Innovative solutions for
Cultural Heritage

From EU funded
R&I projects

INNOVATIVE SOLUTIONS FOR CULTURAL HERITAGE

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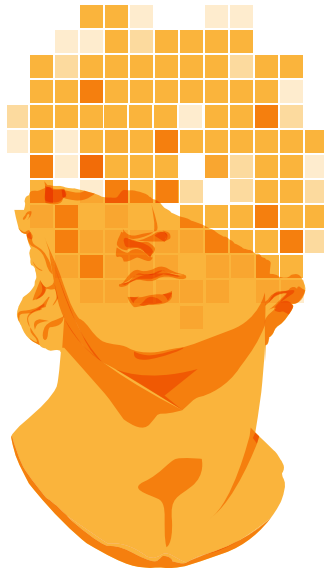
2018
EUROPEAN YEAR
OF CULTURAL
HERITAGE
#EuropeForCulture

INNOVATIVE SOLUTIONS FOR CULTURAL HERITAGE

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FOREWORD

Cultural heritage is a non-renewable, irreplaceable resource that plays a vital role in our future. It brings a number of intrinsic benefits to the economy, the environment and society as a whole. Its importance has been acknowledged by the European Union's decision to make 2018 the European Year of Cultural Heritage.

EU Research and Innovation (EU R&I) has promoted a renewed and a forward-looking approach to cultural heritage. Rather than considering it static – a relic of the past to be conserved – we recognise it is a strategic living asset that evolves through our engagement with it. Cultural heritage has a ground-breaking role in building our future: it contributes to our sense of belonging to a common European space, helps b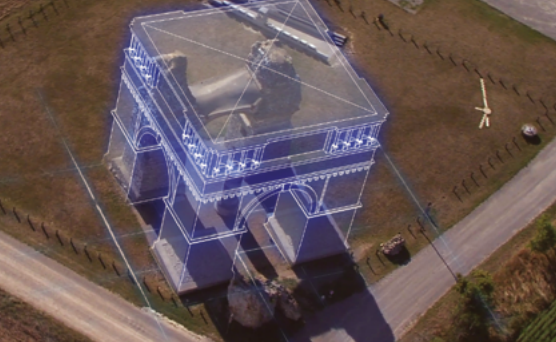uild community cohesion, and boosts social integration and job creation. It increases the resilience of places and helps to reduce the use and waste of resources.

Cultural heritage research has been supported by the EU since 1986 within its research framework programmes. Through EU-funded projects, European and non-European partners have developed multiple innovations related to all aspects of our outstanding tangible, intangible and digital heritage, from protection and preservation to innovative management, enhancement and immersive experiencing. These solutions are often highly sophisticated and can benefit other aspects of everyday life beyond heritage. They are also transferrable to other fields, like environmental monitoring. This is why it is important not only to innovate in cultural heritage, but also through cultural heritage.

Furthermore, solutions have been co-created through the years by a variety of stake-holders, practitioners and actors, such as municipalities, small and medium enterprises, museums and civil society, going beyond universities and research centres. All these communities now contribute to an innovation ecosystem that transcends silos and disciplines.

To capitalise on the successful results achieved so far, in 2018 we launched the concept of an open Community of Innovators in Cultural Heritage. Such a Community responds to the need to give more visibility to EU project results, bridge the gap between research, society and market, and open up to the 'change-makers' in the field. The idea has been taken up by two Horizon 2020 projects that are currently developing an online platform that will gather the 'innovation providers', the 'innovation supporters', such as investors, businesses, incubators, and the 'innovation end-users', such as cities, museums, public offices.

In the future, we will keep on investing in cultural heritage and supporting open processes of innovation through a stronger focus on co-creation of solutions. We will also continue valorising the extraordinary social and human capital made up of different networks and expertise that has been created along the years in R&I heritage-related projects.

Jean-Eric Paquet
Director-General for
Research, Science and Innovation

EXECUTIVE SUMMARY

This publication is conceived in the frame of the European Year of Cultural Heritage 2018 and in particular as a contribution to the pillar on 'Innovation'. Seizing the opportunity of the Year, it presents a collection of innovations developed by EU-funded projects in cultural heritage under different EU Research and Innovation Framework Programmes.

EU investments in projects related to key aspects of tangible, intangible and digital cultural heritage under the Seventh Framework Programme for Research and Technological Development have been around €200 million. Under Horizon 2020, the current EU Framework Programme for Research and Innovation for 2014-2020, we estimate that almost €500 million will be invested in cultural heritage-related research under all three pillars of the programme: Excellent Science, Industrial Leadership and Societal Challenges. Given this picture, the Report seeks to respond to three main questions: 'What has been achieved so far?' 'What is the evidence base that can be provided through EU funded projects?' and 'What happens when the projects are over?'

To respond to these questions, the report provides a taste of the results achieved so far with the aim to help their dissemination among specialists and the general public. It has been prepared after an extensive two-year survey that involved more than 200 EU R&I funded projects in the field. The replies received have been selected and compiled with the aim of representing the variety of innovations produced and the diversity of projects and disciplines involved. These range from social sciences and humanities to biology, chemistry or physics.

The innovative solutions present differing degrees of development. Some of them are very recent and have been selected for their innovation potential to solve the most recent problems and societal challenges. Some others have already been fully developed and their products have been commercialised. Many others are in a middle stage. They have been tested and prototyped and have started to enter the market.

They include, among others:
- pan-European research infrastructures
- advanced materials and future technologies for the protection, conservation and restoration of heritage artefacts and arts
- cultural platforms and novel solutions for transmission and sharing of European cultural heritage, cultural literacy, identities and common past, including the troubled one
- models and solutions for European collections of archives, museums, libraries

- new digital opportunities for reconstruction, re-creation, co-creation and immersive experiencing of cultural heritage
- methodologies, devices, strategies and systems for monitoring and assessing cultural heritage under different conditions, in particular against climate change and disasters, including at the landscape level
- technologies for energy efficiency of historic buildings
- tools and technologies for underwater cultural heritage
- innovative governance and partnership models, products and services to improve urban and rural environments and to foster the adaptive re-use of built heritage.

All these solutions have been grouped into four clusters – 'Circular, Creative and Sustainable Cities', 'Heritage at Risk', 'Shared Management of Cultural Heritage' and 'Advanced and Future Technologies for Heritage and Arts' – according to the audience and end-users they are targeting. Strong focuses are given to the 'why' factor, i.e. the challenges underlying the solutions, and to the benefits innovations are providing.

In fact, through the innovations collected, the Report makes a strong case that innovations developed for cultural heritage can also benefit different sectors of everyday life. Also, it makes explicit their future potential uses, giving an insight of how research and innovation in cultural heritage will contribute to tomorrow's challenges by improving people lives, cities and places, intercultural dialogue and the common environment.

The survey on innovative solutions has been conducted on funded projects from FP5 to H2020.

The innovations presented have been selected in collaboration with:

- DG Communications Networks, Content and Technology
- EASME (Executive Agency for Small and Medium-sized Enterprises)
- ERC (European Research Council)
- JPI CH (Joint Programming Initiative on Cultural Heritage)
- JRC (Joint Research Centre)
- REA (Research Executive Agency)
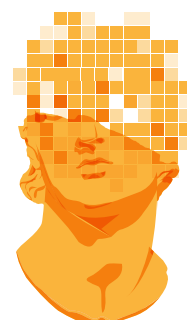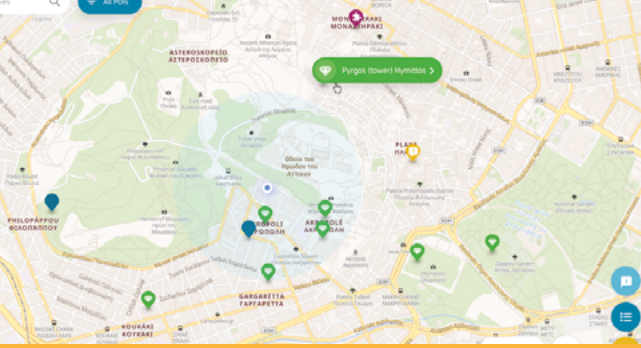
CLUSTER 1

'Circular, sustainable and creative cities'

This cluster supports urban regeneration and the integration of cultural heritage into environmental, architectural and planning policies. A strong focus is given to the adaptive reuse of built heritage aimed at integrating cultural heritage into a circular economy model. Solutions include novel governance and business models to foster new uses of Europe's abandoned heritage, the development of creative spaces and hubs in urban city centres, as well as digital tools and maps that assess citizens' behaviours, perceptions, preferences and emotions. The cluster also includes technologies and systems to improve liveability in historic buildings and districts, by increasing energy efficiency

Cultural gems
a free, open-source app
for European Cities

31 CULTURAL ROUTES PROMOTE
CULTURE
HISTORY
MEMORY
EUROPEAN INTEGRATION

CLIC

The Circular Heritage Impact Assessment (CHIA) and the Urban Heritage Development Fund (UHDF) for adaptive reuse of built heritage

Turning neglected heritage sites into sustainable projects through targeted funding and support

Many heritage buildings and sites in Europe are abandoned, neglected or underused. This is an urban 'waste' that can be turned into a precious resource through adaptive reuse under a circular economy approach. However, existing examples of reuse are not always successful. Sometimes, the private sector invests in piecemeal projects that do not adhere to the same vision and don't contribute to equitable cities; in other cases, innovative bottom-up practices of reuse with high social participation are too weak and fragmented. These key challenges are addressed through two innovative solutions: the Urban Heritage Development Fund (UHDF) and the Circular Heritage Impact Assessment services and toolkit (CHIA).

