Sandro Parrinello Raffaella De Marco

editors

Digital Strategies for Endangered Cultural Heritage

FORTHCOMING INTERSPECIES

Handbook of Research on Strategies and Creative Interdisciplinarity
for the Digitization and Safeguard of Endangered Heritage

PaviaUniversityPress

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The volume consists of a critical collection of contributes presented at the International Summer School 2022 "Digital Strategies for Endangered Cultural Heritage: Forthcoming INTERSPECIES", organised at the University of Pavia, in virtual mode, from 6th to 11th September, 2022.
The event, organized by the international network INTERSPECIES and by experimental laboratory of research and didactics DAda-LAB of DICAr - Department of Civil Engineering and Architecture of University of Pavia, aims to introduce a Cross-fertilisation of Competencies among institutions and partners within the scientific fields and disciplines involved. It wants to address the necessary background for advanced strategies on safeguard policies for Cultural Heritage, thorugh the topics of digital survey, numerical computing, structural evaluation, technological intervention, restoration design, visual communication, and service marketing-
The event has provided the contribution of international experts and lecturers, from the scientific and professional sectors in the field of Cultural Heritage. The scientific coordinator of INTERSPECIES Network is Prof. Sandro Parrinello, and the scientific responsible for the organization of the Summer School is Dr. PhD. Raffaella De Marco.

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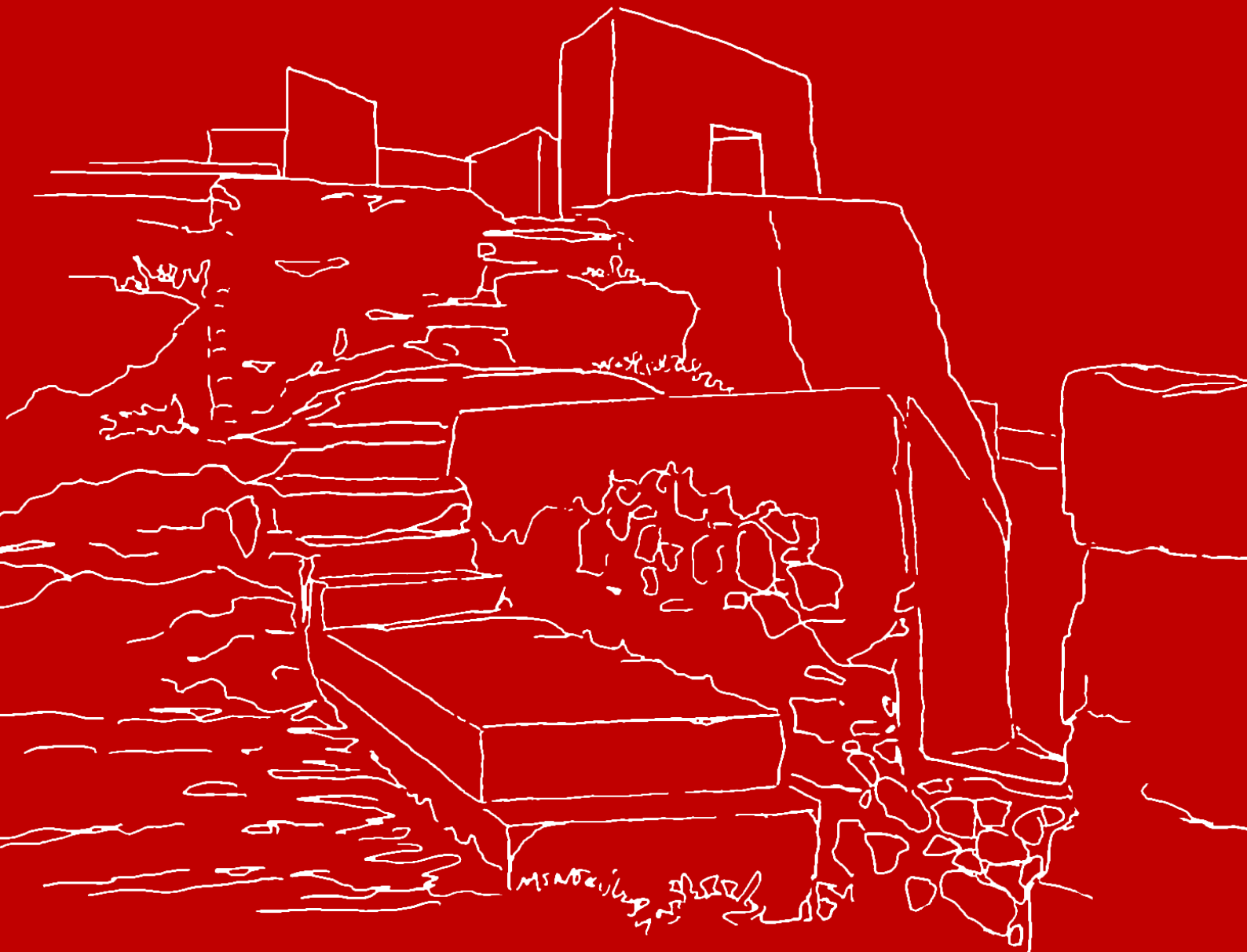

Antonella Forlino
ProRector of Internationalization
President of the CENTER FOR GLOBAL STRATEGIC ENGAGEMENT (GLOBEC), University of Pavia

The interest in Cultural Heritage emerges with increasing urgency at international debating tables, where academics are expected not only to represent but to anticipate awareness and research flows needed by the European and worldwide community. In a society increasingly fragile with respect to its geo-political, environmental, and social dynamics, the same fragility of the world's Cultural and Endangered Heritage cannot be ignored by university research and teaching.

The international arena clamours for the need to focus more and more energies and declinations of scientific language on the key pillars of Culture at the community level. The Sustainable Development Goals, as well as the 2030 Agenda, increasingly but decisively highlight the need for a less direct and sectorial approach to Cultural Heritage, which has to be transversal and multi-thematic. A choice that makes us increasingly aware of the relevance represented by each cultural site, through its physical medium, as a responsibility to forward stories, knowledge, values, and opportunities from the communities that host it to future generations, the same ones that the universities are in charge to educate and advance.

The wide participation from international countries in the 2021 Summer School "Digital Strategies for Endangered Cultural Heritage: Forthcoming INTERSPECIES", both among lecturers and participants, students, and young researchers, makes us realise the geographic breadth of interest and commitment given to the topic of Endangered Heritage, and strengthened our satisfaction as a university in supporting and making possible such workgroups. This is a call that international civil societies, cultural networks, and organisations have been making for some time, asking to stay at the forefront of existing and emerging challenges, policies, and practices, and to lead the mobilisation of the wider heritage world to address them.

Precisely in this comparison, international universities and academies cannot fail to participate and share the scientific innovation and creativity that has always accompanied and advanced sustainability to global issues, involving students, researchers, and tomorrow's professionals in a unique and heartfelt way.

"*Young people are the messages we send to a world we will never see. It is not them who climb on our shoulders, it is us who climb on theirs, to foresee things we will never have the chance to experience.*" (R. Piano). To them, then, our greatest efforts and commitments for sustaining an international dialogue, with the wish to act as increasingly aware citizens of our society and our World Heritage.

Alessandro Reali
Dean of DICAr - Department of Civil Engineering and Architecture
University of Pavia

The interdisciplinarity of knowledge is central in an academic context such as that of Engineering, where it is precisely the '*ingenium*' (that is also the root for the Italian word "*Ingegneria*", i.e., Engineering) to be cultivated and placed at the service of problems and challenges that our society, in a continuously dynamic and updating manner, is facing. The major global crises of recent years, from energy-climate problems to wars, show us the necessity to collect and share different but still valid visions of the same issues of global perception, which can constitute the basis to develop and enable functional solutions for the community.

For this purpose, it is the dialogue and commitment to interdisciplinary exchange launched by our researchers, first and foremost, that sets an encouraging example in the scientific community. In a 'digital' era where we feel able to break down any space-time barriers in connecting people and cultures, we discover precisely in the 'digital' world a variety of languages, terms, and processes that seem to differentiate research fields. Indeed, it is enough to have opportunities for dialogue and discussion, even within the physical limits of the pandemic, to discover that the 'byte' datum still astonishes with infinite opportunities for declination and sharing between disciplines such as those of architectural surveying, numerical simulation, virtualization, and narrative communication up to the fields of economics, social sciences, and service marketing.

The Department of Civil Engineering and Architecture of the University of Pavia, in organizing and coordinating the 2021 Summer School "Digital Strategies for Endangered Cultural Heritage: Forthcoming INTERSPECIES", once again demonstrated the curiosity of its researchers, experts, and young students, to go beyond the sectorial exchange of knowledge and stimulate creative dialogues on topics of common sensitivity, such as Endangered Heritage. This initiative was shared, with great satisfaction, by a large arena of international scientists and lecturers, who gave a fundamental contribution with their willingness to participate and cultivate exactly that creative dialogue necessary for the successful application of that '*ingenium*' that is at the basis of Engineering and problem-solving. Our greatest gratitude as Department and University is for them.

We also wish the best for the development of their research and careers to the organizers of the event, all participants, and the students who were able to enrich the scientific dialogue. We are sure that they will be able to continue growing and fertilizing their interdisciplinary knowledge, contributing to the enhancement of our academic excellence.

Frank Marx
Deputy Head of Unit
Unit REA.A.1. Marie Skłodowska-Curie - Innovative Training Networks

The European Union observes and supports with commitment the efforts to encourage more young women and men to make a career in research. Attention is dedicated to promoting youths' attractiveness for scientific purposes. In this way, a horizon of wider opportunities to reintegrate new knowledge and advances in the future of society is pursued.

Main topics of development emerge considering training and experience challenges. It is possible to support high levels of training for young people, who are engaged in advancement and specialisation studies. In the same way, the construction of interdisciplinary dialogue and scientific commitment is encouraged between researchers. The aim is to support their development and positive impact as both new individual scientists and professionals.

The Marie Skłodowska-Curie Actions programme is proud to represent the European reference for doctoral education and postdoctoral training. Its contribution to increasing the quality of researchers' training and supervision offered has been proven. It is with pleasure that we follow the development of researchers who have or are benefiting from the programme, both experienced and young. Their stories of passion and willingness show an opportunity to become in turn catalysts of impact and training for new generations.

We take this opportunity to recall how the new Horizon Europe framework programme (2021-2027) has ambitiously renewed its intentions to support research and innovation. Increasing resources from the Next Generation EU recovery plan have also been included. It is hoped that this support will increasingly find applicability in building partnerships between universities, research institutions and research infrastructures. The involvement of other socio-economic actors and parties from different countries across Europe and beyond is also welcomed.

Scientific networks are increasingly showing their willingness to engage in interdisciplinary dialogue and exchange. Their definition is seen by the MSCA programme as a guiding force for responding to well-identified needs in various R&I areas. It actualizes a way to expose researchers to the academic and non-academic sectors and to offer training in research-related, as well as transferable skills and competencies. These practices are relevant for both societal innovation and long-term employability.

We hope that scientific involvement and individual creativity can find more and more space and acceptance among the young and established generations. It prospects an effort to work towards a strong and lasting impact of research in support of the issues, crises, and priorities for which the European Union is committed to progress.

PREFACE

Endangered Heritage and the Digital Practice: an Overcoming Challenge of Interdisciplinarity and Creativity

Sandro Parrinello, Raffaella De Marco
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Contemporary society is embroiled in multiple challenges concerning the stratified Heritage context, which continues to coexist and host the main societal and environmental mechanisms despite the territorial and infrastructural changes. From climatic variations to armed conflict frameworks, Cultural Heritage faces the context of a 'floating' landscape, highlighting all its physical fragility along with the resilience of its values.
In this way, the recognition of an Endangered Heritage becomes more relevant in this updated panorama, as much as the definition of its specific field of interest comes more complex within the dynamic changes of the communities and territories.
The term 'Endangered' has been introduced focusing on the univocal existence of associated 'dangers', assessed for Heritage objects and assets that become potentially threatened by unplanned alterations (World Heritage Convention, 'List of World Heritage in Danger', 1972). Despite this fact, after 50 years, the classification between 'ascertained' and 'potential' dangers still remains the only statement defined regarding this category of Heritage, involving all the criticalities and uncertainties entailed in the recognition of a specific 'endangered' identity and in the integration of suitable instruments for its related practices.
The first critical aspect regarding the classification of an Endangered Heritage system immediately concerns the extreme variety of tangible Heritage. Even limiting its discussion in the European context, it comprises the inclusion of a wide field of features, considering the involved mechanisms through history, identity, and policy sectors which can be related to the endangered framework of observation.
Within the last UNESCO 'Recommendations' (2011-2015), national and local sources have highlighted their unstable effort on expected Cultural Heritage processes, lacking the support of updated inventories and reliable provisional models to put in action management plans and conservation mechanisms. This requires a multi-disciplinary mandatory purpose to review the integration and interchange of technological, cultural, and social strategies.
Concerning physical sites, the extension of Built Heritage, from single buildings and monuments to wider historical centres and cross-national landscapes, faces a wide variety of scientific and professional expertise.
Practical applications extend to the static safety of structures, analysis of historical materials and technological compatibility of intervention, concerning the integrity of the site with respect to conservation conditions. At the same time, the technical aspect is combined with the cultural reflection expressed on the aesthetic, ethical and historical instances of the representation of monuments and structures with respect to the values of the cultural framework of the heritage location. Despite its relevance as a museum, city, or ruined landscape, the relationship between Endangered Heritage objects and context must consider the social

Fig. 1 International cases of Cultural Heritage sites affected by hazards and damage conditions, triggering an endangering process at different scales, effects and self-increasing conditions. From top left: Cathedral of the Exaltation of the Holy Cross, Solikamsk in Upper Kama (Russia, 2020), in the seasonal rising conditions of the Kama River reservoir; Church of Santa Maria del Suffragio, L'Aquila (Italy), following the 2016 earthquake sequence; Church of the Annunciation of the Blessed Virgin, Pokcha in Upper Kama (Russia, 2018), ruins surviving collapse from thunderstorm event attracted by conversion into an industrial site; medieval Civic Tower, Pavia (Italy), structural collapse and damage in 1989; historic centre of Nicosia (Cyprus-Turkey, 2018), historic buildings in ruins following the events of geo-political occupation and abandonment of the city; Notre Dame de Paris (France), damage and roof collapse following accidental fire in 2019. Photos from the web.

background of the communities assigned to receive and preserve the artefact. They are the social party involved to apply and maintain management and economic policies, often in terms of uncertain planning, that link back their applicability and impact on the character of preservation of the integrity of the heritage.

Considering the risk and danger assets affecting different scales of Cultural Heritage and its values (World Heritage Convention, 'Operational Guidelines', 1972, par. 179-180; ICCROM, 'Endangered Heritage: Emergency Evacuation of Heritage Collections', 2016), the second critical aspect regards a vague and uncertain workflow defined on the preservation perspectives for Endangered Cultural Heritage. A systematic recognition program on Endangered Heritage is still missing, although the background for its emerging topic has been already achieved in the new millennium (Council of Europe Parliamentary Assembly, 'Europe's endangered heritage - Recommendation 2038', 2014).

The absence of a dedicated knowledge structure on the integrity of configurations, quantified risk characters, and cultural resilience (specified through coherence, authenticity, and significance statements) in endangered conditions deeply affects the quality of development of creative pipelines for intervention and preservation purposes. The monitoring action of Endangered Cultural Heritage sites actually concerns unidentified knowledge parameters influencing its reliability in territorial mapping, which deeply affect the time and impact of intervention actions.
The European committees involved in Cultural Heritage protection (above the main ones, World Heritage Committee, ICOMOS, IUCN, ICCROM, and local national Heritage offices) coherently agree on the necessity of adopting a shared best practice for continuous action of assistance and scanning of Endangered sites conditions. Although the development of an Information System of reliable data for the State of Conservation of World Heritage properties (World Heritage, 'SOC', 1979) has increased in the last 20 years, the mapping of Endangered Cultural Heritage sites (UNESCO, 'List of World Heritage in Danger', 1972-on course) is still fragmented and does not correspond to the local and public domain highlighted by communities. In this way,

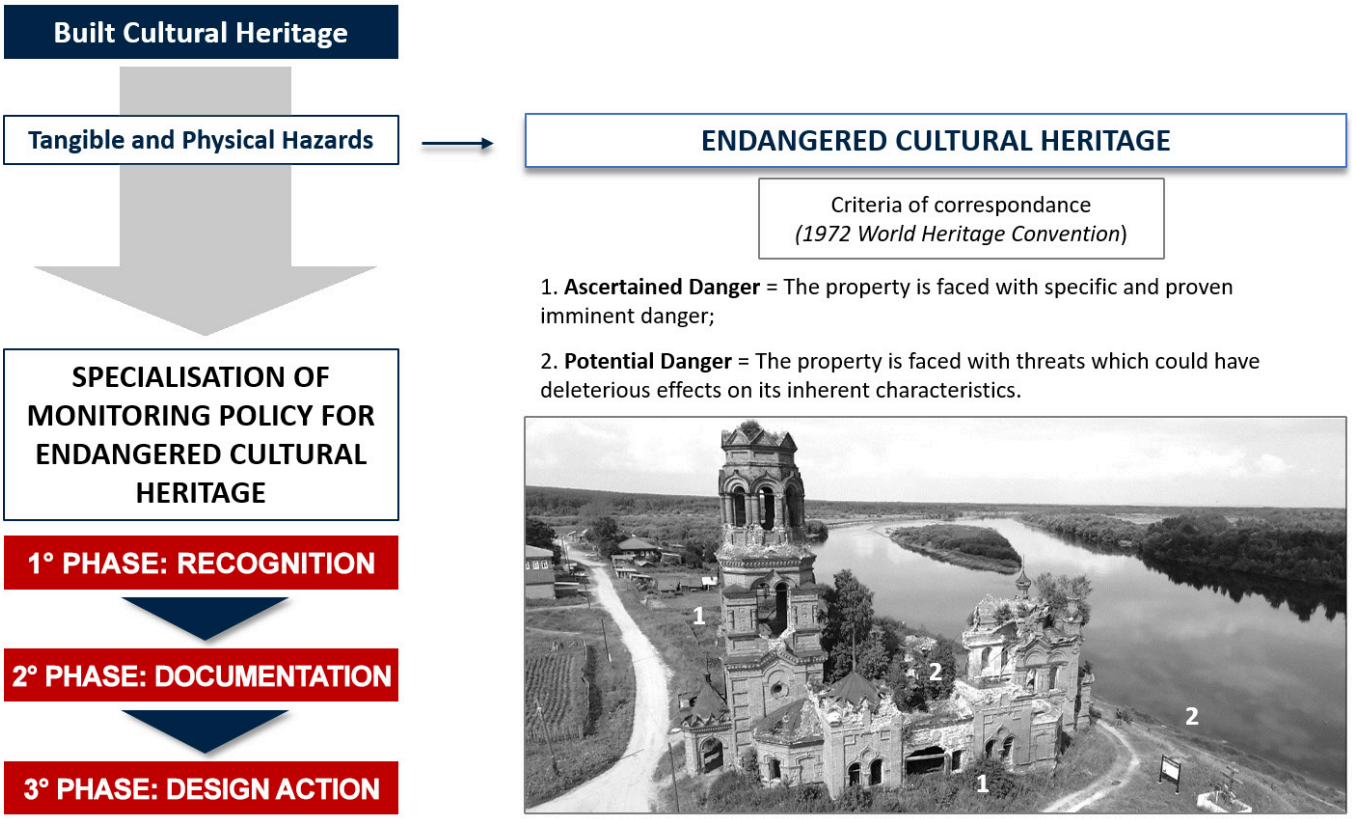


Fig. 2 Preliminary process of Endangered Heritage research: from the recognition of endangered conditions to the triggering of intervention.

the support of recognised voices of civil society (Europa Nostra, '7-Most-Endangered programme', 2014) to catalyse action and raise awareness from the public attention has encouraged to evaluate not only the physical sites' conditions but also the cultural weakness of their contexts and the preservation of connected social identities. Although their commitments to safeguarding and promoting cultural and natural heritage, their variable statistics of monitoring are highlighting a lack in the disposal of scientific-technical indicators on Endangered Cultural Heritage assets' documentation, a missing correspondence between interventions and reality-based analysis on sites, and a scarce awareness of social constraints between Endangered Cultural Heritage and conservation services.

The result is the incompleteness and, consequently, the invalidity of monitoring reports on the real framework of Endangered Cultural Heritage sites and their conservation emergency, due to the missing of interdisciplinary skilled and trained figures able to cover scientific and professional roles with an integrated knowledge of Cultural Heritage in the digital era.

In this context, the challenged compatibility of Technological and Social Sciences is claimed to reach an overall global scheme regarding the research field on Endangered Cultural Heritage. The progress of

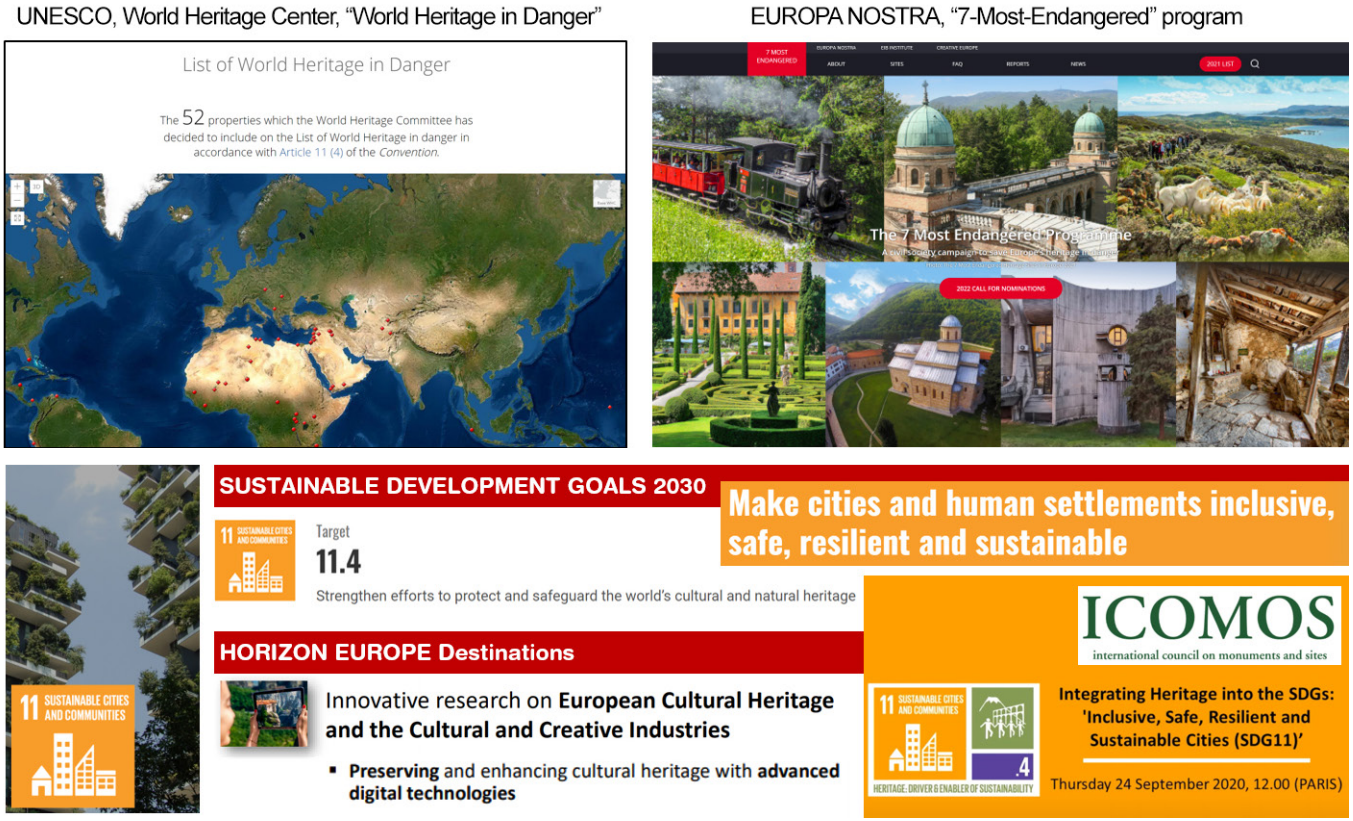


Fig. 3 Overview on the international panorama of interest and awareness of the conservation and sustainability conditions of Endangered Heritage: UNESCO, Europa Nostra, SDGs structure and Horizon Europe 2021-2027 declinations.

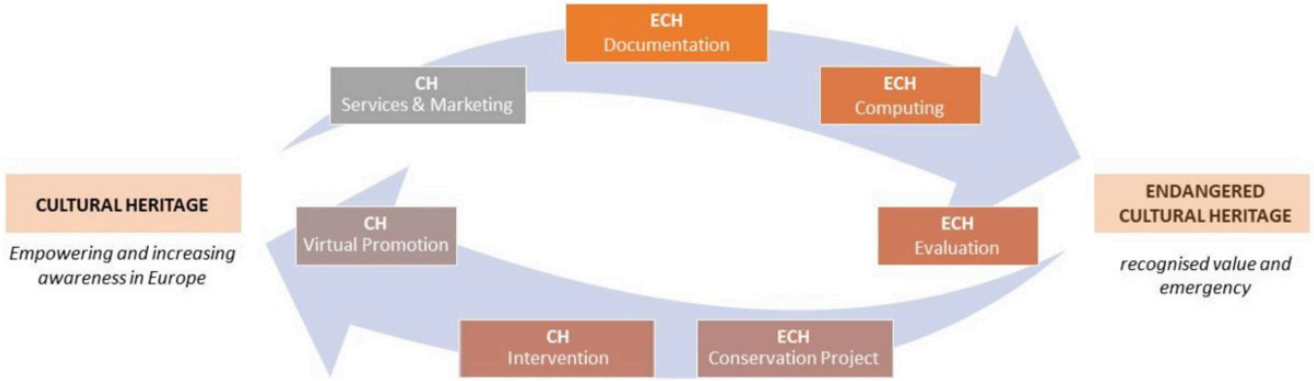


Fig. 4, Fig. 5 Scientific disciplines, aim and topics for a joint educational contribution on the Endangered Cultural Heritage (ECH) awareness and recognition process on Cultural Heritage (CH) assets, as proposed by the INTERSPECIES network.

digital skills and ICT practices has moved, in the area of Cultural Heritage, all forms of documentation systems towards the realization of digital platforms, useful for the development of new methodological protocols, and the comparison of heterogeneous information.
In recent years, the increase of databases regarding cultural assets has marked the creation of numerous libraries and archiving systems. A crucial starting point regards digital databases, which are advanced to assume complex forms, considering also 3D visual forms, and to interact with different kinds of data and information, including representation systems of space and web-designed communication structures. As a result, the main critical issues are both: linguistic/cultural, where the digital data not only involves lexical communication but also defines the forms for the representation models; technological, where ICT technology, web-graphic, drawing and different engineering and digital humanities solutions for communication shall find a proper way to interact, in order to unify languages of digital nature.
It is necessary to point out the representative nature of the resulting digital models on Cultural Heritage, validating a methodological path to lead them as essential communication and management systems specifically for Endangered

INTERSPECIES

INTERSPECIES Network aims to introduce a Cross-fertilisation of Competencies to address the necessary background for advanced strategies on safeguard policies for Cultural Heritage, considering research integration among:

- CH Survey and digital documentation
- CH Numerical Simulation and risk modelling
- CH Structural Damages and security prevention
- CH Constructive Technologies and historical materials
- CH Restoration Planning and Conservation theories
- CH 3D Visualization and virtual fruition assets
- CH Marketing, Conservation and Management services

Heritage. This purpose collects the aims of reliable Cultural Heritage data sources to reach new methods of shape analysis and diagnostic computing for technical communication, enabling direct simulation and conservation predictions.
This topic relates to the challenges of EU high-level education, where the fragmented interdisciplinarity between technical and social approaches to Endangered Cultural Heritage emerges. In this way, it originates the vision for a new training challenge addressed to integrated professionals-researchers, as an INTERSPECIES

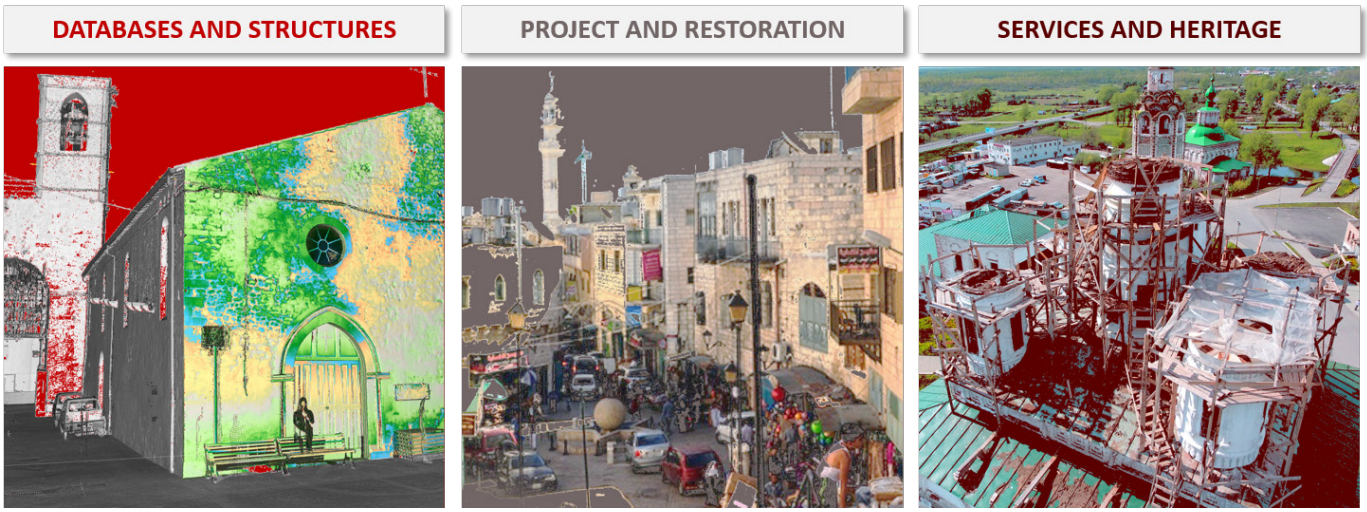


Fig. 6 Thematic Challenges (TCH) proposed by the INTERSPECIES network for interdisciplinary scientific coordination on the topic of Endangered Heritage: key topics and recognition of the challenges among the overall structure of the Summer School and scientific presentations.

(INnovaTivE tRaining of SPECialized figures for Endangered heritage Safeguard) challenge, aimed to combine wide Cultural Heritage competencies into integrated multi-source digital models, to be adopted as a basis for effective intervention projects and services.
Based on this aim, the INTERSPECIES network of European universities, since 2020, has based an attempt at interdisciplinary dialogue on cross-sectoral scientific and methodological applications focused on the common theme of Endangered Heritage, addressed through perspectives of digital applications in the various fields. Converging the respective reports between Information-Computing Technologies and Social Sciences, the network has defined the aim to review and implement the perspective on Endangered Cultural Heritage protection, starting from the European one, combining the high impact of digital technologies to the key purposes of Cultural Heritage interdisciplinary studies.
The network has projected to cover a creative innovation potential on Endangered Heritage study through 7 main goals:

1. fast mapping and control of Endangered Cultural Heritage sites;
2. non-invasive diagnostics and facilities design for Endangered Cultural Heritage intervention;
3. collaborative management on intervention project cycles;
4. societal and marketing growing perception of Endangered Cultural Heritage sustainability;
5. promotion of widespread Endangered Cultural Heritage knowledge through fruition tools;
6. compatibility and investment in sustainable resources on Endangered Cultural Heritage;
7. reveal of cross-potentialities for Endangered Cultural Heritage sites towards territorial governance and Cultural Heritage policies.

To pursue these goals, INTERSPECIES team proposes to define a leading structure of the scientific dialogue on Endangered Cultural Heritage through targets of Safety, Conservation and Valorisation, structuring the correspondence of 3 Thematic Challenges.

Thematic Challenges are intended to constitute the conceptual basis for the renovation of joint training programs, and for their integration into the overall research-related scheme.

Thematic Challenge 1: DATABASES AND STRUCTURES (Safety)

It focuses on the physical simulation of damage qualities of sites into digital structures, to identify elements, conditions, and timeliness of emergency for Endangered Cultural Heritage provisions of safety and preservation. Its challenge objective regards the incorporation of integrity and strength evaluations from Cultural Heritage Digital Survey strategies, enhancing the reliability and potential of documentation for Endangered Cultural Heritage safety from structural instabilities and conservation policies. Reliable diagnosis for historical structures and sites would be optimized by architectural reality-based databases and models on conservation systems.

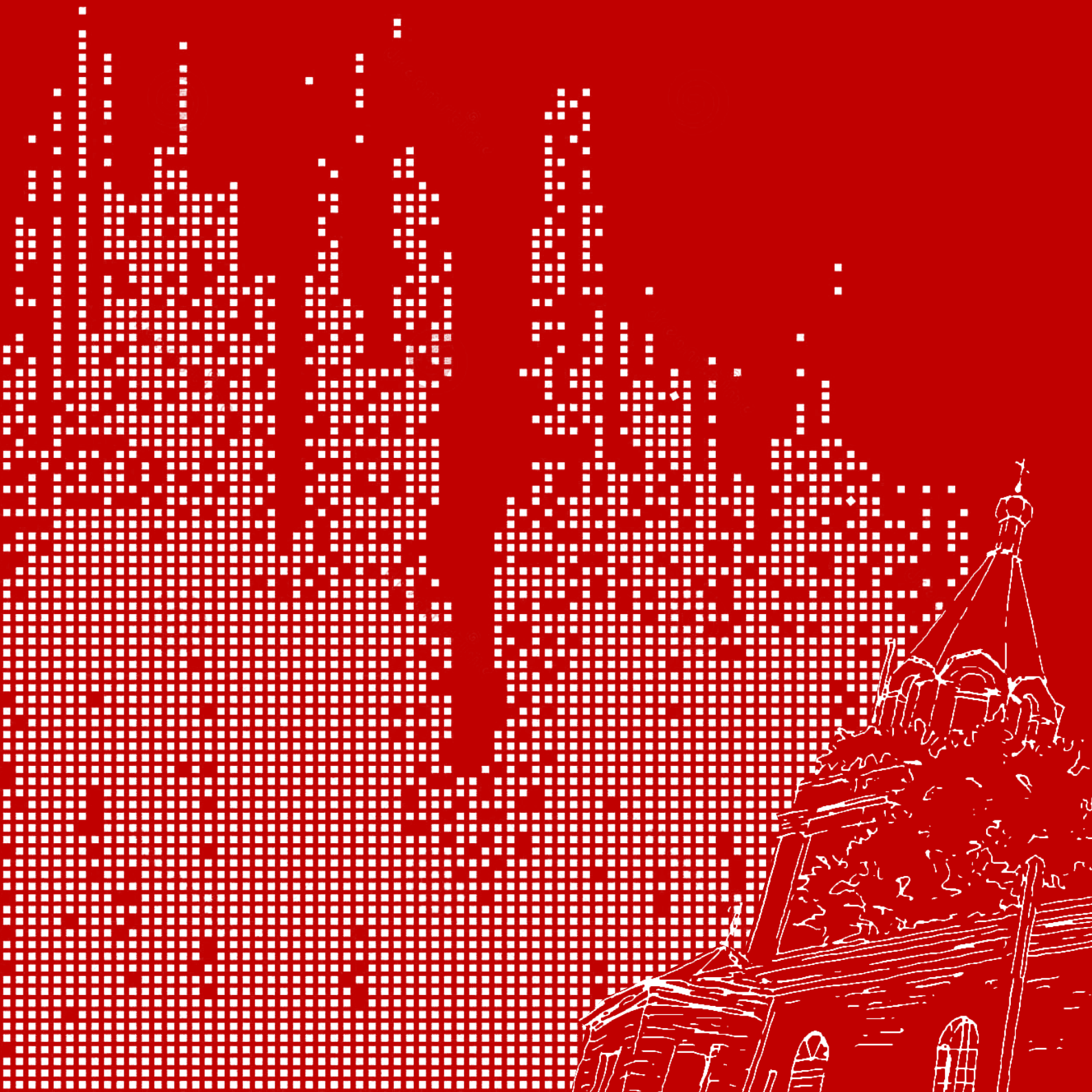
Thematic Challenge 2: PROJECT AND RESTORATION (Conservation)

It focuses on information flowcharts, geometrics, and semantics for technological, restoration and design data, to enable coordination between Endangered Cultural Heritage conservation theories and intervention practices. Its challenge objective regards the contextualization of restoration practices on Endangered Cultural Heritage conservation and functional requirements, in terms of emergency control and preservation of cultural value, to guide the technological and managerial strategy of intervention projects. It would result in an expected entrepreneurial scientific leadership to combine technical skills and services on constructive solutions, materials, and resource plans, practically orienting the Cultural Heritage preservation chain.

Thematic Challenge 3: SERVICES AND HERITAGE (Valorisation)

It focuses on the visual and communicative support necessary to provide tangibility for Endangered Cultural Heritage knowledge and services within socio-economic purposes and the applicability of benefits and enhancement actions for Cultural Heritage management. Its challenge objective regards the identification of correlations between heritage values and Cultural Heritage conservation services, to enhance Endangered Cultural Heritage valorisation and to strengthen the contribution of operators and providers on their territorial heritage identity and expected services. It results in an improvement of socio-cultural and marketing-based strategies to better link research to outsourcing products and benefits, adopting ICT, Visual repositories and dissemination of digital models to improve Cultural Heritage policy/benefit.

It is within this perspective that the Summer School 2021 'Digital Strategies for Endangered Cultural Heritage: Forthcoming INTERSPECIES' has aimed to introduce a scientific table for sharing international experiences and applications, related to case studies of Endangered Heritage or related conditions. The extended Chapters, presented by professors and researchers invited to contribute to the Summer School's Open Lectures programme, provide a wide dynamic framework of applied examples and research studies on Cultural Heritage, through which the correspondence to INTERSPECIES Thematic Challenges is confirmed.
Specific projects' declinations aimed at qualifying risks and emergency frameworks on Cultural Heritage are presented, for which the character of interdisciplinarity emerges as a principle of maturity and sensitivity to the European and global projections of documentation, project and preservation of Endangered Heritage, reinforcing the purposes advanced by the network with wide creativity of dialogue and didactic application.



CHAPTERS

THEMATIC CHALLENGE 1
DATABASES AND STRUCTURES

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Since 2012 he has been visiting professor at Perm National Research Polytechnic University (Russia) and in 2015 he received an honorary degree from the State Academy of Civil Engineering and Architecture in Odessa (Ukraine). In 2011 he was appointed Expert and Voting member as referent for Italy to the international scientific committee ICOFORT (ICOMOS International Scientific Committee on Fortifications and Military Heritage). In 2016 he was Visiting Professor at Cracow Polytechnic University (Poland) and in 2017 he obtained the National Scientific Qualification as First Level Professor.
He is director of "DAda-LAB." laboratory and of the joint laboratory "Landscape Survey & Design" at the University of Pavia. He is responsible for numerous national and international research projects, member of editorial committees of international scientific series and journals and he has organized numerous international conferences on the subject of heritage documentation.

Abstract
Cultural attitudes characterise research concerning heritage documentation. Documentation procedures involving architectural and landscape heritage assets, also from World Heritage sites, are assumed for a conceptual discussion on the digital-virtual applications, supported by a report of technical elaborates from digital survey actions. These elaborates, viewed in their complexity, are intended to provide an explicative framework of key qualities and characteristics that can be discussed through research to configure a determined system for heritage representation.
The documentation corpus provided by research, aimed at the documentation of historical and architectural heritage sites, is configured as a set of metadata, models, drawings, media, databases, and texts, which are oriented to explain certain mechanisms of information fruition. These mechanisms are activated to reconnect the digital outcomes to the needs of virtual representation.

Keywords
Digital drawing, Digital survey, Cultural heritage databases, Virtual model, Digital communication.

01

Experiences and Strategies of Digital Survey: Drawing Assumptions and Virtual Developments

Documentation and Communication

Although digital technologies have changed the representation mechanics and intrinsic values of heritage over the last few years, fundamental concepts have been based concerning the sciences involved in a heritage documentation process. Firstly, the main concepts related to Drawing and Surveying have remained completely unchanged, despite technological advances.
Therefore, in defining the most appropriate documentation and digital survey strategies, specific updated methodologies have been developed to collect meaningful data, then trying to outline a form and structure to the same data in response to the needs assessment for Cultural Heritage knowledge.
The scientific issue in drawing, aside from technical complications, can be simplistically referred to as a problem of communication, more or less simplified, of analysis procedures, more or less correct.
"*It is impossible to not communicate*" as Bateson and the Palo Alto group remind us in their theories (Bateson, 1977; Bateson, 1984), and it is through the communication process that networks of relationships for connection and interconnection of data are developed. This communication process is not only active, referring to the systemic paradigm between individuals, but it concerns the continuous flow of inputs that connects people to objects. In this sense, architecture, environments, spaces and, even more, Cultural Heritage objects, are participants in the communicative dialogue and the process of interaction. It is through this discourse with the 'place' (Hall, 1968) that the paradigm of inhabiting is defined, and forms of connection and cultural dialogue through physical heritage are made possible.
In the age of the digital revolution, the main question relates to how forms, images, data, and metadata, by a multimedia nature, can move the cultural dialogue, especially related to Cultural Heritage objects, and change its constituent syntaxes and paradigms.
At least, the Drawing is established on this dialogue, and it uses digital language to elaborate a critical thought that actualizes signs and forms. Therefore, the problem of the cultural interpretation of languages is addressed from another perspective regarding drawing (Ciastellardi, 2009).
If the drawing deals with a Cultural Heritage object, relating to an object developed from a cultural process such as architecture, decorations and models from the past, a higher level of entropy in the communication of heritage contents is introduced, and it increases the uniqueness of the message.
The drawing, which is intended to describe a certain complexity, becomes a critically simplified copy of the heritage object, capable of communicating specific relationships of the cultural system to which the object refers. In the drafting of signs, traits and language that explicates some of the Cultural Heritage object's meanings, a process of memorization is then made explicit. It is therefore an issue of defining languages so that communication processes are activated, and memorization actions are qualified. This phase takes place through a dual synergy within the drawing: considering

Fig. 1 Digital survey of a 'canniccio' vault and its wooden structure in the Uffizi museum complex. Photographic survey (left) and 3D point cloud views (right).

