a shift in conservation practices towards more holistic ones.

Material / Data:

ChemiNova aims to develop an intelligent computational system that goes beyond current technologies to improve the conservation, analysis and monitoring of European cultural heritage assets. Using a myriad of data, we will tackle structural and chemical damages, focusing on two specific human-induced threats: climate change and civil conflicts. We will focus mainly on damages linked to slow on going variations of climate and pollution parameters, such as temperature, relative humidity, rain, SO2, NOx and particulate matter. Surface blackening and soiling, biodeterioration, decohesion and fracturing due to salt crystallization will be of major consideration. The alteration forms will be defined based on the typologies detected at the ChemiNova pilot sites:

- Kyiv's Saint-Sophia Cathedral (Kyiv, Ukraine)
- Collection of the Università degli Studi di Palermo (Palermo, Italy)
- Schloß Schönbrunn (Vienna, Austria)
- Collection of the Universitat de València (Valencia, Spain)

Methodology:

We are developing novel and cost-effective ways for remote and on-site monitoring of cultural heritage assets by reusing existing technologies. To that end, ChemiNova considers a set of non-destructive and portable technologies in a modular way that will allow adaptable inspections according to the different case scenarios: monuments, buildings and artefacts. Furthermore, our impact lies in the fact that we will not build an ad hoc device, but our technology is adapted so that anyone can access it from anywhere. Specifically, we are working on:

- ChemiModel: New methods and tools considering multi-dimensional representations of the object, supporting not only spatial information, but also spectral, photometric, semantic and temporal. These 3D models will be called e3D models, where the “e” stands for “enriched”.
- ChemiAI: Development of methods based on deep learning to automatically detect types of damages on CH assets due to climate change and other human-induced threats.
- ChemiPortal: Web-based application that acts as the main access point of the entire ChemiNova Database. For ChemiNova Platform administrators it provides necessary capabilities to manage users and integrate new tools. For specialists and contributors ChemiPortal integrates the necessary functionalities for content management and review of resources created with all other ChemiNova tools.
- ChemiAnalisys: Desktop application created in Unity, that provides ChemiNova users with capabilities of integrated visualization and analysis of the artefacts stored into the ChemiNova Database, defined as extended 3D models (e3D). Users will have the possibility to visualise the same artefact scanned with different sensors (e.g. RGB, RTI or infrared) and to easily navigate through the timeline of existing scans, highlighting the damages produced in time. Functionalities unique in the ChemiNova Platform will allow the extraction of relevant information from the scans for in-depth analysis. ChemiAnalysis will also allow users to create new annotations and view annotations created with any other ChemiNova tool, supporting a collaborative effort for cultural heritage preservation.
- ChemiInspection: The application is designed for use with hand-held devices and is focused on on-site inspection of artefacts. The application employs augmented reality to facilitate guided inspection following specific procedures. The application enables the digitisation of conditional reports and the determination of the spatial relationship between the virtual information and the elements of the real world during the on-site inspection.
- ChemiSensing: Collaborative mixed-platform shared space in which local and remote users will be able to work together in the inspection and documentation of the damage of selected tangible e3D models. In a virtual environment, the area under investigation will be recreated using e3D models. Local users provide information through augmented reality, while remote users can access the environment through mixed reality.
- ChemiSee: A non-expert targeted platform will attempt to connect the data generated by the ChemiNova suite of applications with the cultural heritage artefacts and the communities in which they are embedded. ChemiSee will be implemented as a decentralised web platform that local communities will be able to run to integrate their local cultural heritage into a European or global digital network of digital cultural heritage twins.

Results & Conclusions:

ChemiNova involves the close cooperation of an interdisciplinary team, including areas such as conservation, art history, architecture, restoration, capacity building, heritage interpretation, chemistry, biology, computer science, multimedia engineering, and photogrammetry.

Currently, the project is focused on identifying the targeted audiences’ needs to design the set of technologies above-mentioned and the related functionalities. Also, we have acquired data (hyperspectral images, RTI, thermal images, etc.) of two of our pilots (Valencia and Palermo). The first outcomes of ChemiNova prove the need and added value of an interdisciplinary-based research.

Discussion:

We will involve local communities in conservation practices, from providing data (citizen science) to raising awareness on the effects of climate change, natural and human hazards affecting CH. Our aim is to promote best practices that enhance community engagement in protecting heritage, thereby contributing to environmental, social, and economic sustainability. Also, ChemiNova will involve heritage practitioners and non-experts in conservation processes, while considering end-users at the centre of our tools and methods. It achieves this by studying and promoting cultural heritage conservation, mobilizing expertise to address critical conservation issues, and providing training and research tools to strengthen the professional community. Through ICCROM's involvement in the ChemiNova project, we aim to promote effective disaster risk management strategies and provide innovative responses to emerging issues, impacting both European and international policy frameworks for cultural heritage conservation.

References

European Commission, Directorate-General for Education, Youth, Sport and Culture (2022). 'Strengthening cultural heritage resilience for climate change – Where the European Green Deal meets cultural heritage'. Publications Office of the European Union. DOI: https://data.europa.eu/doi/10.2766/44688