The Urban Heritage Development Fund, a portfolio of different urban cultural heritage projects, coordinates multiple investments over extended horizons, captures synergies and tailors the financial structure of individual projects. By offering an integrated investment strategy and combining financial and non-financial returns (i.e. environmental and social impacts) the portfolio obtains a multiplier effect in the financial returns. UHDF is designed mainly to attract investors: pension funds, commercial banks, and development financial institutions.

The Circular Heritage Impact Assessment services and toolkit provide a practical tool to assess the impacts and performances of cultural heritage adaptive reuse projects. It is based on assessment criteria and quantitative and qualitative indicators that define three levels of circularity – values conservation, building construction and regional impacts. CHIA supports non-profit organisations and social enterprises to become more accountable for the impact investment funds category, as it gives transparent assessment of financial returns and social impacts. It will be tested in the cities of Salerno (Italy), Rijeka (Croatia) and Amsterdam (Netherlands) and in Västra Götaland Region (Sweden).

Cultural gems

A free open source app to support the Cultural and Creative Cities Monitor

Offering tourists a more comprehensive look into a city's cultural scene through a Europe-wide mobile-sharing platform

The main tourist-oriented outlets tend to highlight a few iconic attractions, guiding travellers and users in their visit to the most visible spots, often creating a gap between the city's touristic image and its cultural and creative richness and diversity. Attempts to overcome these issues usually consider only specific geographical areas or topics, resulting in a fragmented or partial overview. Cultural gems aims to contribute to overcoming these issues by providing a common interface for cultural and creative places at a European level.

Cultural gems is developed to support the administrators, visitors and residents of EU cities to share and highlight lesser-known cultural spaces, going beyond the main touristic spots. The app is the logical next step of the Cultural and Creative Cities Monitor, which shows how well cities perform in cultural and creative areas and is designed to help policymakers identify local strengths and opportunities for cities.

The app forms a Europe-wide mobile-enabled sharing platform that is open-source, goes beyond the current proprietary solutions and collects information from a great diversity of sources (ranging from museums to live music venues and arts centres) to overcome the specialisation of culture and creativity maps. The app encourages sharing favourite cultural and creative spots in a map-based interface and allows residents and visitors to discover the "cultural pulse" of the city. Users can take part in fact finding and quiz solving challenges to discover hidden treasures located at cultural points of interest and earn game points or coins.

Potential users of the app include tourists, residents, city administrators, cultural third sector representatives and tourist offices – all of whom can share their knowledge of the local culture in one convenient place.

EXPLORE MORE

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Cultural heritage interactive map
A map journal tool for citizen engagement

Taking European citizens on a visual journey through European cultural heritage sights and initiatives from the comfort of their own home

This tool was developed for the "European Year of Cultural Heritage" to respond to the absence of a harmonised repository of EU initiatives supporting the preservation of European Cultural Heritage. More than just an information source, the web tool serves as an outreach effort to increase the public's involvement in their own cultural heritage. The tool seeks to depict the many layers of European cultural heritage in a consistent and harmonised way.

The Cultural Heritage Interactive Map invites the general public, as well as cultural heritage experts, to browse cultural initiatives and events across Europe using interactive story maps online. This map journal interactively showcases what the European Union and its partners are doing to protect, promote and raise awareness on cultural heritage in Europe. It combines panels with rich content – text, photos, illustrations, videos – and maps that can be queried by the user. Maps and stories are thus integrated to create a unique storytelling experience.

Users simply scroll down the journal to discover new sections around themes relevant to the preservation of cultural heritage in Europe. Each story map features easy-to-read content and enables users to zoom in and out as well as hover over map locations for additional information. As users navigate the site, they can instantly find the most important cultural heritage sites around them. Story maps also allow users to discover endangered cultural heritage sites, explore the Cultural Routes of the Council of Europe, learn about the DiscoverEU initiative and get inspired for a culturally rich Interrail trip.

PROJECT: Cultural Heritage Interactive Map
FUNDED UNDER: JRC
RESOURCES: http://arcg.is/0TjSai

EFFESUS

A Decision Support System (DSS) to improve the energy performance of historic districts

Combining data modelling and innovative technologies to prioritise energy retrofit measures for historic structures

Buildings in Europe are responsible for 40% of the EU energy consumption and 36% of CO_2 emissions. Trends in energy demands are expected to grow in the future. Currently most efforts to improve energy efficiency in buildings address new constructions, without considering the historic structures and their urban dimension. The EFFESUS project has filled this gap with solutions which improve energy efficiency of Europe's unique urban heritage while preserving cultural and historical values.

The DSS supports evidence-based diagnosis and decision-making to identify and prioritise retrofit measures and improve the energy performance of historic districts. The DSS consists of a data model, a solutions repository, a software tool and a methodology to implement different strategies within the framework. The service is designed for urban planners and municipalities as well as associated stakeholders such as energy agencies and real estate companies. A business plan is ongoing.

EFFESUS is complemented by specific technologies for energy retrofitting of heritage buildings:

- Spacefill Aerogel insulation, a highly efficient insulation for walls with lath and plaster finishes, which is designed for use by public bodies, housing associations, caretakers of historic buildings and homeowners. Owner: A. Proctor Group Ltd. registered it as a trademark. An industrial up-scaling is foreseen.
- Isocal Insulation mortar, a natural hydraulic lime NHL5 insulating render for historic masonry, designed for architects, consultants, building owners and contractors. Owner: BOFIMEX, registered as a trademark and ready for production and commercialisation.
- Radiant reflective coatings with high Infrared (IR) reflection reduces the amount of solar heat absorbed by the envelope. The coating is designed for use by contractors and companies, municipalities, architects, general public and stakeholders.
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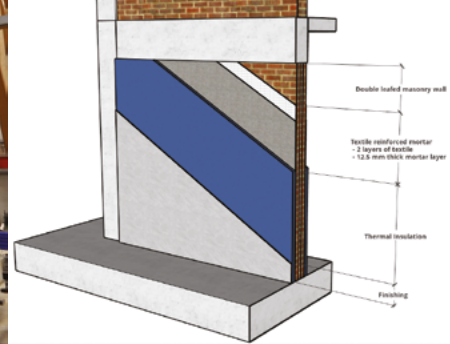
iRESIST+

Advanced materials and system for improving earthquake resistance and energy retrofitting of buildings

Reducing the costs of meeting seismic and energy performance needs using state-of-the-art materials in retrofitting old buildings

Upgrading the existing building stock in Europe is becoming increasingly important due to their poor seismic and energy performances. However, replacing existing buildings is prohibitively expensive or not desirable for historical buildings and would have a significant societal and environmental impact. To the date, energy and seismic retrofitting are treated separately.

The iRESIST+ project is at the cutting edge by integrating advanced materials for the simultaneous seismic and energy retrofitting of the existing building stock. It combines inorganic textile-based composites with thermal insulation systems. This innovation has the potential to significantly reduce the costs of meeting seismic and energy performance needs simultaneously. In the EU, an estimated 1 million buildings annually need seismic and energy retrofit. Moreover, a common approach for building performance classification is proposed, allowing to assess whether energy efficiency and disaster-resilient practices could be integrated.

The innovation will be beneficial for all communities affected by seismic risk but will also benefit society as a whole by reducing energy consumption and hence reducing costs and greenhouse gas emissions. Home owners and governments renovating buildings of societal or cultural importance will benefit from reduced costs of the proposed retrofit compared to separate seismic and energy retrofitting. The innovation will also benefit the construction industry, as the combined retrofit, in combination with adequate policy to incentivise retrofitting, will lead to an increase in demand for retrofit specialists.

PROJECT: iRESIST+
FUNDED UNDER: JRC

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RIBuild

A probability-based life-cycle assessment software for retrofitting historic buildings

Helping building designers and owners assess environmental impacts and building retrofitting costs

In Europe, 30% of all buildings are historic buildings and they are expected to last for decades. Therefore, there is great potential for energy savings and emission reductions through renovation measures. However, the long-term perspective of historic building interventions together with several structural, architectural, and social constraints have made it very difficult to apply standardised procedures such as Life Cycle Assessment (LCA) and Costing (LCC) and support decision-making on building retrofitting.

The RIBuild Software tool allows a "probability-based" life-cycle assessment of environmental and economic impacts of building retrofit measures. LCA and LCC data inputs – such as building component prices and embedded energy – can be combined considering their "uncertainty ranges". The software provides results in alternative scenarios. Furthermore, it offers an idea of the significance of input parameters' uncertainties and their impacts on the results, through a detailed sensitivity analysis. In this way, the user is made aware of the inherent uncertainties related to environmental impacts and costs of building retrofitting and, during the design stage, can work on the most proper and effective solutions. The software can be effectively applied as a decision support tool during the building renovation phase.