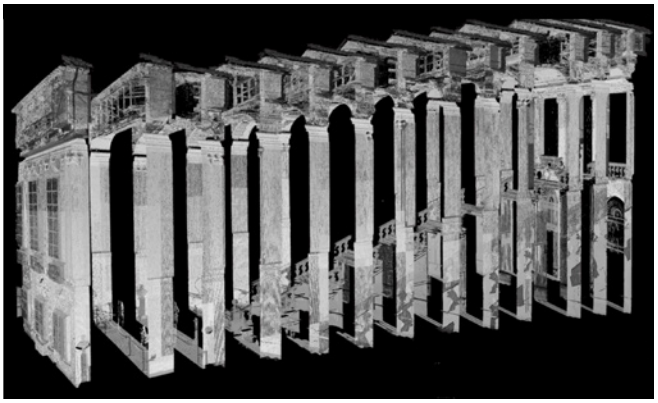


Fig. 2 Digital survey offers the possibility of processing 'n' sections of the vault, defined by extrados and intradox, to understand its morphometric characteristics and analyse the deformations undergone by the structural system.

it as an experience, thus as a perception memory, and as a document, constituting a narrative memory.
Reproducing a Cultural Heritage object requires establishing a multitude of dialogues, with the object, with the author of the object, with the space in which the object is experienced, and with the user of the object or site. Drawing an architectural object, therefore, goes beyond the simple concept of reproduction, or copying. Drawing, by its own definition, allows for an interpretation, simplification of forms, or even a transformation of meanings to create, from a physical object, something 'more'.
It regards a path of knowledge based on drawing, in which an attitude to material and physical knowledge of landscapes and Cultural Heritage objects is approached in an analysis of forms and processes of measurement. It is therefore a comparative process, more cultural than strictly dimensional, of recognizing morphometric qualities in relation to measurement units.
The drawing reproduction does not aspire to be a fruitless copy: it comes from a communication between the drawer and the heritage object where the drawer tries to establish a dialogue with the object to elaborate the related system of signs. The drawing intends to contribute to the specific analysis, enhancing the forms that characterise the drawn figures and decorations. Therefore, the drawing sets graphic limits that segment the continuous reality, whereas not already established.
If a digital drawing represents a heritage object, it is relevant to consider two aspects for its methodological interpretation: it is necessary to evaluate the more complete cultural and historical framework in which the drawing is formed, also assuming the goals and the purpose of the digital activities, and to evaluate the nature of the digital drawing itself, considered as a database.
It is evident that an overall documentation procedure can only establish and constitute databases of different natures that jointly dialogue themselves. Even if based on comparative and analytical activities, the process is aimed at reproducing forms, proportions, and models in a digital language, creating files that can be interconnected

through several software (Parrinello & Picchio, 2017). Therefore, the process of creating a cognitive database on Cultural Heritage is a fundamental step in the definition of memory on Built Heritage (Parrinello et al., 2018).
Referring to the issue of memory related to the 'digital' or 'real' asset, comparative practices are rarely defined through linear continuity. A recursive logical-temporal development is adopted, composed of recall, re-proposition, remembrance or reflection, rapid analogy, etc. (Hofstadter, 1990).
In this way, the communication meaning is mixed with the meanings of knowledge and data archiving. It concerns how a certain form of knowledge and archiving could or should be represented, acknowledging the limits of digital methods and tools concerning representation, which even being symbolic also brings limits to the fundamental assignment of meaning.
Through architectural digital surveying, it is possible to obtain reliable models, in terms of metric data, aimed to duplicate the heritage object or environment under investigation. From these 'twins', it becomes possible to develop multiple studies and analyses, and digital simulations to control the development of conservation realities for the heritage object, predicting activities of design, monitoring, restoration, or enhancement.
However, instrumental reliability comes to relate with metrical accuracy, and then to the simplified reproduction of digital geometries and shapes from real measures. This topic, central to the science of architectural representation, could be elaborated in a 'qualification', rather than a 'quantification', of digital models.
Every phase of the modelling process is characterised by a tension that concerns the approximation of the form, and the definition of the limit in the processing of digital survey data. Discretisation, selection, and systematisation of the wide amount of acquired digital data (with a standard superficial density range of 1-10 mm) are procedures aimed at simplifying the digital model. This simplification of forms gives the digital model a simplicity to the

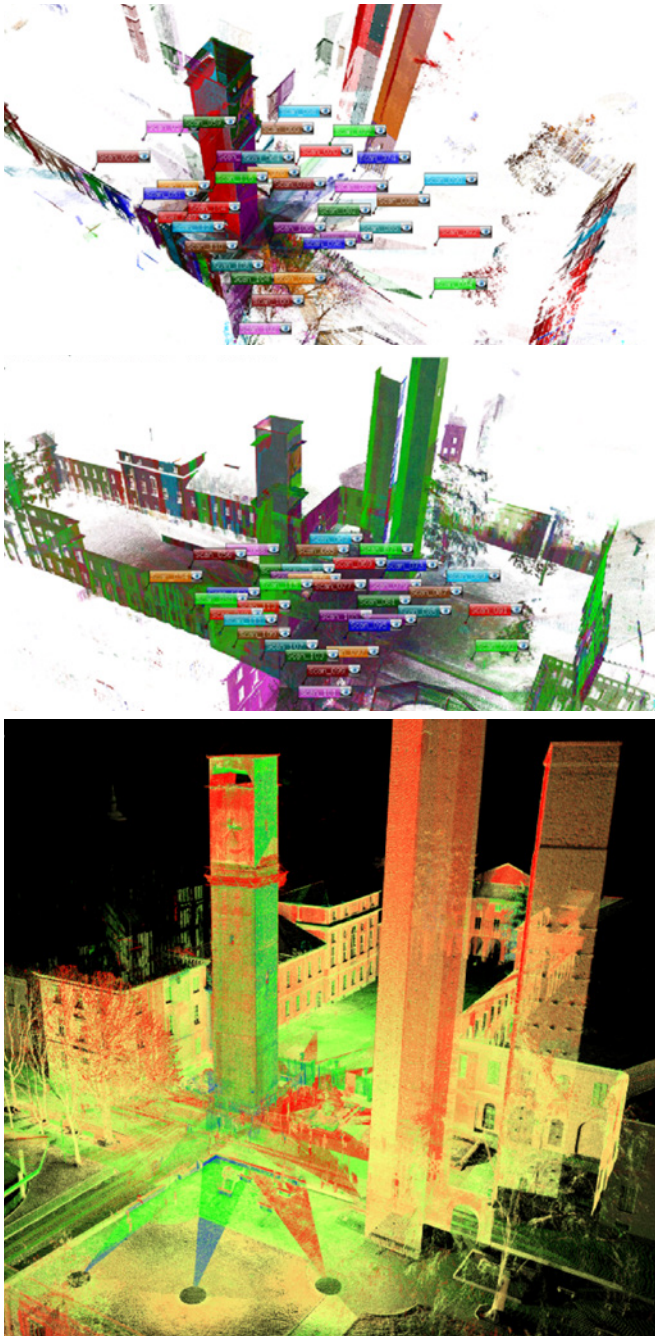


Fig. 3 Digital survey of a mediaeval tower in the historic centre of Pavia, processed in order to understand the deformations of the masonry apparatus.

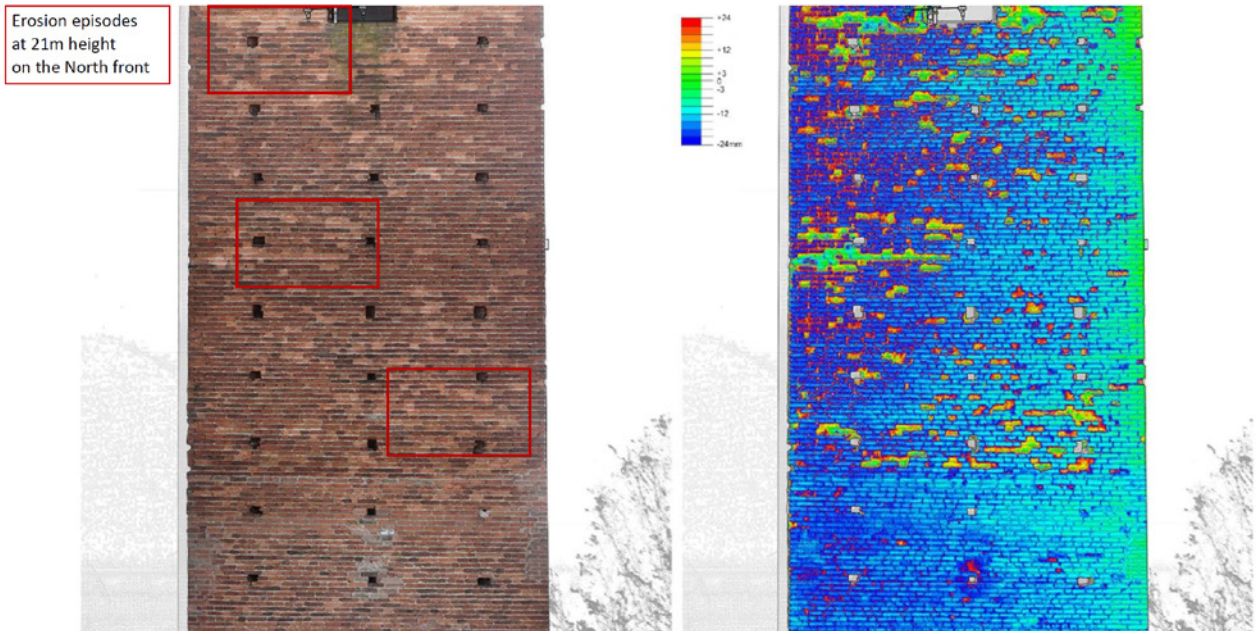


Fig. 4 Detail of the orthophoto from the tower survey and analysis conducted with elevation map on the laser scanner point cloud, to identify missing bricks and states of erosion in the masonry on the structural front.

Fig. 5 Collapse of the Civic Tower of Pavia in1989. The absence of monitoring activities on the historical structure did not evidenced the crak conditions and damages.

advantage of its interconnectivity, which makes it an aid to the assignment of knowledge contents precisely because, in some way, it is incomplete.
The focus of this chapter, which emphasises the practical and applied aspects of digital survey practices, concerns communication, memorisation, comparison, and knowledge of digital products, through a series of references and recurrences based on the nature of the different models obtained.

Preserving memory through digital databases

The issue of digital databases, nowadays, can relate to many topics. In this chapter, its declination to the means of digital drawing is considered, and it is related to the development of complex models as archives and graphic supports of a multiplicity of systematised information which generates the so-called 'information systems'.
However, the connection between the information system of an architectural object, or a city, and the connotation of a digital twin is not automatic. The virtual representation of a complex system, such as an architecture, must be able to exchange data and information between real and digital in both synchronous and asynchronous modes, in order to configure itself for functional purposes.
As in the metaphor of the portrait of Dorian Gray, the virtual simulacrum fulfils specific functions with respect to the real. In the story, Dorian Gray keeps himself young by delegating the task of ageing to his 'model', the painting. Similarly, through digital twins, heritage objects and sites, architecture, and society are kept efficient and resilient, and they can activate processes that increase their value over time.
A parallel consideration that highlights the real goal of a documentation process. Documentation is performed to preserve memory, to determine images that will survive the changes of time, to update languages and to govern the transformation processes themselves.
Representing a given architectural complexity is a necessary practice to initiate design considerations. In this sense, representing complexity in Cultural Heritage becomes a mechanism in which the many signifying relationships that exist in a specified context are ordered. Therefore, attention will be paid both to the relationships in Cultural Heritage and to their influencing factors, analysing what can be relevant to highlight a specific relationship. Also, the heritage context is analysed, interpreting it as an overview of the specific relationships. The information model is assumed as the result of these analyses. It becomes a model since it simplifies, abstracts, and determines a specific system in which it explicitly displays discrete information.
When the heritage object regards a city, or in any case a space that transcends the dimension of the single architectural complex, intended as a singular entity, it is necessary to introduce landscape as a term of reference. Landscape and territory are two domains on which any consideration of the city is based. The first includes not only cultural, social, and emotional connotations but also those connected with the historical sedimentation of procedures that determine the construction episodes and their alteration over time. The second includes notions of space and, more specifically, those that depend on a precise position and the geographical connotation of the place.
It immediately emerges how the attempt to simplify and order the characteristics of a heritage place is itself a very delicate operation. This process might easily lose something significant, erase or omit certain information that might instead be necessary.
Research practices are particularly aware of this pressure when the knowledge synthesis transmission does not concern the development of an analogue cultural product, but rather a digital system.
From a methodological point of view, the digital practice still deals with critical syntheses, as well as with the development of designs and narrative languages and models. However, its present digital potential, even at the media level, changes the extent of this practice.
The impression is that the digital transmission of signs,

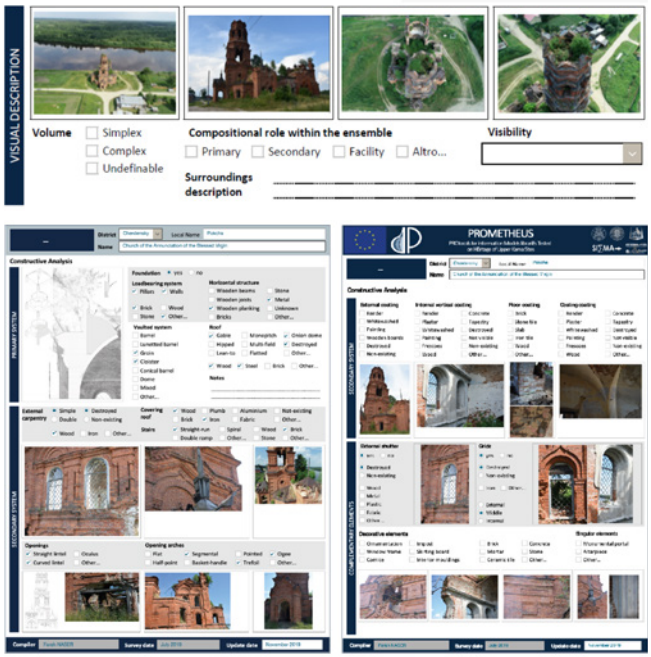


Fig. 6 The creation of heritage censuses, aimed at collecting qualitative data on the technological and historical components of architecture, produces databases that can be interconnected with models and drawings. The archiving of digital data is thus structured on numerous levels, giving rise to a 'network', similar to a neural network, of interconnected data stored in different database containers.

languages, gestures and grammar that shapes the life of a given place can, even guarantee or at least attempt, to initiate a memory preservation process. Today, the development of a digital documentation system means giving the history of the digitalised object a chance to survive. Just as for the wide public and private archives, which conserve past memories and which, if not digitized, risk being lost and forgotten, any cultural phenomenon must start thinking about its digital double, its digital existence, if it wants to avoid forgetfulness of its real existence.
This is the responsibility of our times when faced with sudden social transformations: to wonder about what will survive and how based on the cultural traditions that are transmitted over the centuries.

In the many projects promoted by the DAda-LAB Research Laboratory of the University of Pavia, conducted in recent years, the theme of memory preservation on heritage objects has been central. If the apparent objective was to generate a tool to organize a planning praxis, to define the future of heritage objects, monuments and cities subjected to maintenance and restoration plans, it should still be highlighted the core analysis of past relations to undertake the correct path of knowledge towards the future.
That is the reason why, despite technical tasks, every survey action that is undertaken, from the acquisition of data to its systematisation, synthesis and redrawing, is aimed at the protection of memory.
The systematisation of data and information, however, inevitably results in a loss of memory. Both in the updating of monitoring techniques on buildings and in the construction of a digital prototype of the city, which is functional in mapping the existing and the reference to each property, it was not possible to document everything. 'Whole' documentation, by its definition, is impossible.
The attempt to transfer processes, relations and information into databases, and to build data and databases where the former are organised, requires a particular documentation dialogue with the heritage place aimed at determining its core knowledge.
If the drawing is the main vector of this cognitive process, it is worth noting that, like any form of dialogue, it must be based on a common grammar on which to support the different considerations.
Therefore, from the creation of reliable survey systems to the construction of synthesis models and the development of information systems, at every step of this knowledge process, attention has been paid to testing, verifying, and optimising the products of drawing.
The digital drawing takes shape line by line, through an incessant dialogue between the drawer and the city, and the definition of the lines and signs which make the drawing measures a cultural differential. Its awareness not only makes manifest the real cultural boundary but also explicates the contours of the project's goal, the construction of a shared path of knowledge.

An architecture - many architectures in a digital multi-dimension

Regardless of the degree of approximation, the digital city expresses, narrates, and suggests some aspects of the real one. The possibility of abstracting and interconnecting data makes it possible to create an infinite number of digital cities that derive from the real one. There is no trivial solution to the shifting of urban data from the real to the digital, not least because there is not a 'unique' problem.
Defining, structuring, developing, deepening, and detailing the specific features of the knowledge request, so that a solution could be devised, was certainly the first step in any documentation project. However, although the resulting solution was not unique, it was considered the optimal or most efficient one in terms of its functionality to solve both knowledge applications and technological processing.
Does the digital city narrate the real city, or is it the opposite? Does the real city describe only one dimension, even if articulated, compared to the many possible alternatives that otherwise find their own identity in the digital one?
Both considerations are valid. But whereas the change in the real city is relentless and difficult to control, in the digital city nothing happens unless active parameters of transformation are initiated. It might almost be desirable to transform the digital tool into an immersive interaction platform, where a potentially unlimited number of users could interact with the virtual space while enjoying it. This would foster greater interaction with the model and build expressions of 'virtual life' in the digital model, assuming the virtual space as the locus where data exchanges would occur regardless of the technical aspects. This possibility only reveals one of the many potential applications of a 'reality-based' information system.
Even if the alternatives of the fruition of the model can be explored, the digital architecture is at risk of remaining stationary, unchanged over time, and overcoming its connection with reality.

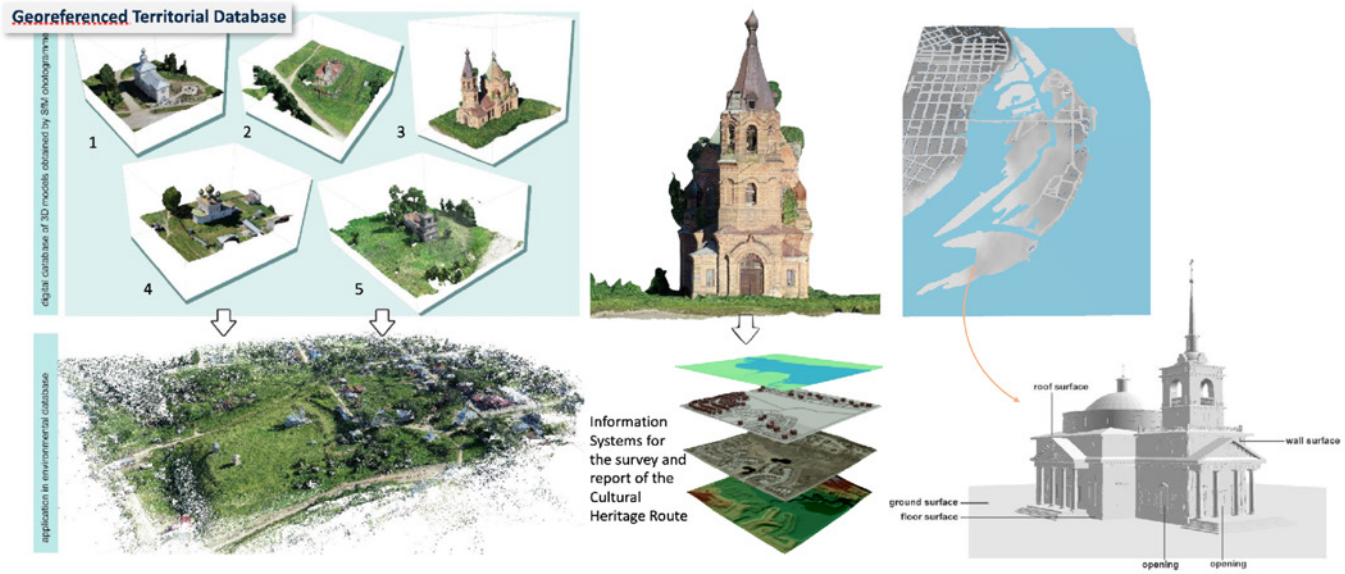


Fig. 7 Digital survey support the territorial representation and interpretation, through the semantic decomposition into environmental levels from the general to the particular. In this way, the digital territory becomes a place of interconnection between data organised and structured for many purposes. Digital architectures hold three-dimensional models of buildings which are linked to data and metadata that refer to other libraries, related to architectures and models in an endless chain.

The concept of time in the virtual model is absent unless it is dependent on the 'real' time, and it can also move incredibly faster than the real one or not be aligned with it. In any case, it relates to a perception level from the real context of the heritage object, and it can affect the character of the model.
In the functioning of the bi-dimensional space, real-digital, time is precisely the most relevant variable in terms of applications and interactions. Time also plays a part in the 'mortality' of digital data. For this reason, in order to valorise the expressive potential of the three-dimensional model and of the information system, it is not merely worthwhile but also essential to assess the future transfer possibilities of this system regarding the timeline relations. The digital product should not remain isolated from technological updating. The more applications the model can communicate with, the greater the chances of survival. Likewise, the more institutions it manages to interface with, the more useful and appreciated it will be, and thus the higher it will be considered by parties, such as the municipal administration to benefit from it, as an asset to be protected. It is worth emphasising that today a digital product is an 'asset' and not just a 'resource' with respect to the society it belongs to.

In-formation

Through the information system, it is possible to break down wide heritage objects, such as a city heritage asset, into its many descriptors selected for the research and to display what is contained in a specific building.
Using a simple navigation interface, colours are associated with the individual attributes to be examined on a particular building, thus making the information immediately readable. The individual values are matched by corresponding chromatic scales, which can be modified at any time, resulting in an explicit display of data on both the individual building and the entire urban landscape, thus defining thematic maps focused on many possible topics (e.g., technological, constructive, structural, on the state of conservation and design priorities).

Fig. 8 Old city of Bethlehem, interested by a research for the documentation and digitisation of buildings and urban infrastructures. Historical aerial photographs of the urban complexity in the 20th century, aerial photo from UAV on dense aggregates in 2019, 3D point cloud from digital survey (2018-2020).

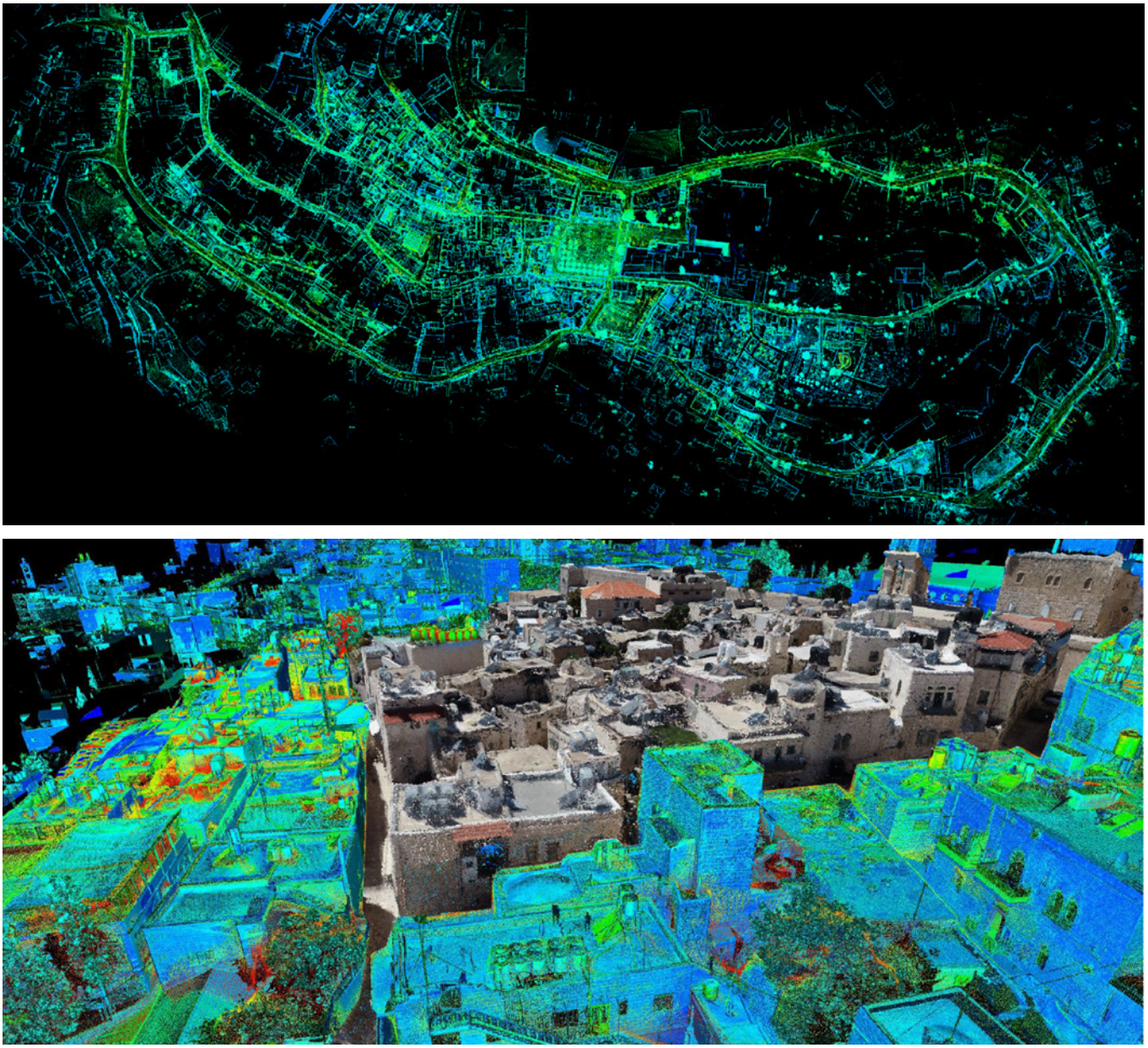


Fig. 9 Above, nadiral view of the laser scanner point cloud. The archive contains more than 2200 scans made in the historic centre. Laser scans are taken along streets, squares and stairways as well as on the roofs of accessible buildings. Below, the three-dimensional measurement database is then integrated with the data acquired by means of photogrammetric surveys conducted with UAV systems, in order to obtain homogeneous data over the entire surface area of the historic centre.

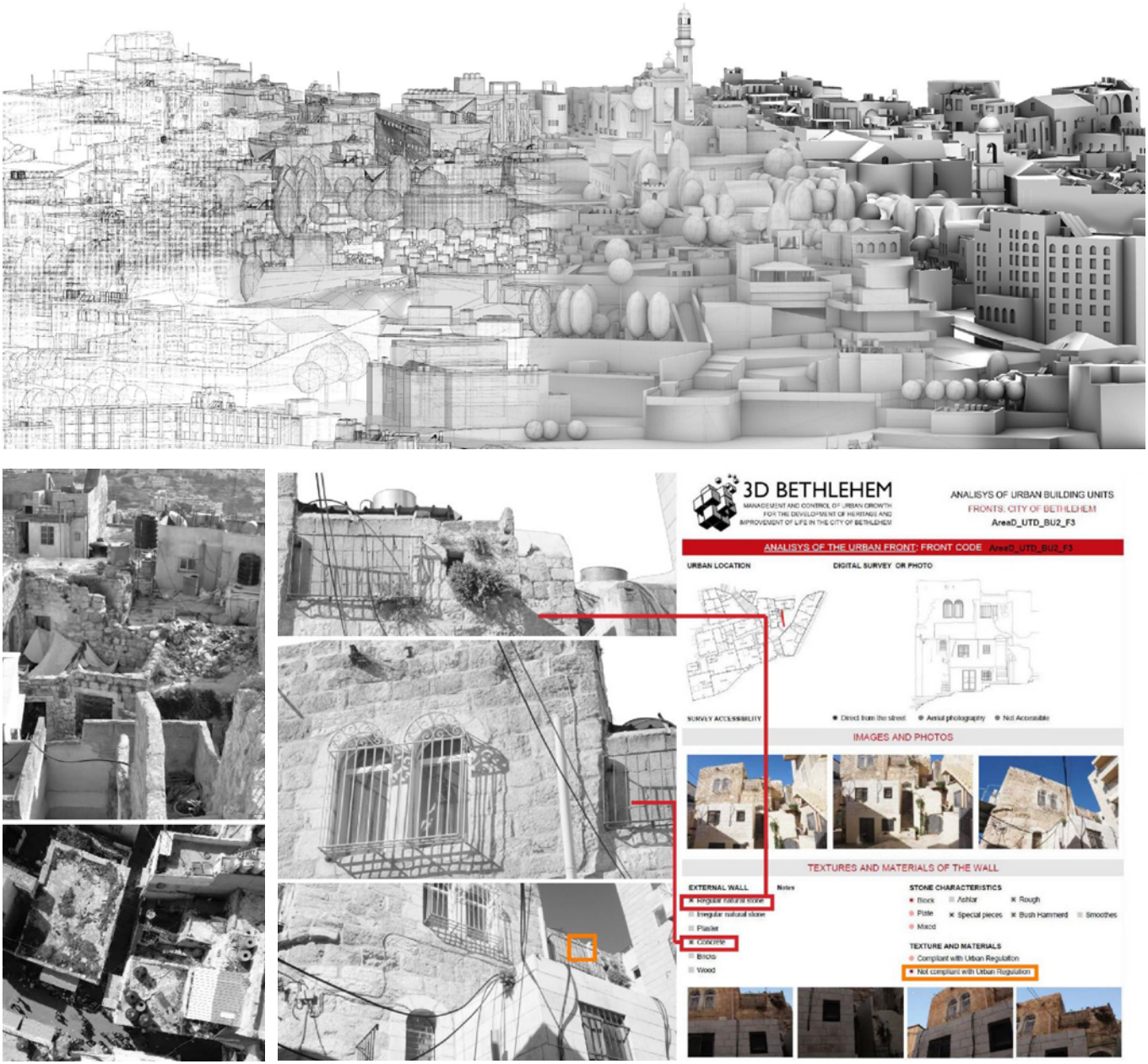
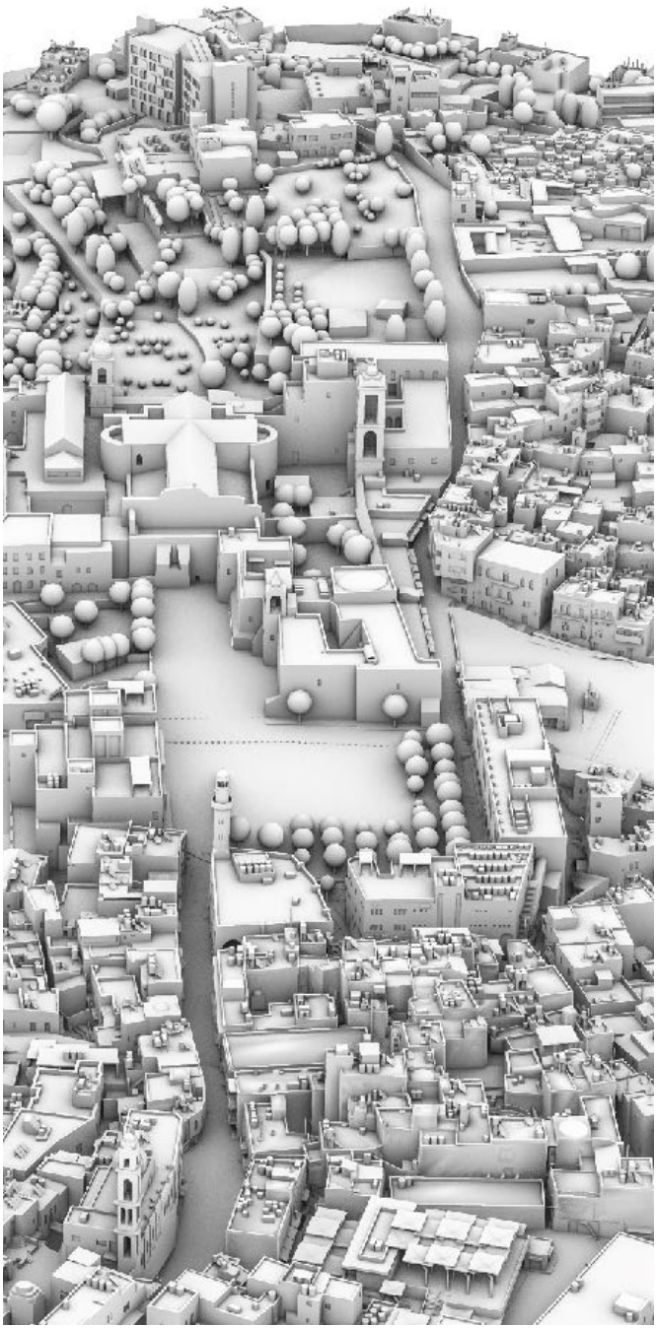


Fig. 10 Processing of the 3D model of the Old City of Bethlehem by defining regular surfaces extracted from the point cloud and refined through integration of photogrammetric data. Vector elements of the model are associated by means of identifiers to the census sheets on Filemaker, regarding architectural technologies.



Although this is the main result achieved, it does not define a limit that cannot be overcome. On the contrary, descriptors can be implemented, fields added, and archives interconnected. The digital city that provides information should become smarter over time and begin to process data across the board, thus increasing application possibilities. The result is a model that not only describes the outcome of synthesis, but also produces elaborations on data that it collects semi-automatically from the environment to support readings and, over time, perform automatic associations for service management.
Also, the process of applying Artificial Intelligence in the field of building and urban heritage, not only as a reading device but also as a tool to systemise data on the quality of the built environment, aims for more sustainable management of urban elements, heritage objects and infrastructures.
The several images that can be extrapolated are anyhow static and acquire dynamism only if updated over time. The possibility of providing these tools with Artificial Intelligence and linking them to active sensors may revolutionise the prospects for their use and confirm what has already been anticipated by the 'Internet of Things' for years.
If considering the HBIM (Historical Building Modelling) paradigm applied to the architectural heritage and more in general to the city, it emerges how the interpretation and relation between data will be increasingly addressed in the future through AI (Artificial Intelligence) engines at the building and urban scale. The interpretation of the collected data will produce correlation effects with the spatial-technological terms of the digital models, validating the informative components and simplifying the performance activities in terms of simulations on the measured values.
The research topic develops in a knowledge hybridisation, intended as an integration of qualified competencies, coming from very different disciplinary fields, which have the management of the building heritage in common. The survey and urban representation, and more generally the design and representation science, are considered the cultural tool that not only allows for

Fig. 11 View of the 3D model of the Old City of Bethlehem.

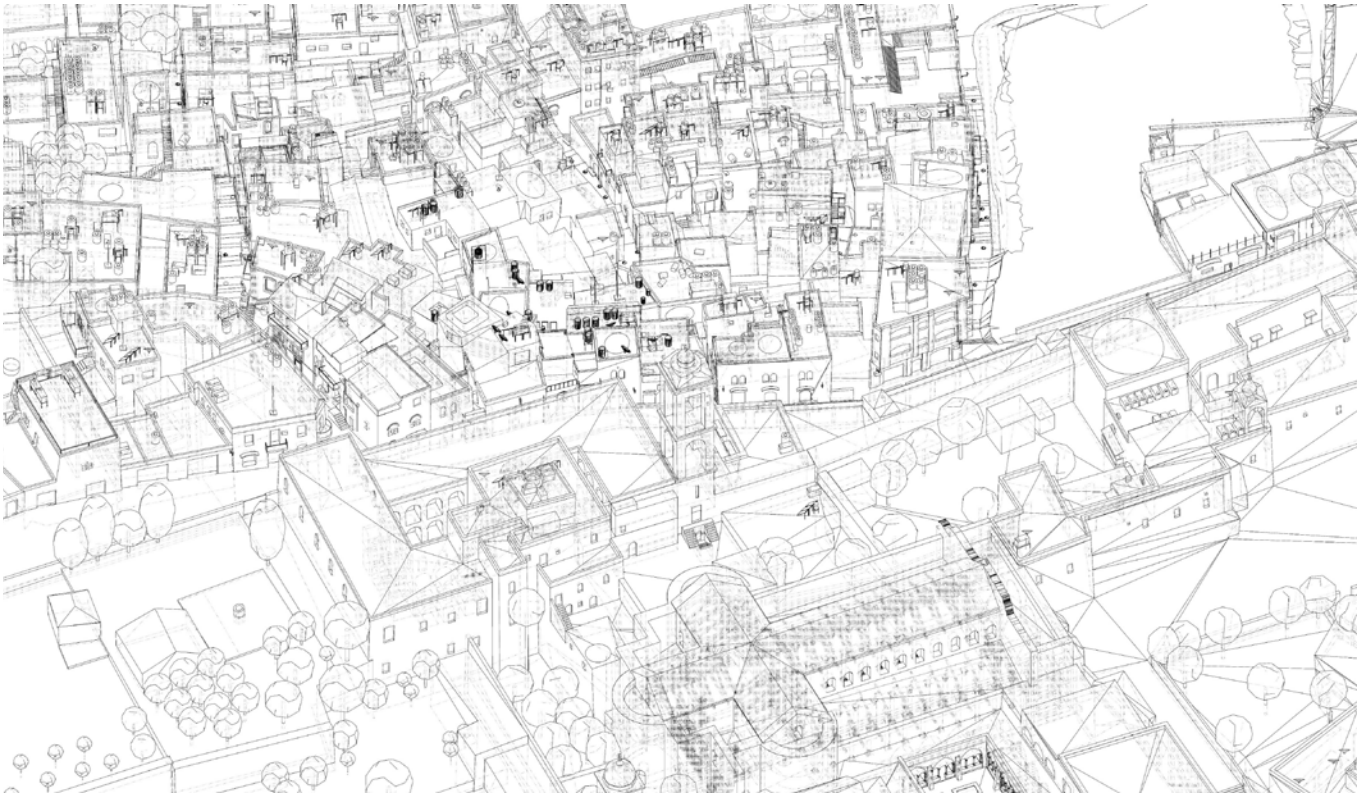


Fig. 12 Digital drawing infrastructure of NURBS and mesh components which compose the overall 3D model of the Old City of Bethlehem.

the collection but also systematises and provides an overview of such a complex logical framework.
Therefore, the development of a graphic language that belongs to the territory and does not merely represent it turns into the locus of communication thanks to information models. The product of digital design enables the mutual exchange of skills and promotes the broad interpretation of the universe of data collected.
With reference to the discourse presented, it is highlighted the similarity to the dystopian future in "*Brazil*" (1985) by T. Gilliam, where a mechanical tangled bureaucracy has completely overtaken the daily routine, making living not only difficult but also dangerous. In this 'Babel tower' of data and information about the digital city, future advances are directed not for an increase in complexity but rather, as suggested at the beginning, for simplification. A mechanism where the lemmas of the information system can help human thought but never replace it.
Hence, in a historical moment caught between wars and pandemics, in a social and cultural reality where symbols and signs have been gathering and layering up for thousands of years, it will be possible to build an interdisciplinary but common digital language that respects this complexity and safeguards, protects, and supports management actions, founding the premise of any consideration about Cultural Heritage, analysed as monument, architecture, city, object and system, on the knowledge and respect for its identity, conservation and future.

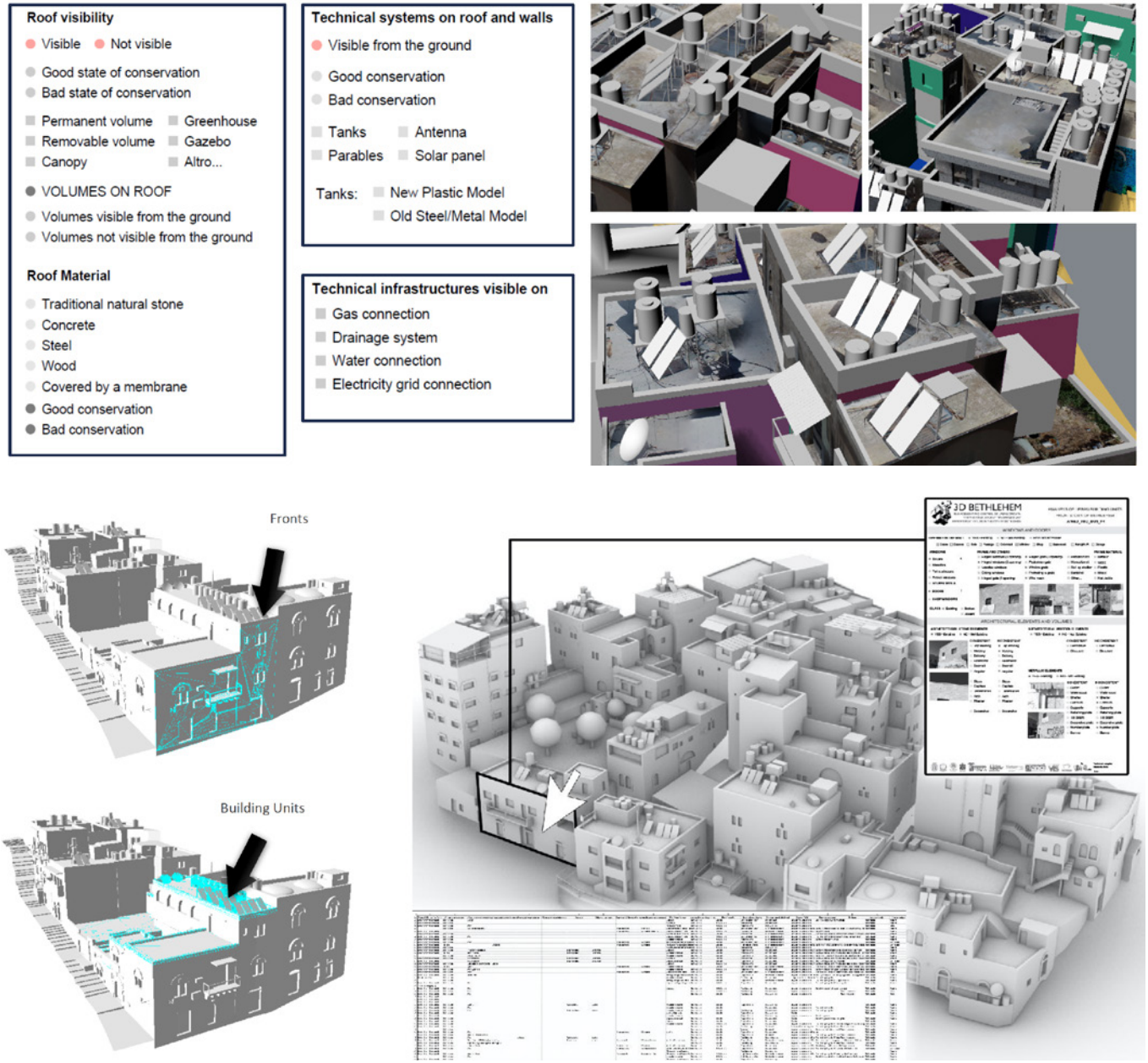


Fig. 13 Examples of the descriptors for roof systems in the census sheet and characterisation of the 3D model by building units (corresponding to the roofs) and urban fronts (corresponding to the surfaces delimiting the building volume in the model).