The tool's primary target groups are building designers and owners. The innovation has already been applied to several buildings and will be further employed to develop guidelines for "safe" internal insulation of historic buildings. The tool can also be used to investigate the affordability and environmental benefits of different design solutions, especially related to the energy efficiency issue, so that researchers, building engineers and real-estate stakeholders can benefit from the tool.

ROCK

ROCK video neuro-analytics (VN) and City People Flow application for urban regeneration

Determining public reaction to heritage-led regeneration actions by combining anonymised data analytics on people's emotional states and environmental data

Video Neuroanalytics (VN) for Public Spaces identifies human emotions, mood and mental health in urban spaces, which can be useful in achieving planning objectives. City People Flow, an app by LBASense, detects the presence of people in public spaces to enhance safety and security (and the perception of security), rate event successes, city rehabilitation efforts and urban policies, and manage urban areas.

The breakthrough with City People Flow, delivered by DFRC AG, is its large-scale application for measuring the impact and effectiveness of heritage-led regeneration actions, pulling data such as people's origins, how long they stay somewhere, etc. The technology analyses mobile phone signals in compliance with the EU's GDPR. Data is then transferred to a local server where aggregated figures are used to produce Crowd Analytics. The VN innovation analyses and rates cultural heritage according to a viewer's valence, arousal and ten emotional states. It integrates anonymised data analytics collected on people's emotional states with environmental data – such as air temperature, humidity, wind, air pollutants – to discover trends and correlations on how public spaces and properties are perceived, as well as to rate social, emotional, hedonic and utilitarian values. It then offers tips on effective management of public spaces.

City People Flow is useful for municipalities, universities and stakeholders wanting to measure the success of initiatives. For museums, concert halls, tourism operators, etc., the system can be an effective marketing tool. VN is ideal for urban planners, communities, developers, architects, contractors, landowners, environmentalists, consultants and businesses. Long-term, it will help improve sustainable, effective and participative regeneration and adaptive reuse of cultural heritage assets.

CLUSTER 2

'Heritage at risk'

'Heritage at risk' cluster promotes solutions to preserve, manage and increase resilience of vulnerable artifacts, sites, cities and landscapes. It includes innovative decisions and assessment systems, ICT tools and guidelines, mitigation strategies and disaster risk management models along with quick damage assessment techniques and technologies. The definition of risk encompasses a broad variety of threats to cultural heritage, from climate change to hazardous events, including extreme weather-related events. Particular attention is given to cultural landscapes and the threats posed by the loss of biodiversity, as well as to the changing socio-economic conditions, such as migration and depopulation, especially in rural areas.

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ARROWS

Zeno, the autonomous underwater vehicle for underwater archaeological campaigns

Light and highly-manoeuvrable unmanned underwater vehicles will open up new horizons for underwater archaeologists

Underwater cultural heritage sites are particularly challenging compared to sites on land. Discovering, surveying, conserving, protecting and developing their potential involves high costs and external constraints. Available technology is still discouraging the use of marine robotics and Autonomous Underwater Vehicles (AUVs) in underwater archaeological fields, even though the latter are considered to be more efficient and safer than divers. A light and highly-manoeuvrable unmanned underwater vehicle could enable extensive optical and acoustic mapping of underwater sites, reducing costs, time and risk to human operators.

Starting from the experience gathered by the University of Florence in the FP7 ARROWS project, MDM TEAM SRL, the official spinoff of the University of Florence, has developed ZENO AUV in the framework of EU-EASME ARCHEOSUb project. Zeno AUV is a high-performance Autonomous Underwater Vehicle supporting archaeologists during all steps of a typical underwater archaeological campaign. The vehicle has hovering capability, is able to counteract currents in any direction, has eight thrusters (with a high level of isotropy), can be customised with the main optical and acoustic payload sensors, and has a fast replacement battery package complete with a user-friendly interface. ZENO AUV is light and transportable, requiring only two persons to be operated.

The ZENO AUV prototype, soon to be launched on the market, will open up new horizons for underwater archaeologists, but further applications are already foreseen. The vehicle could be useful also for organisations active in monitoring and conserving underwater infrastructures and components, such as entities managing hydroelectric reservoirs as well as offshore oil and gas companies.
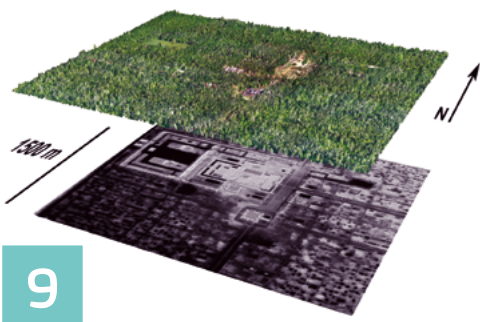
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CALI

A high-resolution airborne laser scanning for mapping cultural landscapes

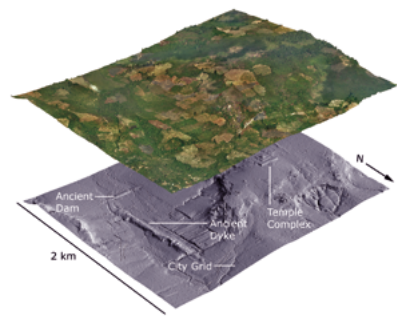*Allowing archaeologists to look through dense tropical forests with the use of 'Lidar' applications*

Conservation of heritage landscapes, both cultural and natural, demands a sophisticated understanding of the physical qualities of the landscape together with an overarching understanding of possible threats such as urbanisation, deforestation and overtourism. Normally, the solution to this problem is to undertake comprehensive surveys on the ground and from the air, using remote sensing techniques such as satellite observations and aerial photography. However, in many areas, in particular tropical environments, the remoteness and inaccessibility of archaeological sites, as well as dense vegetation cover, can create serious obstacles for conducting such comprehensive surveys.

To overcome this problem, the CALI project has developed the largest-ever airborne lidar data acquisition ever achieved by archaeologists and heritage managers, scanning and compiling more than 2000 square kilometres of Cambodian forest, in the heartland of the Khmer Empire. High-resolution airborne laser scanning or lidar applications offer an opportunity to create richly detailed three-dimensional models of heritage landscapes, 'seeing through' vegetation, even dense canopied tropical forest, and documenting features that were previously obscured, inaccessible or unknown. Such surveys are now achievable in a matter of hours, using an aircraft equipped with lidar technology, acquiring billions of digital measurements that open up new horizons for archiving, analysing, visualising and communicating information about natural and cultural heritage landscapes.

The CALI project's experience has provided a model of international and interdisciplinary cooperation (i.e. PECUNAM Lidar Initiative), acting as catalyst for an active community of end-users and developing a range of applications based on lidar data. Current developments in UAV or 'drone' technology, as well as miniaturisation and technical innovations in lidar sensor technology, offer the promise of covering ever-wider areas at ever-lower costs in the near future. Airborne lidar is now positioned to become an essential tool in the toolkit of archaeologists and heritage managers worldwide.

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Heritage and Threat – HeAT
Understanding threats, improving policies for cultural heritage

An online platform and handbook for stakeholders aims to increase protection of cultural heritage at risk

Achieving a deeper understanding of processes leading to the destruction of cultural heritage is key to help policymakers develop more proactive strategies. The dearth of information and wide variety of threats constitutes an obstacle for governments and institutions. Crisis evaluation and post-conflict reconciliation are effective only if threats to cultural heritage are analysed in a context that takes into account the intrinsic values embodied by the heritage for local and international communities. Such an approach requires a careful identification of the mechanisms possibly leading to threats.

The HeAT project analyses threats across different geo-cultural locations to achieve a sophisticated cross-cultural typology of a threat. It is a web-based platform to visualise the destruction of cultural landscapes via map overlays, accompanied by a handbook for governments, global organisations, NGOs and peace-keeping forces. Understanding and addressing threats facing cultural heritage is key to enable policymakers' intervention and increase protection of cultural heritage at risk.

In order to increase the appreciation of good heritage management, a travelling exhibition has taken place in 20 different locations in Denmark: 'The Street Show'.

In addition, an online web GIS and a documentary on the impact of dams on the cultural heritage have been shared through open-access platforms:
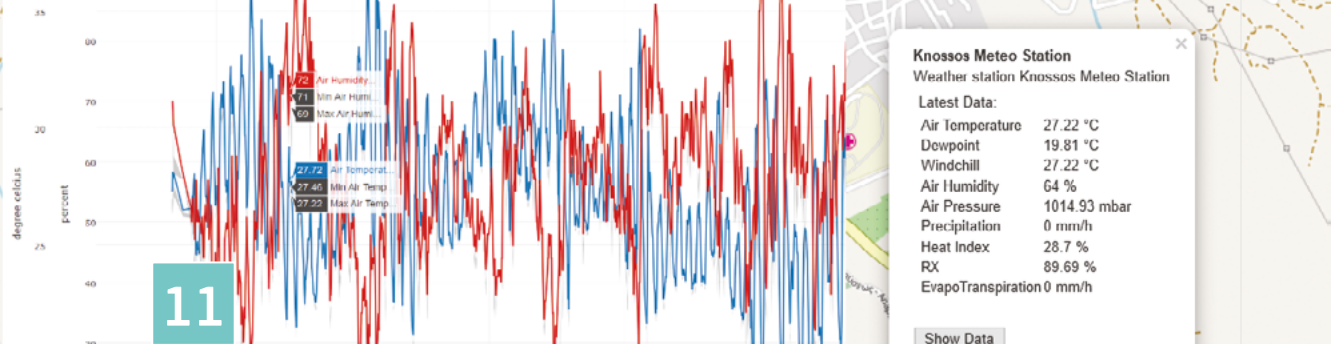
http://www.orientlab.net/orientgis/#OrientGISProjects

https://www.youtube.com/watch?v=PJoLKfWDDok&t=1902s

https://ccrs.ku.dk/research/centres-and-projects/heat/

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HERACLES

An ICT Platform to help restore and maintain cultural heritage under the impact of climate change

Collecting and integrating data for situational awareness and supporting decisions for heritage at risk

The cultural heritage diversity in Europe, together with the wide range of climatic regions, creates a complex picture that requires different adaptation policies for conservation. Effective collaboration among specialists in different domains – coordinating methods, models, systems and vocabularies – is key to this process. The management of such a varied information flow calls for the definition of an 'ontology' (encyclopaedic dictionary) enabling specialists to understand the information at hand, along with tools to efficiently query the data through semantic filters.

A new scalable and flexible innovative ICT platform has been developed by the HERACLES project with the aim of collecting and integrating heterogeneous data for situational awareness and decision support. The tool helps to identify and suggest new environmentally-sustainable solutions and materials for the long-term maintenance and restoration of cultural heritage impacted by climate change (taking into account also economic sustainability and cultural and social integrity). It helps define procedures and coordinate people and analysis, and enable operators to share information. The ICT platform gives the possibility to access raw data of ex- and in-situ sensors/ analyses available directly from the Knowledge Base that can be displayed in graphs and on maps. The Platform has been implemented in four test-beds located in two different European regions, presenting risk implications and climate change issues which can be applied to many other European assets.

The platform supports different levels of end users according to their role and involving the different actors along the entire workflow management. Therefore, heritage associations as well as private and/or governmental organisations will benefit from the tool.

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HERCULES

## A Knowledge Hub for landscape practices supporting landscape stewardship

Sharing, obtaining and creating landscape knowledge through an interactive platform

Cultural landscapes are at the interface of nature and society, being the interplay of physical features of the human environment with social structures and human ideas. In Europe, landscapes are largely recognised both for their cultural value and for their contribution to people's quality of life, through the provision of ecosystem services and biodiversity. Nevertheless, the different approaches and experiences are often isolated, lacking a common repository of scientific information and a structured knowledge exchange system.

The HERCULES project has developed the Knowledge Hub for Landscape Practices, an interactive open platform to support the sustainable stewardship of cultural landscapes. The Knowledge Hub enables the visualisation of the interface of nature and society and provides a tool to share, obtain and create landscape knowledge. Sinergise has developed the interactive, open platform for the HERCULES project, aiming to provide a powerful communication tool for bringing together citizens and landscape stakeholders supporting the sustainable stewardship of cultural landscapes. The Hub goes beyond being a cartographic viewer of existing scientific information, and enables constant exchange of knowledge and ideas between different stakeholder groups, allowing for the creation of content by any person interested.

Researchers, practitioners and the general public benefit from information and knowledge exchanged by creating, sharing and visiting the different contents of the Innovation. The Knowledge Hub for Landscape Practices has already been used in several local workshops across Europe to encourage local residents and policymakers to look elsewhere for inspiration and collaboration in the field of integrated management of landscapes.
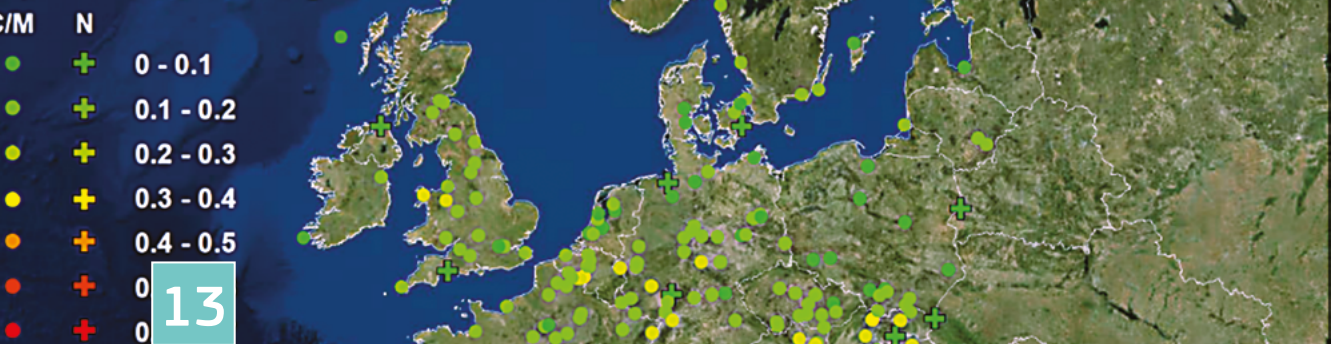
PROTHEGO

Space technologies for monitoring geo-hazards in heritage sites

Combining remotely-sensed data with geological analysis to assess vulnerability of UNESCO World Heritage sites

Geo-hazards represent severe threats to tangible cultural heritage sites. Currently there exists no comprehensive picture of such threats or how they could affect sites due to the lack of information on number, typology and distribution of cultural heritage across Europe. Such information is crucial for the purpose of assessing their vulnerability.

The PROTHEGO project seeks to enhance a vulnerability assessment of cultural heritage sites. It applies novel space technologies based on radar interferometry (InSAR) to monitor some 400 UNESCO World Heritage List (WHL) sites in Europe which are potentially unstable due to geo-hazards. Data obtained is crossed with existing databases of geo-hazards to identify and rank the cultural heritage sites that are at the highest risk. The analysis of remotely-sensed data in conjunction with local-scale geological analysis has been tested in different sites in Cyprus, Italy, Spain and the United Kingdom. Advanced modelling and field surveys have been carried out to validate and calibrate the methodology.

The technological solutions mainly target policymakers and executive institutional actors at the national level, in particular those in charge of disaster preparedness for heritage properties. Site managers thanks to the transfer of knowledge can also take up the solutions, from space and earth sciences to cultural heritage conservation sciences in this case. In the long term, the solution will improve the resilience and reduce the general vulnerability of tangible cultural heritage sites, saving money of post-disaster recovery and obtaining long-term cost benefit.

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STORM

A toolkit of technologies and methods to protect cultural heritage from threats

Predicting environmental changes and threats to heritage sites using non-invasive technologies

Europe's heritage assets are extremely exposed to climate change and natural hazards. To better protect and conserve them, the decision-making process has to be supported with a number of tools. Needs include the evaluation of historical records, real-time on-site monitoring, large-scale climate projections and their downscale to individual cultural heritage sites, and the collection and processing of data coming from different sources and sensors.

The STORM project uses a set of novel predictive models and improved non-invasive and non-destructive methods of survey and diagnosis to predict environmental changes and reveal threats to cultural heritage.

These are low-cost, eco-innovative, non-invasive, non-destructive sensors and solutions to perform surveys or real-time monitoring on heritage assets. They include accelerometers, sensor networks and emergency communication boxes as well as LiDAR, UAVs, Fiber Bragg Grating Radar Interferometry, Electrical Resistivity Tomography, Ground Penetrating Radar, Digital Photogrammetry and also the 'human sensors' through crowdsensing and crowdsourcing techniques. A collaborative cloud-based platform that covers situation awareness, diagnosis and quick assessment of heritage before and after disaster is put in place.

There are also processes to support all phases in the disaster lifecycle including prevention, preparedness, response and recovery activities.