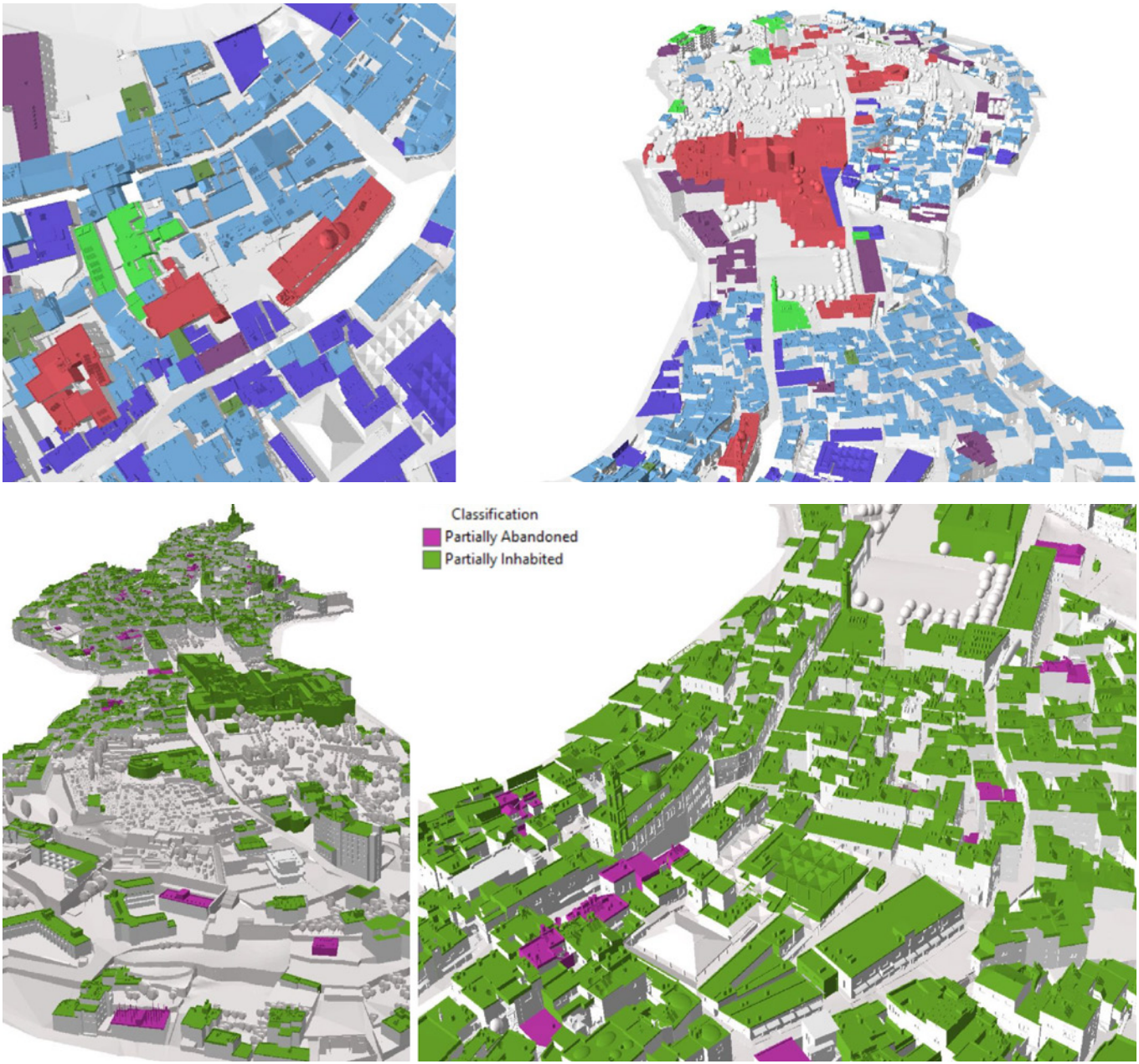


Fig. 14 Thematic maps elaborated on portions of the historic centre. The G.I.S. (Geographic Information System) tool makes the various descriptor queries explicit by producing summary maps from which the individual building can be analysed in relation to the vastness of the urban system.

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Early-Stage Researcher in the EU project Horizon2020 Marie Skłodowska-Curie Actions (MSCA) Research and Innovation Staff Exchange (RISE) H2020-MSCA-RISE-2018, "PROMETHEUS". Since 2022, she is Marie Skłodowska-Curie Fellow and Principal Investigator in the project "MOEBHIOS - Multi-attribute values' OntologiEs to improve Built Heritage InformatiOn assessment in cluStered territories", for the development of an advanced digital mapping protocol for the architectural, archaeological, social and economic parameterisation and valorisation of sites in Palestine according to European strategies for the protection and promotion of Cultural Heritage.

Abstract

Close-range 3D digital survey methods (e.g., terrestrial laser scanning, photogrammetry) offer the opportunity to collect a wide amount of morpho-metric data on Built Heritage without invasive actions. Their detection ensures a high level of detail, till to permit the analysis of the shapes of single constructive components and masonries including the signs and variations derived from damage.
The increased resolution of point cloud databases can be preserved within 3D high-poly mesh models. However, the reliability and accuracy of digital data from damaged conditions must be certified, in the passage from the discontinuous database to the continuous system of 3D surfaces. The chapter presents a pilot test of 3D mesh models for the monitoring of structural damages from earthquake sequences, advancing further opportunities for the assessment of risk conditions and intervention priorities. Survey actions and technical results have been developed from a research collaboration in the laboratories of EUCENTRE Foundation in Pavia (Italy).

Keywords

3D mesh models, Reality-based models, Digital survey, Structural monitoring, Structural risk.

Reliable 3D Mesh Modelling Workflows for Non-invasive Structural Diagnosis on Built Heritage

Introduction

The study of the Structure as a Form is the premise for the presented research in non-invasive digital survey to identify and monitor the risk of instability[1] in Historic Architecture. The 'visible' architectural morphology, without the auxiliary of penetrations and material samples, is proposed as a key to understanding static behaviour in buildings, as a means of expressing signs of cracks, deformations and displacements linked to the interpretation of states of stress and instability[2]. As a function of these formal characteristics, engineering methods for monitoring structures (e.g., potentiometers, accelerometers, 3D image tracking, etc.) (Senaldi et al., 2010) can be sided and compared to digital surveying practices in architecture (e.g., terrestrial laser scanning, photogrammetry, UAV survey, close-range survey systems) (Guarnieri et al., 2013; Bertocci, 2015; Parrinello & De Marco, 2018). Such systems offer the opportunity to acquire large masses of metric data with millimetric measurement reliability, and they can be calibrated to focus the object of research on the morphological variation properties of structural surfaces (Fortunato et al., 2017).

In particular, with the application of digital surveying techniques aimed at defining reliable 3D models, specific functional workflows for documenting static behaviours can be identified and associated with non-invasive survey procedures (Meier & Will, 2007), allowing for the mobilisation of expeditious in-situ monitoring actions also in emergency contexts (Pieraccini et al., 2014; Chiabrando et al., 2017).

In terms of research in the Digital Representation of Architecture, the topic is related to the explication of the dichotomy between Form and Model, as a perceptual synthesis of the structure (real component) and a communicative elaborate of its statics (virtual component) (Vernizzi, 2007). The certification of the digital development from the Form as documented in-situ to the elaborated 3D model enables the interpretation of data inherent to the structural system in multiple formal and technical variations on the significant static properties, operating both a geometric and computational knowledge (Oreni et al., 2014).

The wide repertoire of recurring static patterns in damage scenarios of historic structures (Penna et al., 2019) introduces an equally wide formal variability of documented geometries from the macro (system) to the micro-scale (constructive pattern). This results in a complexity of meaning to be associated with the interpretation of the data collected in a digital survey (natively, points measured and reproduced in a virtual 3D space, as a point cloud). Besides this, there is the operating topology of the computational platforms used in building engineering for the handling of such data, which concerning the high 'mimetic' density of point clouds requires a drastic decimation of the data for the association of parameters and mechanical constraints.

The objective of the declination of Digital Survey to the present research for structural diagnostics is to achieve,

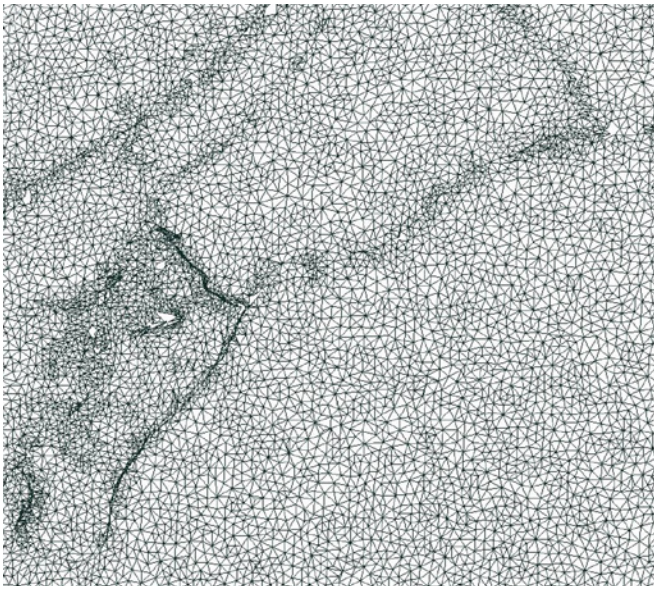


Fig. 1 The shape derived from structural damage to Built Heritage is recognisable, and defines a distinct morphometric character both as a crack and as a continuous deformation. For a reliable digital form to perform structural simulations, the detail of 3D acquisition and representation becomes central. Above, local crack conditions in a historic masonry structure; right, 3D polygonal mesh digital surface of a crack with detachment on a structural surface.

through mesh modelling, a rational and codifiable numerical geometry of an architectural structure for analysis purposes, preserving the identity of the drawing and the production of images both as descriptive results and analogue calculation tools (Stanfa et al., 2021).
The choice of mesh modelling for architectural structures places the basis on the development of geometric patterns, based on elementary polygons, as topological modules[3] for a multi-scale 3D modelling method that can be applied at different densities and sizes of the mesh surface. If related to the level of regularity of the pattern, the polygon itself can be chosen as a medium for the geometric and numerical decomposition of the structural form, and it sufficiently characterises the structural representation for scientific-technical measurements (Attene et al., 2013).
The procedure of 'geometry processing'[4] is thus adopted as a principle for processing data from point clouds to 3D mesh models, manipulating and querying the polygonal mesh according to the necessary degrees of abstraction of the structural form for its diagnostic interpretation (De Marco & Parrinello, 2021).

Implications of digital surveying applied to a structural prototype

The updating of structural documentation through digital surveying, from in-situ acquisition to restitution, defines a typologically unified product, the 3D morpho-metric database, with various possibilities for cognitive interpretation from its interaction as a point cloud. Such database can support not only a specific mechanical analysis but also highlight unexpected risk conditions, fulfilling both the 'diagnostic' and "preventive" functions of representation.
In respect of the different surveying methodologies and sensors, the possibilities of technical calibration of instruments and acquisition methods lead to a necessary reflection on the influencing parameters for the metric quality and formal digitisation detail of point clouds. The digital documentation databases are thus evaluated on the detail of the acquired data ('surface density') and its definition within the geometric limits ('dataset coverage' and 'contour detail'), taking into consideration how the achieved form, although discrete, also

derives from the finalisation of processes of 'registration', 'filtering' and 'optimisation' of the instrumental data.

The testing of potentials from Reality-based mesh modelling in the field of structural representation was verified through a pilot project of diagnostic monitoring in seismic conditions. The research was conducted within the project 'Seismic assessment of natural stone masonry buildings in Basel', coordinated by the University of Pavia (Italy) and the École Polytechnique Fédérale de Lausanne (Switzerland)[5], on the monitoring of seismic effects within European historic buildings starting with the case study of the historic centre of Basel (Switzerland). The joint activity with EUCENTRE Foundation, the European Centre for Training and Research in Earthquake Engineering in Pavia, made it possible to organise a digital survey campaign as part of a program of seismic simulation tests. The project involved the realisation at EUCENTRE's laboratories of a scaled prototype of a residential unit in stone masonry, modelled on the typical rowhouse typology of the historical centre of Basel. The prototype was built on a shaking platform for performing single-axis oscillatory tests, on which it was then subjected to a series of dynamic tests ('runs') simulating the effects of an earthquake, increasing, and varying the intensity and duration of sequences. The experimental cycle involved mono-axial dynamic tests, and the application of retrofit strategies[6] to assess the effect of the intervention and consolidation solutions on damaged structures.

Fig. 2 Building prototype construction site within the EUCENTRE laboratories in Pavia. The structure was built directly above the shaking platform.

Fig. 3 Activities of 3D digital survey: above, Terrestrial Laser Scanning acquisition; below, Structure-from-Motion photogrammetric acquisition.

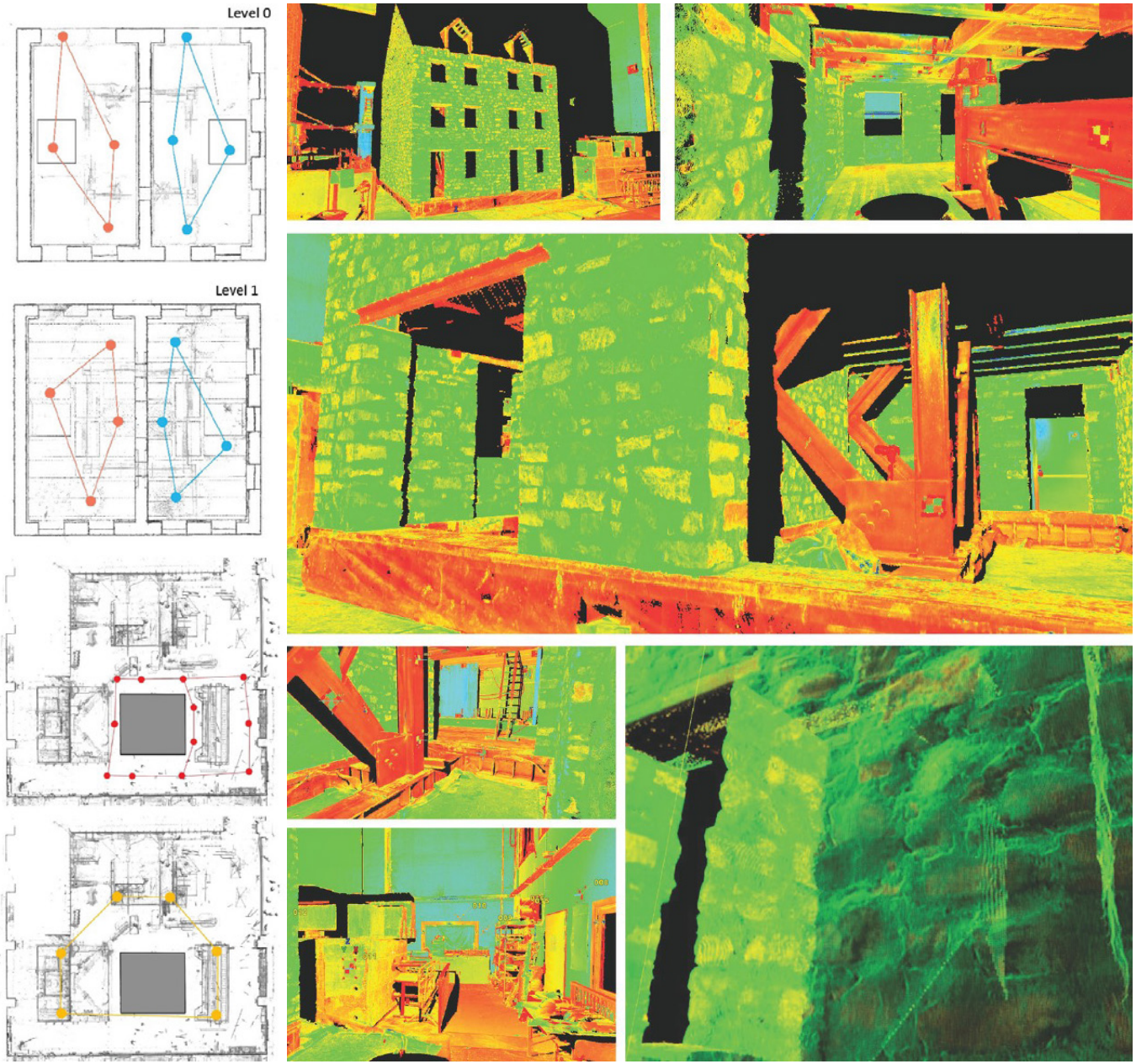


Fig. 4 Polygonals of the ScanStations for the Terrestrial Laser Scanner acquisition. The individual scans of the TLS survey, highlighting the laboratory spaces with the structural prototype and the Black&White targets, allow to appreciate the density quality of the 3D morpho-metric data.

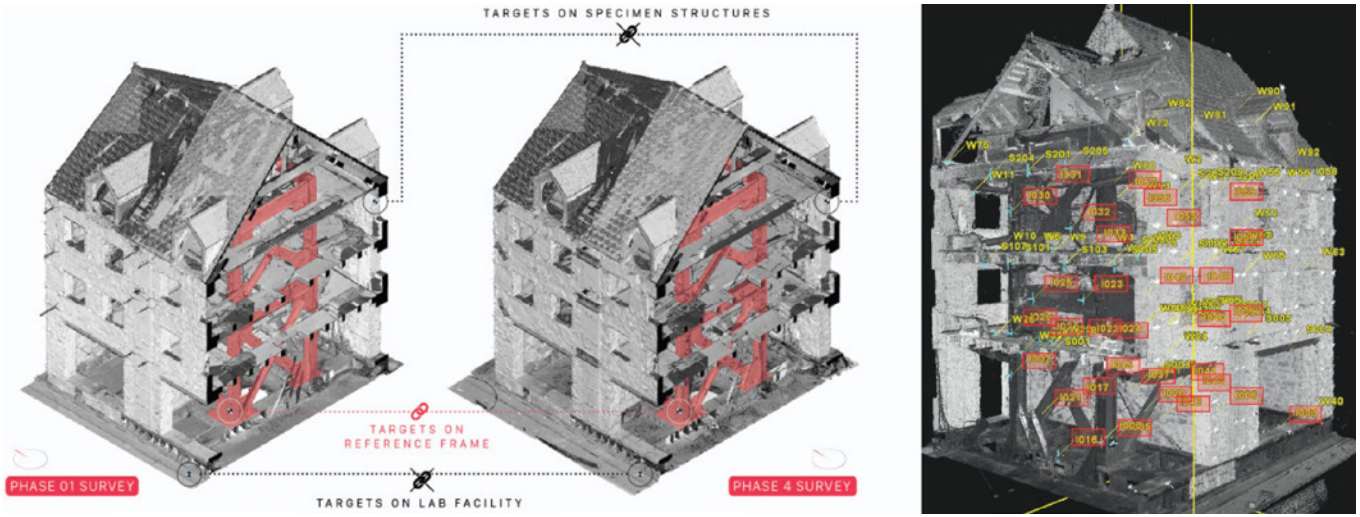


Fig. 5 Registration of ScanWorld between the ScanSets corresponding to the 3D survey of each static phase. For the registration between phases, only Black&White targets placed on the non-deformable structures of the shaking table (in the same UCS of the prototype) were adopted for the referencing.

The acquisition process for the digital morpho-metric survey was developed with an integrated approach between Range-based (Terrestrial Laser Scanning - TLS) and Image-based (camera photogrammetry) applications. The former collected reference morpho-metric databases, according to the highest and certified measurement accuracy, and the latter developed Structure-from-Motion acquisition sequences for localised mapping of cracks and damage evolution.
As a function of the 'scaled effect', deformation intensities were reduced by more than 50% compared to real cases of structural damage, making methodological adjustments necessary during the alignment procedure, beyond the misalignment threshold of 1 cm in the architectural survey and of 5 mm for NTC[7] standards, to appreciate out-of-plane displacements with a minimum tolerance of 1 mm.
These requirements characterised the entire documentation process, defining both the surface density parameters of the point clouds (laser spot not exceeding 1 mm on discrete surfaces) and verifying the registration errors between scans and partial databases on Black&White targets and cloud-to-cloud discrete surfaces (accepted max. 1 mm and appropriately weighted in the alignment)[8].

The process of referencing metric data from monitored residual static phases involved the setting of a fixed UCS spatial reference system, unaltered by the kinematic phenomena. Alignment between static databases was controlled through the selection of targets placed in adherence to the shaking table (59), a system coherent to the prototype UCS origin at the end of each dynamic phase[9].

Comparison of digital data on structural damage from sensors

Besides the architectural surveying activities, an intensive monitoring campaign was conducted by EUCENTRE to monitor the inputs transmitted by high-precision structural sensors, corresponding to dynamic peaks and static residuals of the masonry structure. Sensors, consisting of geophones, accelerometers, potentiometers, geometric control patterns, load cells and extensometers, provided input signals at characteristic stress concentration nodes in the prototype structure. The damage frameworks involved the control of both spatial (1D, 2D, and 3D displacements

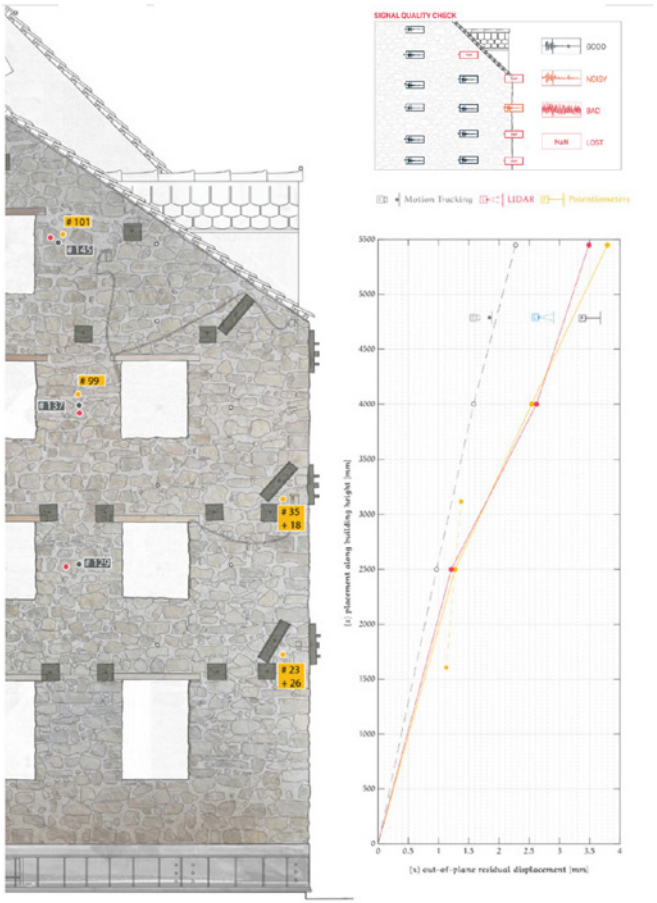


Fig. 6 Comparison of correspondence between displacements measured by 3D Optical Markers, potentiometers, and Terrestrial Laser Scanners, evaluated in selected coordinates. In the latter two, the maximum difference is 0.7 mm.

and deformations) and physical-kinematic parameters (velocities, accelerations, forces). The application of 3D Optical Markers was experimented, with markers distributed according to a regular grid and monitored by combined cameras. The accuracy of the measured positions was related to the parameters recorded by the cameras, such as sensor resolution, frame rate, distance, triangulation angles, general illumination, surface integrity of the markers, and reflectance on similar incidence surfaces. In the optimal configuration of these characteristics, the overall accuracy in marker measurements was estimated to be 0.01 - 0.1 mm in terms of Root Mean Square (RMS) error.

For each 'run', a signal map of the 3D Motion Capture system was created, tracking the temporal positions of each marker. The positional signals were classified between valid data, partially lost or not meaningful data, and noisy data unavailable for evaluation. Positional data with a good signal-to-noise ratio (SNR), considering peak and residual displacement response, were used.

Once all inputs were converted into a spatial metric referencing format, the certification compared the deviational values presented by the potentiometers, the TLS survey and the 3D Optical Markers. Overall, the morpho-metric displacements measured by TLS showed a deviation from the potentiometer data along the height of the building façades contained within 0.1 mm up to 4 m height and within 0.3 mm from 5.5 m height to the top of the building, coherently to the instrumental accuracy levels. In parallel, the 3D Optical Markers recorded the same trend of residual displacement deviation along the height of the façade, but with greater variation intervals following the amplified signal noise[10].

The tests conducted certified the correspondence of the morpho-metric data with the engineering markers, confirming the validity of the digital survey method as a highly implemented solution for the density of mechanical information in structural monitoring.

Development and certification of Mesh Models

The 3D modelling process implies an inevitable process of data management and synthesis from the point cloud. While not guaranteeing the elaboration of a 'perfect' model, control of the digital form in computational terms, as well as visual properties, is considered. It implies the recognition of geometric parameters of surface micro-morphology and the calibration of mesh triangulation algorithms. The attempt has been to preserve a morphological quality of detail, without the replacement by simplified geometric systems.

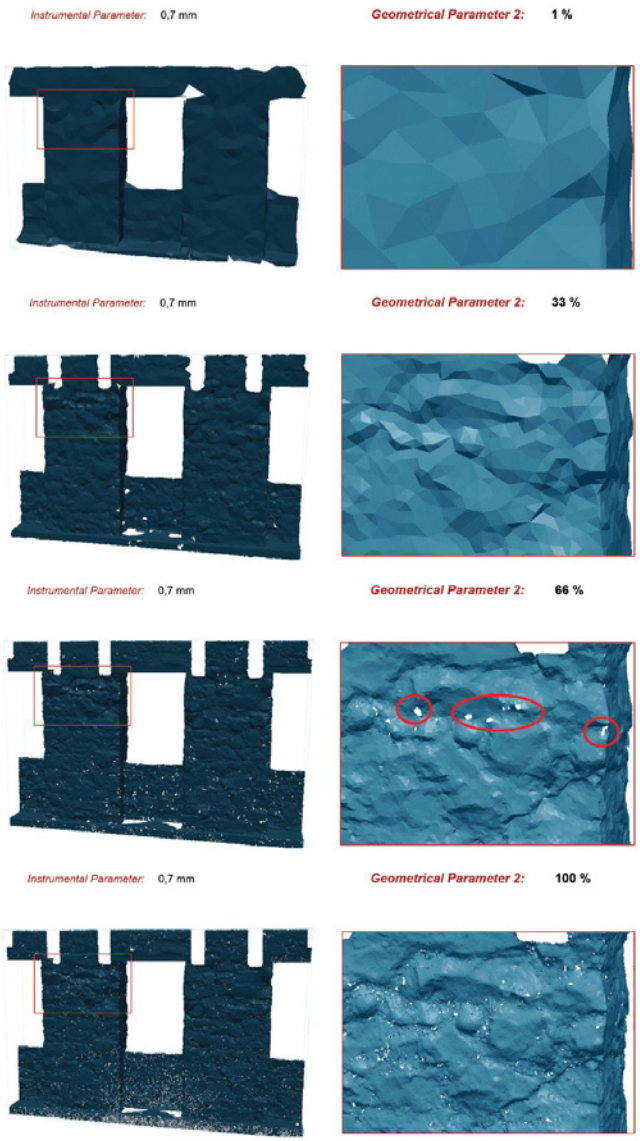
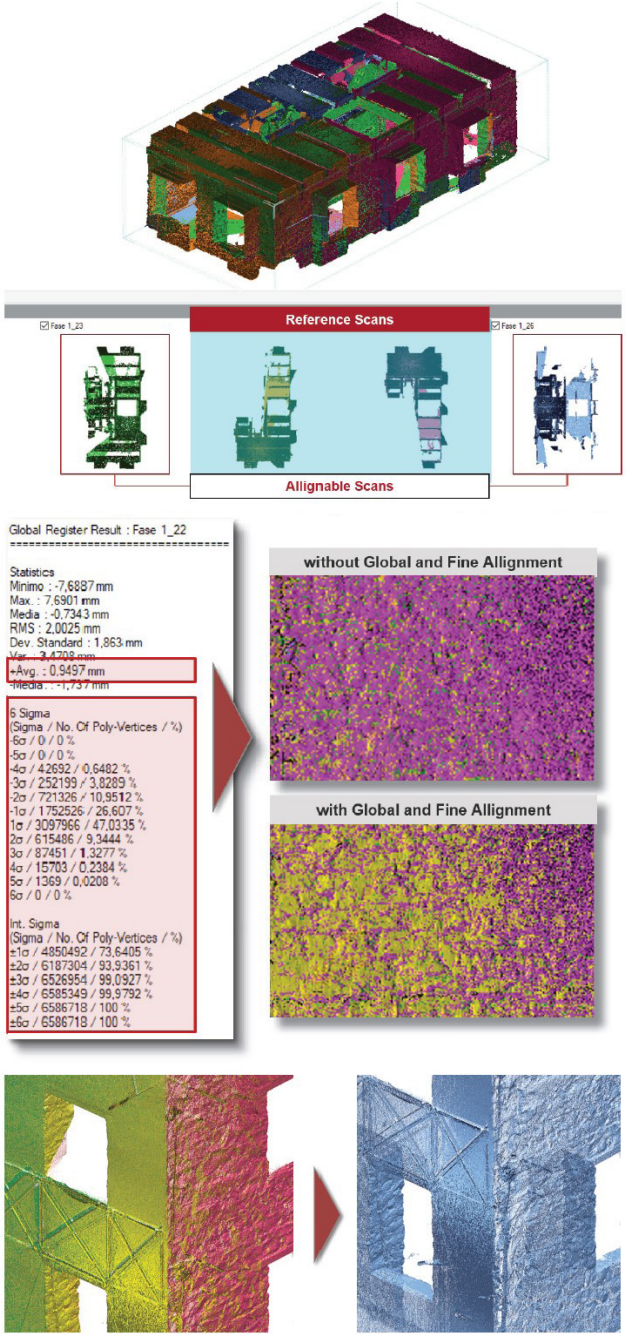


Fig. 7 Degrees of decimation applicable in the triangulation process of discontinuous morpho-metric data in a reality-based 3D mesh model. Reducing the geometric quality, it is possible to obtain simplified surfaces without pattern criticalities. As the morphological detail and polygonal density increases, the pattern becomes more and more adherent to the material reality of the structure, but also it generates polygons alterations in the mesh.

Reality-based modelling, developed for 3D mesh components, was conducted for the reconstruction of the surface envelope of the structural apparatus through the direct triangulation of spatial vertexes into continuous polygonal meshes. These meshes, which can be manipulated as patterns between the vertexes corresponding to the measured points, define various possibilities of decimation and abstraction of the geometric detail, even in millimetres, which are required to not disregard the purpose of mechanical computation of the final model (Castellazzi et al., 2017).
The development of increasingly sophisticated Reverse Modelling software has led to the adoption of modelling platforms and control panels related to the management of dense data till to the result of the final mesh, as both high and low-poly models. Triangulation and data continuity procedures were evaluated against automated 'wizard' practices. The use of semi-automatic algorithms and parameters for Cultural Heritage models tends to prefer a qualitative assessment of mesh surface morphology. Less dense formal details of the discontinuous apparatus are decimated or altered by such processes, although they deserve mechanical significance within the interpretation of structural damage frameworks. The greatest risk is to lose control over the discretization of morpho-metric data, synthesising or even deleting information of mechanical and diagnostic value.

The mesh modelling conducted for the prototype building in Basel tested a workflow for handling, filtering and triangulation of spatial data targeted to the reliability of mesh surfaces for structural analysis.
Despite the alignment between the databases of the seismic 'runs' (certified with millimetric sensitivity), the mesh surfaces obtained by automated data triangulation showed misalignments of up to 2mm (related to the scaled system), compromising the reliability of local mechanism readings. This misalignment between meshes triggered a principle of revision of the modelling process and setting parameters assigned in the passage from the point cloud to the polygonal surface. It reoriented the pipeline on



intermediate checks of both the alignment quality of the discontinuous data and the consistency of orientation of polygons and macro-geometries in the model.
The transition of spatial data to modelling platforms involved import actions and script conversions (such as ASCII conversion), with a variable precision (float or double) in data referencing. In addition, further considerations related to points triangulation and the ordering subdivision grids governing 3D surfaces influenced the models.
Therefore, a 3D structural mesh control and optimisation strategy was experimented with a calibration pipeline consisting of a sequence of actions: 'Actions on the point cloud', 'Mesh Surface Generation' and 'Actions on the mesh'[11].

Actions on the point cloud were aimed at re-establishing the alignment accuracy of the spatial data, as well as defining the surface quality target for triangulation. They included:

- Point Cloud Fencing (manual) with the manual removal of raw noise points and dispersion portions before the triangulation;
- Global and Fine Alignment (semi-automatic) with the iteration of the deviation between scan sets;
- Scans Combining (automatic) by combining multiple scan data into a single dataset and deleting the overlapping point regions from multiple scans;
- Filtering Noise and Smoothing (automatic) with the filtering on dispersed data and domain edge smoothing.
- Masonry surfaces target (manual): manual cleaning of morphometric data for macro-portions of points not belonging to the envelope of the structural system.

Mesh Surface Generation developed geometric continuity through Mesh Triangulation. This process was calibrated according to the preservation of 3D detail morphology (spatial, not projected onto virtual planes or spheres) and topological continuity (favouring the search for continuity relationships between vertex and edges). It was not

Fig. 8 Reverse modelling processes applied to the point cloud: selection of reference scans and refinement of the alignment process with Global and Fine Allignment (6 sigma deviation), prior to data merging.

possible to proceed with an HD Triangulation profile, for surfaces free of interruptions and directly 'watertight', without the development of anomalous curvature solutions at the boundaries of disturbed or removed data domains.

Actions on the mesh were aimed at correcting and refining the surface of the 3D model. They included:

- Healing (automatic) with the correction of polygonal irregularities (tunnels, folded, non-manifold, isolated polygons, clusters and self-intersections);
- Remesh (automatic) with the regularisation of the polygonal mesh and automatic correction of minor holes;
- Filling Holes/Fix Geometry (manual) with the completion of missing data portions (classified between bullet holes, corner holes, and shield holes) by semi-automatic filling or with more complex 3D geometric sketch actions;
- Rewrap (automatic) with the regeneration of the 'watertight' mesh and the association of volumetric properties to the 3D surface.

Diagnostic interpretation of structural survey

Following the optimised modelling process, a comparison was made between the 3D mesh models of the static phases. Mesh Deviation assessments were conducted by setting the Phase 0 model (pre-seismic structure) as the Reference model for comparison, and analysing the deviation of the surfaces generated in the subsequent phases (related to the sequence of 'runs') as Target models. For defining an adequate mechanical reading, tolerance ranges of 5 to 1 mm were calibrated. The colour map showed values of adherence and deviation of the numerical surfaces from the reference model: green represented the areas of tolerated adherence, the red scale the overhanging deformation, and the blue scale the inward displacement.
The analyses conducted showed results consistent with sensors data, and more immediate and quantified identifications of local static alterations. The masonry walls expressed overturning phenomena with out-of-plane

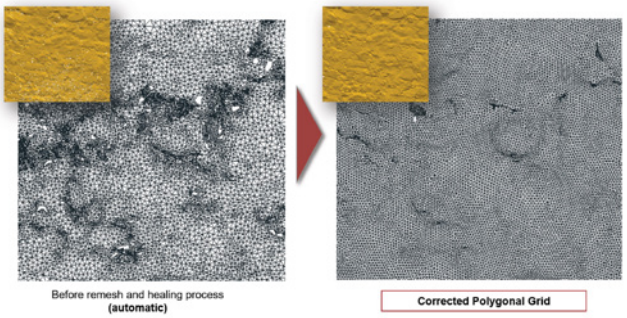


Fig. 9 Remesh of the polygonal grid, from the configuration of triangulated polygons to the orderly refined mesh, without simplification factor (set as 1).

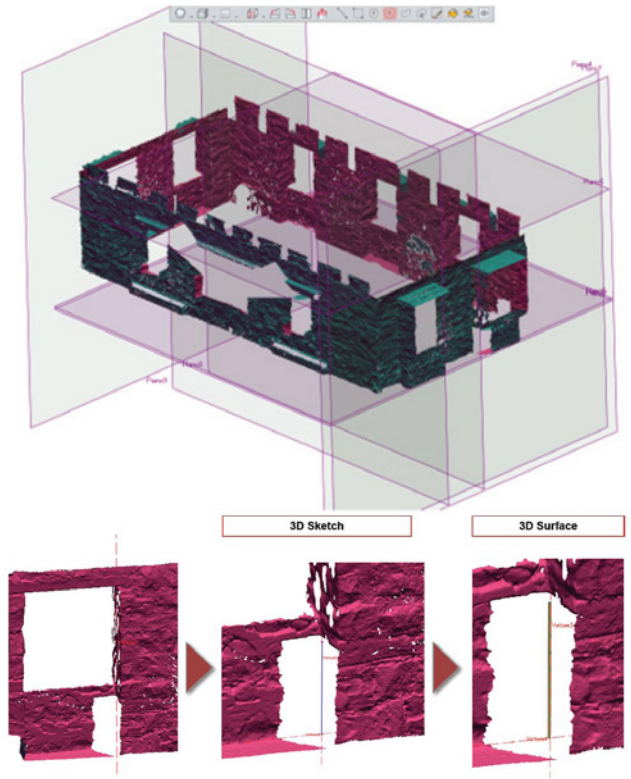


Fig. 10 Correction of holes, with extraction of surface planes and fundamental vectors of structural geometry, and generation of patches for reconstruction of projectual building geometry.

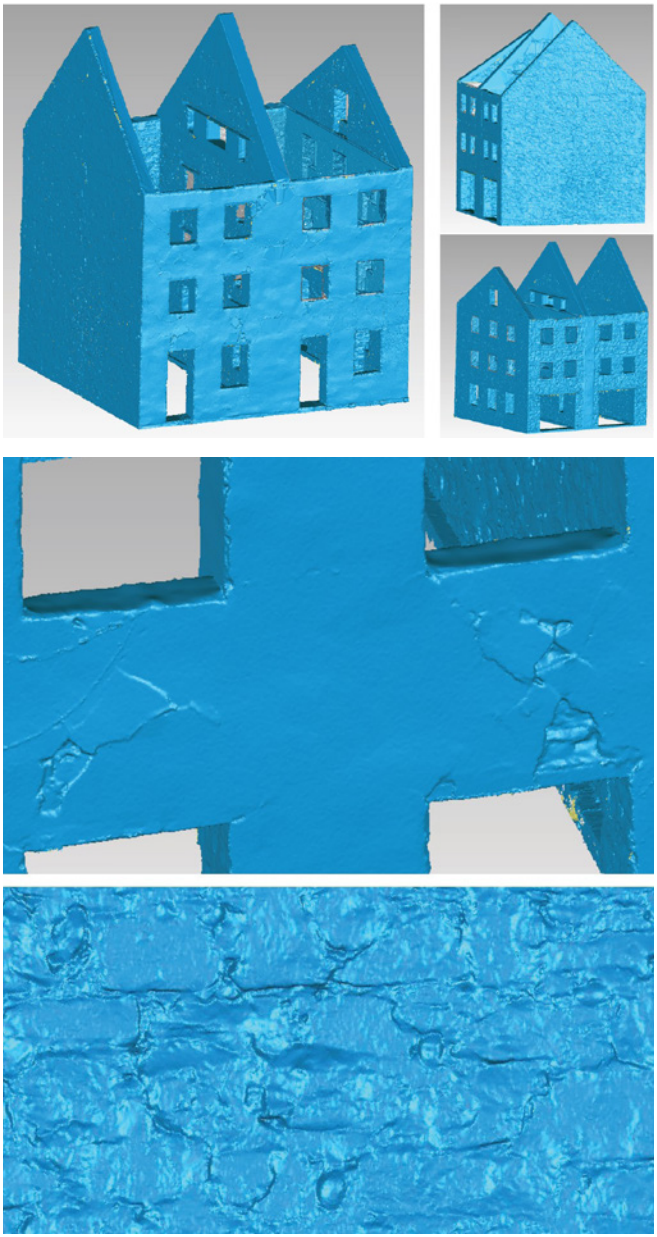


Fig. 11 Morphological qualities of the final structural 3D mesh: watertight envelope of the model, geometric integration in building profiles, preservation of shape detail on cracks, deformations and overall wall texture.

displacements of up to 20 mm, concentrated in the loading walls with higher critical stress, in the diaphragms, and the head façades, particularly in correspondence with the hammering phenomenon of the wooden roof system. With the retrofit interventions, introducing steel tie rods, the damage was both reduced and fragmented, restoring the initial deformative configuration of the load-bearing walls but increasing the unstable portions (diaphragms and gables subject to hammering), with displacements from 2 to 15 mm. The analysis of the entire envelope between exterior-interior surfaces made it possible to identify the correspondence of the logic of mechanisms on the entire masonry structure, confirming the solid behaviour of the blocks or highlighting the independent disintegration of the faces. By isolating the blocks and joining the boundaries, it was also possible to derive quantitative considerations of collapse volumes.