STORM innovations are directed to all cultural heritage users. The main beneficiaries will be CH professionals in the first stage and national authorities in the long term. The concept is currently tested through pilot sites at five different heritage locations, each with unique risk profiles: the Baths of Diocletian in Rome, Italy; the Mellor Heritage site, Manchester, UK; the Roman Ruins of Tróia, Setúbal, Portugal; the Forteza Fortress of Rethymno, Crete, Greece and the amphitheatre of Ephesus, Izmir, Turkey.
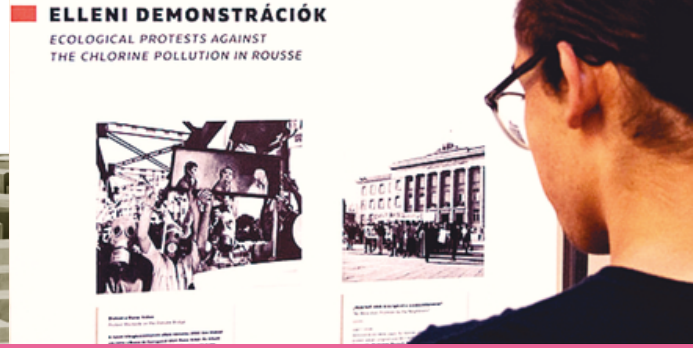
CLUSTER 3

'Shared management of cultural heritage'

'Shared management of cultural heritage' cluster promotes a wide variety of solutions. Some of them have the goal of broadening the audience and make cultural heritage accessible to all by removing social, cultural and physical barriers. Some others aim to digitally map, reconstruct and represent cultural heritage, enrich visitors' experiences and promote heritage co-creation. Other solutions help people to rediscover shared and contested heritage, valorising common values and reinforcing a sense of belonging. All these innovations, from social to digital ones, include methodologies, models and systems for engaging people and local communities and promoting a shared management of heritage in its multiple forms.

ARCHES

Simax, the translation software and sign language avatar for all audiences in museums

Allowing deaf people to enjoy cultural content using computer databases and animated sign language avatars

Deaf people experience serious difficulties in enjoying cultural content. They cannot use audio guides and require written information such as descriptions of art works. To tackle this issue, translation videos in sign language are produced all over the world, although this process entails high production costs linked with human persons in videos and results very time-consuming. More content in sign language, and thus more accessibility, can only be achieved if the translation process is accelerated and costs cut.

Sign Time developed SiMAX, a software for computer-assisted translation into sign language. Within the ARCHES project, the software is adapted to the special requirements of museums but can also be incorporated in apps which visitors can download on their smartphones. SiMAX can save translations and suggest them for similar texts. SiMAX is always operated by a person who knows sign language very well - a deaf translator - who checks the translation proposal and changes it if necessary. An animated computer figure (avatar) provides the final translation, showing emotions (as joy or surprise) and mocking grammatical facial expressions (i.e. an interrogative sentence is marked with raised eyebrows). The software does not work fully automatically, thus it is no substitute for human interpreters who interpret simultaneously, but it is a tool that is ultimately suitable for translating mass content very cost-effectively into sign language.

During the ARCHES project, SiMAX has already been tested with artworks of several museums, like the Kunsthistorisches Museum in Vienna and the Victoria and Albert Museum in London. The software significantly decreases translation costs and can be used for a wide variety of applications besides accessible cultural heritage (i.e. websites, TV programmes etc.). In the future, SiMAX will also be available as cloud service for translation agencies.

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CHIME
A novel app and research tool for music festivals

Helping festival organisers improve festivalgoers' experience through real-time data feedback and an in-app communication platform

Music festivals are very popular worldwide, engaging very diverse branches of population but also offering the opportunity to investigate on how festivalgoers, musicians, and other stakeholders experience and respond to the festival atmosphere, and the people they meet. Currently, the market offers many types of apps, enabling data collection with the concern of data privacy and surveillance topping-up prohibitive costs. Festival organisations, attendees and researchers would deeply profit from technologies enabling cheaper and better protected data collection as well as access to real-time and historic material enabling better understanding of the festival environment.

The CHIME App is a mobile application developed through the EU and JPI CH-funded CHIME project, exploring innovative ways of planning and managing jazz festivals in online environments. The app has the potential to significantly improve the communication with – and measurement of – audiences. A novel way of engaging with the festival environment and fellow attendees helps manage festival schedules, navigate sites and communicate with friends and other users. Festival organisers are provided with a cost-effective solution for communicating with audiences before, during and after festival events, but the latest technological developments of the app are going further. An additional prototype for a CMS (Content Management System) will eventually allow researchers and festival organisations to design, create, deploy and manage their own mobile applications and data collection processes.

Two pilot versions of the app have already been tested at the 2016 Cheltenham Jazz (UK) and the 2017 GMLSTDN Festival (Sweden). In the future, an Open Source version will enable further iterations and potentially apply the technology to other sectors and subject areas. Concurrently, a commercial product will be developed via Birmingham City University's STEAMHouse initiative (https://www.steamhouse.org.uk) or other accelerants and festival partners.

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COURAGE

The platform for sharing hidden counterculture collections and cultural practices

Documenting, curating and teaching the alternative culture of the past through an online registry

In post-war Eastern Europe, a plethora of personal strategies of dissent manifested in nonconformist cultural practices. During communism, this alternative culture was poorly documented, being often just tolerated by the institutions as a result of clandestine practices. Such memories are essential for the understanding of our past and contemporary Europe, despite being under constant threat to fall into oblivion.

The COURAGE project develops tools for understanding the historical dynamics of Eastern European countries related with contentious memories, aiming to enhance the networking capacities of the institutions holding them. The registry is an online platform available in 15 languages, collecting all the scattered and hidden collections representing nonconformity or counterculture. Researchers, educators, students and the general public can find material helping them to think differently about the object under study, turning the attention to how these movements were documented and involving the youth through playful learning methods. The registry also motivates researchers to develop new skills: instead of presenting a linear narrative, they need to imagine the objects they study (the collections) as part of a network where different stakeholders create the links between the collections.

The registry is also complemented by a Syllabus Creator System, targeting higher education, where users can work together developing syllabus modules for their university courses and use the registry (as well as Europeana and other external sources) to curate materials for their classes.

In the future, a marketplace will be created for cultural opposition items and pieces of art from the former socialist countries, and online and offline trainings on cultural history of underground movements will complement the project.

EHRI

Graph technologies for integrating information and collections on the Holocaust

Bringing over 1,900 Holocaust information sources together into one comprehensive virtual portal

Archival sources documenting the Holocaust are highly fragmented and dispersed across more than 1,900 archives, libraries, museums and other cultural heritage institutions in Europe and beyond. Such dispersal has so far presented a significant obstacle to undertaking transnational, comparative and digital approaches to Holocaust research. Moreover, integrating the sources is challenging not just because of their fragmentation and dispersion but because of their inherent complexity, as holocaust sources are characterised by deep hierarchies, complex provenances and semantic heterogeneity, and are typically not catalogued according to international standards.

The European Holocaust Research Infrastructure (EHRI) project has utilised graph technology to integrate and enrich information about heterogeneous, dispersed and fragmented archival sources documenting the Holocaust. This innovative tool virtually integrates information about such physically dispersed sources in the EHRI Online Portal. The portal takes advantage of Graph Database technology to flexibly model information within the complex archival data domain. The EHRI collection graph integrates both concrete and "virtual" representations of archival hierarchies and is therefore able to capture physical characteristics of dispersed archival collections. Utilising graph technology has allowed EHRI to integrate information about more than 230,000 archival units, physically held at more than 588 cultural heritage institutions located in 33 countries into its online portal.

The primary users of the EHRI Portal are Holocaust researchers. However, since its launch in April 2015, the EHRI Online Portal has attracted interest from genealogists, local historians and the interested public. In fact, the use of graph technology to integrate complex archival data from many holding repositories is seen by several cultural heritage institutions in other domains as a blueprint to replicate.

EMOTIVE

A platform and toolbox for emotional storytelling experiences for cultural heritage

Bringing objects to life to enhance visitors experience at cultural heritage sites

Storytelling applies to nearly everything we do. Whether it is to inform, persuade, entertain, motivate or inspire, we all tell stories every day of our lives. Yet despite their power, not all stories are effective in holding their audience's attention or communicating the messages they set out to convey. In heritage locations, narrative tends to be used narrowly, as a method to communicate the findings and research conducted by the domain experts of a cultural site or collection.

The EMOTIVE project works from the premise that cultural sites are, in fact, highly emotional places that regardless of age, location or state of preservation, they are seedbeds not just of knowledge, but of emotional resonance and human connection. Therefore, drama-based storytelling has the power to transform heritage and museum visitor experiences, encouraging repeat visits, facilitating direct and ongoing interaction and deepening knowledge transfer. The EMOTIVE's project innovative approach is fully user-centred and experience-oriented where interactive storytelling and immersive virtual experiences literally bring objects to life.

Emotionally engaging stories target a very wide public, who can experience the cultural site either physically or remotely. Wherever visitors are, they can follow characters, look for clues and explore environments. Special emphasis is put on social interaction between group members, providing visitors with a virtual "toolbox", in which they can store notes, story elements, clues, and anything that they may want to keep for later or share with others. The EMOTIVE authoring platform is designed to attract very different authors and has the potential to address more sectors apart from cultural heritage, such as tourism, education, marketing and advertising.

EURO MAGIC

Linternauta, a web app for magic lantern slides

Reviving the cultural value of magic lantern slides through multi-language online content

Projections of images accompanied by text recitals and the performance of musical melodies obtained significant sociocultural relevance in Europe between the first half of the nineteenth century and the first third of the twentieth. To fulfil their aims, these projections used a new technological device that was given such labels as fantoscope or projection lantern and whose name was lent to a very popular medium for social communication known as the magic lantern. Despite the magic lantern's undoubted influence in modern-era European, it has had only a residual presence as an object of scholarly study, though the educational and exploitation potential of magic lantern slides has still to be explored.