Conclusions

The 3D mesh modelling workflow enabled the continuous development of the structural form, with the certified query of deformation sections and the isolation of 3D volumetric blocks to quantify local mechanisms. Topologically, the product was also available for tetrahedral solid triangulations, compatible with virtual analysis platforms for Finite Elements[12].
Comparing the quantitative data analysis, the non-optimised models were consistent with the certified damage macro-areas but they showed a dimensional difference of more than 10 mm (considering scale reduction) on the real values of deformation.
In conclusion, the conformation of the mesh patterns establishes a valid method of decomposition and management of the digital survey data for a reliable 3D structural representation, and its reapplication is oriented towards the modalities of discretisation and ordering of vertices and polygons, addressing a review of digital strategies to allow the conversion from real to virtual geometrical surfaces.

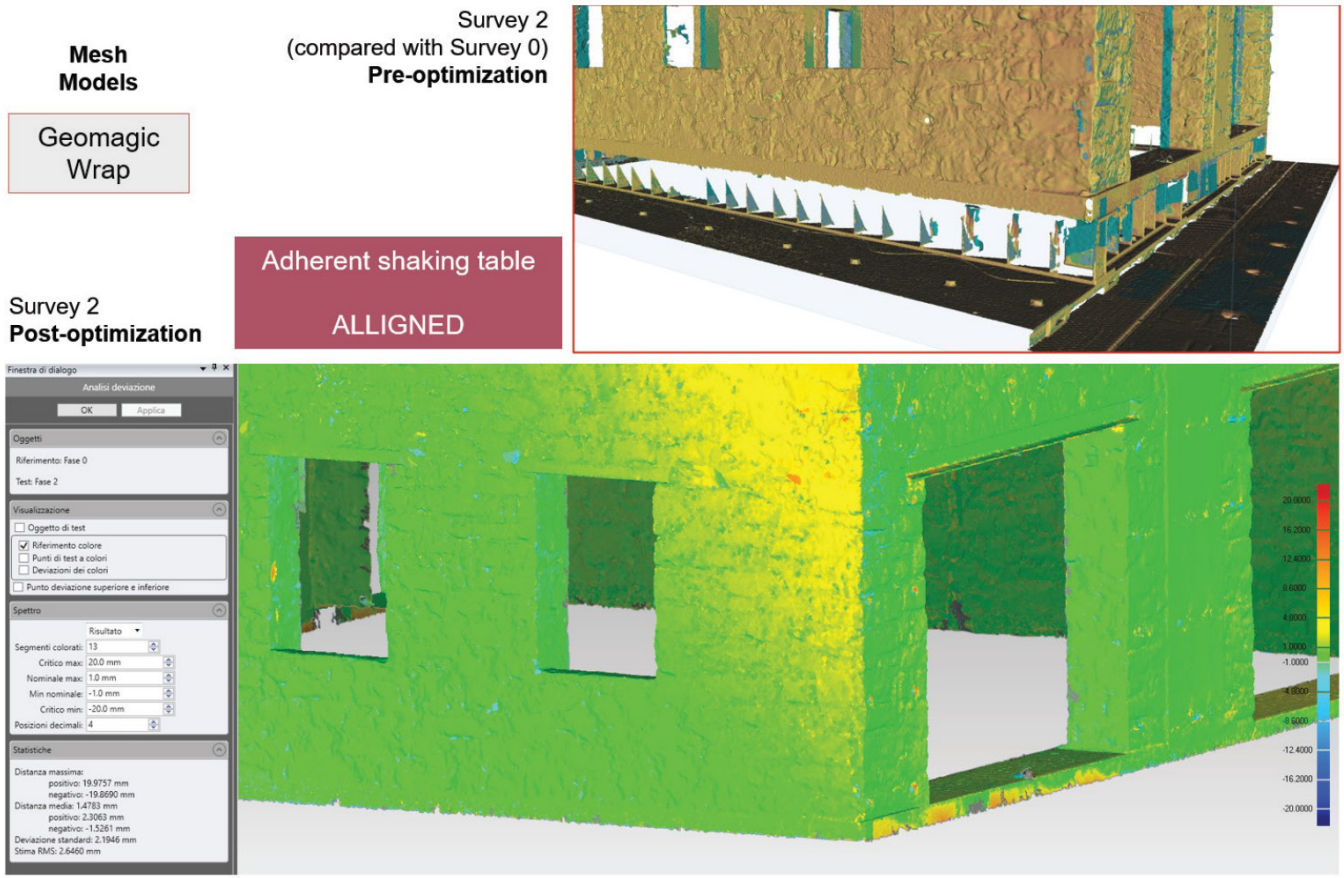


Fig. 12 Altered deviation issues between meshes were resolved (adherence between 3D models in green), ensuring a coherent analysis of deformations (red-blue color scale) between static phases, with correspondence in the non-deformable portion of the shaking platform.

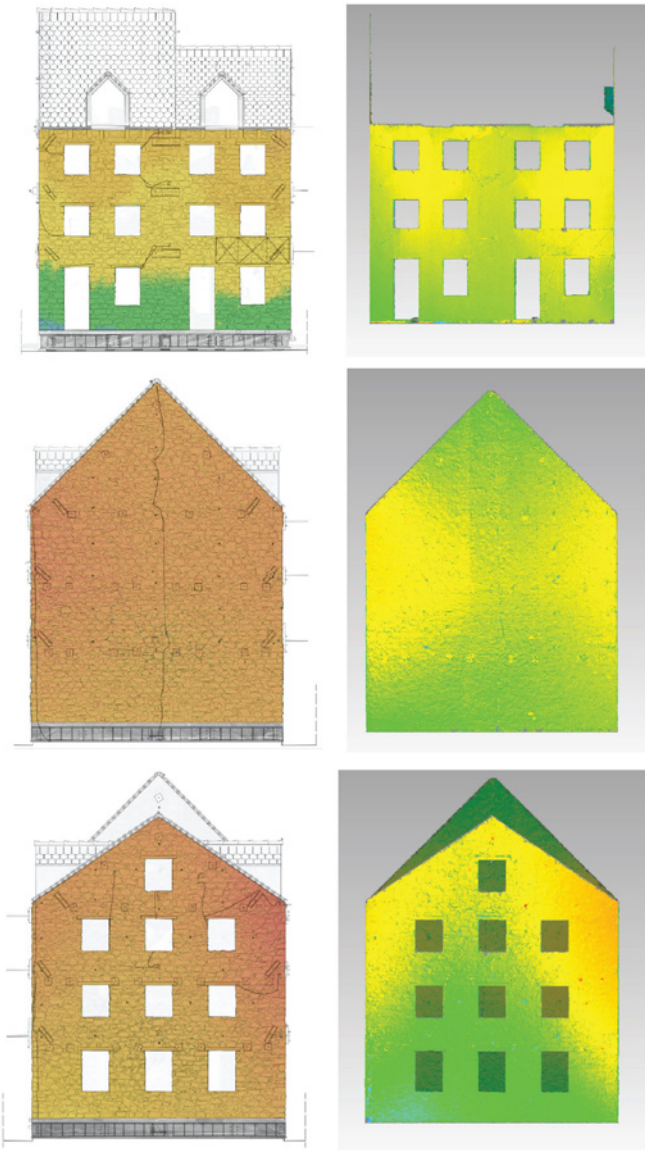


Fig. 13 From the optimised 3D mesh models, it was possible to compare quantitative analysis of mechanical effects due to the seismic simulation, certifying the adoption of the global database compared to the partial analysis conducted on individual scans. It is possibile to observe the general framework of structural damage, with gable overturning mechanisms on the head fronts and deformation of openings portions in the side fronts.

The 'digital structure' thus becomes a reliable model of the 'real structure', and in such terms can be critically interpreted as a form for non-invasively detecting morpho-metric peculiarities and conditions to be related to diagnostic frameworks and monitoring procedures over time.

Notes

1 The structural stability relationship, in addition to episodic events, is most commonly expressed in the characters of alteration to the ordinary wall texture, or profile integrity for discrete structures. When it fails, a self-increasing process of collapse is generated, both locally and by macro-blocks.

2 Instabilities are the manifestation of the alteration of the static equilibrium in an historical building; these may have been caused by three different issues: structural inadequacy of the building; incorrect reuse, rehabilitation, and restoration; external events that have stressed the building by loading the structures. The first cause of instability is congenital to the building, while the second two are due to disruptive causes such as changes in the original static equilibrium due to variations in the loads or dimensions of the load-bearing structures, or natural causes such as earthquakes, floods etc. See Minutoli, G. (2012). Il rilievo come strumento di interpretazione: il rilievo strutturale. In Bini, M., Bertocci, S. (eds), *Manuale di rilievo architettonico e urbano*. Novara: Città Studi Edizioni, 2012, p. 320.

3 The definition of a geometric module, like a critical graphic model, selects only certain aspects of complex reality and, by an inevitable process of reduction, renders them in a schematic and simplified manner. Nevertheless, it may itself be so complex that it is difficult to understand, depending on the co-presence of simultaneous aspects and relations of knowledge on the object of representation. See Cardone, V. (2008). *Modelli grafici dell'architettura e del territorio*. Salerno: CUES, p.22.

4 'Geometry processing' is a field of computer science that concerns algorithms and mathematical models for the analysis and manipulation of geometric data. For a more extensive discussion, see Baerentzen, J. A., Gravesen, J., Anton, F., Aanæs, H. (2012). *Guide to Computational Geometry Processing: Foundations, Algorithms, and Methods*. New York: Springer-Verlag.

5 Scientific responsibles for the research project: prof. G. Magenes (University of Pavia), prof. A. Penna (University of Pavia), prof. K. Beyer (École Polytechnique Fédérale de Lausanne). Scientific responsible for survey activities: prof. S. Parrinello (University of Pavia).

6 The term 'retrofit', considered in the field of structural architecture, refers to an operation to adapt the structural system to resistance requirements, in this case to seismic actions. In the research case, the operations involved the insertion of 2 systems of steel chains connecting opposite façades.

7 The Technical Standards for Construction ('Norme Tecniche per le Costruzioni' - NTC) for Italian legislation are currently defined

in the Ministerial Decree of 17th January 2018. This version of the Technical Standards differs from the previous 2008 version, mainly due to the great attention devoted to the topic of seismic improvement.

8 The data acquisition density range was increased to laser spot spacing of 0.7mm for 2m distance, and 6mm for 10m distance. Targets were enabled during the registration phase with weight [1.000] for errors of 0.000m, and [0.001] for errors of 0.001m.

9 Following the shaking phases, it was not possible to control the return of the vibrating platform to the same position. Thus, the laboratory surfaces measured, as well as the wall surfaces of the prototype subject to deformation, could not be considered as fixed references for alignment. The choice of the vibrating platform was made in order to adopt a consolidated system embedded with the UCS reference of the structural prototype throughout the duration of the seismic sequence simulated during the tests.

10 The data comparison activities were developed through the master's degree thesis by candidate Manuel Desole of the University of Pavia in Building Engineering and Architecture, entitled: "Application of LiDAR survey techniques and 3D dynamic acquisition in vibration table testing of a 1:2 scale prototype of a natural stone masonry building". Tutors: Prof. A. Penna, Prof. S. Parrinello, co-tutors: PhD Ing. I. Senardi, PhD.S. R. De Marco, February 2019.

11 The following tests were conducted on the modelling platforms Geomagic and Rapidform. However, the same methodological steps can be found on other software, even with more limited manual application tools.

12 Related to the computer hybridisation of structural modelling practices for calculation, the FEM (Finite Element Method) is a numerical technique that translates complex structural forms into synthetic domains describable as partial differential derivative equations, i.e. algebraic equations. The overall form is synthesised into cubic or tetrahedral modules (with density relative to the size of the object and the purpose of the compunting analysis) controlled through buondary-variable constraints.

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Abstract
The contribution considers in an introductory way synthetic frameworks relating to aspects of the organisation of the information heritage, the nature and format of data with respect to different thematic areas of the Cultural Heritage, the spatial processing of data in order to build digital information models, finally data management and processing environments, today's evolution of information systems.
The topics will concern: data formats and coherence of interchange flows (some definitions for the design and implementation of interdisciplinary and multiscalar information systems and models); a brief review of methods and tools for the management and representation of data and information in the field of Cultural Heritage; methods and tools for the representation of models and interpretative conceptual schemes related to complex geodatabases; use of graphic information for technical and non-technical communication.

Keywords
Information systems and models, Graphic information, Territorial and cultural heritage.

03

Information Systems and Models for Territorial and Cultural Heritage

"We build our image of the world with data from our senses. By presenting these data in novel patterns, artistic inventions alter our sensibilities – change what we see and therefore how we conceive the world and again how we look at it."

Kevin Lynch, *What Time Is This Place?*, 1976

Urban survey as an information system of knowledge

Information and communication technologies are changing the way we understand Cultural Heritage (CH). Technologies allow researchers, public administration, professionals, to think about the non-digital aspect of heritage in a digital way, using computer simulation and modelling - Geographic Information System (GIS), Building Information Modelling (BIM), Database Management Systems (DBMS) - to manage, visualise, model, design and operate the physical environment from the large scale (building and architecture), to the medium scale (urban), to the small scale (land). The elements of cultural value are now more valuable than ever thanks to our ability to digitise, analyse, design, manipulate and predict trends over time and the evolution of building and infrastructure systems.

Of course, social objectives, political mechanisms and economic development continue to be the main driving forces behind urban forms and their transformation, as well as Cultural Heritage. Investigation and urban design see illustrious references in the research. We observe perceptual, visual approaches, linked to the reading of urban space, scenes collected apparently as a quick sketch, but dense with layers of interpretation, as well as analytical approaches, which break down the image of the city and operate syntheses at different levels of interpretation. However, our attention must also be drawn to the graphic language that conveys interpretations, to the codes of representation that give access to knowledge and allow the conception and implementation of conscious protection and conservation projects.

In recent years, considerable efforts have been made by institutions to digitise Cultural Heritage sites, artefacts, historical documentation, for digital preservation and online sharing. On the other hand, extensive research projects and studies have been published demonstrating the great capabilities of web-geographic information systems (web-GIS) for the dissemination and online representation of Cultural Heritage data. However, the Cultural Heritage data and associated metadata produced by many Cultural Heritage institutions are heterogeneous. To make this heterogeneous data interoperable and structured, an increasing number of public actors are adopting the principles of linked open data[1]. Although the cultural heritage sector has already started to implement linked open data concepts for heritage data to be preserved and passed on (Bizer et al., 2009; McKenna, 2013), there are not many references in the literature presenting an easy to implement, free and open-source web-GIS architecture that integrates 3D digital models of Cultural Heritage with cloud computing and linked open data.

Fig. 1 Analogical-perceptual and analytical approaches to urban surveying (Author's elaboration on sources: Lynch, 1960; Cullen, 1961; Cavallari Murat, 1968).

The integration of web-GIS technologies with web-based 3D visualisation and linked open data can offer new dimensions of interaction and exploration of digital Cultural Heritage. To demonstrate the high integration potential of these technologies, new cloud architectures are enhancing digital Cultural Heritage exploration by integrating digital cultural heritage information models with linked open data from DBpedia and GeoNames platforms using web-GIS technologies[2]. More specifically, an interactive digital map, 3D digital models of Cultural Heritage, open data linked from DBpedia and GeoNames platforms are frequently integrated into a cloud-based web-GIS architecture. Thus, users of the digital platform can easily interact with the digital map, visualise 3D digital models of Cultural Heritage and explore linked open data from GeoNames and DBpedia platforms, which provide additional information and context related to the selected CH site and external web resources.

Research on Cultural Heritage preservation has shifted from emphasising digital information with the advantages of 'accuracy' and 'amplified visualisation' at an early stage, to focus on the development of 'realistic' and 'highly experiential' gamified interactive environments. Just as game technology provides a highly interactive experience, effective communication and a virtual environment provide new application opportunities for the future development of the reconstruction of physical places and cultural spaces (Batty, 2005).

The meeting point of these complementary approaches is the discipline of drawing, graphic representation and the codes that in this language constitute the alphabet and dictionary of storytelling. In the last decade we could say that the approach to urban information modelling for protection and conservation has changed its focus from land use analysis and the balance of transport infrastructure to more complex and dynamic systems incorporating social and economic components. This is to a large extent made possible by the diffusion of analyses based on large amounts of data and the possibility of exercising artificial intelligence to propose alternative

project scenarios. In the following paragraph some definitions of a specific category of data and information, those of a geospatial and geostatistical nature.

Geospatial data and geostatistical information

Spatial geostatistics is a system of analysis that considers different types of data and produces different types of information. The compound term 'geospatial data' can be defined as data representing the position of a specific point or area in a geographical space (including relevant temporal data) and any associated parameters. Spatial data can be classified as follows (Cressie, 1993, p. 32)[3]:

- geostatistical data;
- data networks (lattice data, observations of a random process observed over a numerable set of spatial regions and supplemented by a linear neighbourhood structure; it is discrete data residing on an irregular lattice);
- point patterns (distribution of points in space).

From a strictly technological point of view related to geographic information systems, it is necessary to highlight the paradigm shift from a two or three dimensional vector management to a raster data processing in space, i.e. a matrix of ordered cells where each cell corresponds to a qualitative or quantitative value representative of the entire area covered by the cell (whose dimension defines the resolution of the analysis, i.e. the minimum readable and representable area, below which the variation of values cannot be collected). The need to map the survey in three-dimensional terms is fundamental for the development of a CH governance strategy based on climate, ecology, geology, physiography, hydrology, as well as anthropogenic influences. Compared to extensive fieldwork, the use of remotely sensed data provides remarkably convenient means of collecting data over large land masses. Remote sensing provides high-resolution data with which to structure land representation. For example, the Landsat programme that was launched in 1972 by the United

Fig. 2 Brief overview of open source and free web-gis environments and main functionalities.

Fig. 3 Data-information-knowledge (source: McCandless, 2014, p. 14).

States Geological Survey (USGS) and NASA provides the most continuous record of data used for over 30 years to study the environment, resources, and natural and man-made changes occurring on the Earth's surface. Turning to data processing, statistical surfaces are numerical-graphic representations of the distribution of values of a given phenomenon defined, for each triplet of coordinates, by measured or calculated values as associated parameters (Robinson et al., 1995; DeMers, 2008). The easiest statistical surfaces to understand are those referring to terrestrial topography[4]: geographical entities that change in space: the elevation, the piezometric height of an aquifer or the deep sliding surface of a landslide. There are other examples of statistical surfaces: the representation of temperatures or precipitation over an area, the diffusion of pollutants, socio-demographic and economic parameters, the cultural value of an

asset, its history. The important aspect of these surfaces is the adjective that qualifies them: statistical. The term statistical, associated with the concept of surface area, derives from the fact that this type of representation is obtained by estimating the value of a variable where no measurement has been made. Statistical estimation techniques are used when a variable is calculated at every point on a surface from data measured only at certain positions. Interpolation or extrapolation processes are used to calculate unknown points.

In the McCandless diagram, unstructured information means relationships, i.e. the external world with its complexity. Any phenomenon that can be perceived or measured can be described as information. McCandless finds a metaphor between organisms and interconnected knowledge, looking at atoms as data, going through molecules DNA chromosomes cells, then structured data information, connected information, knowledge and finally interconnected knowledge. Looking at the infographic you will get a glimpse of the whole process.

The range of data types and the development of a landscape strategy from these types is complex, as is the choice of representation tools for these activities. Understanding the principles of the various data acquisition processes enables an understanding of the appropriate tools to achieve results. An example of data

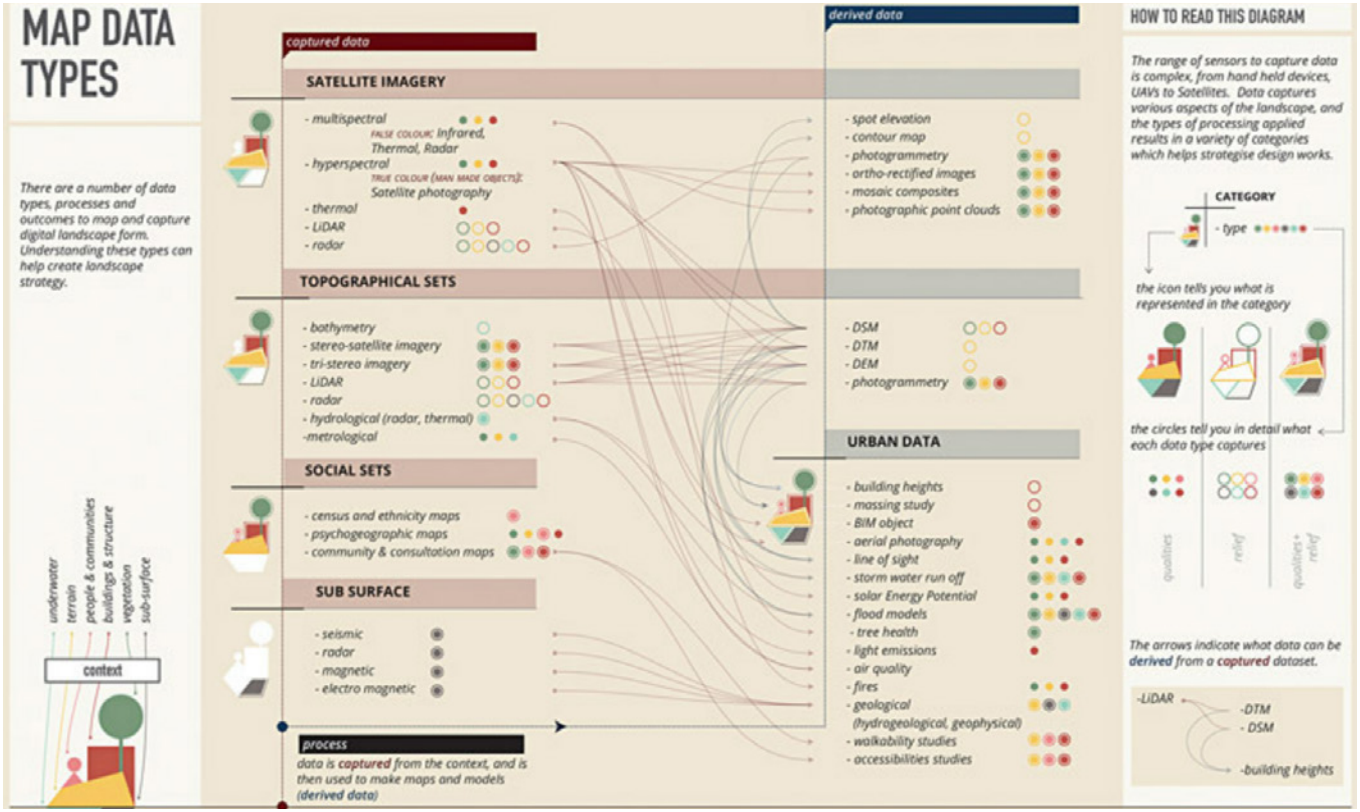

Fig. 4 Serena Pollastri, Imagination Lancaster, Lancaster University, mapping data typology, 2016 (source: Cureton, 2017, p. 39).

and workflow types has been rendered infographically by Serena Pollastri. The translation of the scheme into a sankey diagram helps to make evident some relationships and how the single type of data can contribute to defining more parameters and more indicators of territorial quality and cultural value.
The effectiveness of representation is reflected in more effective and efficient processes of territorial and city government. The brief notes expressed highlight the need to articulate the frameworks according to the necessary geostatistical skills, each for its own disciplinary field of analysis: demographic development, social characterisation, urban development and transformation, cultural value. The point of view that must not be overlooked is that relating to the opportunities to analyse phenomena graphically in order to provide a glance, a synthetic and immediate reading with the specific aim of sharing them with vast and heterogeneous publics. In the following paragraph we will observe the interpretative models that can be applied to the data and some useful references in the literature.

Active protection of the built and social heritage

The senses of the urban environment can be defined as the clarity with which spaces can be perceived and identified by linking experiences, activities and places in a coherent mental representation of time and space, as well as being linked with concepts and values that are not only geometric. Interpretative models and informative elaborations must be assumed for the conservation and care of the built heritage and the social value of communities and places. In literature we can trace four possible models, excellently described by Yamagata & Yang (2020)[5] and here summarised, integrated and adapted to the CH theme.

Urban detection systems as a human interactive model

There is a common ground between the geometric and functional form of the city and the human processes of perception and cognition, the urban senses, which has been termed identity, or sense of place (Lynch, 1984). People tend to identify with the urban places that they appropriate, that they experience, that impose an experience on them (McCullough, 2004). The question of confidentiality and the issue of who controls the data, what are the mechanisms for classifying and analysing the data for applications, and how decision-making is managed collaboratively with communities, define the most central role in the processes of building cities and preserving their heritages. Urban sensing systems define the first dimension of design in terms of attention to socially interactive processes. Systems capture data through sensing infrastructures without compromising privacy, individual choice and participatory processes through community involvement. Human senses are extended to wider urban environments with the help of electronic sensors by engaging human activities in cities through receiving, responding to and interacting with users in near real time: data is captured, analysed and represented for smart city planning (Batty, 2013a).

Data-driven heritage protection as a normative model

Data-driven protection links values and the creation of urban forms that imagine future cities and societies; these are driven by visions, goals and proposals, also based on data and performance criteria that drive system changes. Urban planners now collaborate with systems scientists to develop a dynamic digital city model, or urban cyber-physical systems that constantly renew their data and information with inputs from both inside and outside the system boundaries of the smart city project. Inspired by the performance-based model of city design (Lynch, 1961), data-driven advocacy offers additional dimensions, emphasising the connection of data analysis with design to transform cities and urban spaces. It is driven by normative questions, focusing on the values of urban form. The ability to raise questions such as 'what urban systems should be implemented and how cities are transformed by them' is crucial. In other words, the utopian vision of the future will define what analytical data is selected and how design scenarios

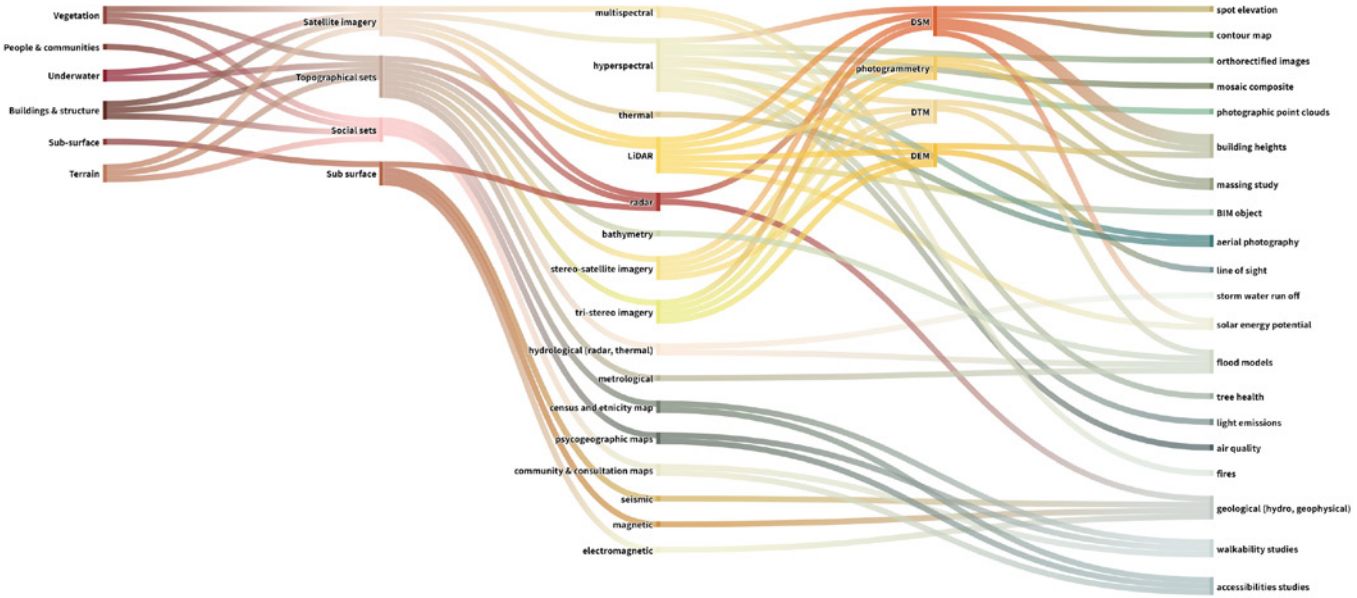

Fig. 5 Types of data, aggregation into sets and processing contexts (source: Author's elaboration on Pollastri infographic, 2016).

	Human sensing environment	Urban form – energy & water	Network system & flow	
System change / design	Experiential modeling	Performance modeling	People flow modeling	Social/cultural/policy context
	Indicators • Visual quality • Thermal comfort • Human behavioral responses	• Urban building energy demands • Renewable energy potentials (solar, wind, and waste to energy) • Stormwater – Flooding	• Walkability • Mobility • Accessibility • Evacuation (Fire, Earthquake, Flooding)	• Guidelines and decisions using big data analytics
• Anticipatory • Participatory • Optimization – Machine Learning	*Tools* • ArcGIS (Viewshed) • Rhino + Grasshopper • Statistical modeling (R, Python) • IoT sensor	• Rhino + Grasshopper (Honeybee) • Building Information Modeling (Revit) • ArcGIS • Statistical modeling	• ArcGIS (Network Analysis) • Traffic Model (MATSIM) • Agent-Based Modeling (MATSIM) • Statistical modeling	
	Data • IoT sensor data	• IoT sensor data	• GPS	

Fig. 6 Summary of modeling approached in urban systems (source: Yamagata & Yang, 2020, p. 25).

are derived. Conservation design is driven by human values and people's desire for their future. It is therefore a participatory model, as opposed to the previous analytical model based on surveying. Both models are based on the observation of present and future urban form.

Urban metabolism as a functional model

The third model is a theory of complex systems and urban metabolism. Urban metabolism refers to system functions. The method sees cities as complex systems containing processes and flows of energy, material, water, human movement and information that transcend different sectors and operate on different spatial and temporal scales. A city does not operate like a machine. It is more like a metabolism. We should conduct a comprehensive urban metabolic study of energy, material and water flows to and from urban areas or cities to explore issues of efficiency, intensity, distribution and recycling strategy (Graedel & Allenby, 2010). Multiscale modelling is needed to analyse the movements and exchanges that can be observed in cities. The model incorporates the complex relationships between infrastructural systems and to what extent the nexus of these subsystems might influence the overall performance of the system. it is therefore definable as a functional and performance model, registers and calibrates to the vital parameters of the urban and social fabric.

Geodesign as a procedural model

Finally, geodesign is a procedural model that manages the surveying and decision-making process from data visualisation, data analysis, project generation, monitoring, and finally impact assessments through collaboration between stakeholders. This type of model requires several rounds of iterations before decisions are made. Geodesign is also seen as a procedural method that combines design with social, cultural and environmental impact simulations influenced by geographical contexts, systems thinking and digital technology. In short, it brings 'design for change' back within geographic information systems (GIS) (Steinitz, 2012; Steinitz, 2014).

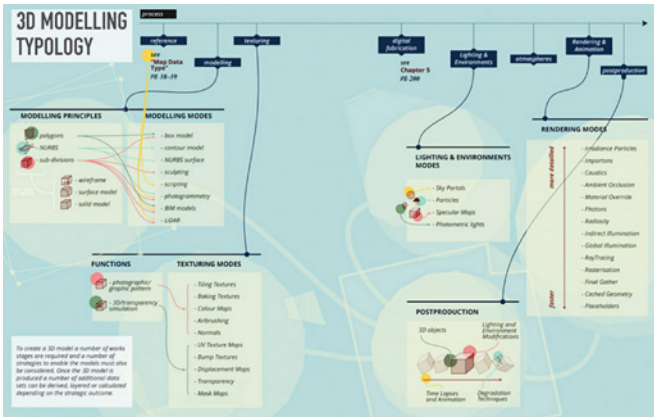

Fig. 7 Serena Pollastri, Imagination Lancaster, Lancaster University, 3D Modelling Typology, 2016 (source: Cureton, 2017, p.157).

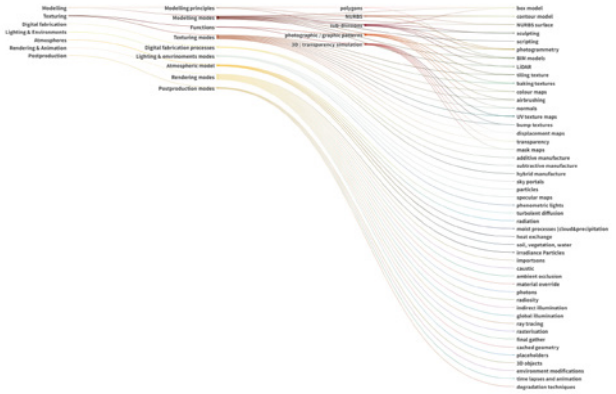

Fig. 8 Geometric digital modelling, parameters and production environments (source: Author's elaboration on Pollastri infographic, 2016).

The design of urban systems with cultural value is based on performance modelling to better understand the consequences of decisions. Three concepts are further clarified in their relation to urban systems: types of modelling, determination of metrics in performance modelling, and constraints on urban systems.

Among the interpretative models described above for the active protection and conservation of the built heritage, the following paragraph focuses mainly on the one more explicitly connected with information systems and models that integrate three-dimensional modelling with information components, GIS, BIM and distributed databases.

From geometric modelling to information systems and models

For a wider audience, the map is the agent that enables understanding of the place it is intended to protect and preserve. The data that various associated disciplines collect reflects scientific commitment and application in understanding environments. Such a super-scale datascape means that we need to think clearly about what is useful, selectable and applicable to natural and built heritage. Alongside this need, it can be argued that contemporary computing seeks fidelity to the territory it represents. As in Jorge Luis Borges' tale, there is a great popular cartographic drive to simulate the world from all disciplines in a high resolution map in real time (Cosgrove, 2012, pp. 1-2). Digital

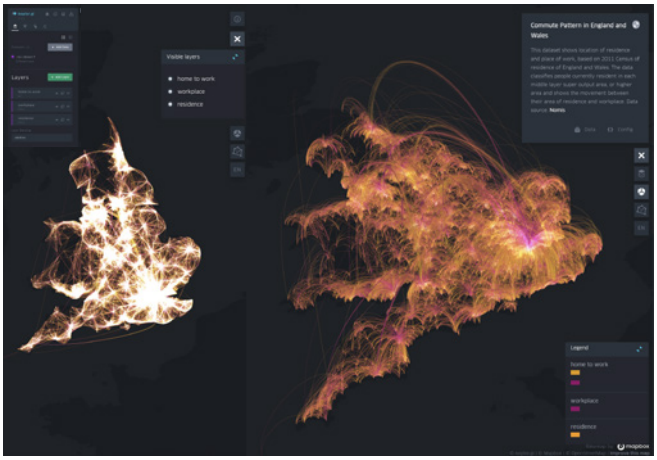

Fig. 9 Integrated GIS applications: Kepler.gl.

modelling combined with reality computing has come more to the fore, a digital simulation with near accuracy of a place that can also be immersive through the use of Augmented Reality (AR), Virtual Reality (VR) devices and many other technologies. Different modelling options can be employed and it is important to understand the processes to achieve

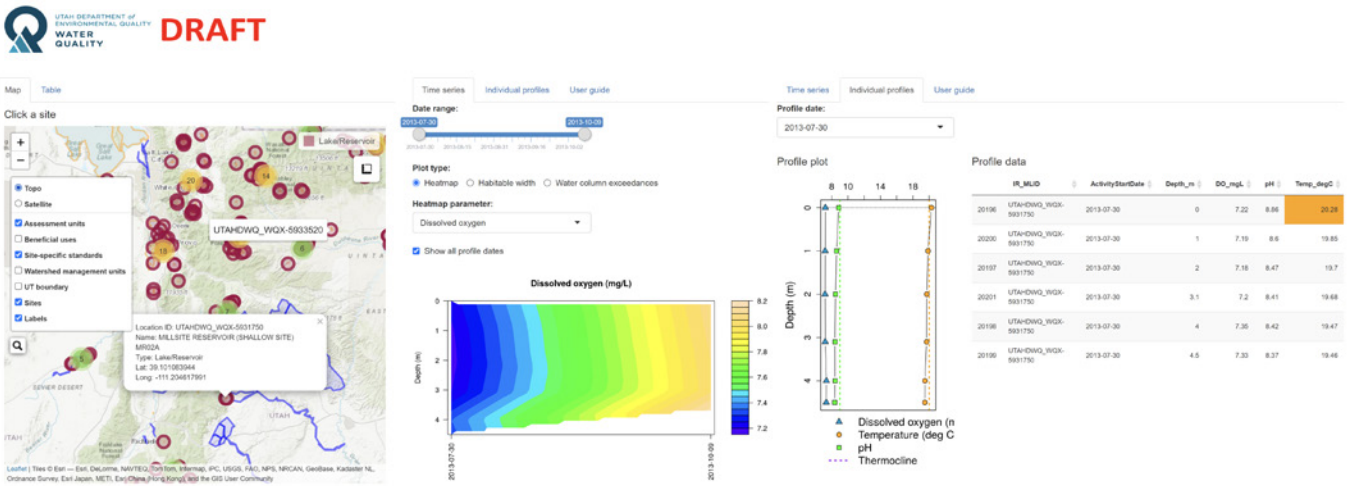

Fig. 10 Integrated GIS applications: Shiny.

the desired results. This obviously improves modelling efficiency and production time.
Quantitative and qualitative analyses of Cultural Heritage (CH) assets need to interconnect individual pieces of information, including a variety of multi-modal acquisitions, to form a holistic and composite view of the studied objects. The need for joint acquisition brings with it the need to define a protocol to store, structure and support the interoperability of multi-source data. Given this multivariate input, hierarchical data organisations have been defined; furthermore, supporting tools have been developed to manage the multimodal data: one for annotating metadata and another for recording geometric, alphanumeric and image information (Ioannides et al., 2018).
The problems of lack of design dimension and adaptability in traditional GIS models have been addressed in the emerging discourse of Geodesign, an initiative that has focused more on the project-oriented method of modelling (Batty, 2013b). Geodesign provides a potential to further elaborate a transformative model to the problem of urban systems, a data-driven process to integrate urban design, performance modelling and cultural and social context (Yang & Yamagata, 2019). To go beyond a linear method, Geodesign offers a collaborative platform for operational iterations that enable communities and stakeholders to manage decision-making processes. The four models in the previous paragraph listed possible models underlying the design of urban cultural systems, a method to model smart cities by integrating design and systems science. It is particularly important when human experiences and senses in cities are extended to multiple dimensions. Skills and knowledge in big data analysis, the tools of digital technologies such as GIS and BIM, and creative design thinking are equally important. The articulation of people, systems and design in collaborative processes offer a transformative approach to creating sustainable smart cities.
Various types of GIS-related technologies have emerged, new challenges to manage large amounts of data,

Fig. 11 Integrated GIS applications: Mapbox.

Fig. 12 Integrated GIS applications: ArcGIS Urban.

introduce interactive systems and integrate different technologies and formats. These include:

- Kepler.gl, which is developed by Uber Technologies, Inc., is a high-performance web-diagnostic application for the visual exploration of large-scale spatial data. By simply dragging and dropping any (large) data with geospatial information from the browser, they can be visualised;
- for the purpose of producing interactive GIS applications in an easy way, Shiny, which is developed by RStudio, Inc., is an opensource R package that makes it easy to build interactive and communicable web applications. Web

applications created in Shiny can be used to run R programs on the fly, and interactively using user input parameters from a browser. Subsequently, the results can be visualised in a dashboard or movie/database explorer;

- a further tool for free integration, Mapbox, which is developed by Mapbox, Inc., is an online location data platform for mobile and web applications (maize mapbox). Mapbox has been installed in many popular software or applications such as Facebook, Foursquare, Snapchat, etc. In addition, new bottom-up opensource data that have emerged (e.g. OpenStreetMap and Mapillary) and API tools can also link to Mapbox;
- finally, ArcGIS Urban, which is developed by Esri, Inc., is a web-based system to support urban planning and decision-making. This system can interactively visualise the natural and urban territory and changes in building and street parameters such as height and width in 3D.

Elements of the city's behaviour are captured by urban informatics - i.e., by obtaining real-time data from sensors and other probes of urban behaviour - which are then stored and analysed in information models of the city. This then allows individuals, organisations, neighbourhoods to evaluate their own behavioural change.

Conclusions

A brief discussion of common data types demonstrates the incredible development that has taken place over the last century. Data sets can be used in study or practice as a basis for collecting and describing elements of interest in the natural and built heritage. The use of such datasets raises a relevant question: what are the required results, what is to be discovered? Government departments may hold vast swathes of publicly accessible information; these repositories should be considered in the initial strategy for collecting mapping data, but may require reading internal manuals and processing guides for use in software packages and chosen hardware. While these large-scale institutional organisations host very substantial mapping data packages, there are also options for using these sets as base layers for mobile mapping applications. Processing environments allow for the mapping and emphasis of any feature associated with cultural heritage, the hosting and sharing of this information, and the production of mapping infographics. The development of graphical codes and representation languages for knowledge and understanding (sensation-perception-awareness and environmental well-being) is a current and vibrant area of research to hybridise the knowledge system within digital, dynamic, interactive and layered information systems and models.

Notes

1 Linked data, in computer science, is a way of publishing structured data that allows data to be linked together. The publication of linked data is based on open web technologies and standards such as HTTP, RDF (Resource Description Framework) and URIs. The purpose of this data structuring is to allow computers to directly read and interpret information on the web. The presence of links also allows data to be extracted from various sources through semantic queries. When linked data links open data, it is referred to as linked open data (LOD) (Bizer et al., 2009; McKenna, 2013).

2 DBpedia is a project started in 2007 with the aim of extracting structured information from Wikipedia and publishing it on the Web as Linked Open Data in RDF format. GeoNames (from the particle geo-, from ancient Greek γεω-, from γῆ, "earth", and from English names, "names") is a database of geographical data accessible through various web services, usable under the terms of a free content licence. Some online references may be geonames.org, pro.europeana.eu, linkedheritage.cab.unipd.it.

3 Refers to data related to geospatial information as geometric data. Further comprehensive definitions of spatial data can be found in Anselin (1988, pp. 16-17) and Waller & Gotway (2004, pp. 38-39).

4 For example: DSM (Digital Surface Model) refers to the earth's surface including the objects on it: buildings, trees and other artefacts. The DTM (Digital Terrain Model), on the other hand, represents the course of the land surface without the anthropic and vegetation elements.
The DTM can also be associated with the term bare earth. Finally, the DEM (Digital Elevation Model) is a generic statistical surface in which a finite number of pairs (X,Y) are assigned a corresponding value, parameter. In common use, the DEM refers to terrestrial topography but can also cover other surfaces.

5 See also Hill (2008), https://www.cityofsound.com/blog/2008/08/two-or-three-re.html.

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Abstract

The highly heterogeneous morphology of urban realities, derived from the development of buildings through different historical periods, characterizes the territory of the Italian countryside. The seismic risk widely exposes the Italian orographic context, so mitigation and reduction of the effects on buildings is a crucial topic. Vital support for the analysis of structural vulnerability is the representation models for underlaying the main vulnerability phenomena. This research aims to define an integrated multilevel tool capable of managing, analyzing, and representing the data's multiplicity, heterogeneity, and complexity necessary to evaluate the seismic vulnerability of masonry buildings in the historical centers. The information acquired through a process of knowledge and elaborated through parametric modeling systems (BIM) can determine the most likely collapse kinematics, therefore, to evaluate each structural unit's levels of seismic vulnerability. This paper shows the methodology tested on the case study of San Rocco Village in Sora (FR) and describes the results in detail.

Keywords

Historical centers, BIM, Masonry, Seismic vulnerability.

04

Multilevel BIM Analysis for the Assessment of Seismic Vulnerability of Masonry Buildings

Introduction

The debate on safeguarding historic centers has reopened in Italy with vigor. In particular, after the last seismic events that affected the municipalities of Central Italy: the L'Aquila earthquake (2009), the Emilia Romagna earthquake (2012), and the Central Italy earthquake (2016). These historical centers are considered environmental monuments to be protected and preserved due to the originality of their urban layout. They were born for the most part in the Middle Ages and Renaissance. The *nuclei* models such as spindle, enveloping, and multi-directional depend on the orography of the place of settlement and its height.

These recurring models occur throughout the national territory: commonly, layouts can be found in all the Italy regions. From a structural and architectural point of view, the historical centers are almost totally characterized by masonry buildings made with materials readily available on the construction site. Over time, buildings have been subject to changes, extensions, modifications, and interventions. This aspect generates heterogeneous systems of construction interconnected between them in aggregate solutions. The heterogeneity of the construction techniques used for the construction of the buildings causes significant vulnerabilities from a structural point of view due to the numerous types and materials for the single parts of the buildings. From a social and cultural point of view, these historic centers represent the cultural identity, and unfortunately, they are subject to numerous degradation phenomena that make them highly vulnerable. They are vulnerable from an environmental point of view and a social point of view, for instance the depopulation of historic centers.

After these considerations, the safeguarding of these centers starts with a knowledge project highlighting the main factors contributing to seismic risk assessment. A map has been prepared to show the location of minor historical centers (less than 5,000 inhabitants) to understand the seismic risk exposure. It is visible that they form the backbone of Italy. It emerged that they make up 70% of the Italian municipalities. These analyzes required the design of a Geographical Information System called HT_GIS, an acronym for Historical Town_Geographical Information System, using an open-source software Q-GIS. The system, based on the data relating to the most recent update of the ISTAT census, integrated with data obtainable from the websites of Regions, Provinces, and Municipalities, can display in overlay the information from the associated database and graphically returns the location and size for n° of inhabitants of minor historical centers. With the overlaying of the INGV map of the seismic hazard with the distribution map of the minor historical centers, it emerges that the minor historical centers are in the Apennine areas in which the most recent seismic classification has attributed the zone 1 and 2 with the maximum macroseismic intensity. The result is evident, thinking that these centers were born in medieval times, and they are on the slopes or top of hills for strategic

reasons. Reducing the seismic risk of these centers means necessary intervention in the reduction and assessment of vulnerability and the identification of the principal vulnerabilities in the preventive phase.
With this awareness, this contribution aims to define an integrated multilevel tool capable of managing, analyzing, and representing the multiplicity, heterogeneity, and complexity necessary for defining the seismic vulnerability of masonry buildings constituting the historical centers. To achieve this aim, it has been developed two types of approach: a 'qualitative' based on a simplified survey and a qualitative analysis capable of defining the most probable local collapse mechanism for masonry buildings; and a 'quantitative' approach based on an advanced survey for the knowledge of the detail of buildings and quantitative analysis for the determination of the spectral acceleration of activation of the collapse mechanism. The integrated tool was structured through BIM to create complex models capable of simulating the risk scenarios to which historical centers are subject.

Methodology: 3D multilevel approach

The construction heterogeneity of these agglomerations, as already mentioned, makes the analysis complex based on a close interrelation between the survey and the structural analysis. For these reasons, state of the art is fundamental for the definition and development of the approaches. Tools, techniques, and technologies used for the traditional direct survey have led to the knowledge of the most recent advanced survey techniques, which, thanks to the digitization of processes, have allowed the development of digital photogrammetry, which is widely used in following applications. At the same time, the background of the methods and empirical approaches for the analysis of existing move toward survey methods and simplified analyzes such as the AEDES methodology developed by the National Group of Defense of the Territory (GNDT) and the CARTIS project recently proposed by the department of civil protection and by ReLUIS for the assessment of the vulnerability of ordinary buildings. The

Fig. 1 Urban layout: a) Arpino – multidirectional; b) Palombara Sabina – Eveloping; c) Opi - Spindle.

proposed methodology highlights the strong correlation between the levels provided for analyzing the seismic vulnerability towards local collapse mechanisms and the related traditional and advanced survey techniques. The visualization of the results in a static way for the first qualitative level and dynamic/informative for the second level constitutes an immediate and easily interpretable tool for the design of interventions in order to reduce the vulnerability of buildings.
The first level, the 'qualitative approach', is based on a quick/simplified survey in situ and a characterization of the materials that constitute the input elements for an algorithm developed in Boolean Algebra language (true/

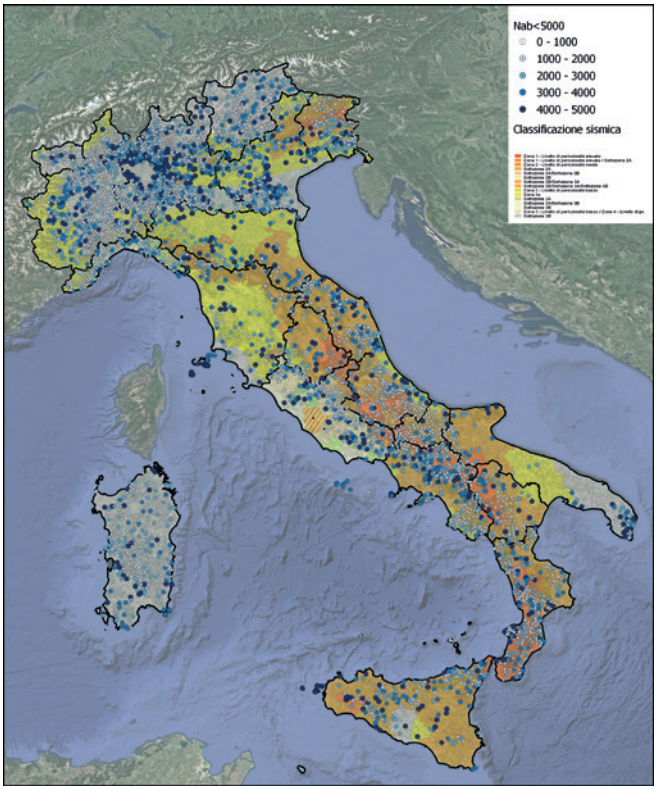

Fig. 2 HT_GIS: overlay of the minor historical centers on the seismic hazard map.

false) for the identification of the most probable local mechanism of the collapse of the facades of masonry buildings. These mechanisms are widely described in the literature as global overturning, partial overturning or along the openings, and vertical and horizontal bending. The methodology allows a 3D graphic model to bring together the information obtained from the survey and the results view of the analysis. Thanks to the algorithm that compares the dataset of the information acquired in the survey phase with the structural peculiarities that characterize the collapse kinematics of masonry buildings, the collapse mechanism with the highest probability of occurrence can be identified. The algorithm's structure is a set of typological, structural, and constructive deficiencies responsible for activating a probable mechanism together with the basic geometric and dimensional information. Therefore, it is possible to determine the probable mechanism that can be activated by comparing the presence or absence of detected structural characteristics and such structural peculiarities that characterize particular collapse kinematics. The algorithm is structured in 3 phases: the first is a data input phase, in which a survey form is compiled with general information on the building and the geometric and structural characteristics derived from the simplified surveys carried out in situ. Attention should be paid to the identification of constructive and structural details that characterize the mechanism's activation and to some characteristics of the geometric composition of the facade, such as the alignment of doors and windows, or the presence of the tympanum in the facade. The second phase consists in processing the data collected with assessing critical issues. The algorithm identifies whether or not the presence of the slenderness of the facade, joints of the slab, curb at the top, joints of the wall orthogonal with the facade, chains and tie rods, alignment of the openings in the façade, discontinuity of wall sections, considerable distance between the walls perpendicular to the facade, presence of the tympanum on the facade. The results obtained from the qualitative approach's analyses can be represented in graphic form by associating the collapse mechanism identified by the algorithm with a 3D graphic model created after the simplified survey. After processing the data based on their combination (true if present, false if absent), it can process the comparison with the critical conditions that activate a specific mechanism. And at the end, the output phase with the identification of the most probable collapse kinematics.

The 'quantitative approach' is defined based on detailed and advanced instrumental surveys aimed at deepening the knowledge of the buildings and performing a quantitative evaluation of the vulnerability of the building. At this level, the procedure's objective is to evaluate the spectral acceleration a_0 activating the potential out-of-plane

local mechanisms detected in the previous qualitative level analysis by using more refined structural models.
To apply the quantitative analysis, therefore, it is necessary:

- to have information on the geometry of the individual elements;
- to know the construction details accurately;
- to characterize the masonry mechanically.

It is necessary to use laser scanners or digital, aerial, and terrestrial photogrammetry to gather structural details to obtain a consistent set of geometric information. The most economical and fastest tool is undoubtedly the digital photogrammetry which allows obtaining 3D models, returned as point clouds, to get the mesh used in the structural analysis software. On the other hand, the mechanical characterization of the masonry can be carried out through non-destructive on-site tests and/or laboratory tests or to refer to the characteristics collected by guidelines (table C8.5.I of the Circular no. 7 of 2019). Alternatively, Masonry Quality Index (MQI) can be used. This method evaluates the MQI to correlate it with the average values of compressive strength, shear strength, and the average modulus of elasticity provided in table C8.5.I of Circular no. 7 of 2019.
The data collected from these phases are employed in the proposed procedure to perform a linear kinematic analysis according to the Italian code for evaluating the spectral acceleration activating the identified potential out-of-plane mechanisms and then quantitatively assessing the corresponding level of seismic vulnerability.

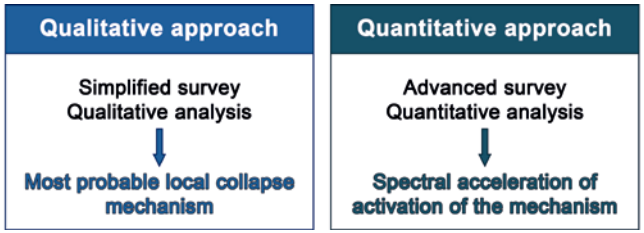

Fig. 3 Qualitative and quantitative approaches.

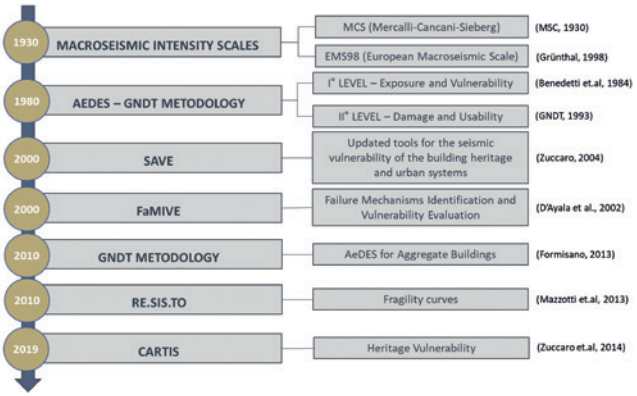

Fig. 4 Simplified and empirical methodology for the assessment of the vulnerability of ordinary buildings.

Case study

The methodology is tested and applied to a real case study: Borgo San Rocco in Sora in the province of Frosinone in Italy. It is a small village in a minor historical center of Roman origin, then medieval, and for its location given the high hydrogeological vulnerability that distinguishes it. It is located near the Liri river and on the side of Monte San Casto. Furthermore, from a seismic point of view because Sora is located in an area with a high seismic hazard and over the years, it has been affected by numerous seismic events, including important ones such as the 1915 earthquake in Avezzano which almost completely razed the urban buildings of the city to the ground. The village consists of 2 building curtains similar to two interconnected structural aggregates. The area is characterized by Porta San Rocco, better known as the Arch of San Rocco. Starting from the first half of the nineteenth century, in addition to redefining the city limits, it essentially became the connecting element between the two opposing buildings.
By applying the approach of level 1 - qualitative approach - it is necessary to carry out a rapid survey of the aggregate consulting the archive material: in particular, the documents held by the Municipal Technical Office relating to the post-earthquake surveys of 1984, consisting of floor plans, section, and elevations. This

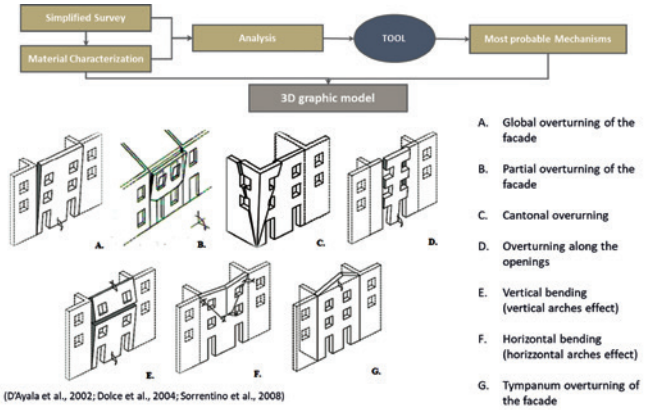

Fig. 5 Qualitative approach: visualization of the most probable collapse mechanisms of masonry buildings.

information makes it possible to identify and define the individual structural units that make up the two aggregates; for convenience, side A is the aggregate on the riverside, and Side B is the aggregate on the mountainside. It is noted that the entire village consists of 36 structural units, of which 20 belong to Side A and 16 to Side B. Each of them has been assigned a unique identifier. For each of them, the general characteristics of the facade have been evaluated, such as the length of facades, the height of buildings, an analysis of the level of horizontal elements, which are often misaligned between adjacent buildings in such configurations, and the alignment of openings, intended as doors and windows. A survey form has been compiled for each US to apply the algorithm developed to identify the

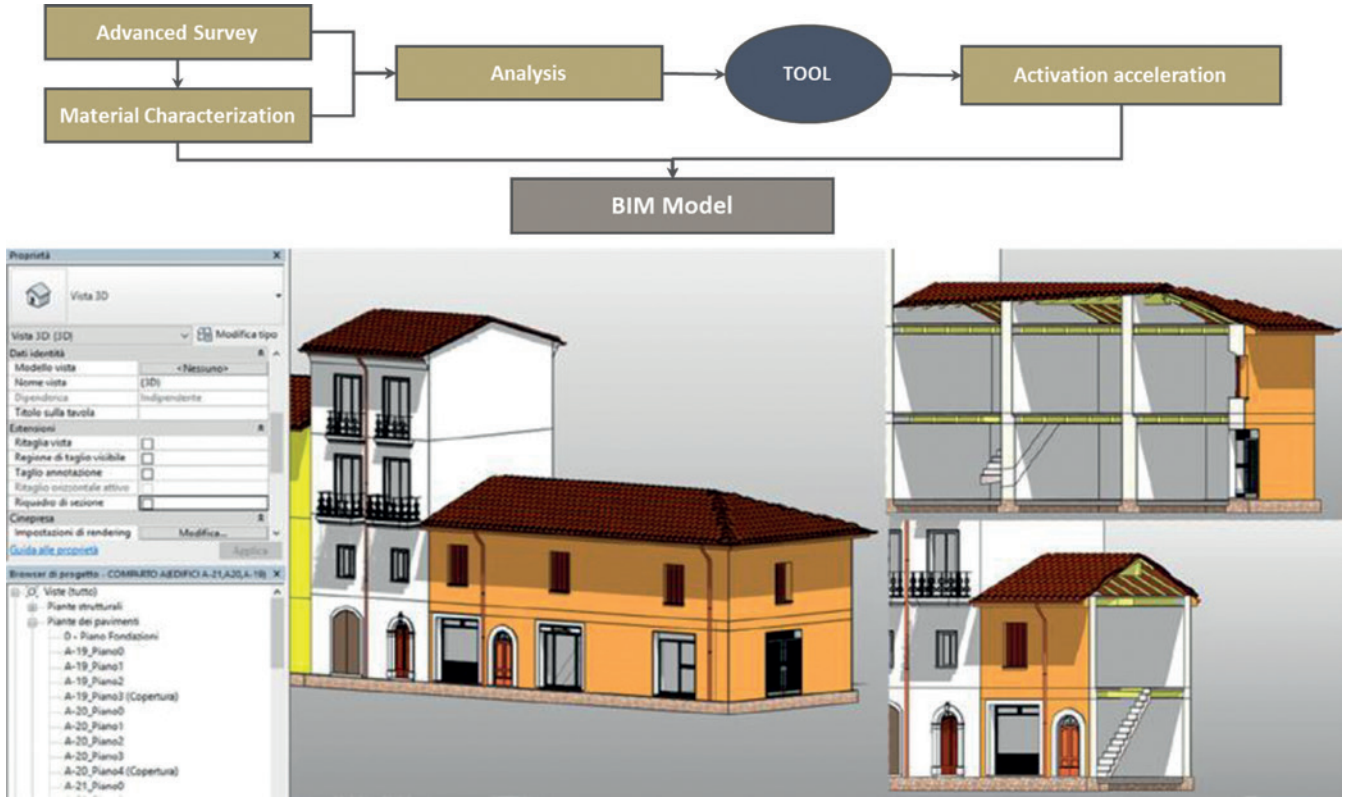

Fig. 6 Quantitative approach: BIM model for structural analysis based on mechanism activation acceleration.

Fig. 7 Sora. Borgo San Rocco.

collapse mechanism. At this stage, attention is paid to identifying those architectural and structural features that allow us to identify the possible local mechanism of the collapse of the facades. It is possible to visualize the types of collapse mechanisms affecting the aggregates by associating the results with an appropriately created 3D graphic model to have a clear qualitative indication of the vulnerability they are subject to. The results show that most buildings have a partial collapse of the facade and horizontal bending mechanism for Side A. At the same time, for Side B, US units have the Global overturning mechanism and the Partial overturning and horizontal bending mechanism.

The second level of analysis is based on a more detailed survey. In particular, aerial digital photogrammetry has been used with drones, which starts from photographs taken by drones; it is possible to reconstruct a cloud of 3D points with a digital process. It has been necessary to design the flight plan in the ideal wind and lighting conditions for taking the images. It has been processed about 1300 photos of the village, which allowed the creation of an easily digital model for the knowledge of the geometric information of the buildings employing suitable photogrammetric processing software. Each cloud point obtained has spatial coordinates X Y Z, and it is easy to know the distance between 2 points. The point

cloud, imported into BIM, constitutes fundamental support for creating the HT_BIM 3D model. It is possible to model from the general to the particular by integrating into a single model all the geometric, functional, material, and performance information of the elements according to the typical logic that characterizes BIM objects. Furthermore, as foreseen by the proposed methodology for this level of detail, it has been necessary to characterize the chemical and mechanical parameters of the materials through tests carried out in the Chemistry and Materials laboratory of the University of Cassino for the determination of the characteristics, as required by the most recent standards. Construction techniques Italian standards NTC18.

All these data, considered input data, were the basis for the realization of structural models for the execution of the linear kinematic analysis that allows obtaining the activation multiplier of the collapse mechanism (α) and the spectral acceleration of activation of the collapse mechanism (a_z). In this way, it is also possible to perform the checks required by Italian standards by comparing the capacity with the demand, thus passing from a qualitative result, indicating the most probable mechanism, to a quantitative one. Since it also indicates whether the mechanism can be activated and, consequently, the level of seismic safety (or vulnerability) of buildings towards these mechanisms.

The diagrams show the results obtained for each US shown on the abscissa the acceleration of activation of the mechanism. On the same graph, the value of the PGA, the peak acceleration expected at the site, is shown in red. It can be observed that most of the facades are subject to the possibility of activation of the identified mechanism. In particular, buildings with a mechanism activation acceleration value lower than the PGA value in red are subject to activation. In other words, it is observed that most of the US has a marked level of seismic vulnerability.

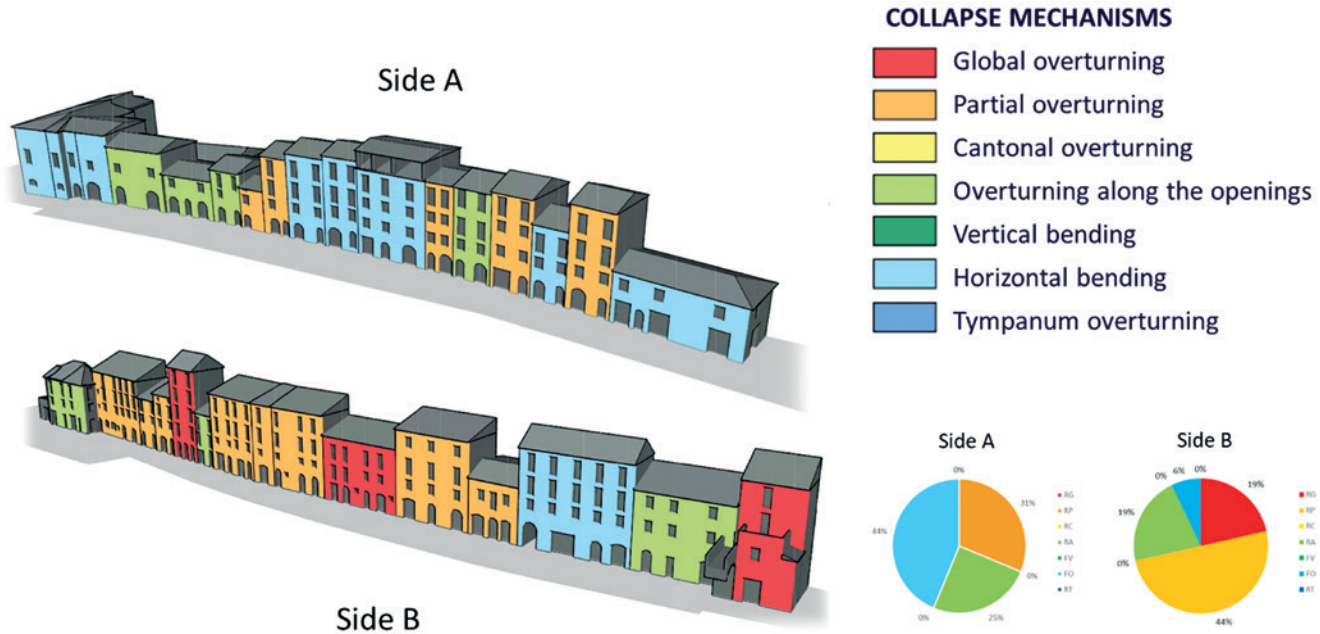

Fig. 8 Qualitative analysis results.

The same results can be viewed in the BIM model developed dynamically and automatically with the color maps based on the activation value of the mechanism. This type of visualization allows immediate recognition and visualization of vulnerable buildings.
The information obtained from the two levels is crucial for the local administrations that govern the territory because it highlights which units prioritize intervention, which is more vulnerable to seismic actions. They, therefore, constitute a support system for technicians who have to intervene because it is identified as the most probable mechanism of collapse. Consequently, they can define interventions to reduce them. Lastly, an attempt was made to verify the possibility of using a national database on ordinary buildings as input data to apply the proposed multilevel analysis. Reference was made to the CARTIS database wanted by the Civil Protection in collaboration with ReLUIS (network of university seismic engineering laboratories) for ordinary buildings' typological/structural characterization. The CARTIS project aims to compile buildings by building and sectoral data sheets of the Italian urban buildings. This information is cataloged in a searchable national database that presents valuable information for the operation of approach 1 of the proposed system. The developed system is dynamic since it allows a national database for its operation, considering the info as input data, and this can allow a rapid assessment of the seismic vulnerability of many buildings.

Conclusions

The research studies the consistency of minor historical centers in Italy by developing the HT_GIS system, showing that they are where they should not be. For this reason, it is needed the development of an instrument based on an innovative multilevel procedure for analyzing masonry buildings by defining tools for surveying, archiving/displaying HT_BIM data, and structural analysis from simplified to complex models, according to a qualitative and quantitative approaches. The application of the tool

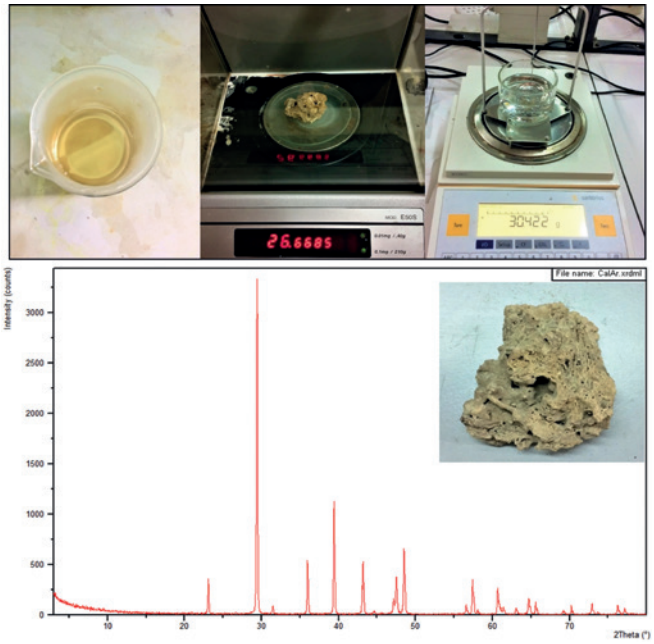

Fig. 9 Open porosity determination, acid attack and diffrattometric analysis (LABMAT – UNICAS).

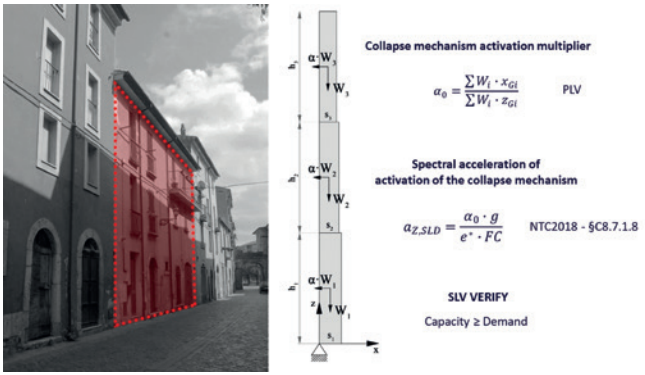

Fig. 10 Linear kinematic analysis on building 12A.

developed on the actual case study of Borgo San Rocco in Sora (FR) shows the vantage of this methodology, along with the verification of possible connection of the developed tool with the national databases on the existing

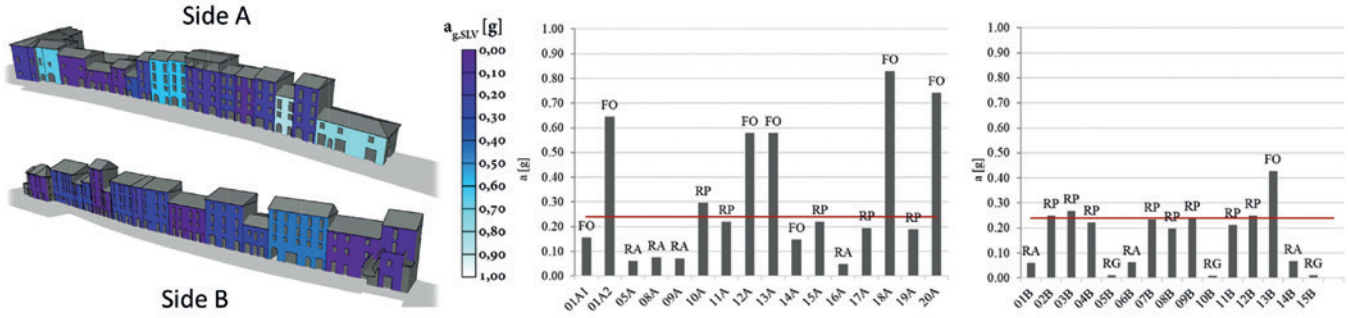

Fig. 11 Quantitative analysis results.

building (e.g., DB CARTIS). Therefore, the developed tool constitutes good support for local administrations (indication of intervention priorities) and technicians (indication of the type of intervention).

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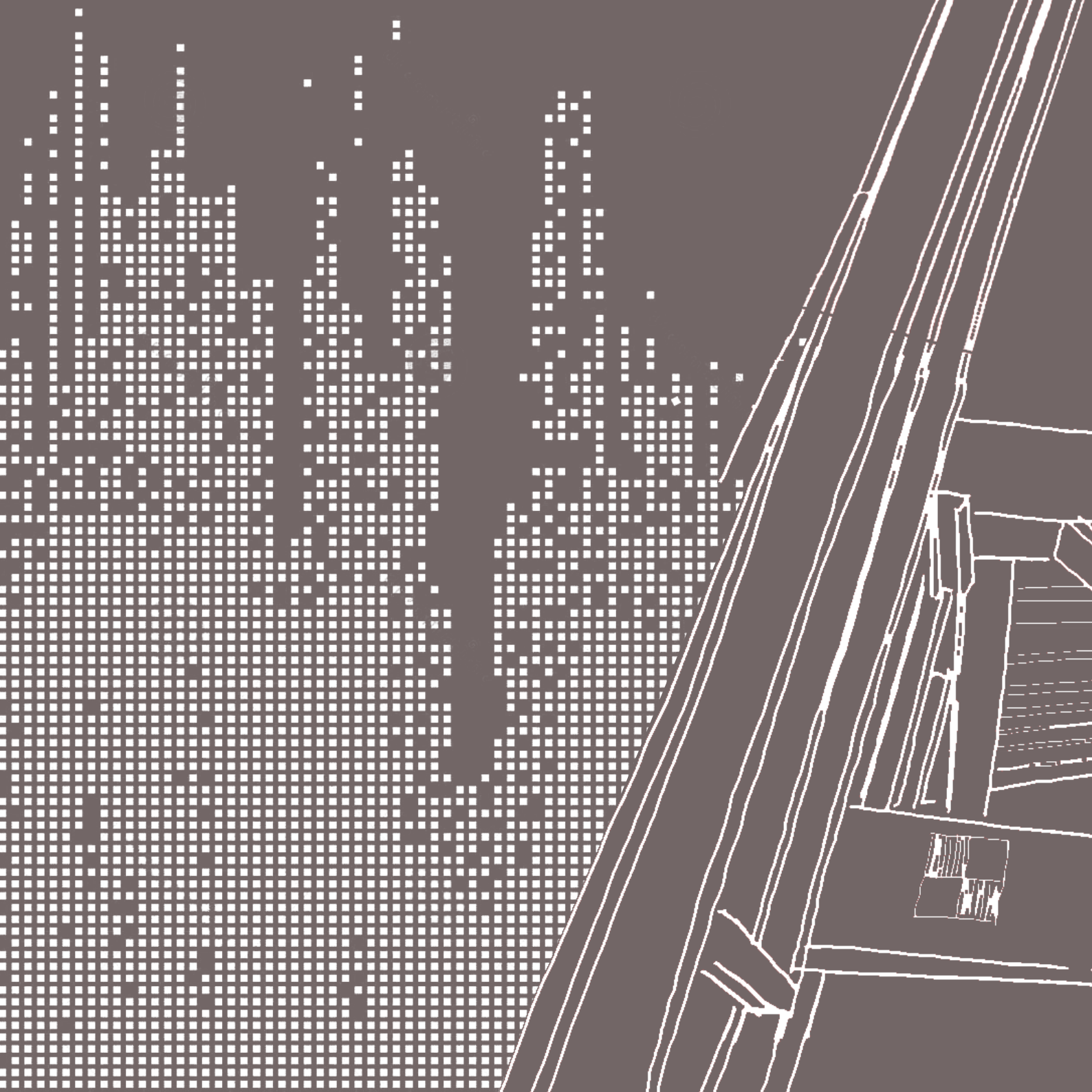
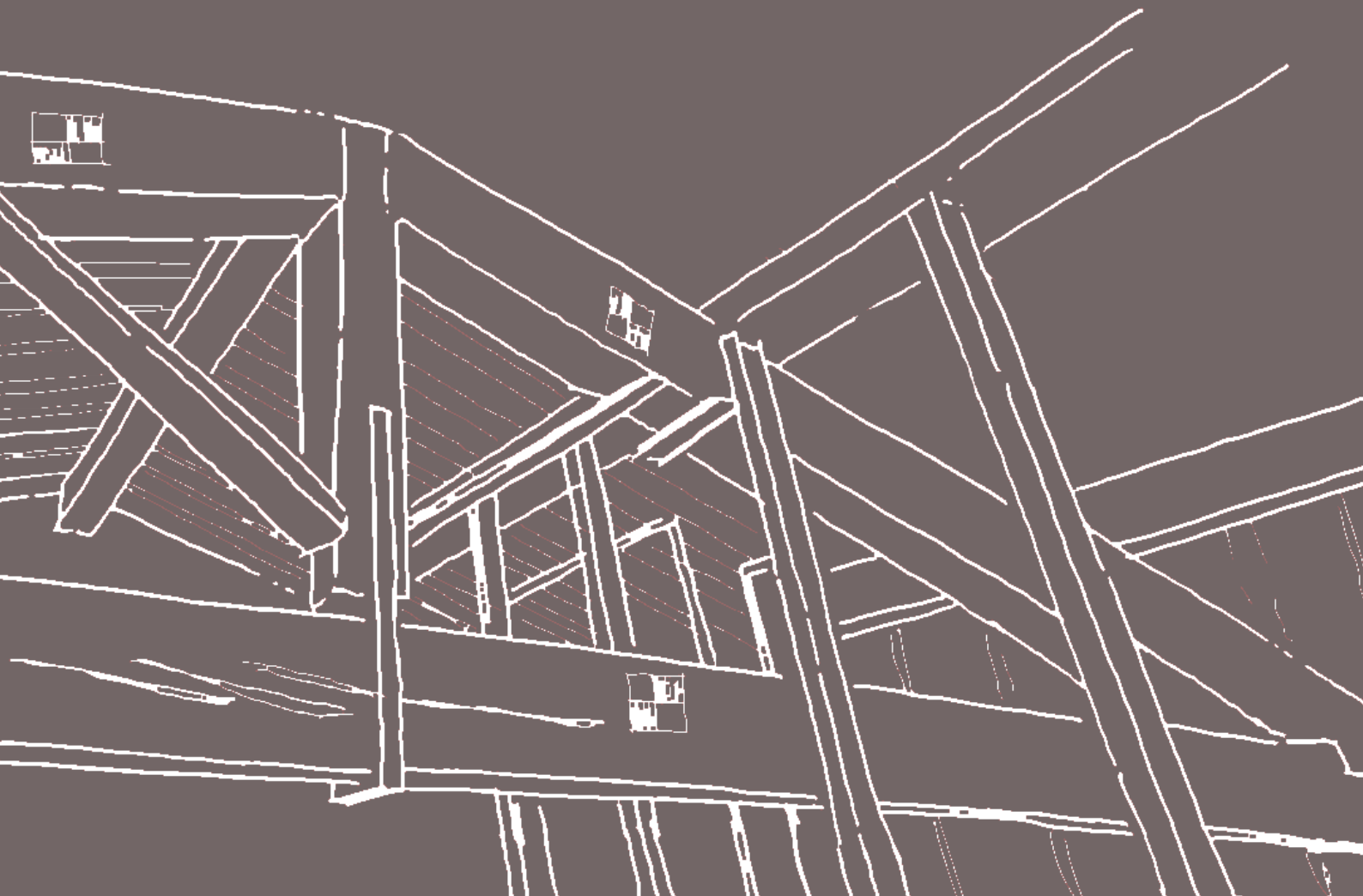


CHAPTERS

THEMATIC CHALLENGE 2
PROJECT AND RESTORATION



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Thanks to interdisciplinary working experiences, both in Italy and abroad, she acquired technical skills on Photogrammetry, 3D modelling, Machine Learning and Neural Networks, HPC, GIS mapping and processing, VR and AR applications; completing these competencies with history of art and architecture and archaeology studies. Europeana Council Member since Nov 2021.

Abstract

Historical photographs and film footage, which have survived over time because they are stored in historical archives, are in many cases the only traces of monuments that no longer exist. Thanks to Photogrammetry and Artificial Intelligence, applied to these sources, it is possible to document and to 3D virtually reconstruct lost architecture in order to preserve their historical memory. The presentation aims to give an analysis and assessment through the extraction of metric information from historical images and to experiment with its potentialities in the heritage field with the purpose of valorising historical iconographical documentation.

Keywords

Photogrammetry, Artificial intelligence, Cultural heritage, Historical images, Metric survey.

Photogrammetry and Deep Learning to 3D Reconstruct Lost Cultural Heritage

Introduction

The Cultural Heritage metric documentation[1] plays an essential role in preserving memory and knowledge of the past and constitutes the set of information useful to plan any kind of interventions on Cultural Heritage assets. The documentation is a common part of all the preservation, restoration, and management actions because provides all the information necessary to understand the object in question and leads to the adoption of best practices for the actions to be planned. The documentation information allows the virtual reconstruction of the investigated asset which forms today the starting point for each design of interventions and for complete knowledge about the present situation and, in case, of conditions of the same object in different historical epochs. All the documentation data represent a valuable source of knowledge that can be passed on to future generations and used for future actions (Stylianidis, 2019).

The knowledge of shapes and dimensions are one of the basic data of metric documentation useful also to locate all other non-metric information to help the comprehension of physical phenomena (e.g. structural diseases, etc.). The modern Geomatics techniques allow obtaining all these metric information with a certified accuracy and by extracting the best possible results by considering the quality of the used primary data.

The metric survey starts from the collection of a significant number of points with known coordinates in a unique reference system and the subsequent creation of a 3D model of the surveyed object. The 3D modelling requires a deep knowledge of the surveyed asset: as far as architectural assets (both single buildings and historical centres) the strong collaboration with specialists in History of Architecture is essential to correctly interpret and represent the original elements and the material interventions that occurred during the life of the investigated asset.

Among the various geomatic techniques, photogrammetry plays a fundamental role, since it allows the recovery of the metric data necessary for the geometric understanding of the object to be documented using only images.

Recent developments in the acquisition and processing of photogrammetric data have reached a high level of automatism and the easy use of instruments and software has increasingly encouraged researchers and experts in the field of Cultural Heritage to use this technique in their works. Consequently, these advantages make it possible to extend the application of photogrammetric methods to low-skilled users and provide those who operate in the heritage fields with a tool for studying and intervening in Cultural Heritage. However, automatism does not mean autonomy and therefore, while it is true that with any series of variously and randomly stereoscopic photos it is possible to obtain a 3D point cloud, it is not true that the quality is certifiable nor even less optimal. Simply the various automatic software does not care about to clearly state the level of precision reached during the process and even less the accuracy.

Accuracy requirements are necessary to extract metric information and obtain high quality certified metric

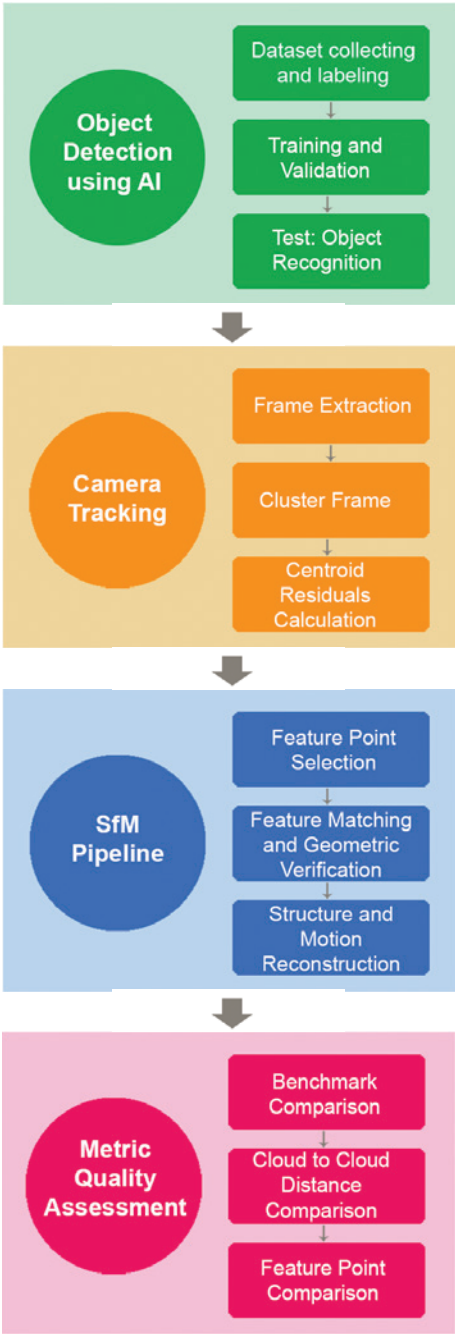
products that are essential for documentation. Metric data without certified quality cannot provide the correct information and can lead to misuse. Researchers have shown more interest in this direction, and several studies have compared different acquisition tools and processing software in different situations and case studies. This continuous development also provides an opportunity to update well-defined approaches to extract metric information from images.