Linternauta, developed by the EURO MAGIC PROJECT, is a web application aiming at interpreting collections of magic lantern slides and promoting technological and educational innovation. The research project 'A Million Pictures. Magic Lantern Slide Heritage as Artefacts in the Common European History of Learning' (part of the EURO MAGIC project) has introduced the use of a descriptive content analysis as a method for the taxonomic organisation of magical lantern slides. This controlled vocabulary facilitates the classification of magic lantern slides according to their discursive gender. The web application Linternauta aims at boosting the knowledge, the accessibility and the cultural value present in the magic lantern slides thanks to the new digital technologies, and directly stimulates the contemporary cultural experience with this audiovisual heritage.

Linternauta offers online multi-language content, tailored to different user types, from the non-experienced to the trained lanternists. The tool has already been incorporated into the catalogue of pedagogical tools used – among others – by the Museu del Cinema for the Col.lecció Tomàs Mallol (SP) and the exhibition 'A return around the world of the magic lantern' produced by the Scientific Culture and Innovation Unit of the University of Salamanca.

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HERITAMUS

Web tool for participatory curatorship of tangible and intangible heritage

Empowering community curation of ethnographic data on heritage using an online tool

Currently, all the established heritage management databases and tools are designed for a hierarchical, atomistic and linear approach. Each item is linearly associated with others, and museum "assets" and cultural "knowledge" remains little articulated. This approach reinforces the institution of master narratives produced by prestigious actors, erasing controversies. It urges to picture, at a finer grain, how actors safeguard old practices and, at the same time, innovate.

The HeritaMus project has developed a technical resource for organising, structuring, and retrieving historical and ethnographic data on heritage (tangible and intangible), to overcome the asymmetrical representation of knowledge by bringing practitioners into the core of the research process using graphs. The online easy-to-use free tool enables community curation of data through a participatory graph database that allows the input of user data and big datasets. The tool is centred on the idea that any item or "node" is defined by its relations with other "nodes". The community and its knowledge can thus be traced by a network of dynamically connected "nodes", or a "parliament of things". The registered user simply has to identify the items that she/he recognises as their heritage (tangible and intangible) and wishes to input in the graph.

The HeritaMus tool has been already adopted by the community of practitioners, stakeholders and researchers. It is being used by the fado community and by the project's associated partner, Museu do Fado. Since its design is not culturally- or object-specific, it can be adopted on objects and subjects other than cultural heritage.

iMARECULTURE
Virtual reality applications for virtual underwater visits

Bringing the unreachable treasures of underwater archaeological sites to the surface through virtual experiences

Underwater archaeological sites are widespread all over Europe and represent an incredible cultural heritage treasure still under-explored by the general public. Accessibility is one of the main issues, limiting public awareness and influencing dissemination strategies to the wider public. Digital technologies can provide valuable support to ensure an authentic experience for the visitors and encourage self-motivated learning.

Virtual reality applications developed by the iMARECULTURE project can now facilitate virtual underwater visits as well as enhance actual dives in archaeological sites. Virtual and augmented reality applications have been developed and tested by the iMARECULTURE project to provide advanced, immersive and personalised experiences to be used at home, in-situ or at a museum. Based on existing 3D data, three sites have been carefully selected for the VR/AR interactive virtual underwater visits, such are Mazotos shipwreck, Baiae archaeological site and Xlendi shipwreck. The visualisations provide visitors an interactive and enhanced experience of diving into an unreachable underwater site, while offering additional information through storytelling about the artefacts displayed. Moreover, more advanced immersive technologies will be tested in Thalassa museum (CY), a partner of the iMARECULTURE project.

The market is showing increased interest in VR applications in the underwater environment since it is exciting and difficult to reach. Demand for VR educational content is expected to increase as VR devices become more affordable. Synergies between virtual and traditional museums and cultural institutions will support the economic sustainability of such actions.

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ITN-DHC/ViMM

Augmented and virtual reality technologies for digital cultural heritage

Improving the authenticity of virtual and augmented reality in the cultural heritage experience

There is a need for a more holistic approach to the e-documentation of the past to "tell the whole story". A holistic approach reveals how the reconstruction was conducted and why each part has its dimensions, materials, actual colour and artistic outlook, especially when elements of intangible heritage are incorporated into virtual reconstructions, such as in Historic Buildings Information Modelling (HBIM) systems.

The approach increases the scientific, economic and social potential of advanced services to users, which capture, reconstruct, model, archive, and enable use, reuse and dissemination of cultural heritage content. Augmented and virtual reality are used widely in the cultural heritage domain to present monuments and objects (reconstructed and otherwise) to the users, but it is still evident that many users think the things that they are looking at are not real. Future applications will provide the best quality possible so that the users will not be able to tell the real objects from the augmented ones.

As a step forward, two EU projects have showcased state-of the-art technology combined with novel experimental apps involving high quality dense matching photogrammetry, novel reverse engineering processes from created point clouds, morphological and holistic reconstruction of monuments, single image 3D reconstructions (camera alignments), 3D real-time implementation to mobile devices using AR, IVR (immersive VR) and VR implementation to mobile devices showcasing 4D cityscapes and sites.

These applications have involved the city of Calw in Baden Wurttemberg (Germany), the Panagia of Asinou church in Cyprus, the ancient site of the Roman legionary fortress of Carnuntum in Lower Austria and a museum and cultural and educational centre in Thessaloniki (Greece).

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meSch

A digital platform for creating smart objects and spaces linked to physical visiting experiences

Bridging the gap between the material and the digital with personalised content for cultural heritage visitors

Cultural heritage continuously seeks to engage visitors via digital means in novel ways, but screen-based interactions are not new. Screens also capture visitors' attention to the detriment of the experience and the appreciation for the collection. In contrast, the meSch project's installations use smart objects and intelligent spaces to bridge the gap between the material and the digital and deliver curated and personalised digital content as part of the physical visiting experience.

With meSch, cultural heritage organisations and professionals can easily create smart objects and spaces for novel interactive experiences. The platform is composed by a browser-based editor to upload content and define the visitors' interactions, and a set of smart blocks (sensors, actuators, and small computing units) to compose the smart setting the visitor interacts with. The use of Cloud Computing (for the online editor) and the Internet of Things (for the physical smart components) allows to edit the content and instantaneously deploy it. The visitors' experience on-site continues online via personalised and recommended content created using the data from the visit. meSch enables cultural heritage institutions to independently create personally meaningful experiences for the visitor.

meSch targets cultural heritage professionals – curators and exhibition designers – for the benefit of their visitors. It allows professionals to quickly prototype and deploy interactive installations that engage both the senses and the imagination. Over 40 professionals and 20.000 visitors have tried the meSch technology in hands-on events organised by the meSch team. The system has already attracted interest from cultural and tourism organisations.

PLUGGY

A software platform and smartphone tool to bring out and share local cultural heritage

Creating, modifying and safeguarding heritage with the help of virtual heritage communities

The Faro Convention (2005), emphasised the role of cultural heritage as an asset and a responsibility for all, fostering greater democratic participative actions with concern for the local communities and the everyday life. Currently, there is a shortcoming in ICT tools for enabling people to bring out their local cultural heritage. The existing applications and repositories target a more professional audience, whereas social platforms may offer potential to build networks, but they have still been little exploited for cultural heritage.

The PLUGGY project is working to develop an innovative social platform and a suite of smartphone tools that will enable individuals, community groups, industry, museums and countries to document and share their heritage online. The PLUGGY software platform will facilitate a continuing process for creating, modifying and safeguarding heritage, helping to build new virtual heritage communities. Content will be either uploaded by end-users or derived from digital collections such as museums, archives and cultural institutions, allowing users to create links between seemingly unrelated facts, events, people and digitised collections, leading to new approaches of presenting cultural resources, and new ways of experiencing them. Moreover, four PLUGGY-derived applications will be developed and released to demonstrate the potential of the PLUGGY software platform.

Both the PLUGGY software platform and the four applications (augmented reality, geolocation, 3D sonic narratives and collaborative games) will be released as technological tools made freely available under open source licenses and, as such, applications will remain free for any external organisation or developer to use and modify them.

TRACES

CCP, the innovative Creative Co-Productions approach for heritage transmission

Collaborating with artists to bring visibility and awareness to contentious local heritage

Practices of transmitting cultural heritage in the memory-identity-heritage complex show that the arts inhabit an increasingly central position in today's social formation. Institutional heritage providers are increasingly seeking collaboration with artists who are working on cultural heritage, not only to present existing heritages in aesthetically more appealing ways, but also to make difficult, awkward or silenced heritage more visible by using aesthetic and communicative methods and techniques.