Open Issues and motivation

If this need for precision and accuracy assessment is important for new surveys, the same approach is necessary for the data extracted from historical information. In fact, one of the most fascinating challenges is the use not of new data but resources stored in historical archives.
Processing historical images, apart from some praiseworthy but very rare cases, the optimal conditions obtainable with images acquired *ex-novo* are rarely present and therefore it is all the more necessary to be able to verify the maximum result obtainable in terms of accuracy even more rigorously than in the case of images specially acquired for a photogrammetric survey.
However, archives are powerful platforms for saving invaluable treasures of enormous informative potential and play an essential role in the conservation of Cultural Heritage. In addition to written documents, old photographs and videos, which have been preserved over time, are in many cases unique witnesses to architectural and urban transformation. Monuments, historic buildings, and landscapes, that have been transformed or destroyed over time, appear in them and they become the only way to document changes of currently existing objects and parts that are no longer visible and to testify the state of buildings, parts of a city and urban environment at a specific time. It is obvious that terrestrial laser scanning (TLS) or photogrammetry on-site cannot be applied for buildings that do not exist anymore. In the case of assets that no longer exist, historical photographs and films footage are the only sources to recover their forms, dimensions and locations. This is an opportunity that could support historical studies and help in some way with restoration and conservation decisions.
In all international charters for the conservation of Cultural Heritage, photography is mentioned as one of the best ways of documenting cultural assets. These recommendations have always been interpreted as a need for photographic documentation, without taking into account the metric potential of photographic images and the benefit that these properties could provide for the effective documentation measures required before any kind of restoration.
Albrecht Meydenbauer, a young German architect, became a pioneer in the valorization of Cultural Heritage through photogrammetry (Albertz, 2001). In 1858 he had the idea to use photographic images for the metric documentation of buildings. He was aware of the imminent danger to cultural assets and was convinced that the most important Cultural Heritage objects should be recorded in a Cultural Heritage Archive so that it could be reconstructed even if it was destroyed. Photogrammetric images were the most effective means to achieve this goal, and he had fought against many obstacles and criticisms to establish it as a method of scientific documentation. These images were widely used during the reconstruction of the city of Berlin at the end of the last century.

State of the art

In recent years, thanks to the digitization efforts of many archives, the interest in historical photographs and videos as valuable sources for the study of Cultural Heritage and the reconstruction of historical development has increased. The main problem with historical images is the availability of material of different types with low image quality, a total lack of camera parameter knowledge, the presence of deformations of the original dimensions, and damage due to improper storage.
However, recent developments in the field of image processing and Computer Vision have led to a renewed interest in processing data with a lack of essential properties for 3D metric information extraction. These



improvements have increased the already demonstrated metric power of old images.

This research aims to examine the possibility to extract metric information of historic buildings from historical photographs and film footage for their 3D virtual reconstruction. To reach this objective, two issues are analysed: the availability of historical archives material, often made difficult by an enormous quantity of unorganized data on historic heritage, and the limitations in processing historical photographs and film footage by the presence of characteristics that make difficult to implement photogrammetry.

Thanks to the effort of cultural institutions such as museums, galleries and heritage management organizations in investing a great deal of resources to digitize and preserve their collections using state-of-the-art acquisition technologies, this process have often been considered a success. Multiple initiatives such as high-quality replicas of cultural objects, virtual museum tours, digital valorisation, etc. have developed a new cultural and systemic awareness of the importance of data on Cultural Heritage.

With the recent hype in the field of Artificial Intelligence (AI), new techniques have been developed to manage them with Machine Learning (ML) and Deep Learning (DL) provide tools to decision-makers. In the past, cultural data enrichment was only possible using manual annotations that did not fully exploit the hidden information that could be extracted with AI technologies.

Today, new challenges have arisen for researchers to make the digital preservation of assets more efficient with Artificial Intelligence techniques for content classification and generation.

One of the most successful aspects of the spread of AI is its application in several disciplines. Artificial Intelligence, in fact, involves, for example, computer science, engineering, art, medicine, linguistics etc. The blending of disciplinary fields is also the starting point for a cultural change that no longer differentiates between humanities, science and art disciplines (Andrianaivo et al., 2019).

Fig. 1 A sketch of the proposed workflow.

Fig. 2 Tour Saint Jacques.

Fig. 3 New state of the tower.

Since the lack of involvement of the researcher in the humanities in the design of infrastructures on historical heritage material, the application of AI methods in urban and architecture projects can improve the participation of the final users of such tools.

In fact, for what concerns the documentation process and in particular the collection of data and information about heritage, can really be improved if Artificial Intelligence is combined with techniques widely used in the heritage field such as photogrammetry.

For this reason, recent research in this field has seen a rapid development of technologies to support the management and analysis of historical heritage data. Through Artificial Intelligence, tasks such as processing these large amounts of data and reducing human effort

Fig. 4 Pavilions of the Halles.

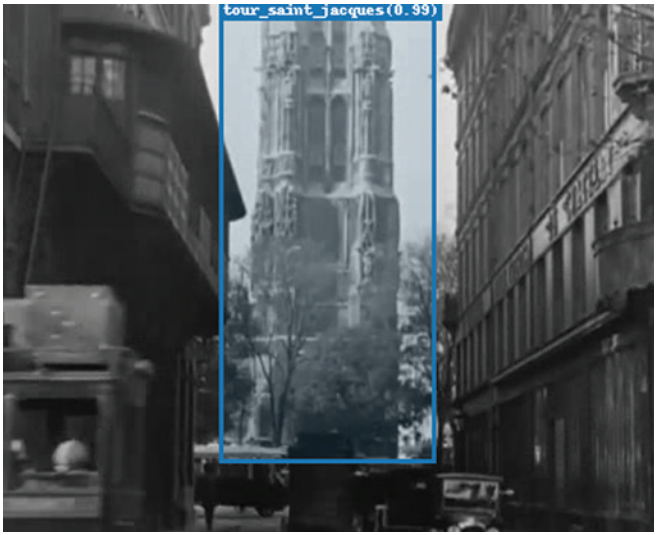
Fig. 5 Demolition of the Halles.

can be automated and thus made more efficient. The creation of new tools for the end-user of these data is an interesting research topic, especially in the field of Cultural Heritage. Indeed, the volume, the size and the variety of historical data lead to certain critical factors. The most important of these is the manpower required to organize and search for the documents. To solve this problem, the application of Artificial Intelligence offers the possibility to enhance historical archives and the retrieval of information on Cultural Heritage.

Methodology and results

Considering these open issues, in this research a workflow is presented to process historical images and to assess the metric quality of the reconstruction combining Deep Learning techniques with photogrammetry. Deep Learning is used for the retrieval of primary data used as input material in the standard Structure-from-Motion (SfM) pipeline used to reconstruct lost Cultural Heritage.
The first step of the workflow aims to make automatic the research of a specific architectural heritage identifying and tracking features from the video. This was performed using an object detection Neural Network trained to automatically recognize the monument in the film footage.
In the second stage of the workflow, the frames suitable to be processed with photogrammetry are selected from all the frames detected by the Neural Network. The selection is performed according to specific camera motions within the scene of the video. Only the shots taken from multiple points of view of the same scene are suitable for the photogrammetric process. The third step concerned the photogrammetric reconstruction of the Heritage with open-source algorithms. During the process specific feature points are manually selected in order to guarantee their presence in the final point cloud. This step will be very useful during the fourth step of the metric quality assessment of the model.
The results of the 3D reconstruction of the Heritage were compared with a benchmark specifically created to evaluate the metric quality of the model according to the type of camera motion used. The assessment was completed with the scale of the model through the feature points selected during the photogrammetric process and the comparison with existing material from which extract metric information: a point cloud, if present or historical drawings, for example. In both cases, the presence of specific feature points in both point cloud resulted from the process and the existing material is necessary for the metric comparison and scale.

In order to test the workflow, two case-studies in Paris were chosen, the UNESCO Heritage of the Tour Saint Jacques and the pavilions of the Halles of Baltard. These case studies represent two different situations of the heritage because the tower was transformed over time but still exists and the pavilions were destroyed in the 1971. For this reason it is possible to compare the different results obtained from the implementation of the workflow to the two case studies. The Tour Saint Jacques is chosen for the tuning of the networks in the best situation of a heritage that still exists, and Les Halles to test the algorithms on a real case of an architecture which has been destroyed.
The experiments were conducted using the CINECA High-Performance Computing (HPC) clusters IBM Power9 with NVIDIA v100. Thanks to the use of this hardware, the results show that the reduction of the time required to process an image during the training stage is about 95% (0.3 s/image VS 9 s/image of a mid-range laptop).



Conclusions

The results show that combining different information from historical archives such as old surveys, projects and photographs of buildings, a three-dimensional reconstruction is possible, with acceptable range of precision. This research will prove useful in expanding the understanding of how the use of Machine Learning could really improve and boost well-known methods for the documentation of lost heritage. There are several areas where this study makes an original contribution in the field of Cultural Heritage. Besides the creation of a new tool for searching for historical material in archives thanks to the automation of a manual task and the improvement of the photogrammetric process by selecting the right material for the application, the research has a great impact on the protection and valorization of Cultural Heritage from a different point of views.
The virtual reconstruction of transformed or lost Cultural Heritage allows historians and architects to explore how it was in the past and to understand its development and the original state of buildings and urban environments.

In order to enhance the archive and innovatively exploit archival resources, the use of Deep Learning actually strengthened known methods of documenting lost heritage. It gave an impact not only on improving the existing images archive platform creating a more efficient and accurate system for the users of digital resources (scholars, educators, student, museum, etc.) but also offered some

Fig. 6 The first step of the workflow: the identification and tracking of feature from the video.

important insights into the management and organization of historical information and the protection of the past.
This information is extremely useful to make decisions and interventions on the heritage, for management, restorations works and structural analysis.
Despite its limitations, the study certainly contributes to greater awareness in the valorization of Cultural Heritage data and should be repeated using different datasets and imaging conditions. The approach described in this work can be applied to different historical monuments. Further research is needed to evaluate the effectiveness of the experimental methodology and to extend its application to other case studies, especially lost heritage. In particular, it would be interesting to apply the procedure to other destroyed monuments for which 3D

reconstruction from historical videos is the only possible option. Another interesting future extension of this study could tackle the complexity of historical data. Further research will expand the discussion on open issues in historical archives and provide references for possible solutions. The development of a standard structure for metadata concerning historical images, for example, will allow the classification and the link of collections across different database and institutions.

Taking advantages of photogrammetry and Artificial Intelligence technologies allowed the identification and the virtual reconstruction of remaining traces of heritage monuments and parts of a city that have been lost or changed over time. However, the potentialities of the method go beyond the simple process of documenting something real that existed in the past. The strength of the method lies in creating the information and knowledge base for the future generation. In fact, the pictures and the videos that are taken every day simply by walking through a city can be used in the future to reconstruct the Cultural Heritage. Finding new ways to re-discovering the past and dealing with the historical material that will become a memory for the future is the main challenge faced in this research.

Notes

1 Part of the work described in this Chapter has also been previously published in the PhD thesis by Condorelli, 2021.

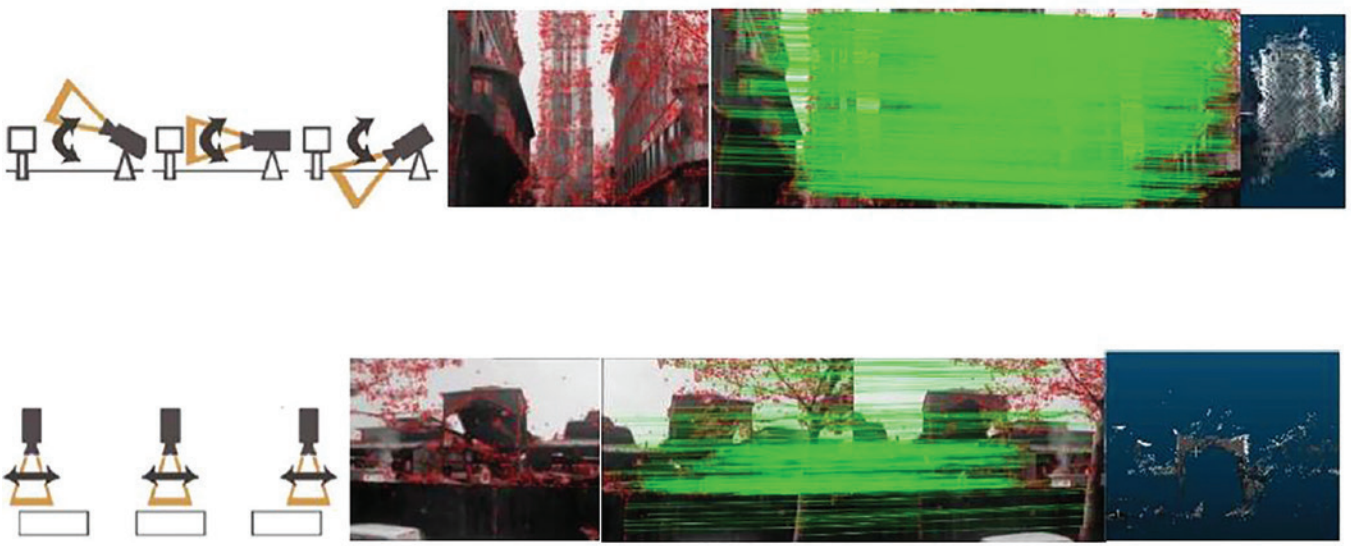


Fig. 7 The second, third and fourth step of the workflow: the automatic extraction of the frame with the coordinates of the bounding boxes that contain the monument, the identification of the camera motions, the photogrammetric reconstruction and the metric quality assessment.

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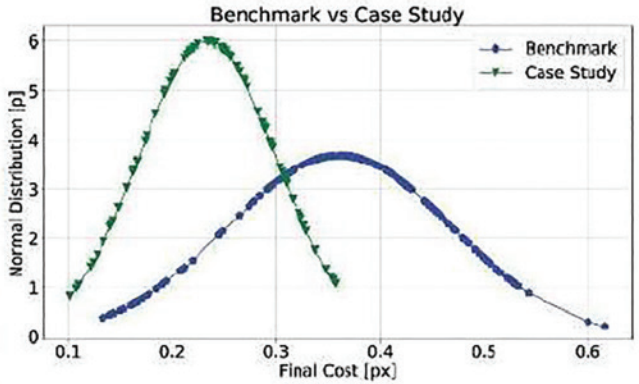

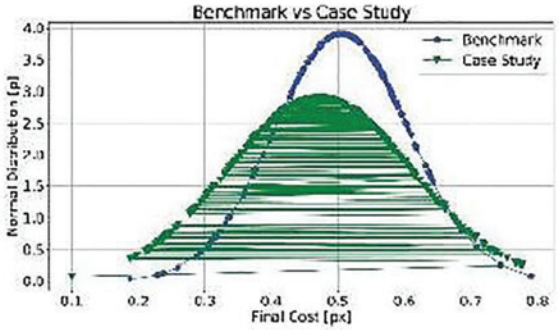

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Abstract

General aim of Asset Management is to achieve the organizational objectives through balancing risk, opportunities and costs. It has become more and more relevant, both for producing value through management of the built environment and for supporting the sustainability strategies, while the market is shifting from selling products to selling services. Its relevance may become even greater if we take into consideration Cultural Heritage assets, due to the more crucial balancing among historical values, improvements requirements and conservation constraints. Nowadays, the increasing adoption of Information Technologies pushes for a transition from the traditional Asset Management to the Digital Asset Management. This happens by means of the integration among different digital technologies, from survey and documentation, to modelling, to management of existing structures, including planned conservation strategies and resilience planning tool through sustainable adaptive reuse.

Keywords

Sustainability, Reuse, Cultural Heritage, Asset management, Digital innovation.

Cultural Heritage Digital Asset Management between Planned Conservation and Sustainable Reuse

Cultural context and global scenario

As known, the Architecture, Engineering, Construction and Operations (AECO) sector is strategic in the global market and within the European Union economy, providing 18 million direct jobs, more than 6% of European employment, and generating about 9% of gross domestic product (GDP) (Baldini et al., 2019). Although especially in the Italian national market the scenario is being strongly stressed due financial and structural factors which are generating a fast shifting of costs, both due to internal fiscal policies applied in the last couple of years, and by the increasing of cost of energy and materials, it is undoubted the strategic role and relevance of the sector itself within national economy.

Sustainable management of built heritage is a priority that cannot be postponed on a global scale. Existing and foreseen policy plans and targets of UE in the Sustainable development area will imply the need of a huge number of experts with green competencies and skills. Within this framework the United Nations Sustainable Development Goal (UNSDG) 11 'Sustainable cities and communities' is assumed here as one of the reference topics for the development of appropriate national and supranational policies.

Furthermore, the sector is quickly moving forward the so called 'servitisation' process, shifting from selling to the final user the physical asset (the product) to selling the physical asset with a set of services that can be activated after the purchase (Robinson et al., 2016). This hugely impacts on the organisational core business and shifts to the use phase a large part of the value generation and may have further development by means of an integrated and interconnected digital approach.

It is impossible to define the ongoing scenario, without take in consideration the impact of recent European policies in the field of sustainable development, before and after the Covid-19 pandemic, which came at a time when the need to adapt the current economic model towards greater environmental and social sustainability was already evident. The European Green Deal that aims to make Europe the first continent with zero climate impact by 2050, is dated December 2019. The pandemic, and the following economic crisis, prompted the EU to formulate a coordinated response with the launch in July 2020 of the Next Generation EU (NGEU) programme (EUR 750 billion), that support a huge transition towards a more sustainable development scenario.

At national level, it shall be evaluated the impact of this transformation due to the acceleration process generated by the Italian national recovery and resilience plan (PNRR) which focus about three strategic axes:

1. digitisation and innovation;
2. ecological transition;
3. social inclusion.

Due to the typically Italian high level of political uncertainty, and also due to some structural weaknesses

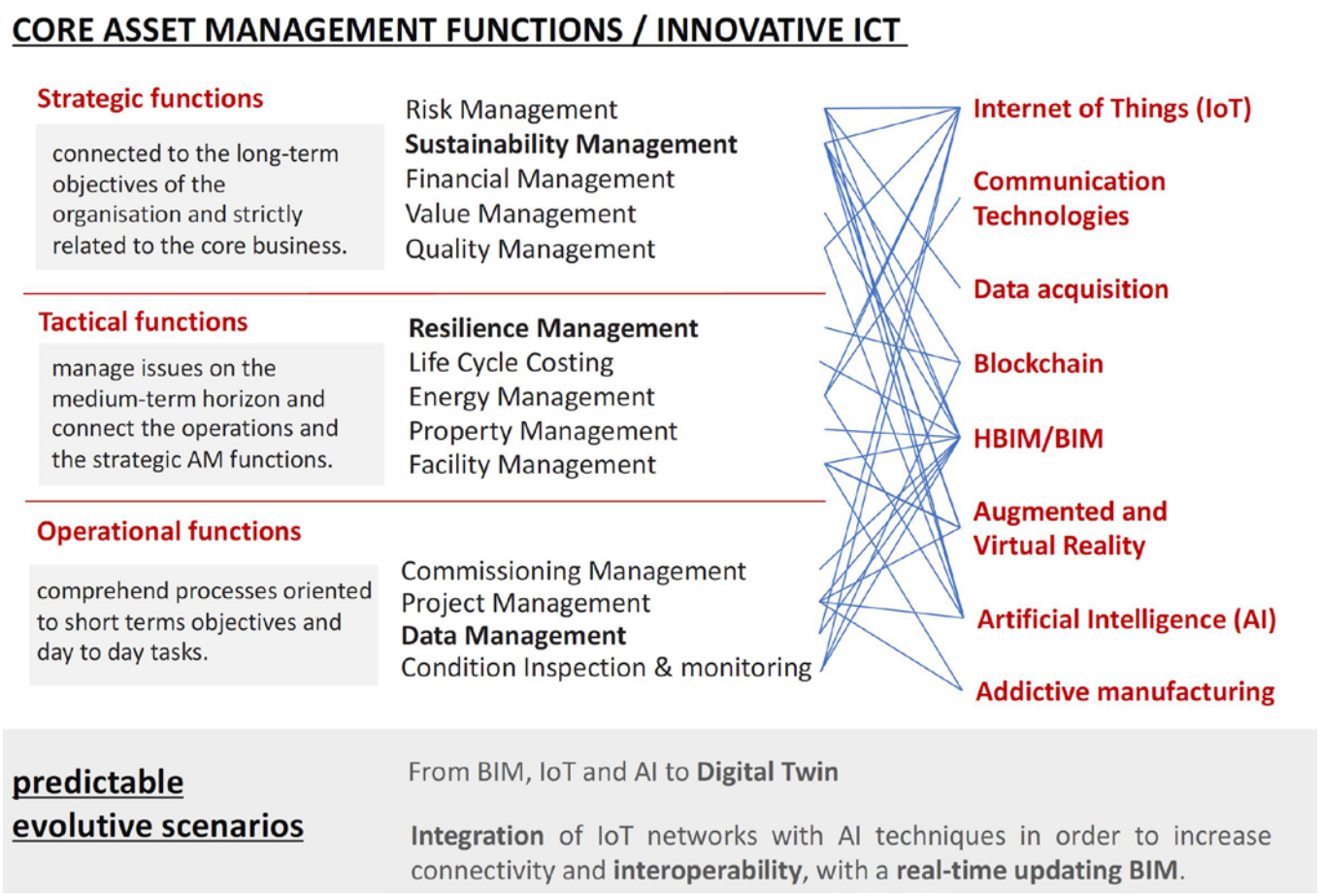

Fig. 1 Asset Management articulation and possible interactions with innovative ICT technologies.

within the national AECO sector the real impact of such a relevant number of financial resources, available in a relatively short time, it is debatable whereas the impact will be as positive at it could have been. Anyway, some degree of technological and procedural innovation will be surely achieved in the next few years and will probably be focused on a more pervasive inclusion and integration of digital asset management strategies in a wider range of applications.

Digital asset management and sustainable management of Cultural Heritage

Asset Management (AM) as a discipline has three different and integrated aims:

1. achieve the organizational objectives through balancing risk, opportunities and costs by means of the integration among different digital technologies;

2. produce value through management of the built environment;
3. support sustainability strategies.

In the present paper AM will be considered in the application to historical buildings, therefore some specific declination will be provided.

The first aim, 'integration' is probably the most relevant keyword, as a crucial factor of the whole process, and it involve not only integration among technologies, but also between technologies and users, and between users and buildings.

In the perspective of historical buildings, the second aim may be related to the valorisation of cultural heritage, and therefore connected with sustainable reuse, further than the economic dimension of building process by itself.

The third aim, dealing with sustainability strategies is somehow relevant and transversal to the whole process, and fully compliant with some of the key pillars of global development strategies previously described.

Asset Management may be articulated into strategic, tactical and operational functions (Rampini et al., 2020).

Strategic functions are connected to the long-term objectives of the organisation and strictly related to its core business and include risk management, sustainability management, financial management, value management and quality management.

Tactical functions include processes aimed at managing issues on the medium-term horizon and act as a connection between the operations and the strategic Asset Management functions, such as Resilience Management, Life Cycle Costing, Energy Management, Property Management and Facility Management.

Operational functions comprehend processes implemented for realizing short terms objectives and day to day tasks, such as Commissioning Management, Project Management, Data Management, Condition Inspection & monitoring.

Within this complex and interrelated structure, the paper will focus more, due to given space limits, with just one function for each level, not only focusing on historical buildings, but also connecting them to specific research activities already developed.

As regards strategic functions, it's worth a brief overview the 'sustainability management' function, as it is truly pervasive within several actions and decisions either the design phase and the management one.

Within a life-cycle oriented restoration approach is based on three main theoretical pillars:

1. functional sustainability;
2. energy oriented sustainability;
3. life-cycle oriented sustainability.

The first one concerns functional compatibility and the reduction of impact between new features and existing building envelopes, recreating in this way even possible strategies for rationalising the use of existing space.

The second one focuses on the perspective of a progressive reduction of consumption, obviously

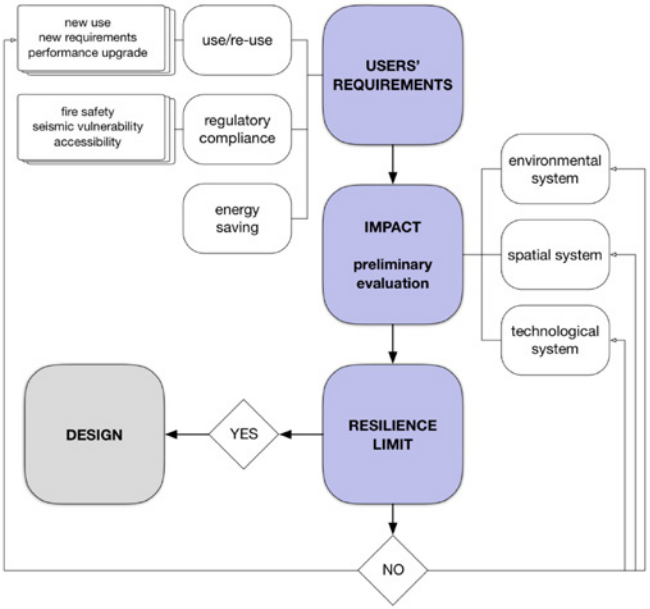

Fig. 2 Functional sustainability and impact management of new function on existing buildings as a possible gateway to define sustainable strategies for rationalising the use of existing space.

STEP-1: PERFORMANCE EVALUATION

			SCENARIO 1			SCENARIO 2			SCENARIO 3		
USABILITY	DIMESIONAL SUITABILY		2,480	0	1	1,263	2	2	0,959	3	2,5
	DISTRIBUTIVE SUITABILY	HORIZONTAL	0,407	1		0,407	1		0,407	1	
		VERTICAL	24,818	3		24,818	3		24,818	3	
WELL-BEING	THERMAL		0,279	1	0,5	0,279	1	0,5	0,279	1	0,5
	VISUAL		0,387	0		0,387	0		0,387	0	
SAFETY	STABILITY	SEISMIC VULNERABILITY	D	1	1,5	D	1	1,5	D	1	1,5
	SAFE USE	FIRE SAFETY	medio	2		medio	2		medio	2	
ACCESSIBILITY			0,539	2	2	0,539	2	2	0,539	2	2
CONSERVATION	MATERIAL DETERIORATION		2,175	\	2,5	2,175	\	2,5	2,175	\	2,5
	STRUCTURAL DETERIORATION		2,748	\		2,748	\		2,748	\	
FLEXIBILITY	STRUCTURAL		2	2	1,5	2	2	1,5	2	2	1,5
	MEP	VERTICAL	0	0		0	0		0	0	
		HORIZONTAL	0,31	1		0,31	1		0,31	1	

USABILITY	dimensional suitability		avalilable/required area
	distributive suitability	horizontal	area served by horizontal connections/total area
		vertical	maximum distance between stairs
COMFORT	thermal		effective/required transmittance
	visual		rooms that meet the window/floor surface ratio [%]
SAFETY	stability	seismic vulnerability	vulnerability class (D.M.28/2/2017)
	safe use	fire safety	risk level (DM 3/8/2015)
ACCESSIBILITY			accessible/total area
CONSERVATION	material deterioration		percentage of degraded surfaces [%]
	structural deterioration		entity of cracks and fractures
FLEXIBILITY	structural		span/structural layout
	MEP	vertical	maximum distancebetween shafts
		horizontal	rooms with false ceiling [%]

Fig. 3 Within the research activities of the STEP Lab at the University of Pavia an approach called 'Re3 method: Resilient Reuse and Restoration' has been defined. It is articulated into two main steps, the first of which is a synthetic indicator able to measure the remaining performances of the existing building, related to the expected functions to be settled.

applicable not only to new constructions, but also to existing structures though with increasing constraints. A sustainable approach to the conservation of buildings should also imply an effective attempt to optimize energy behaviour, also by means of increasing levels of self-adaptivity of the building's behaviour.
The third one deals with the efficiency of management, with particular reference to practices of maintenance and of predictive and programmed conservation.

As regards tactical functions, it may be interesting shortly deepen the analysis on 'Resilience management'. Asset Management is relevant while assessing adaptive reuse approach and strategies as it strictly interact with Adaptive reuse strategies, and therefore to the management of continuous transformation and adaptation of existing buildings.
These are usually based upon the assumption that buildings, areas, districts, and sites are not static entities,

as they are not designed simply for one single use during their life cycle. On the contrary it consists of the practice of introducing new content in an existing site, paying particular attention to the needs of society, and following the principle of maximum conservation and minimum transformation. Within this perspective an integrated digital asset management strategy may integrate several instruments and tools related to predictive evaluation of impacts and decision support strategies, taking a real advantage from integrated and interactive models and increasing huge amounts of data. Resilience is nowadays recognised as one of the key topic within social, ecological and urban sustainable development. The attitude of a territory, a city, or a complex organized system to adapt and to respond positively to the changes and demands of the context, or "*the capacity to lead to a continued existence by incorporating change*" (Folke et al., 2003), is recognized as one of the primary values in a sustainable evolutionary perspective. In the specific case of historic immovable cultural heritage, resilience will be defined as the tolerable transformation that a generic existing building system can undergo without the impact that it has on its constituent systems (material, typological, distributive, constructive) generating undesirable transformative effects (Morandotti et al., 2018). The pre-determination of the impact level of the redirection of use is in fact essential to the logic of a sustainable approach to the conservation of the asset, since only this pre-design

STEP-2: TRANSFORMATIVE IMPACT'S EVALUATION

		PAV			IMPACTS								RTV
		existing building	design hypothesis	increase	material removal	structural alteration	spatial alteration	surface alteration	morphologic alteration	identity weakening	TOTAL (0 –18)	TOTAL (scaled 0 –3)	1 2 3
1	USABILITY	2	2,25	0,25	2	2	2	1	3	2	12	2	
2	COMFORT	0,5	1	0,5	2	0	0	2	1	0	5	0,83	
3	SAFETY	1,5	2	0,5	1	2	2	0	1	1	7	1,17	
4	ACCESSIBILITY	2	3	1	3	1	2	1	2	1	10	1,67	
5	CONSERVATION	1,5	2,5	1	2	1	0	2	0	0	5	0,83	
6	FLEXIBILITY	1,25	1,5	0,25	1	1	2	1	1	2	8	1,33	

Fig.4 The second step of the 'Re³ method: Resilient Reuse and Restoration' guarantees a consistent evaluation of the negative impact on the building in relation to the improvement of each Performance evaluation parameter.

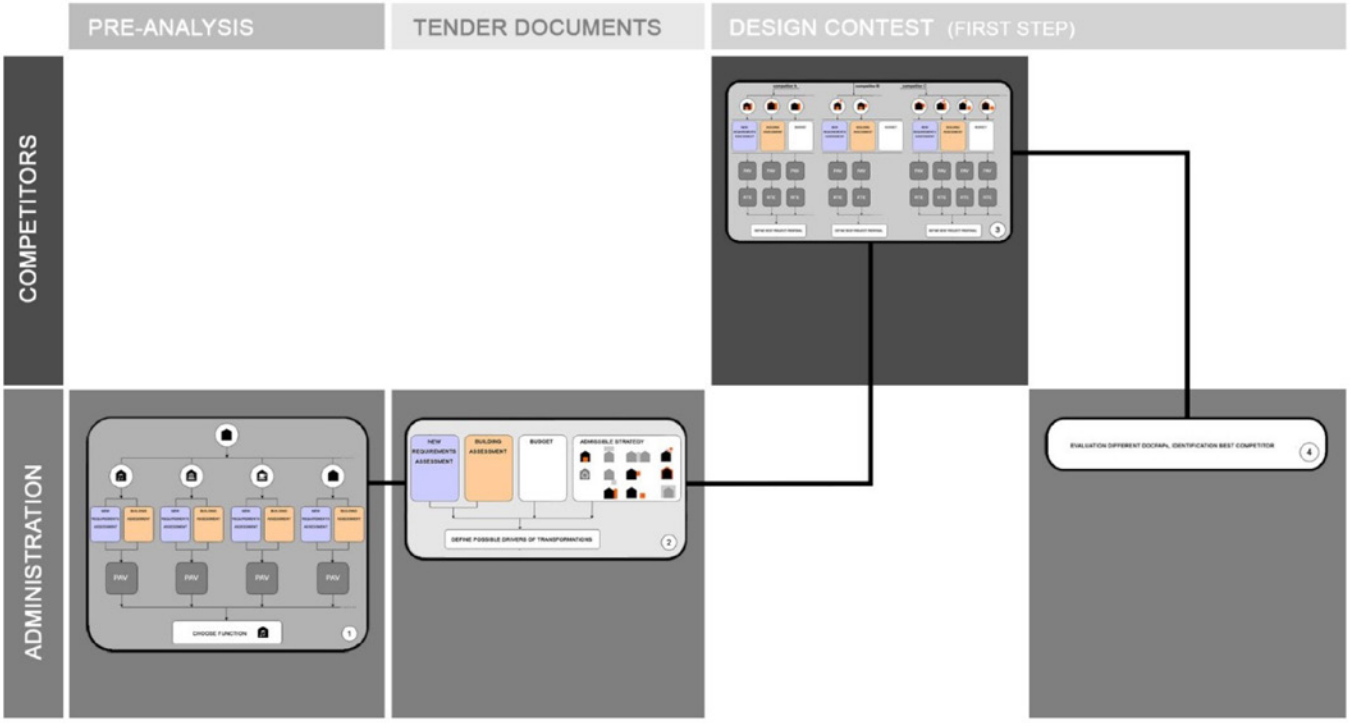

Fig. 5 The 'Re³ method: Resilient Reuse and Restoration' is fully compliant with national regulations concerning public procurement and may be a useful tool within the process itself to compare different design solutions on the same building.

phase can lead to the determination of requests for transformation or adjustment induced by the functional choice, therefore allowing an evaluation of compatibility with requests for conservation. It is necessary to identify thresholds of transformation that are compatible with the thresholds of resilience of the same envelope, so as not to affect irreversibly material and documentary consistency and - ultimately - the preservation of its identity cultural values. The aim of this meta-design 'assessment' is to prevent the forced placement of inadequate functions in an existing building structure. The typological and constructive motives that would make such a functional choice obligatory may in fact be highlighted. Failing this, a design solution albeit one congruent with the new framework of needs and with current regulatory dictates, could generate drastic compromises of material, typological, or pre-existing technological integrity (Morandotti & Besana, 2020).

As regards operational functions, it is interesting to slightly deepen the 'condition inspection and monitoring' function, due to its possible interaction with planned conservation activities, stepping from restoration as event, to preservation as long-term process. It requires a strategy that moves beyond maintenance and monitoring: it is a rather complex strategy, merging a large-scale reduction of risks and a careful organization of daily activities that may take a huge advantage by the integration in a coordinated digital ecosystem. As the sustainability of an intervention is also related to a reduction in consumption and a minimization of resources, including

those for restoration and preservation, it is not possible to disregard the definition of plans for programmed conservation, oriented to permit – following intervention – ongoing retention of the levels of disrepair and limits of performance within thresholds of acceptability defined in advance of the plan itself. Familiarity with the asset and its dynamics of alteration, scalar monitoring for constituent elements and problematic issues, and expeditious procedures for targeted and circumscribed intervention form the generating hubs of a 'life cycle-oriented' approach to the conservation of cultural heritage that today seems to be an no-longer deferrable alternative in a sustainable perspective of preservation and valorisation of architectural heritage.

Near future perspectives

We shall consider 'digital' Asset Management not only as a simple translation of traditional Asset Management in a digital environment, but we are expected to analyse how Asset Management strategies and tools may interact with even more pervasive ICT disruptive technologies, in order to reach a new level of integration, efficiency and effectiveness in the perspective of and increasing integration of the previously described functional, energetical and life cycle oriented sustainability.
A short list of these ICT disruptive technologies may include Internet of Things (IoT), Communication Technologies, Data acquisition, Blockchain, BIM and HBIM, Augmented and Virtual Reality (A/VR), Artificial Intelligence (AI), Addictive manufacturing.
It is interesting to focus on the kind of interactions that may be assessed among these functions and some innovative ICT technologies, in order to evaluate the impact of the digital revolution in the asset management perspective.
From a comprehensive analysis of these mutual interaction, it is possible to forecast at least two predictable evolutive scenarios:

1. a fast shifting forward from BIM/HBIM, IoT and AI to a spread implementation of interactive Digital Twins;
2. an increasing integration of IoT networks with AI techniques in order to enhance connectivity and interoperability among users, digital models, and buildings, with a real-time auto-updating BIM/HBIM.

In the end, this scenario may configure a real 'Digital Asset Management revolution' based upon two pillars: an incoming onthologic mutation generated by multidimensional and multiplatform integration and interaction among humans, things and model, both in a real and virtual context; the rising of a new 'digi-real' paradigm and ecosystem based on smart, auto-adaptive buildings and models within the so called 'everything everywhere' paradigm.

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Abstract
Restoration of historic buildings is a process related not only to the need to protect their historic value but also to the need to adapt them to modern standards and policies of human environmental protection.
Ensuring the comfort of use, reduction of Co2 emissions, energy efficiency, regulation of moisture problems in the building are just a few issues having a direct impact on the positive public perception of the built heritage. The lecture discusses the controversial solutions used in the restoration of historical buildings adapted to the contemporary needs of users.

Keywords
Risk assessment, Built heritage, Preventive conservation.

Basic Methods of Risk Assessment Analysis in Preventive Conservation of Architectural Heritage

Introduction

Typical conservation practice is associated with various interventions usually related to the repair of damage that has already affected the heritage site. It is primarily reactive and restorative in nature. One of the bases of preventive conservation is the study of potential threats to a given monument.

Interest in the possibilities offered by the assessment and analysis of the risks threatening building heritage in the preventive conservation of buildings arose relatively late, since only at the beginning of the 21st century. Much earlier research on this issue was undertaken in the context of protecting museum collections. Models of risk assessment and analysis developed for museum collections were first adapted for buildings, supposedly while preparing scenarios for the preventive protection of collections (Keene, 2002). However, the methods of risk assessment and risk analysis developed for museum exhibits are difficult to adapt directly to the built heritage. Risk analysis for historic building structures requires quantifying the hazards inherent to them, and examining the vulnerability and resilience of the entire building. To create probabilistic data for these elements, sufficient reliable data must be acquired and appropriate analytical or numerical procedures applied. In the context of built heritage sites, data collection is quite complex and usually requires large financial, equipment, time and expert resources. The acquisition of data on the identified hazard is relatively least problematic, although it is usually not a single factor but a set of factors that sometimes represent different hazard categories. However, a bigger problem is to assess the value in the context of percentage damage and to calculate the vulnerability of the building. Every year more and more studies appear, proposing various methods of analysis concerning vulnerability of buildings to selected categories of threats (Ferreira et al., 2021) however the complexity of the problem and lack of sufficient research experience concerning the behaviour of a given type of building under the influence of a particular threat, result in the most often accepted simplified conclusions (Watts et al., 2001; Ortiz et al., 2014). The situation is similar in the case of analyses of threats and their effects on historic buildings (Cimellaro et al., 2010; Arbon et al., 2012; Henry et al., 2012) . The multidimensional nature of the building heritage and the specificity of the historic fabric of the building contribute to the complexity of the assessment, which means that so far there is no universal model for assessing the risk of impairment of historic buildings (De la Torre, 2002). Contemporary models for risk calculation are based on three basic analyses: qualitative, quantitative and mixed.

Basic terms in Built Heritage Risk Assessment

Most of the terms, and procedures used in risk management for built heritage are borrowed from

the economic and business sciences, especially the business administration management industry. One of the first definitions of risk used in the built heritage context was given by B. Feilden, defining it as: "*probable loss, combining hazards associated with the location, vulnerability of the building, and its contents*", where hazard is: "*the probability that a catastrophic event of a given intensity will occur at a given location" and vulnerability is: "the degree of loss that a facility will suffer from an earthquake of a given intensity*" (Feilden, 1987, p.22).

For the purposes of this article, risk is defined as the potential for adverse events to occur that threaten the historic values of a site. Risk assessment, then, in this context will be a process that seeks to identify general and specific risks (one or more) that potentially threaten a given historic site or area, and to calculate the magnitude of its impact on the site. Risk assessment is related to risk analysis, which is the examination of quantitative or qualitative results obtained through the evaluation of data and output parameters associated with both the monument in question and the threats identified for the site (Waller, 2003).

Risk is a function of one or a combination of several hazards, the effects of those hazards, and vulnerability. Where vulnerability is a function of an object's sensitivity and adaptability. Vulnerability is a characteristic associated with interaction with hazards. Resilience is a characteristic of a system related to vulnerability to threats and also protective capabilities after a threat has occurred. Adaptive capacity is defined as a combination of resilience and reflexivity. Risk is thus a derivative of all the above elements.

A comprehensive risk assessment for an architectural monument examines the scale of all the risks in combination with their impact on the whole property, taking into account the different types of heritage values (including intangible assets).

Risk assessment is a process consisting of 3 main parts:

1. Hazard Identification;
2. Threat Analysis;
3. Assess the Impact of Hazards.

Hazard Identification

In order to identify the risk, it is necessary to understand two issues: whether there is something that may threaten the historic value of the building and what may be the causes of that threat. During the obligatory site inspection it is possible to use predefined risk categories which are given in some publications and sources such as UNDRR (United Nations Office for Disaster Risk Reduction) or Copernicus Emergency Management Services Geodatabase or Middle Eastern Geodatabase for Antiquities (MEGA), ect.

Hazards can have different origins. According to the United Nations Office for Disaster Risk Reduction (UNDRR), hazards can be divided into several basic categories: biological, hydrometeorological, technological, geohazards, chemical, environmental, extraterrestrial, and societal (UNDRR, 2020, p.22). These hazards do not directly relate to the magnitude of the risk, but to the source of potential harm, most commonly referred to as the risk factor. In the risk identification process, factors are grouped into: environmental, socio-political, economic, physical, and managerial. The risks identified for an area or building are linked to at least one of ten deterioration factors. In this regard, the division of factors is taken directly from the methodology adopted in the assessment for museum collections. These factors are the mechanisms and processes that are the sources of threats. Deterioration of a historic site is typically caused by: physical forces, criminal activity, fire, water, pests, pollution, light, inappropriate temperature and relative humidity, and dissociation. The deterioration factors are analyzed in terms of the likelihood of their occurrence, their potential intensity, and the severity of their impact on a historic building. Each identified threat to the monument should be defined broadly enough to fully capture its nature and enable its quantification.

As part of preventive conservation, hazard identification should be carried out in a systematic and structured manner. Individual data for hazard identification is usually obtained through statistical data, community interviews, expert surveys, and past assessments.

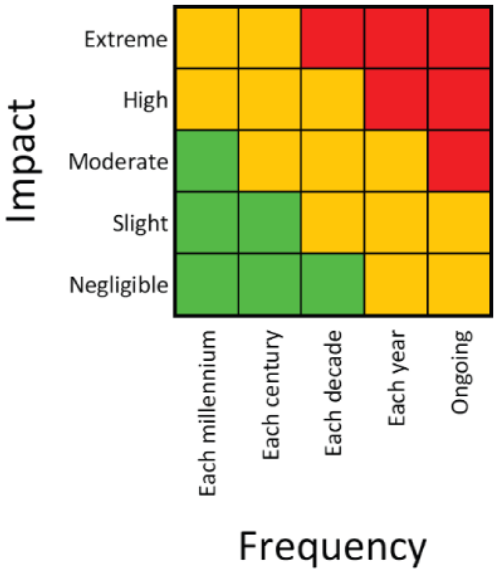

Fig. 1 An example of an impact x frequency matrix. After Waller, 2019, p. 72.

Threat Analysis

Threat analysis is the process of diagnosing the situation in which a facility may find itself if a previously identified hazard occurs. The interpretation of data refers to the source of danger as well as its indicators. It is the first step in evaluating and ranking the risks that threaten the loss of historic values in a facility. A proper understanding of the threat allows a decision to be made about the need for preventive action and the manner and limits of preservation interventions.

The analysis involves a series of investigations to determine, among other things, the direction in which a hazard will propagate from its source and the path it will take towards the building it is protecting. The research aims to determine which part of the building is most exposed to the potential impact of a given hazard and how this will affect the statics and value retention of the rest of the building. The joint action of several hazards, e.g. wind and water, changes the value of the resulting risk.

Collections researchers have proposed a classification into three types of threats (Waller, 2019), but it is used for built heritage as well:

- type 1: the hazard is rare, although it has catastrophic consequences;
- type 2: the hazard is unlikely to occur and the effect is moderately severe;
- type 3: a given threat acts on our object continuously and, although its impact is mild, it still leads to damage to the object.

Threats analyses also examine the relationships between the severity and frequency of a given hazard on a building. Such analyses are carried out for each of the identified threats separately, but the interrelationships between the different types of threats that may affect the site. It is also important to rank all the threats in terms of the highest probability of occurrence and the strongest impact on the monument.

There is also the need to analyze the form and character of the building under this study. Depending on its size, one can decide to analyze only a selected part of the building. The results obtained for such a fragment, can be further appropriately extrapolated to the other parts of the building. This approach allows to accelerate the identification of the necessary indicators, and to prioritise the preventive actions. It is important to remember that the data collected on different hazards, may be incompatible and in varying degrees of completeness. Therefore, it is worth considering the right choice of hazard analysis method. Depending on the area of research focus, in addition to basic analysis methods such as qualitative, semi-quantitative or quantitative, one can also conduct system or process analysis. The results of the hazard analyses (one or more) can be represented with the help of a model or by extrapolating the study of the collected data (ISO, 2007, p.11).

Qualitative scales for frequencies of ocurrence			
Level	Rate	Descriptor	Descriptions
A	5	Almost certain	It will happen in the majority of cases
B	1	Probable	It will probably happen in the majority of cases
C	3	Possible	Eventually it will happen
D	2	Improbable	It may happen in some cases
E	1	Rare	It may happen in exceptional cases

Fig. 2 Qualitative scales for frequencies of occurrence for hazards. Source: adapted from standard ISO 31000 and the technical norms for risk management (ICONTEC, 2004; ISO, 2007).

Qualitative scales for impacts		
Rate	Descriptor	Description
1	Insignificant	There is no damage
2	Minor	There is slight damage
3	Moderate	There is some damage
4	Major	There is considerable damage
5	Catastrophic	Significant damage or loss

Fig. 3 Qualitative scales for impacts of hazards. Source: adapted from standard ISO 31000 and the technical norms for risk management (ICONTEC, 2004; ISO, 2007).

Assessing the Impact of Hazards

The results of risk analysis from various hazards make it possible to select those that most threaten the monument and can bring the greatest damage to its values. Such discernment is usually done with the help of comparative estimates, based on predetermined criteria and methods. It is important that the methods used to assess the impact of the threats be consistent with the methods used for hazard analysis. Such comparisons also allow the level of acceptability of a given hazard risk to be determined for the facility under study.
The value of the risk of losing historic values in a building increases when the frequency of occurrence of a given hazard and the force of its impact increases. Not without significance is also the condition in which the object is preserved and its susceptibility to the given risk. The frequency and strength of a given threat factor is examined in relation to the events that took place on a given site in the past.
The direct effect of any identified hazard is usually multidimensional, as it usually includes direct exposure to human life and health, as well as an economic dimension and may also include environmental damage. The impact assessment is a numerical value, depending on a certain scale, where the highest value means a catastrophic effect and the lowest is treated as the lack of effect of a given hazard.
The methods used to calculate the impact of a given hazard on the historic building are constantly evolving. One of the first methods was developed in the late 20th century by Robert Waller, who prepared a risk assessment for the collection of the Natural History Museum in Ottawa. He examined the impact that each of the risks has on the loss of the collection. Comparison of the individual values allowed for the selection and prioritization of appropriate preventive actions. The Cultural Property Risk Analysis Model he proposed distinguished three types of risk depending on the frequency and severity of a given threat. It was type 1 risk, where the probability of occurrence of a given threat is rare (once every 100 years), then type 2 risk treated as an occasional event, and type 3 risk, where continuous threats from various directions can be expected. Further, within this model four variables were extracted which were used to estimate the level of risk according to the formula:

$$MR = FS \times LV \times P \times E$$

Where:
MR (Magnitude of Risk) is the amount of risk,
FS (Fraction Susceptible) is the susceptibility to damage,
LV (Loss in Value) is an impairment of value,
P (Probability) the probability of a given hazard occurring,
E (Extent) is the extent to which the hazard will cause impairment.

For each variable, it was possible to estimate the value on a scale of 0 to 1, where 0 means no impact of a given threat

on the collection and 1 is the value of extreme impact.
This model was adapted to risk assessment for built heritage. The study of a building's vulnerability and loss of value is unfortunately more complicated because here the environment of the monument cannot be regulated as in the case of a museum. There is also currently insufficient knowledge of how a particular type of building behaves under the influence of a particular hazard (Strlič et al., 2013). Relatively little experience based on post-catastrophe studies and the unique character of the built heritage means that every newly proposed model for calculating risk from hazards has its limitations, restrictions and drawbacks. Apart from the problems resulting from the methods of calculating vulnerability to building damage, even more troublesome is the estimation of the potential loss of some percentage of the heritage value of the object. The most commonly accepted comparisons of an estimate of a fraction of the loss of heritage value with a percentage estimate for so-called resale prices is not a good solution and requires searching for new solutions. The best solution (so far) is very simplified assessment model, where 1 means total loss of historic value and 0 means no loss. Risk assessment means assigning some value. It is always relative, because it is connected with conceptual and logical reference to the analyzed data, made by assessor.
Despite its shortcomings, this assessment helps to make conservators of the monument aware of the seriousness of the potential threat, enabling them to implement a preventive strategy even before the threat strikes. Taking into account the already mentioned fact that the building is usually affected by several hazards, in preventive conservation, the resultant risk is calculated, which consists of the sum of the risk scores calculated for each hazard separately.

Select Hazard analysis methods used in risk calculation

Quality criteria systems

Qualitative risk analyses include analytically recognized and evidence-based risk characteristics. They use descriptive information that aids in understanding this analysis by reducing the complex input data parameters. Qualitative analysis uses descriptive words or scales to determine the magnitude of potential effects and the likelihood of their occurrence. The scales can be adapted and adjusted according to the relevant circumstances, location, nature of the historic building, but also different types of hazards. The ISO 31000 standard, provides a basic compendium of knowledge on the principles, and framework of assessment, including the selection of an appropriate scale for this assessment.
The qualitative risk assessment of the impact of a given hazard on the heritage values of a building combines the previously analyzed level of vulnerability of the building with the probability of the occurrence of the given hazard and obtaining knowledge from the analyses regarding the level of hazard intensity. This method usually uses expert elicitation or an approach based on pre-formulated indicators. The selection of experienced experts is extremely important, especially in analyses of the state of deterioration of heritage values and assessment of the vulnerability of a given part or material. One of the most important factors of such assessment, which supports expert evaluation, is the question of verification whether and how it will be possible to repair possible damage and whether the examined object can be used still as it was before the danger came. According to ISO guidelines, ready-made tables can be used in these analyses.
Among the 5 classes of increasing risk, ratings 1 and 2 indicate instances for which the impact of a given hazard is acceptable. Grade 3 is at the limit of acceptability and requires constant monitoring. For grade 4, more detailed analyses need to be conducted to determine the most effective mitigation measures. For grade 5 risks, preventive action is given absolute priority.
Among the methods that use qualitative analysis we can mention Store Assessment Form, a series of questionnaires created in 2002. Many researchers also use methods based on the Draft European Standards CEN/TC 346/WG1/TG 1 of 2010, the Delphi Method of 2013 or the Multi-hazard Risk Analysis of 2016.

Semi-quantitative methods - scoring system

This method involves assigning appropriate points to a qualitative scale. This combination of a qualitative and quantitative method gives a more precise risk assessment than using only the qualitative method, although it is difficult to talk here about the exact magnitude of the risk, especially in borderline assessments, between the different categories, because the points do not have to correspond to an exactly defined magnitude or impact of the hazard on the building in question. In the case of the method using the 'point system' also three elements are taken into account:

a. probability or extent of harm;
b. the degree of destruction (loss of value or integrity) as a result of the threat;
c. the fraction of vulnerability to a given hazard of the building being evaluated.

The risk assessment relates directly to the problem of loss of material value as well as the heritage value associated with it. Individual components A, B, C are evaluated on a scale of 1 to 5 (from low to high values). The sum of individual components gives the amount of risk calculated for each type of threat. By appropriately sorting the obtained results it is possible to select priority actions in order to weaken the potential damage to the examined object. The size of the risk is calculated using the following formula:

A (probability) + B (impairment) + C (vulnerability fraction) = risk size

Indexes developed for a given hazard or building type can assist experts The distribution of points in risk assessment for built heritage was developed in 2007 by ICROM, CCI and ICN. Tables are provided for each component of the equation that suggest general rules for assigning points for the risk posed by a given hazard. The expert can interpolate the points from the table, adjusting them for the special characteristics of the historic site or the particular impact of the hazard in question.

For the probability of occurrence of a given risk (value A), the assessment depends on a scale that scores the moment of occurrence of damage or the extent of damage due to the hazard (scale range: ½ year to 100 years). Depending on the probability of frequency of occurrence, values from 1 to 5 are assigned, as suggested in the table.

For the degree of damage that a particular hazard (Component B) can cause, analyses include consideration of the potential loss of value due to the actions of the hazard. Assigning a number (from 1-5) for the value of Element B depends on the degree of loss of heritage value or also the loss of integrity of the site. Loss of intangible values such as sentimental value, symbolic value, use value, etc. can also be considered under loss. The probability of loss expected as a result of a given type of hazard should also be considered in economic, social and environmental terms. It is also important in this case to examine to what extent these losses are non-renewable.

In the case of assessing the fraction of a building's vulnerability to a given hazard (Element C), the analyses examine the types of potential damage in the context of a building's specific vulnerability to a given hazard category. For this analysis, the facility is divided into appropriate segments, while grouping them into sets of similar characteristics (e.g., construction type, material, or exposure). The assessment of each group is performed separately, assigning values from 1 to 5 as suggested in the table.

The magnitude of impairment risk is the sum of the valuation scores of the three components (A,B,C). Among the five levels of risk values, all values above 9 points require preventive action. The semi-quantitative method of risk analysis seems to be convincing and not very complicated, especially if ready-made point indicators are used. However, the point method of risk assessment has recently been increasingly criticized by researchers (Hubbard, 2009). The quality of the assessment analysis depends on the accuracy of the experts' reliability, but also on the integrity of the data. Although it uses quantifiable and objective data for all components of the equation, already the assignment of values for these data is mostly subjective and depends on the experience of the assessors. The result of this type of assessment should be confronted and averaged with several opinions.

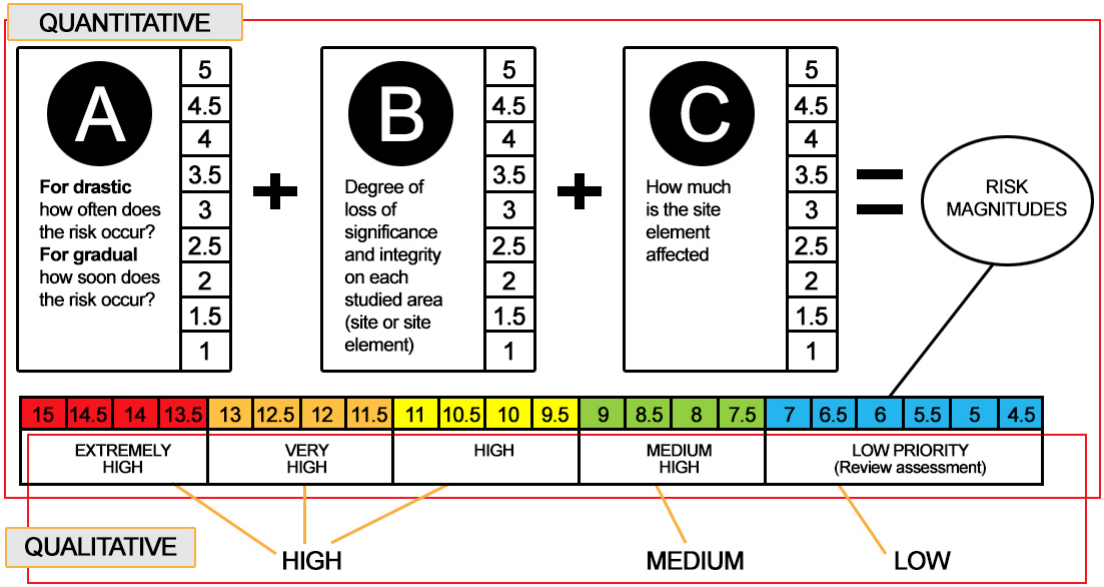

Fig. 4 Risk volume calculated according to the ICCROM-CCHCN model (2007).

Quantitative methods - scoring system

Quantitative methods use numerical values for threats criteria, which consist of collected quantifiable and objective data on numerical data for asset value, probability of loss, and associated risk. Researchers using quantitative analysis need access to high quality data, a well-developed facility model, and an already prioritized list of threats. In practice, it is used to build models for vulnerability curves or the sensitivity of heritage to loss. It assess the probability of achieving a certain goal, to achieve realistic cost and schedule data for e.g. preventive actions, and to identify the threats that need most attention.

Quantitative analyses have been successfully used for multi-criteria risk assessment methods, where a building may be exposed to multiple hazards, or where there is a need to apply the analysis of multiple indicators in parallel. Multi-criteria methods allow the selection of several options to solve a particular problem. Evaluation allows more than one objective to be achieved. Evaluation criteria can be equivalent or compensatory. Solutions are provided by building a model showing the relationships and impacts of the various alternatives associated with the different criteria. Through this method, the priority and degree of importance of one risk over another can be determined. To calculate the risk for architectural heritage, the most common method used is: Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP), both developed by Tomas Saaty in the 1980s. They allow a holistic approach to the risk problem by comparing factors and criteria set in a hierarchical (AHP) or network (ANP) structure. The network structure is preferred for risks that interact with each other and are not organized in a hierarchical order. The hierarchical structure is chosen for identifying the most troublesome hazards. The assessment is made by comparing lower level elements with some or all of the higher level elements. These comparisons are made taking into account the preferences of the evaluator or decision maker. Preferences are determined

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Fig. 5 Saaty's fundamental scale, after: Saaty & Vargas, 2001.

with the help of the so-called fundamental scale proposed by Saaty (Saaty, 2001).

The analysis consists of setting the matched pairs in two levels (criteria and alternatives). The set of criteria includes all the factors that transform a hazard into a risk. Typically, these include impact, probability, exposure to the hazard, sensitivity of the building, etc. The set of alternatives includes the different types of hazards that can act on the Built heritage. Following the Saaty'ey scale, one can give weight to each level in pairwise comparisons. For example, for an exposure - impact pair, the assessor should decide whether, in a particular case, the exposure to the risk of the site is more important than the impact of the hazard itself, and to what extent one criterion is more important than the other. In selecting the next pair (sensitivity - exposure), the expert must resolve the question of which factor is more important and to what degree. Once the options for comparisons between criteria have been exhausted, one moves on to evaluating the threats. In comparisons of all criteria and their alternatives, appropriate numerical values (indices) are assigned to them. At the end of the evaluation process, numerical priorities are calculated for each alternative that distinguish the most effective action.

This complex multivariate method is extremely effective and fast when used with the free program SuperDecision. This program allows to pair and read the evaluations of appropriate pairs. Criteria weighting can be carried out by an expert, but can also be supported by surveys,

interviews or scientific literature. Once all the matrices have been identified the priorities for preventive actions are synthesized. This avoids the problems arising from the use of complex mathematical calculations. However, this method does not solve the problem resulting from different preferences of assessors. Graphically, these analyses are visualized with the help of Monte Carlo simulation or building a decision tree model (Hajialikhani, 2007). This method has already been used with great success in Italy (Bottero et al., 2008) and Scotland (Lopez, 2016).

Conclusions

Undoubtedly, in the assessment of risks to architectural monuments a holistic approach in a systemic approach is necessary, which will allow not only to analyze the relationships between the elements of the building as a whole, but also to look at the risks in relation to their integral nature and not to the action of only one of them. This approach, which allows us to see the relationships between hazards, facilitates an integrated assessment of the entire risk.

The biggest obstacle to using most quantitative and mixed methods is the need to be familiar with sometimes complex algorithms. Without investment in software, most multi-criteria methods will be inaccessible.

Advances in technology and researchers' ongoing search for the most universal model will mean that the needed solution will probably appear soon, but it will just be a tool that should make us all aware of how important the role of preventive maintenance is in risk assessment.

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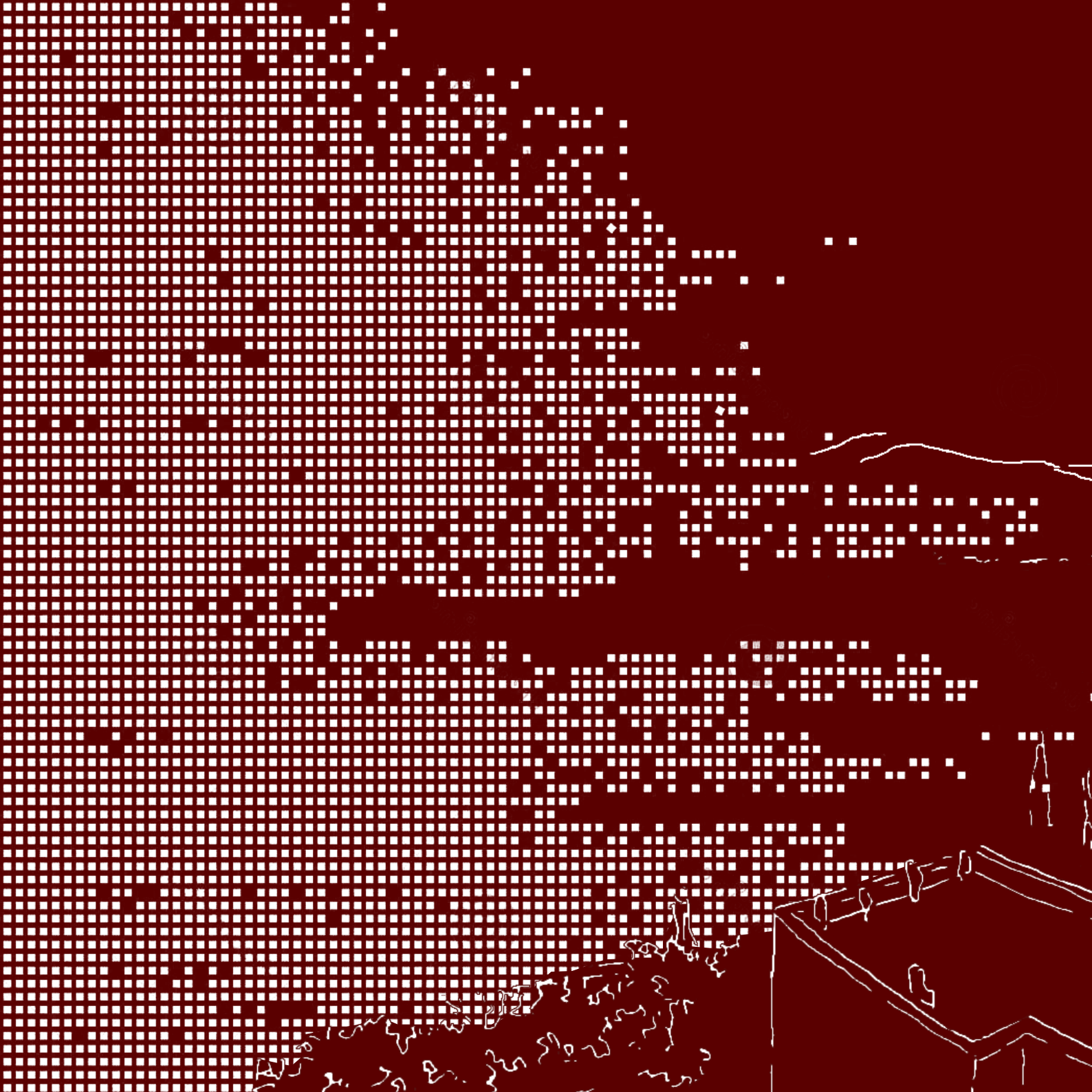
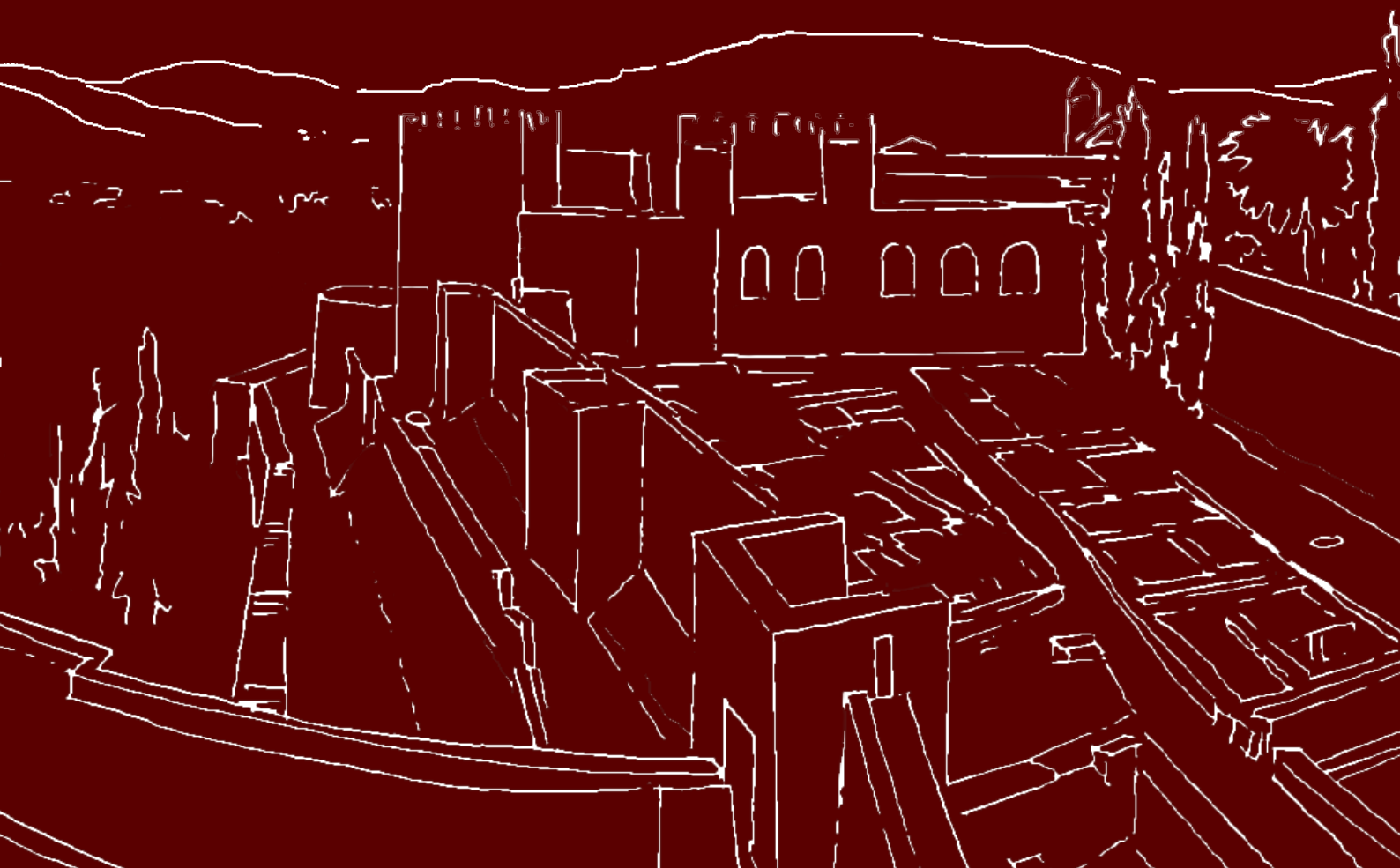


CHAPTERS

THEMATIC CHALLENGE 3
SERVICES AND HERITAGE



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Abstract

This chapter deals with the marketing of architectural heritage in a situation where the target group is the general public - i.e., a set of very different people representing a variety of age groups, professions, interests, and leisure preferences - .
In the search for a common denominator for marketing efforts to effectively reach such a diverse group of potential addressees, the author focuses on two aspects that can be considered universal pillars of a successful marketing strategy for historic sites: their relevance to the general public and the experience of visiting, using, or simply enjoying these sites. The considerations are based on the Burra Charter Process of 2013 on the one hand and on the principles of service marketing and word-of-mouth marketing on the other.

Keywords

Marketing of historic places, Social relevance, User experience, Burra charter process.

08

It is All About Relevance and Experience. Marketing of Historic Places to the General Public

Introduction

Architectural heritage from an economic point of view can be regarded as cultural capital (Throsby, 1997) or a cultural good (Lipp, 1997). As such, it is subject to at least some degree to the laws of the market. On the one hand, there is a supply of historic places, which is globally quite stable; although some objects are suddenly destroyed as a result of wars or other random events, others - abandoned or neglected - are gradually degrading; at the same time - at a similar pace - there is an increase in the number of objects considered worth preserving due to their architectural features, technical and artistic value, or association with a given event or historical figure. On the other hand, there is a demand for historic places. This demand is expressed by various groups of actors representing different interests, such as investors, who look for attractive buildings in which to operate their businesses. Then there are tourists who want to fill their time in the best and most fruitful way possible while visiting the respective country or city and decide to get to know the local architectural heritage. After them, organisers of cultural events - small or large - who are looking for a suitable venue for their event; such as schools that use historical sites so that pupils can learn organically about the history and heritage of their homeland. Last, but not least, the local people, whose demand is expressed by the fact that they appreciate the attractiveness of the location as a place to live, dwell, and spend leisure time. Within the market for historic places, their supply meets the demand, and if there is an imbalance between the two, especially if there is insufficient demand for the historic places in question, additional activity is needed, namely marketing activity. It involves the planning and implementation of the conception, pricing, promotion, and distribution of ideas, goods and services to meet the objectives of the supply side (in our case: the caretakers or managers of historic places) and the needs revealed by the demand side (i.e., those who may derive some benefit from these historic places) (Kotler, 1991).

The academic literature on heritage marketing takes different perspectives. The applicability of marketing tools to preservation and conservation of heritage is discussed, e.g., by Cerquetti & Ferrara (2018) and Parowicz (2019). Concerning the identification of marketing in the heritage sector in terms of audience development, the works of Thoburn (1986), Greffe (2001), Fullerton et al. (2001), Chhabra (2009), French & Runyard (2011), and Colbert (2009) should be mentioned. Other groups of works are devoted to analysing the role, responsibilities, and involvement of various stakeholders (with sometimes conflicting objectives) in creating marketing strategies for heritage tourism (Vernon et al., 2005; Wray, 2011; Panyik et al., 2011; Hanna & Rowley, 2011), to strategic marketing planning for heritage tourism destinations (Alvarez & Korzay, 2011; McCamley & Gilmore, 2016), and more generally, to perceiving heritage as a commodity which increasingly becomes subject to public interest, especially in terms of mass tourism (Rowan & Baram,

2004). Szromnik (2019) proposes a very interesting and comprehensive model wherein cultural potential and market potential of a historical building is explored.

There is no doubt that marketing activities focusing on historical places must always take into account a number of different factors - the history of the place, its type (architectural, sacral, utilitarian, element of cultural landscape etc.), its historical context, state of preservation, and tourist or utilitarian potential (if any). Only after taking these factors into account will it be possible to develop a specific marketing concept that would be both pertinent and applicable to a given historical place. A separate issue will be tailoring the offer of a historic place to a specific target group; different marketing efforts will target tourists, connoisseurs of cultural heritage, investors or children and school classes. But is it possible to find aspects common to all historic places that can be made into pillars of marketing thinking that would support their existence and allow the potential of each to be unlocked and realised? This chapter highlights two such pillars universal to historic places regardless of their type, purpose, and groups targeted. These are the 'social relevance' of a place and the 'experience' that is derived from interacting with it. Both of these factors contribute to a certain 'value' that a person or social group can attribute to and derive from the existence of a historic place and the use of it. This value, being a complex, subjective, and elusive concept (Woodall, 2003; Grönroos, 2011) emerges from people's usage or possession of resources as a result of an experience they had or service they used. Hence, it is called 'value-in-use' (Vargo & Lusch, 2004). As Grönroos (2008) points out, such value means that people, "*after having been assisted by the provision of resources or interactive processes, are or feel better off than before*". He emphasises moreover (2011) that such value can be measured not only in monetary terms; it may also have a perceived dimension.

Social relevance of historic places

The starting point for presenting the first of the proposed pillars of marketing thinking about historic places is the Burra Charter – the Australia ICOMOS Charter for Places of Cultural Significance, first adopted in 1979 and last updated in 2013. The rationale for signing this Charter was the specificity of sites representing Australia's tangible cultural heritage, in particular, the heritage of indigenous peoples, which often consists of natural and man-made elements that could not always be classified in one of the categories accepted in the Western world, such as architectural structures or monuments. The notion of 'cultural significance' was therefore used as an inclusive and universal criterion to protect all those objects that are historical records and are important expressions of Australian identity and experience (Burra Charter, 2013). According to the Charter (Art. 1.2), "*Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations. [It is] embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects.*" The Charter emphasizes further that: "*Places may have a range of values for different individuals or groups*" (Article 1.2).

The term, cultural significance of a [historic] place, was subsequently used by the Burra Charter as the basis of the management model for these places. Article 6 of the Charter outlines the steps to be taken in what is known as the Burra Charter Process - that is, the steps in planning for and managing a place of cultural significance (Fig. 1) -. First, it is necessary to understand the significance of the place - thus to have a firm comprehension of the place to be cared for and managed - e.g., its history, significance, and possible uses. Second, the cultural significance of a historic place must be assessed and clearly defined. In the next step, we focus on developing a policy for action. We need to establish what responsibilities come with the significance of our historic place. We need to define future needs, the means we have at hand and those we must obtain, the opportunities and the constraints - that is the conditions under which we are able to act. On this basis, a specific management plan for the given historic place is developed, including priorities,

resources, responsibilities, and timeframes for individual actions. The final stage is the management of the historic site in accordance with the previously developed policy - the implementation of the management plan and the monitoring of the effects of the actions undertaken and, if necessary, the plan's revision.

The Burra Charter Process is thus a versatile tool that allows a structured management plan to be developed for any historic place in the world, based on its cultural significance. The prerequisite for the success of such a plan is an in-depth understanding of the site in question, its potential, and its significance. A sensible management plan for a historic place can only be designed if its significance is fully recognized and taken into account.
Now, the Burra Charter Process is not only a very helpful tool in developing a management plan for historic places. As Mackay (2019) rightly observes, it is "*a dynamic document that has evolved to reflect changes to professional practice and emerging issues*". It can also be a valuable inspiration in designing marketing activities for these places. For this purpose, it is useful to replace the term 'cultural significance' with 'social relevance' in the chart (Fig. 2).

The definition of relevance according to the Merriam-Webster dictionary is "*relation to the matter at hand*" and "*practical and especially social applicability, or pertinence*". A thing is relevant if its features are able to satisfy the needs of the user. The Cambridge Dictionary defines the relevance of something in terms of its usefulness. Researchers studying the issue of relevance perceive it in terms of the practical applicability of knowledge or "*knowledge for action*" (Pelz, 1978; Dehler, 1998). Albee (2015) adds that conversational competence plays a key role in social relevance. Now, it is not possible to separate heritage from its social context, and the relationships between heritage and society are three-dimensional: 1) Heritage is internal to society; 2) Heritage is socially constructed; 3) Heritage constructs society (Birkeland, 2018). Fairclough (2012) goes as far as calling it 'raw material' crucial for human psychological, emotional, and social health. Rivet (2012) describes the relevance of heritage as "*the emotional, mental, and intellectual relationship with a community of interest to address contemporary needs stimulate future developments*". Therefore, for the purposes of our discussion, it can be assumed that in identifying the social relevance of historic places, it is necessary, on the one hand, to identify their holistic potential (historical, spatial, aesthetic, and last but not least, narrative) in a social sense. This is about the potential that can correspond to the needs and expectations of the general public (and even generate demand hitherto undisclosed). On the other hand, in order to unleash this social relevance, it must be skillfully communicated to the public and to the individual target groups concerned.
Returning to Burra Charter Process graphic in its modified version (Fig. 2), a good starting point for developing a marketing strategy for an historic place could therefore be to understand the place in terms of its social relevance and to make a statement of such relevance. It is then useful to identify the potential of an historic place based on its social relevance and from this create a marketing strategy. Within the latter, specific marketing concepts and campaigns can be implemented. Needless to say, all these marketing undertakings must not lose sight of the overarching principle of the sustainable preservation of the historic place in question. Therefore, as with the original Burra Charter Process, not only is the final phase in which a marketing concept is implemented is important; the effects it has should be monitored, and if necessary, the original marketing concept should be reviewed and adjusted accordingly.

This chapter cannot, of course, offer concrete ideas for successful marketing tools or campaigns for historic places. Their form will always be determined by the specifics and conditions of the place in question, its history, location, potential, state of preservation, as well as by the available financial and human resources that can be freed up to implement the marketing concept. However, just as the cultural significance of an historic

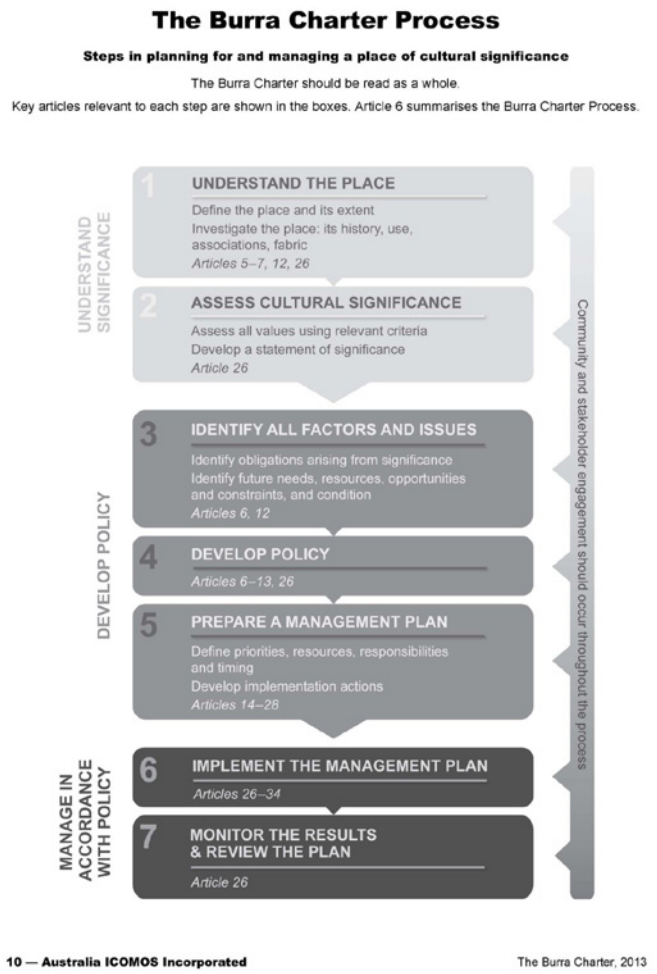

Fig. 1 The Burra Charter Process, source: https://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf (Last access date, 8th March 2022).

place should always form the basis of its management plan, the correct identification and highlighting of its social relevance can determine the success of a marketing strategy designed for that historic place.

Experiencing historic places

The second pillar of the proposed marketing approach is to take care of the very experience that the managers and caretakers of historic places offer to the general public. As the supply side, managers and caretakers of historic places meet the demand side - in this case the general public - and make a certain promise to them which takes the form of a marketing concept. On the one hand, it is of course a question of how this marketing concept is put into practice, i.e., the attractiveness of the actual offer and its compliance with the promise made to the potential public. On the other hand, it is about the functional aspects that accompany the fulfilment of this promise, i.e., what is actually experienced by the public.

In this regard, it is useful to refer to the principles of service marketing, and in particular, to the way in which the quality of services provided is assessed. People interacting with an historic place will experience a specific service offered to them. Whether, e.g., as either part of a tourism proposal, or in a spontaneous and informal way (e.g. by passing by a historic place every day), they perceive it with their senses and in a cognitive way (e.g., noticing whether the place is well maintained, clean, safe, and secure for walkers).

Grönroos (1984) makes a distinction between the 'technical quality' of a service (what is offered to people) and the 'functional quality' of a service (i.e., how it is provided). Lehtinen & Lehtinen (1991) refer to the former dimension as 'output quality' and the latter as 'process quality'. If we relate this principle to the experience of interacting with a historical place, output quality could be defined, for example, as the fact that a person visited the Eiffel Tower, climbed to the top of it, enjoyed the view of Paris, and took some souvenir photos. All technical aspects of the experience were delivered to the tourist's expectations. Process quality encompasses the quality of all activities and impressions that accompanied the tourist's interaction with the Eiffel Tower. If a tourist is not

able to buy a ticket in advance, e.g. online, if they first have to stand in a long queue to buy a ticket, then move to a second queue to get in the lift, if on subsequent floors they are also confronted with huge crowds and squeezes that make it difficult for them to get into the next lift taking them to a higher level, and if they face problems with getting out into the crowd on the observation deck and taking pictures, then the process quality of their visiting experience is not fully satisfactory.

In the deliberately exaggerated case of the Eiffel Tower, we are talking about a historic site which, because of its popularity, attracts a general public despite all the potential disadvantages. It is one which tourists are prepared to visit anyway, regardless of the discomfort mentioned. However, in the case of less popular places, which still need to be promoted and to attract the interest of the general public, the quality of the process is even more important as it will determine not only how satisfied people are with their interaction with the historic place, but also whether they will be inclined to recommend the place to others (word-of-mouth marketing) or rather discourage them from visiting or otherwise enjoying it. Especially in the case of previously less known or less popular places, such recommendation behaviour cannot be overestimated. The exponential reach of word-of-mouth - its ability to communicate a given marketing message to a wide audience in a short period of time (Silverman, 2001), and in a way that does not generate additional costs for the manager or custodian of the historic site - cannot be overestimated either.

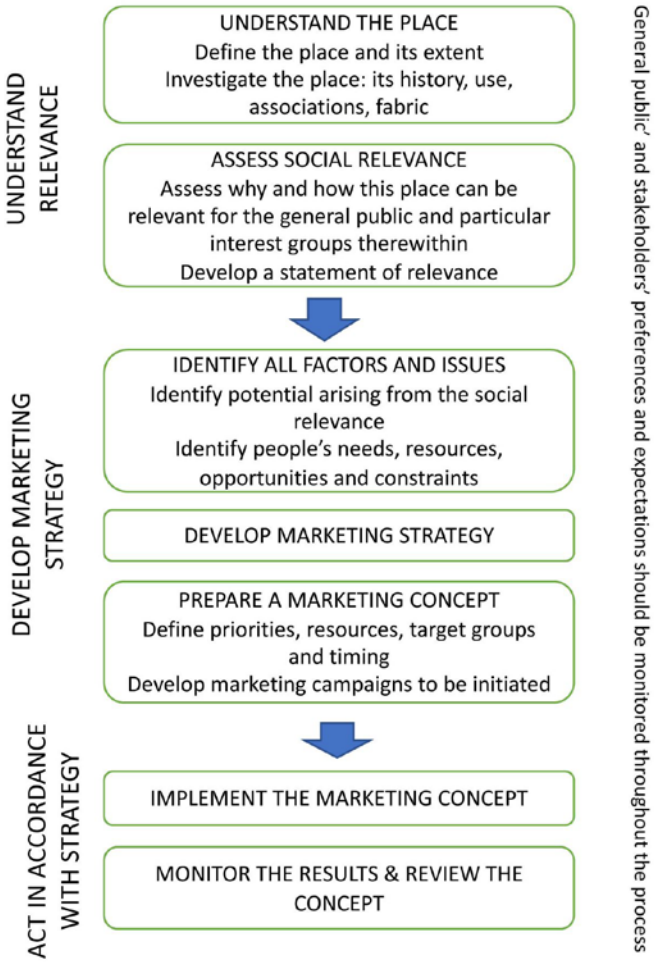

Fig. 2 The Burra Charter Process and social relevance-based model for building a marketing strategy for historic places. Own work.