With the innovative approach of Creative Co-Productions (CCPs), the TRACES project moves beyond the way art-and-research projects usually function in the cultural field. The CCPs are based on a mutual, equal process in which artists, researchers, heritage agencies (museums, sites, phenomena) and stakeholders (citizens, organisations, policymakers) collaborate on ways to approach, research, communicate, display and educate on a specific case of contentious local heritage. Members of the CCP start working together from the onset of the project and share not only the creative process, but also the formulation of the scientific questions, research strategies and methodologies. The artists have to open their ideas for discussion and be able to share the creative process and practices, while the researchers have their scientific methodologies challenged.

Local administrations and heritage institutions are the first beneficiaries of the results, able to take advantage of the range of strategies and good practices created throughout the research process and benefit from the innovative use of CCPs in the field. The CCPs are intended to represent replicable action methodologies, able to be used in other areas exhibiting a complex heritage territory. Moreover, the innovation opens new perspectives on job creation in one of Europe's most dynamic sectors, such as the one represented by cultural and creative industries.

CLUSTER 4

'Advanced future technologies for heritage and arts'

'Advanced future technologies for heritage and arts' cluster focuses on cutting-edge technologies to better study, protect, conserve and transmit heritage artefacts. The wide spectrum of innovations provide an in-depth insight of what cutting-edge technology can do for historical buildings and their building materials, archaeological artefacts, modern art and contemporary collections. The use of nanomaterials, sensors, digital technologies and powerful new software gives a taste of how future conservation practices will be shaped by today's innovative solutions.

AMECP

Glass sensors assessing the environmental impact on cultural heritage

Detecting when environmental conditions become threats to pieces of art by using thin glass sensors

Environmental assessment is still not a routine method in many museums due to high costs and highly sophisticated equipment needed, which often only measure the current values surrounding an object. The state-of-the-art glass sensor developed within the AMECP project allows an integrated assessment of the real impact of the environment on artwork for a longer duration (usually three to six months).

Glass sensors are now able to carry out efficient environmental monitoring on artworks in museums over an extended period of time. This solution has been developed by the AMECP project to avoid damages on cultural heritage in museums, libraries and historic buildings caused by environmental pollution and by varying temperature and humidity levels.

The sensor is a thin glass platelet (0.7 mm thick) made of a potassium lime silicate glass with a fire-polished surface. Under the environmental influence of temperature, humidity and/or air pollutants, the surface of the glass corrodes and a water-containing gel layer is formed by leaching of potassium and calcium ions. This gel layer serves as an indicator for the corrosiveness of the environmental conditions, warning when the local environment is in non-optimal conditions and calls for improvements. Such system is suitable for detecting even small amounts of pollutants such as SO_2, NO_x, volatile organic compounds, formaldehyde and organic acids, as well as temperature and humidity, allowing small scale mapping and comparison of different sites and locations.

The system has already been extensively applied to museums worldwide. Further possible applications are foreseen in early warning system for potential health risks caused by industrial exhaust gases of production plants or in hospitals.

ArchAIDE

A novel app for automatic image recognition of archaeological ceramics

Efficiently identifying, classifying and documenting archaeological pottery finds with a newly-developed app

Archaeologists invest considerable time, effort and funding to identify, classify and manually characterise individual finds, much of which is pottery. Pottery finds are of fundamental importance for the comprehension and dating of archaeological contexts, and for understanding the dynamics of production, trade flows, and social interactions. ArchAIDE will help to hasten many time-consuming tasks, while ensuring archaeologists are still in control of how their pottery is identified.

A new app designed by the ArchAIDE project aims to improve the practice of pottery recognition in archaeology, using the latest automatic image recognition technology. The app is designed to optimise and economise the process of pottery identification, making knowledge accessible wherever archaeologists are working (including during fieldwork). Pottery fragments are photographed, and their characteristics are sent to comparative collections (incorporating digitised paper catalogues and multiple photography campaigns), which then activates the image recognition system. The response contains all relevant information, which is linked – and ultimately stored – within an online database. The tool also utilises an automated system to digitise paper catalogues and improve search and retrieval, as well as a multilingual thesaurus of descriptive pottery terms in six different languages.

The ArchAIDE app will be tested during the final six months of the project but has already gained the interest of a wide stakeholder community, including archaeology specialists, cultural heritage and ICT companies. Moreover, the image and shape recognition technologies developed by ArchAIDE may have excellent application opportunities for publication suppliers and mechanical industries.
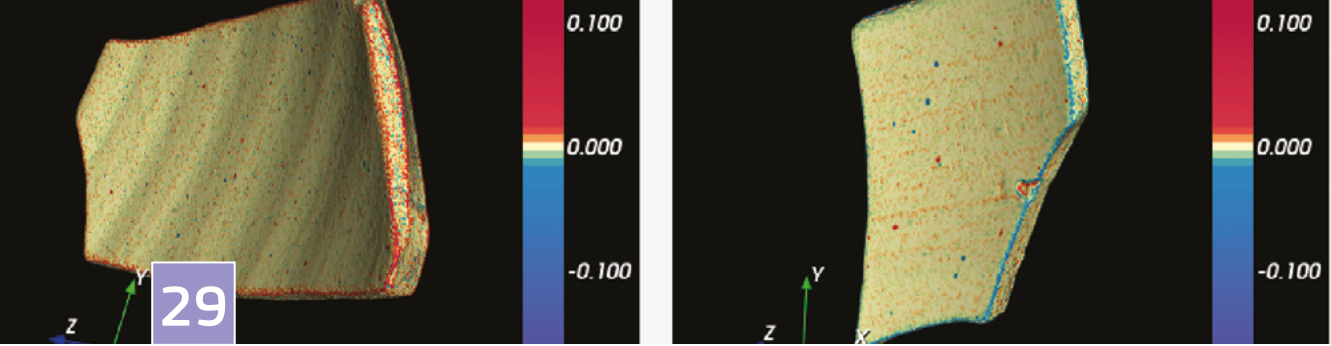
GRAVITATE

A platform for the reconstruction and reunification of fragmented archaeological artefacts

Reunifying fragments of artefacts and solving archaeological mysteries using a digital research platform

A common issue affecting archaeological artefacts is their fragmentation and dispersion among different collections. Often fragments belonging to a single object are held by different institutions, private or public, which might be scattered around very distant locations. Information relating to the integrity of the object, its relations with other objects as well as the simultaneous access to collections are instrumental to answer archaeological questions.

The GRAVITATE project has developed a digital research platform addressing the digital reunification of items belonging to the same collection, the re-association of objects under defined criteria and the re-assembly of fragmented artefacts. The methodology integrates archaeological research with computer graphics, computer vision, natural language processing and semantic technologies. The platform investigates objects' 3D geometry, surface properties, colouring texture and related semantic information within a single digital environment, where they can conduct 3D shape analysis, feature comparison, semantic and 3D annotations and similarities search by exploring collections. 450 artefacts have already been studied, including a collection of 250 ancient votive terracotta statue from Salamis (Cyprus).

The users of GRAVITATE will mainly be cultural heritage practitioners: curators, researchers, restorers, archaeologists and historians. The GRAVITATE toolset is flexible enough to support them in their everyday jobs, as reported by user trials and surveys. Nevertheless, the GRAVITATE platform can be adapted to deal with a large variety of objects with similar challenges such as forensic activities dealing with bodies and bones, industries testing crash and breakage patterns of their manufacturing products, geological studies investigating shattered meteorites and medical studies.

HEROMAT

Photocatalytic self-cleaning coating and consolidants for mineral substrates

Developing innovative, environmentally-friendly materials with value-added functions to protect immovable cultural heritage assets

Some properties of coatings and consolidants are physically, chemically and aesthetically incompatible with the original historical materials, having negative consequences on the original materials' resistance to microbiological corrosion and its change of properties over time.

The HEROMAT project developed a set of novel inorganic materials to protect different mineral substrates such as brick, mortar, stone, concrete and colour layers. The self-cleaning hydrophilic coating (NANOFAS) enables historic and modern façades to keep their aesthetic appearance longer, decreasing regular maintenance costs. The product is eco-friendly and uses UV light energy to decompose organic (microbiological) pollutants, while rain subsequently removes them together with dust particles from the surface. It does not affect water vapour permeability and other physical properties of the substrates, and easily adapts to different application techniques and levels of substrate physical damage. HEROMAT's solution is highly effective in urban areas and improves the appearance of urban landscapes.

The new water-based consolidant is tailored to reach the deeper layers of carbonate-based historical degraded materials (wall paintings, renders), resulting in greater durability of the intervention, with no whitening effect on the surface.

Novel solutions can be applied for the conservation and restoration of historic buildings and for the protection of modern architecture. The self-cleaning coating and consolidant have been tested in Serbia and Slovenia, with exceptional results. NANOFAS was used in the conservation project of the Medieval Fortress in Bač (Serbia) which won the European Heritage Award/Europa Nostra Award 2018 and Grand Prix in category of conservation.

InnovaConcrete
Multifunctional treatments for historic concrete conservation

Using calcium silicate hydrates (C-S-H) technology to increase the longevity of old concrete

Twentieth century concrete-based structures were designed and built in a time when no care was given to factors that increase the structure's longevity, such as the water to cement ratio and the thickness of the concrete layer, because decay mechanisms were still largely unknown. Thus, historic concretes often have a very low durability. So far, research on Cultural Heritage materials conservation has largely addressed traditional materials, but little focus has been given to concrete preservation or the application of nanoscience and advanced materials for this aim.

The InnovaConcrete project is working to fill this gap by developing advanced materials and techniques specifically designed for concrete heritage preservation. Products and techniques encompass the development of multifunctional impregnation treatments (with improved super-hydrophobic performance and the ability to produce calcium silicate hydrates), cementitious coatings containing inorganic nanotubes, portable atmospheric plasma devices and self-healing impregnation treatments. Such technologies are based on multiscale modelling and are validated in a relevant environment. Moreover, a set of awareness-raising tools are under development, aiming at highlighting the relevance of 20th century cultural assets. Such tools include identification badges of significant concrete-based Cultural Interest Assets, user-friendly web interface for 3D monument reconstruction, a guide to conserve and manage historic concrete, a decision-making tool for concrete conservation and an Ecosystem Services approach methodology to assess the value of Cultural Heritage.

Such products will be essential for the work of restorers and conservators, but also represent an interesting market opportunity for protection and conservation of current concrete. In addition, it can be interesting for companies involved in waterproofing natural and artificial materials.

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NANOMATCH

Consolidants for stones and stone-like materials to improve the resistance and durability of historic materials

Producing alkaline earth alkoxide consolidants that guard against environmental and climactic attack

Anthropogenic activity and climate change have worsened the natural decay of historic building materials. To cope with the problem of deterioration, many treatments have been proposed. Traditional treatments have been drastically reconsidered due to their effects on products. Organic products undergo chemical modifications with loss of efficiency and treatment irreversibility, and inorganic products suffer from scarce compatibility or low concentration and penetration. Nanostructured materials, such as nanolimes, were developed for stone conservation, but have also shown some limitations and have, therefore, been used mainly for the recovery of superficial de-cohesion.

NANOMATCH products are based on alkaline earth alkoxides with a great potential for the development of nanostructured materials, thanks to their high versatility of metal functionalisation. They are suitable molecular precursors of consolidants for carbonate stone and stone-like materials, achieving a better consolidation and resistance towards environmental and climatic attack. Calcium alkoxides are proven to withstand the problems faced by the use of organic polymers and the limitations of inorganic treatments. In fact, NANOMATCH products are produced as nanosuspensions with a particle size smaller than 100nm and have a higher calcium nanoparticles content in suspension with respect to nanolimes. Their products have also proved to be efficient consolidants, with no risk to release hazardous nanoparticles.

Currently, NANOMATCH products have been applied in historical objects in four locations such as Santa Croce Cathedral in Florence and Cologne Cathedral. Such products are environmentally compatible, reduce restoration and maintenance costs for those in charge of the monuments and historical buildings and present interesting business opportunities by capturing a market gap.

NANORESTART

Advanced materials for the conservation of contemporary artworks

Slowing premature degradation of modern art through groundbreaking nanotechnology

Modern and contemporary art exhibit a complex composition that is radically different from that of classic works of art. Contemporary artists have experimented and used a large variety of materials coming from industrial production. As a result, modern artworks are often affected by fast degradation processes which pose a serious threat to the preservation of global heritage in the next years, requiring innovative methodologies not achievable with conventional technologies.

NANORESTORE materials are realised within a new scientific framework based on nanoscience and soft condensed matter that differs from classic polymer chemistry and the use of noxious organic solvents. New materials are truly nontoxic and "green". The technologies proposed by the NANORESTART project present improved durability, non-invasiveness, long term protection and security, minimisation of environmental and human risks, feasibility and the low cost of the conservation solutions.

Important restoration workshops have already tested NANORESTORE products on prestigious artworks such as on Pollock, De Chirico and Picasso paintings (Peggy Guggenheim collection) and Roy Lichtenstein and Eva Hess artworks (Tate Modern). Products developed within the NANORESTART and the NANOFORART projects have been distributed to end-users in several European and non-European countries, with 300 institutions being regular customers of the new products. The new solutions are more affordable than the traditional methods, in terms of cost and complexity of operation to the conservators. Four trademarks have already been registered by CSGI – a spin-off of the NANOFORART and NANORESTART projects – and are now available to conservators.

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NEMOSINE

Packaging solutions based on cellulose derivative for storage and conservation of 20th century cultural heritage artefacts

Working to improve traditional storage solutions and conserve digital heritage cellulose derivatives in an affordable and effective way

A huge percentage of the recent European cultural digital heritage can be found in movies, photos, audio tapes and posters produced since 1895. Such valuable digital heritage was made using cellulose derivatives, which are now in danger to be lost, due to the natural instability of cellulose acetate (CA) and cellulose nitrate (CN) materials. The worldwide estimation of such holdings within professional film archives is around 18 Mio of film reels on cellulose acetate, with approximately 5% in a critical stage or showing signs of vinegar syndrome that can damage and destroy these valuable assets. Replication of the original material in modern digital format is extensively used to reduce the high costs related with material conservation.

The NEMOSINE project is working to enable affordable, extensive and effective material preservation of cellulose derivatives from photographs, movies and audio for private and cultural institutions. The development of active packaging (using non-odour additives), active acid absorbers (based on functionalised Metal Organic Framework integrated in low density and porous structures), gas detection sensors (based on nanotechnology to monitor the presence of dangerous chemicals and water), multi-scale modelling (to correlate degradation and sensor signals for maintenance prediction) and curative packages (containing controlled release of natural antifungal additives) has the potential to drastically improve the accessibility and effectiveness of preservation strategies for such precious digital heritage.

Estimations have showed an incredibly wide potential market of millions of users, spanning from research archives and cultural institutions to museums, collectors (public and private) and private citizens who wish to preserve their family memories.

Scan4Reco

Advanced decision support technologies for 3D digitisation and conservation of cultural heritage artefacts

Harnessing digitisation to document the condition and anticipate the deterioration of cultural heritage items

A crucial issue in the field of cultural heritage is the effective documentation of items in terms of not only their current state and condition but also the estimation of their deterioration and the prevention of any harmful effects, so that all this information is easily accessible.

The Scan4Reco solution provides the extraction of cultural heritage through automated methods using a cost-effective, modular and extendable portable device. The system is based on a modular platform for hierarchical surface scanning, able to reveal below the surface structures, material identification and stratigraphy in a non-destructive manner. The system supports mechanically-enhanced acquisition via a dedicated motorised mechanical arm. It combines techniques for 3D reconstruction and ageing simulation offering a holistic approach towards the digitisation of cultural heritage items, while also providing conservation scientists with a software to examine the deterioration process over time. Scan4Reco also provides an ageing simulation framework for forward and backward simulation.

Through Scan4Reco, a wide range of scientists, including archaeologists, historians, art restorers, IT scientists and 3D technicians can approach cultural objects from a new point of view. They will not only be able to evaluate the object's present condition, but also add information about its past while studying the future restoration needs. This low-cost solution will enable museums and galleries to make the conservation procedures accessible and effortless. Visitors will also profit from advanced virtual tours among the cultural site, allowing them to inspect heritage content through highly advanced 3D models.

SMooHS

NDT wireless system for monitoring environmental conditions impacting architectural materials

Detecting environmental risks to cultural heritage architectural sites through data-driven models and miniature sensors

Historic structures are often characterised by fine design and precious building materials. Aggressive environmental conditions trigger fast material deterioration processes, which require continuous monitoring and quick action. However, most of these monitoring systems have limited data acquisition abilities and can only implement basic models for data analysis. Therefore, the real influence of the environment to the structure or the structural material is often unaccounted for.

The SMooHS project has developed wireless monitoring systems using new miniature sensor technologies for minimally invasive installation as well as smart data processing. The technology is easy to use and completely non-destructive, with only minor visual impact on the application surface. A large variety of sensors (i.e. relative humidity, temperature, TVOC, light, UV light, air velocity, material moisture, salt content, stress, strain, vibration, and fine dust) are able to detect very diverse environmental influences and their effects in terms of deterioration and damage risk. Due to the implemented data pre-processing and the usage of real data-driven deterioration and material model's identification of risks, suitable measures for preventive conservation can be taken more easily than before.

The SMooHS technology has already been applied in several test beds (i.e. Petra's stone monuments and The Blue Tower of Bad Wimpfen, Germany), monitoring different types of deterioration processes, like salt- and moisture-led decay. The system is already exploring market opportunities, especially for cultural heritage managers and specialists. An application monitoring the quality of indoor environments is currently being explored.

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EU Research and Innovation recognises cultural heritage as a driver for sustainable development and a strategic living resource for our societies. In seizing the opportunity of the European Year of Cultural Heritage 2018, this Report presents a collection of results achieved by EU-funded projects, selected after an extensive survey including different R&I Framework Programmes.

The Report showcases not only the variety of innovations developed, but also how they can benefit different sectors of everyday life. Capitalising on these results and the rich vein of expertise, networks and communities involved in their creation is fundamental to promoting a future European cultural heritage innovation ecosystem.

Studies and reports

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