Summary

In the introduction, it was said that the two discussed pillars of marketing historic places, namely their social relevance and the experience that comes from interacting with these places, make up their value-in-use. While the identification and skillful use of the social relevance of historic places in the process of creating a marketing strategy and individual marketing campaigns fulfils the role of arousing curiosity and interest among the general public, the experience had by representatives of particular target groups seals the marketing success of a historic place. While the identification of a place's social relevance triggers its marketing potential, the quality of the actual interaction with an historic place realizes this potential.

The perception of value derived from interacting with a historic place can be significantly impacted by the memory of attitudes, emotions, and behaviours accompanying peoples' experience (Echeverri & Skålen, 2011). If activities and interactions taking place within the framework of experiencing a historic site are positively evaluated by people, favourable opinions are created (Alam & Perry, 2002). As time goes by, value-in-use accumulates from peoples' experiences; it can also be envisioned in their future experiences (Helkkula et al., 2012; Voima et al., 2010), as well as in their recommending behaviour. The addressees of a given marketing campaign, whose expectations will be reconfirmed through the lived experience of a given historical place, can serve as disseminators of these [positive] experiences to third parties, shaping their expectations and decisions (e.g. in the sphere of tourist plans, leisure activities, etc.) (Yi & Ahn, 2017). Indeed, it should not be forgotten that one of the strongest incentives to make these decisions is being guided by the opinions of 'people like me', especially if it is possible to relate directly to such people (Harris, 1999).

The above proposed approach to marketing historic places aims to attract sustainable attention from the general public and to maximise the satisfaction of those who have chosen to interact with the place (by visiting it or otherwise using it). This approach has the advantage of structuring the thinking of caretakers of historic places. By defining the potential of these places based on their social relevance, this approach facilitates the search for creative ways to exploit this potential for the needs of residents, tourists, and other target groups. Furthermore, it releases ideas for communicating (i.e., marketing) this potential to all interested parties. It makes the manager or caretaker of a historic place take care of all (functional and aesthetic/cultural) aspects of the people's experience thanks to which historical places in question truly gain relevance in the eyes of the general public, and they become increasingly popular (which can be an important issue especially for those historical places which are less known or for some reason undervalued by the inhabitants or tourists of a given locality). Last, but not least, parties who are convinced of the social relevance of a heritage site, and who experience first-hand the benefits it offers, will be willing to share their feeling of satisfaction and various emotions with others, which will significantly increase the impact and reach of the marketing strategy adopted by the managers or caretakers of a heritage site.

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She has experimented with operational and methodological application in national context, mainly related with tangible and intangible case study, focusing on the relationship between survey, representation in the field of digital heritage and BIM environments. She has collaborated in several public contexts dedicated to modelling from the territorial scale to construction scale to finalize BIM and Virtual Environments.
She has held conferences, curated some monographs and several papers on different topics: modelling, BIM, HBIM, Virtual environments and representation. She is responsible for projects on Virtuality and Digitalization, Digitalization and BIM and HBIM and Task leader in H2020 projects regarding Virtual and Augmented implementation.

Abstract

The richness of the Italian heritage has favored mass tourism phenomena, desertifying areas that, abandoned to themselves, risk being forgotten or, even worse, transformed. UNESCO heritage sites and abandoned places are sometimes just a few kilometers away. The attention to the diffused art and to a slower tourism has the possibility to bring back in vogue paths and routes that assume a new value in the post-pandemic era. Digitalization, smart visit, immersive and augmented reality can become the best promotion of Cultural Heritage in a crowded future.

Keywords

Virtual environment, Holography, Immersive, Heritage, Digital replica.

09

Passing on Endangered Cultural Heritage

Introduction

We Europeans recognize the value of a life and education fed by culture, art, and beauty. We easily visit different countries of the Community and while we appreciate their differences, we are educated to accept plurality. Our different arts and Cultural Heritage, represent the enactment of our stories and the instrument that collectively concert the orchestra of Europe. A 2015 European community report (EU, 2015) focused on how to exploit the Cultural Heritage that abounds in our territories for the benefit of Europe.

On March 7, 2014, the Council of Europe Parliamentary Assembly adopted Recommendation 2038 on Europe's Cultural Heritage in danger, calling for activities to unite Culture, Cultural Heritage, and Education, to link cultural heritage to the process of developing democratic citizenship. As recalled in many documents Europe arts and Cultural Heritage have a role in shaping the way Europe is perceived from afar as well and are the soft power for promoting Europe's place in the world.

However, at present, the most visible appreciation that the world shows towards Europe is by visiting it.

Some countries host overnight stays of tourists up to 300Mio a year, some cities like Venice have hosted more than 12Mio tourists for year and in the last ten years it has seen constant growth in their presence; some monuments such as Notre Dame had more than 15Mio visitors a year; some museums such as the Rijksmuseum have almost 3Mio tourists a year.

Among others over the last 10 years, the number of nights spent in the EU by tourists from an Asian country is more than tripled (EU Eurostat, 2021).

Yet there is no doubt that almost half of the UNESCO sites (453) are in Europe. Alongside these statistics, there are other data that show the risks of such as an overexposure of heritage, such as an unsustainability of the receptivity of some places, a trivialization of the contents. The most valued places can be endangered by various man-made threats (such as urban development or excessive tourist interest) or by natural disasters, weather conditions, and climate change. At the same time, monuments often receive sustenance from Touristic visits as well as from the creative industries that are growing around them. The question is: is there a limit beyond which tourism goes from being a resource to a problem? We need to identify ways of reinforcing common European Actions to promote Europe's cultural values and interests. To address this problem the possibilities of immersive fruition created by recent digital technologies, using the persuasive power of images to create digital and immersive copies of Heritage can be a solution. And not only that; the accuracy and ease of virtual fruition could become an important weapon for the recognition of the cultural values of a single country.

Immersive environments could also become part of a mixed reality in which human destiny seems to be heading (Voinea, 2019).

This paper intends to make a series of thoughts on the characteristic of three-dimensional digital models, not

necessarily HBIM models in support of other activities such as conservation, just immersive models, to highlight the issues and limits existing in the effective use of 3D Visualization despite the developments of the modelling phase.

Background

Even if in recent years BIM has grown in diffusion and technicalities bringing many benefits to the AEC sector, the visualization process of a 3D model out of a flat screen, in the space, seems to have not yet had a real output if not limited to certain sectors: video games, with immersive virtual reality, some augmented reality applications in the field of industrial automation or aerospace using specific devices.
Also, many of today's challenges in Cultural Heritage practices concern the need to have a visual assessment of 3D models that is as accurate as possible (Reaver, 2019). The growing gap between a real spatial visualization of designed solutions of buildings and remote access to Heritage (that in the future we will probably no longer have) necessitates better 3D Visualization tools enabled by digital technologies towards new paths of virtual construction practices (Marasco, 2018).
Virtual, Augmented, and Mixed reality with Holography seems to be the right tools to create complex architectural representations that enable cognitive understanding of space more like a reality world just for their possibility to offer an immersive environment and interactive use. We define the different areas of digital visualization: Virtual Reality (VR) (Kersten et al 2017) allows a complete immersion in a digital world, presenting an environment disconnected from the real one. Augmented Reality (AR) (Cranmer, 2020) is a reality intermediated by a virtual layer that helps to enrich what we see in the real world with holograms. AR is located within a well-known spatial interval between real and virtual called X-Reality (XR). Holograms can be considered as a world by themselves, being a form of Stereograms because without projection background. All these systems can improve the understanding of the Heritage through the integration of virtual information, expanding immersion and environmental knowledge (Anderson et al., 2020). Only through a serious analysis and contamination through these worlds, a complete path can be developed to better represent and use a 3D Visualization.

In this page, we will evaluate two different forms of virtual approach useful for CH resulting in line with the expectations of the 2021-2024 agenda of the European Union (EU) a stereogram in a Hologram Table and a Virtual Theater. These two experiences bring with them many critical issues that are the open challenge to reflect upon regarding:
- accuracy of the models in the visualization stage;
- scale of the digital replica;
- interoperability of models, devices, platforms;
- size and storage of models, size of a projection space;
- viewing information related to models;
- interfaces between the model and user;
- usability by several users at the same time.

We will use two case studies to do a state-of-the-art and issues related to the study of two immersive modes, out of a screen laptop: the first case visualized through a Hologram Table, Santa Maria delle Grazie in Milan, the second through a Virtual immersive theater, farmsteads in Monza Park.
We develop two immersive visualization paths to analyze strengths and weaknesses.

The Hologram Table

The table consists of a horizontal surface (2.1m x 2.1m) with four integrated projection devices and it is one of the equipments of the new LaborA - physical and virtual modelling laboratory (Politecnico di Milano). It is composed of a large and flat surface (2.1m x 2.1m) and a metallic frame structure to which all technological components required for the holographic display of 3D models as well as the wooden panel of the top plane are attached (Euclideon, 2013).

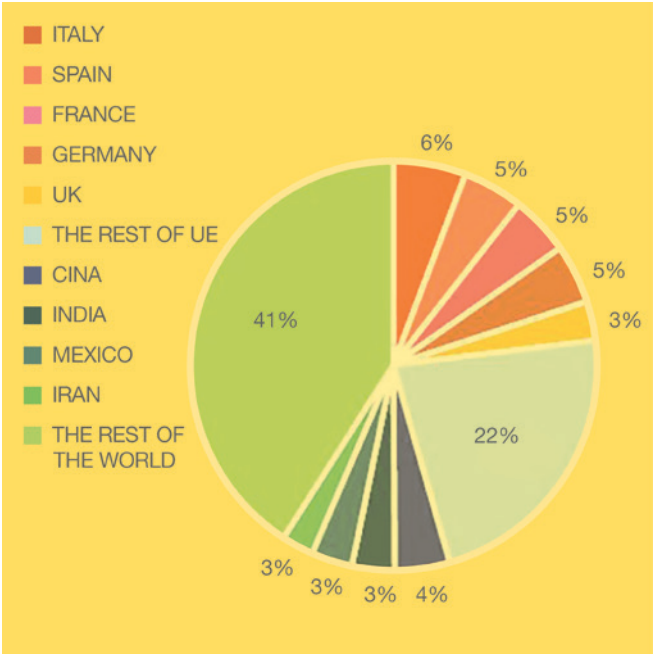


Fig. 1 Top destination for tourism in the world; Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tourism_statistics_-_top_destinations.

The workstation connected is a standardized Dell 5820 workstation (Dell, 2020) equipped with two Radeon WX 5100 graphic cards (AMD, 2020). Four main projectors of the hologram table to display the 3D model on a flat screen. Interaction with the holograms is performed with a specially designed wand, which, as though the glasses, uses an infrared tracking system to calculate their position and orientation in space. The spheres on the wand and the glasses are used to compute their correct position.
Tracking equipment consists of tracking domes and controller, Radio Frequency Dongle and Sync Emitter, which are USB connected to the PC. Sync emitter will receive light from glasses and wands and sync all devices to work together.
The flat-screen area comprises a rear-projection material (white cloth) that is sandwiched through a 10 mm thick acrylic sheet and a 1.5 mm one. This area (1390 mm^2) is the central display where the holographic display takes place. The system projects the 3D models so that they appear to rise from the centre of the table to a height of approximately 0.7m in a hemispherical volume (Makey, 2019).

A holography of Santa Maria delle Grazie

The whole complex of 'Santa Maria delle Grazie' in Milano has been surveyed in its actual state (Bruschi, 1983).
Due to the large dimension and the complexity of the structure, the convent survey provided more measurement campaigns. Moreover, the case study for its architectural importance, its constructive transformations and significant survey problems connected to its shape were considered an in-situ research laboratory (Bolognesi et al., 2019).
A first laser scanning survey campaign was conducted in 2019, using a Leica HDS7000 for the 'cloister of frogs' (16 scans) and a Leica P30 for the cloister of the prior, the old and the new sacristy (36 scans) (Bolognesi and Fiorillo, 2019). The merge of both TLS surveys reaches more than 2 bln points.
The second survey campaign more recent (2020-21) was set up with a more innovative instrument, Leica RTC 360, to scan the dome (interior and exterior surface) and outer perimeter of the church on the other two days of in situ activities. This last 3D survey implies 122 scans reaching around 4 bln points.
Each TLS survey campaign has generated a related project with all scans registered in a local coordinate system. Each of the 174 aligned scans was sampled to 5mm resolution, removing duplicate points to obtain the global point model of Santa Maria complex.
The workflow from raw data to the hologram is multiple steps and time-consuming. Furthermore, when the related point model has the lowest point-to-point spacing and the higher number of points, it is more complex to manage and visualize.
The final point model is composed of 597.619.636 points and has been exported in two different versions in LAS format: 1) X, Y, Z, R, G, and B values for the point cloud with real colors coming from scanner cameras and

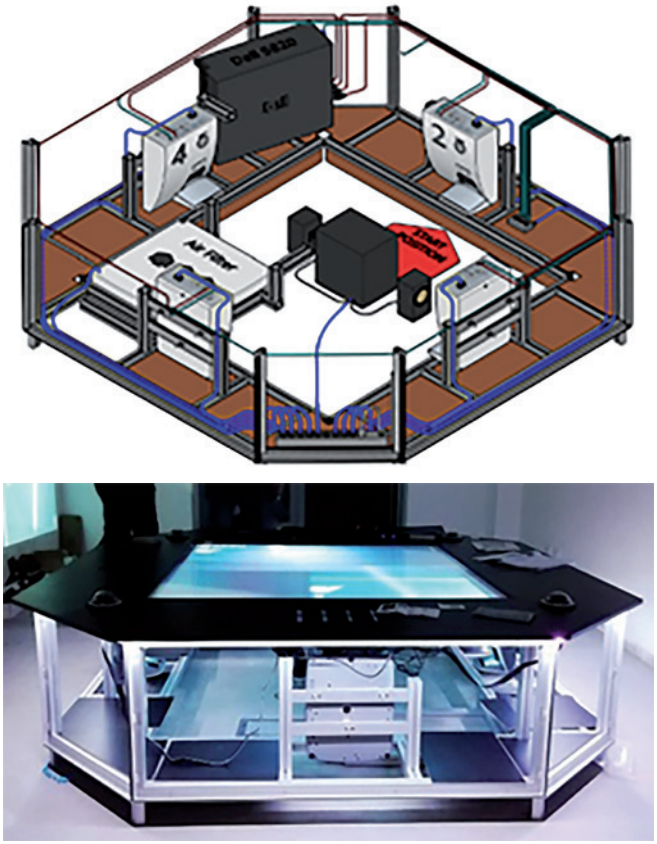


Fig. 2 The Hologram table set up.

2) X, Y, Z, R, G, B values for the point cloud with intensity scalar field transformed into its color components.
The two different LAS files of 14.4 Gb are imported inside the Holoverse Presenter environment, the table proprietary format. Inside the software, it is possible to set up the position of the cloud model in relation to the Hologram table digital reproduction. Once the user is satisfied with the disposition of the 3D content, it is possible to convert the LAS model imported to the Euclideon UDS proprietary file format, the final format for Holographic Visualization. For our test case, the maximum file dimension that could be imported from a LAS file to Holoverse Presenter is 14.4 Gb; after this limit, the import process fails to return a software error. The result, in this case, is an accurate point cloud visualization of the points coloured in RGB colours.
The display of the Santa Maria delle Grazie complex proved the Hologram Table can manage and render a huge dataset with great details without problems. Interaction with the model is performed using a controller (the wand) that allows different actions on the model displayed with three buttons. It is possible to zoom in/ out, to pan and to select the model. All navigation actions (zoom in/out, pan and rotation of the model) are performed without loss in performance or smoothness of the exploration.
However, for the holographic presentation (as well as for most point cloud viewers and exploration systems), a high-quality visualization can be performed after cleaning the raw point model and deleting all bad points from each scan station.
Indeed, distant points and low-quality measurements (e.g., taken with a high laser scanner incidence angle) will result in an irregular line of points, ruining the quality of the final point model.

The Virtual Theater

The second example, a mesh model, was tested in an immersive theater with a totally different workflow. The theater is formed by a cylindrical structure of 350 m in diameter that provides 360° projections on the wall and floor (Speicher, 2021). The projection height considered sufficient for the immersive experience is 2.50 m, being all the technical equipment contained in a limited space from 2.50 m to 3.40 m; a higher technical space allows for the housing of other equipment. The round is equipped with 6 projectors that ensure the projection on the wall and on the floor with an overlapping as in the drawing. The floor is also covered with a material suitable for projection. The technology used provides Laser projectors of high

quality and resolution (1920 x1200, 4K compatible) projecting content as they are or allowing interaction among the browser and the server facilitating real time applications through Unity developments.
The technology of the projectors is Panasonic and Canon, both with Laser technology and with the use of ultrawide optics (0.28:1 for the Panasonic provided for the floor and 0.56:1 for the 4 Canon of the round). The management of the projections is entrusted to a Media processor server with 4 out 1920x1200 on active mini-DP (with m-space functionality for warping) + 1 IN 4K + 1 IN full HD capacity 240 Gb. The floor is served by a Media processor server with 2 OUT 1920x1200 on active mini-DP (with m-space functionality for warping 240 Gb capacity) 1 in 4K. The round has been equipped with an integration software, useful for interfacing with the server on which the Unity rendering engine is located to be able to select the different projects to be shown in the round.

Villa Reale

This second example deals with the modelling and texturing of some farms located in Monza Park and a final visualization through the immersive theater.
All the buildings in the case study were surveyed for several days using Terrestrial Laser Scanner (TLS), RTC 360 and an initial cloud-to-cloud recording in the proprietary Cyclon Field 360 application. The used Leica RTC 360 is equipped with five cameras to track the scan stations and reconstruct the scanner trajectory with the Visual Inertial System (VIS). The instrument is equipped with 3 HDR cameras with five bracketing exposures for the simultaneous acquisition of 360° spherical panoramas, which are then used to colour the single point cloud (RGB values).
All the scans related to four buildings have been settled the resolution to a value of 6 mm at 10 m, mainly carried out using TLS: 20 to represent the external perimeters. The raw registration of the scans was then optimised using

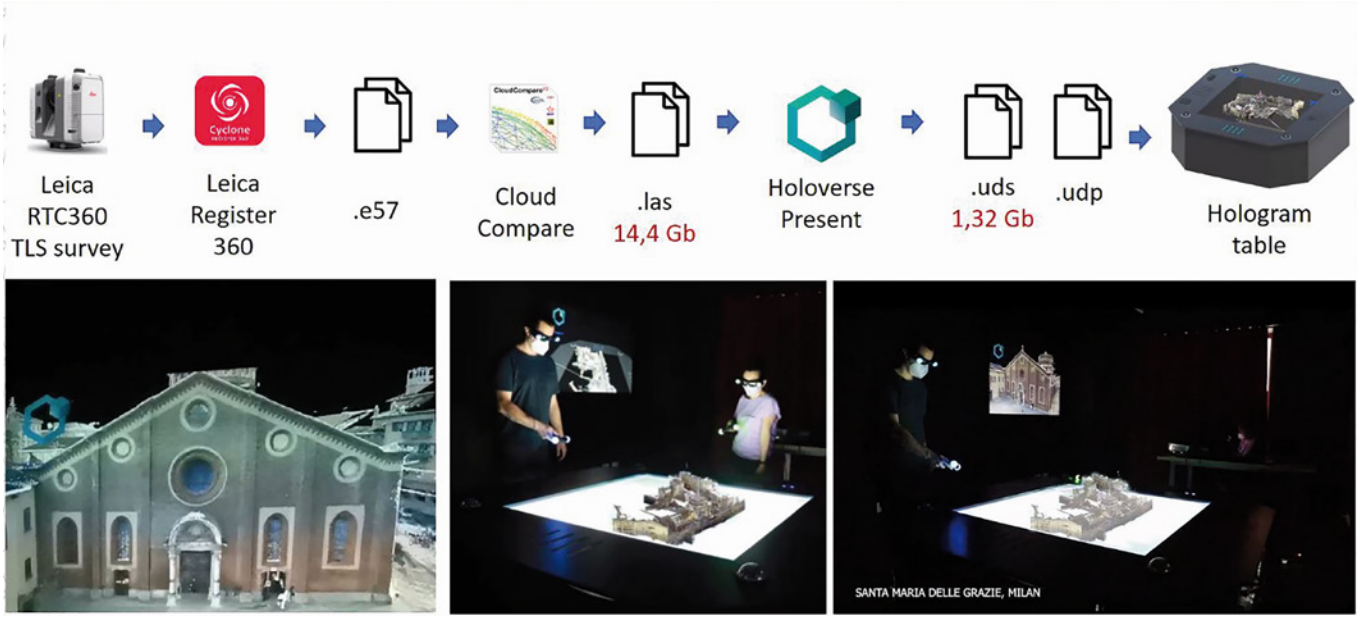
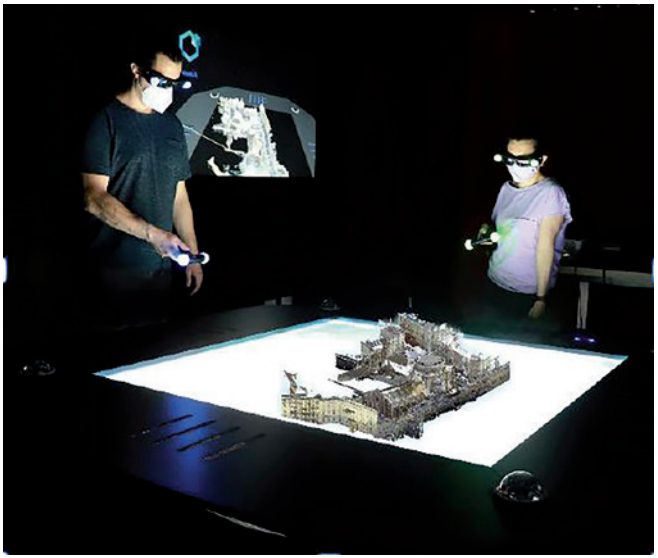
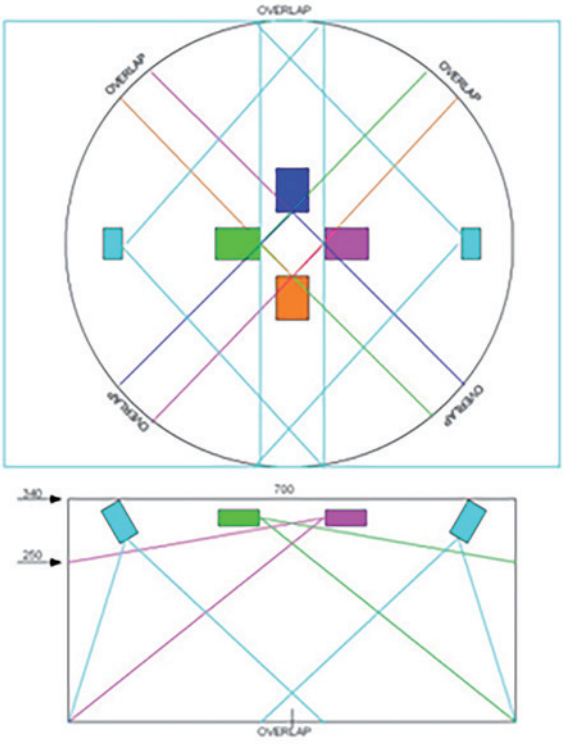


Fig. 3 A standard pipeline in Hologram Table.

a cloud-to-cloud alignment algorithm within the Cyclone REGISTER 360 software, taking care to eliminate all vegetation around the buildings.
Moreover, a small terrestrial photogrammetric survey campaign of the buildings was conducted using cameras in different situations: a Canon EOS 6D Mark II (Full-Frame CMOS sensor, 6240x4160 px, pixel size 5.75 µm) with a 24mm fixed lens. The acquired data were processed according to the classic photogrammetric pipeline.
Point clouds were used to model from scratch, but with precision, orthophotos to be used as a texture for models. The quality of texture has a dominant contribution of realistic visualization. Having built Rhino model with blank surfaces, the texturing objective is to tell the same feeling of original buildings with correct building information as much as possible. The whole project has several building volumes with hundreds of faces for each to be manually unwrapped with maps. The speed, output quality and procedural simplicity are therefore worth discussed to improve work efficiently. The output should be guaranteed to reach the same taste with real world objects in a most rational workflow (Jouan, 2021). Related to the best accuracy in visualization it was discussed and optimized a way to texture relating quality, speed, and simplicity for so many buildings: the objective is the selection of a texturing procedure without loss of detail to achieve an accurate output within the Unreal Engine software, useful both for Immersive Theatre and presentation formats for Hologram Table. The theme of the reproduction of the elements of coating geometries needs a decided in-depth study.
Inside the Unreal Engine platform, the VPL allows a wide range of development of blueprints, useful to increase the experience in terms of movement and fruition. But the rich libraries of materials provided cannot meet the requirements of heritage modelling, necessary to increase the levels of immersion and interactivity if not by modifying them and using additional VPL nodes to modify materials in specially added platforms.





(Above) Fig. 4 Santa Maria delle Grazie in the Hologram Environment; (below) Fig. 5 Plan and elevation of the theater with overlapping images flows.

(Above) Fig. 6 The Mill of the Cantone, state of fact; (below) Fig. 7 The Mill, point clouds+nurbs model.

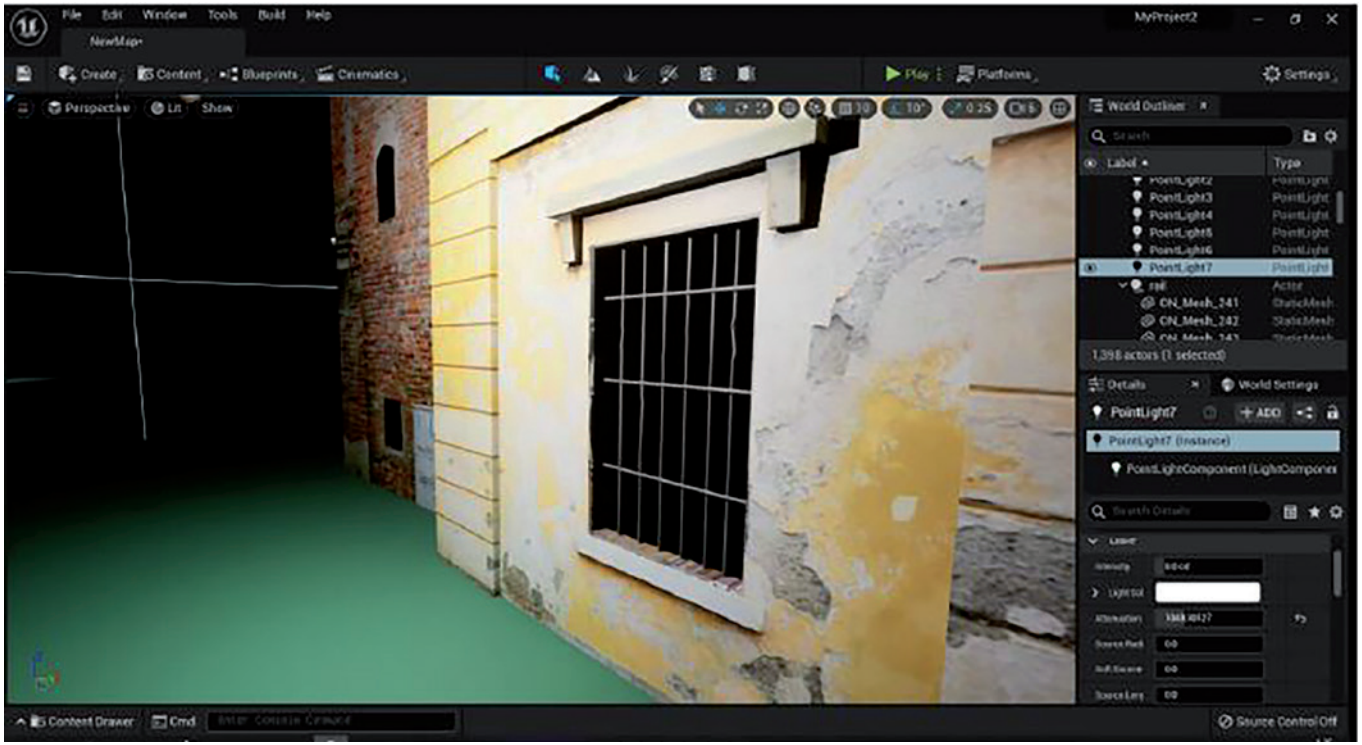


Fig. 8 The Mill, point clouds+nurbs model.

Though the software varies in their ways of creating 3D assets, they perform the same principle on projecting texture it can be involved into the workflow as the following steps:

1. obtain Orthophotos from Metashape (camera scanning) as maps;
2. UV Mapping the maps on surfaces in Blender imported from Rhino7 through obj format;
3. export the fbx format model to UE5.

Quality: The information can be expressed in the best possible way by taking directly from site photos. The outcome can meet the requirement of the project objective.
Speed: Blender has UV Mapping Tool as an independent section inside the engine. It has more options compared with Rhino (project from view, etc.). What's more, one the movement of UVs can update synchronously in the 3d layout window. These features can improve the efficiency and accuracy of the mapping process. Simplicity: the exchange between software causes the Nurbs surfaces model in Rhino converted to Meshes in Blender. As a matter of practising, it does not affect much about the unwrapping experience.
The visualization of the single buildings has been tested in the Virtual Theater through an application realized in Unity environment for the visualization of the model realized in Unreal.
The accuracy of the models realized has clashed with the limitation of some equipment of the theater, first the power of the projectors. The immersive environment of the model was ensured, and the use of multiple users compared to the Holographic Table, effectively usable by 2-4 users at a time, is an advantage.

Conclusion

The path to virtual fruition of cultural heritage environments is a possibility that we must take into account in order to be able to present their memory in the coming years. However, at the state of the art, many aspects are not solved. The reproduction of digital works can be done either with the visualization of point clouds or with textured mesh models but in both cases, and with different results, it is an excessively time - consuming process. In addition to this, the limitations of hardware applications were also an issue; the ability to visualize models of any size in the Holographic Table necessitates application development in the cloud, to support usage otherwise limited by the size of the clouds. The ability to visualize the model in the Virtual Theater brings back the limits of the visualization of a mesh model, reconstructed on point cloud, and the limits of the hardware tools.
On these short considerations we must think that it is still a long way to reach the faithful and usable reproducibility of our Heritage and while it is shortening the time of its physical existence, we are given to accelerate to be able to capture and replicate all its aspects virtually in the shortest time possible.

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Elisa Bonacini is an archaeologist and an expert in digital cultural communication. She is currently working as consultant on Cultural Heritage dissemination and enhancement through new technologies and storytelling projects. Since 2017, she is Courtesy Visiting Adjunct Professor for the University South Florida's Institute for Digital Exploration. She has a first BA in Classics (2001) and a second one in Enhancement of Archaeological Heritage (2010); specialized in Classical Archaeology (2005). She has a first PhD in Humanities and Cultural Heritage (2014) and was a Research Fellow (2015-2017) on Digital Enhancement of Cultural Heritage at the Catania University. She has a second Ph.D. in 2022 at the University of Cordoba (Spain) on "Digital storytelling as a teaching tool for transmission and cultural enhancement".
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She participated in many national and international conferences and published many papers and books: a full list of publications can be found on Academia.

Abstract

The topic of this paper is about the digital recovery of memories of human tragedies and disasters: it wanted to highlight how new technologies can allow us to save the 'digital memory' of individuals and communities, thanks in particular to digital storytelling.
Starting from a definition and a classification of digital storytelling, the paper focused on some examples of how these tragedies can be told.

Keywords

Digital storytelling, Digital platforms, Digital narratives, Digital memories, Digital archives.

10

Earthquakes, Floods, Shipwrecks. The Story of Human Disasters through the Recovery of Digital Memories

Digital Storytelling: definitions and types

Humans are 'storytelling animals': we can define storytelling as an ancestral aptitude, something we have in our DNA, since from the caves, born to convey precise knowledge and ideals. Intended as the art of telling stories, it allowed humanity to build narrative so powerful as to create above them an entire collective imagination, based on archetypal figures and fantasy; religions themselves as the most powerful storytelling humans have created, a sort of archaic virtual reality technology (Gottschall, 2013).

The word storytelling is a sort of umbrella word, meaning both the process of telling stories and the product of narration itself (Perissinotto, 2020). If the 'analogical version' of storytelling dates since prehistoric times, a born digital storytelling (native digital stories, enjoyed in a digital format) has a precise birth date: in 1994 the Center for Digital Storytelling (now named StoryCenter[1]) had been founded, in California, by Joe Lambert and Dana Atchley. Then, it started soon to be intended as a tool for democratizing cultural content through specific languages (Lambert, 2013).

Another great center for digital storytelling has been founded by Bernard Ross Robin at Houston University in 2004[2]. In the recent 15 years, many other centers have been founded around the world.

Storytelling has in fact started to have a widespread success in every field, transcending borders and different fields of application, to the point of talking about a real storytelling 'revival' and a 'narrative age' (Salmon, 2008), allowing an emotional approach and an increasing interest in many sectors of our life, from culture to tourism, from politics to branding and marketing, from social inclusion to communities' cohesion and sense of awareness and belonging. Scholars, in fact, recognize the value of cultural co-creation in promoting local heritage, and the social integration and cohesion of local heritage communities (Bakhshi & Throsby, 2012). It is no coincidence, therefore, that among the most innovative communication and interaction options between a cultural institution and its users there is a great trend in the cultural heritage domain, thanks to digital platforms and applications, by facilitating creation of UGC and participatory and crowdsourced approaches (Roued-Cunliffe & Copeland, 2017; Hetland et al., 2021). According to scholars, it's the greatest way in creating interactive engagement and entertainment for the public (Handler Miller, 2020).

However, digital storytelling is a still emerging practice, because it is closely linked to the evolution of new technologies, which continue to change not only forms and ways of cultural communication (Alexander, 2017; Handler Miller, 2020), but the relationship between the public and culture itself (Keskin et al., 2016; Dunford & Jenkins, 2017).

During the last 15 years, scholars tried to better define digital storytelling.

According to Robin, *"all revolve around the idea of combining the art of telling stories with a variety*

of digital multimedia, such as images, audio, and video" (Robin, 2006, p. 709). Not so different is the definition by Leslie Rule, founder of the Digital Storytelling Association: "*digital storytelling is the modern expression of the ancient art of storytelling. Throughout history, storytelling has been used to share knowledge, wisdom, and values. Stories have taken many different forms. Stories have been adapted to each successive medium that has emerged, from the circle of the campfire to the silver screen, and now the computer screen*" (2007). In more recent years, the AthenaPlus European project researchers defined digital storytelling as "*relatively a new term and refers to the use of digital tools to tell stories. It can be seen as the modern way of telling stories, combining multimedia features*" (Brouillard et al., 2015, p. 35).
In a recent book, the writer tried to define it as "*a human attitude, a technique and an art that, supported by knowledge and digital technologies, give life to the various and multiple forms in which digital storytelling is articulated today*" (translation from Bonacini, 2021, p. 24).
According to a recent study, 14 main categories of digital storytelling have been classified (Bonacini, 2020, pp. 61-272):

1. Oral storytelling;
2. Written storytelling;
3. Video storytelling;
4. Visual storytelling;
5. Animated storytelling;
6. Interactive storytelling;
7. Immersive storytelling;
8. Social media storytelling;
9. Participatory storytelling;
10. Generative storytelling;
11. Geo-storytelling;
12. Multimedia mobile storytelling;
13. Crossmedia storytelling;
14. Transmedia storytelling.

The examples here described, presented in previous researches (Bonacini, 2013; Ead., 2020; Ead., 2021), have been selected between these categories.

How to tell a shipwreck through digital storytelling

Two examples have been selected to describe how to tell a shipwreck through digital animated storytelling, both using the graphic novel solution.
The first one is 'The Boat'[13], an unconventional narrative experience, launched in 2015 by the Australian TV channel SBS, with the sound effects (the howl of the wind and the noise of the rain), visuals (the lightning) and the vertical scrolling of the page, where the story of a Vietnamese refugee is told, floating among the waves. The style is exactly the one of a traditional comic, with the stripes painted in ink and the typical clouds for the dialogues.
The second one is 'The Boat that disappeared'[14], a multimedia storytelling reportage produced by the BBC in 2020 to tell the tragedy of a shipwreck of illegal immigrants along the coast of Libya with 2D cartoon graphics.

How to tell a storm through digital storytelling

A great digital interactive storytelling project was 'After the Storm', launched in 2015 by an independent production company in collaboration with the Washington Post, in which the terrifying tornado that hit Alabama in 2011 was reconstructed. Divided into 15 chapters, it was a real interactive digital journalistic reportage in which the protagonist of the story, the independent film-maker Andrew Beck Grace, was the narrator who survived the tragedy of Tuscaloosa.
Combining audio narration with full-screen video display, music and animation, the reader moved within this autobiographical digital documentary by interacting with the scrolling pages, leafing through albums of images, as if he were looking himself into a camera. The project is no more existing online.

How to rebuild a historical site through digital storytelling

Now we are used to the 3D reconstructions of ancient urban landscapes thanks to games such as 'Assassins' Creed', but one of the first cases of institutional game and one of the first examples of the use of gamification to let people know the real appearance of a destroyed historical site was 'Versailles 1685: Complot à la cour du Roi Soleil' (1996). This is a great example of the environmental reconstruction accuracy (architecture, landscapes, interiors, costumes, characters, etc.), thanks to the scientific and archival support of the project partner, the Réunion des musées nationaux.
The rooms were reconstructed in 3D, helped by ancient engravings, plans and models for rooms no longer existing; furnishings on the basis of historical inventories; costumes based on the period clothing collections from the Musée des Tissus de Lyon; the characters based on court portraiture. The graphic result was accompanied by soundtracks and music for harpsichord, while the interactive dialogues (in which situations of life at court were described as documented by historical sources), were interpreted by actors. As shown, 'The Ambassador Staircase', no more existing as it was demolished by Louis XVI in 1752, had been digitally rebuilt.

How to tell an earthquake through digital storytelling

Recent earthquakes have been told in many different ways through different categories and solutions of digital storytelling, such as by geolocating images and memories, through VR experiences, multimedia and geolocated storytelling on digital platforms and, finally, through participatory storytelling to recover collective digital memories.

Fig. 1 Screenshot of a scene from The Boat graphic novel.

Fig. 2 Screenshot of a scene from The Boat that disappeared graphic novel.

In the last decade, Google and its technologies helped communities to digitally rebuild their destroyed urban landscapes. The very first project - no more existing - was about the 3D reconstruction of the historic center of L'Aquila (devastated after the 2009 earthquake), called 'Comefacciamo' (How can we do?) launched by a British architect helped by Google, using Google SketchUp software. 'ComeFacciamo' was connected with the geo-website called 'noilaquila.it' (no more existing) launched in June 2011 for the 3D reconstruction of the city, made by images or videos of the views of the city, accompanied by citizens' memories (Farinosi & Micalizzi, 2016).

Just after this project, a second one, so far existing, was 'Memories for the Future' (*Mirai e no kioku*)[5], after the Japan earthquake and tsunami in 2011. The before and after situation in the landscapes can be compared thanks to the Street View coverage, while the 'Building' section of the platform collects the photographic documentations of the exteriors and interiors of damaged buildings. This is a recovery of landscapes and buildings' original aspects, without a real collecting of stories and memories by people.

In 2014 'Rebuilding Haiti'[6] was launched as an interactive reportage, between digital journalism and interactive storytelling, a project by the European Journalism Centre in collaboration with the Innovation in Development Reporting Grant Programme. The interactive story has been divided into six chapters: users need to read every section to go on, after answering some questions, as he was one of the authorities who decided something about the safety of people or the reconstruction.

A recent project is an immersive film 'Noto 1693: the day of fear' in VR (23 min.), where the last moments

Fig. 3 Screenshot of an interactive photo-album from the After the Storm interactive storytelling project.

Fig. 4 The 'Ambassador Staircase' demolished by Louis XVI in 1752, image from the Versailles 1685: Complot à la cour du Roi Soleil videogame.

of the city are told, creating a 'digital bridge' between generations to regain awareness of their ancient roots (Bonacini & Deva, 2021). The 1693 earthquake destroyed 70 cities in south-eastern Sicily. The survivors, revealing a great sense of resilience, rebuilt soon their cities. Among these, the well-known Baroque UNESCO Noto was built elsewhere, by abandoning the destroyed one (Noto Antica). The VR project stands out, compared to others, for the production process (participatory both in involving an experts commission and in 'returning faces' to the real protagonists, thanks to a 3D casting of the modern citizens, so involving local heritage communities in rebuilding the last moment of Noto, according to the principles of the Faro Convention) and the tragic issue itself, told with an emotional and evocative storytelling. 20 people were selected and digitally replicated in 20 3D characters, by enhancing the historical protagonists with traits of real people, who can recognize themselves in the faces of the characters of the movie, who were then associated with really existing people, with their social rules, dressed in keeping with XVII century fashion, as agreed by the scientific committee, in order to obtain convincing, charismatic figures, endowed with complexity and personality. In the texturing phase, all the urban and architectural elements have been reconstructed with a precise and evident note of general degradation (the city suffered much damage from the previous shocks), mixed with poor chromatic tones to simulate a veil of decadence, a suspension of the drama that is bearing down on people, buildings and objects. From the emotional and evocative side, an external storyteller introduces the story in some scenes, rebuilt according to the sources, such as the emergency meeting among the city personalities. Voice actors were also involved: some characters were also able to express themselves vocally, thanks to facial animation and lipsync techniques.

The same 1693 tragedy has been told in two audio guides on the izi.TRAVEL free platform, made by the students of a workshop coordinated in 2020 by the writer, in the Institute for Superior Instruction of Noto. The first one is the audio guide 'Netum – Ancient Noto. The face of the town before the Baroque explosion'[7], which tells the stories about the city before and after the 1693 earthquake, describing it according to the visual sources (such as paintings and maps) and to the literary ones (such as poems and personal memories of the people). This project is strictly connected to the audio tour 'Discovering Netum – The Ancient Noto'[8], where the point of interest in the archaeological area of Ancient Noto is described in an evocative way, according to their architectural remains and the literary or visual sources.

Fig. 5 A screenshot from the noilaquila.it Google Street View geo-storytelling project.

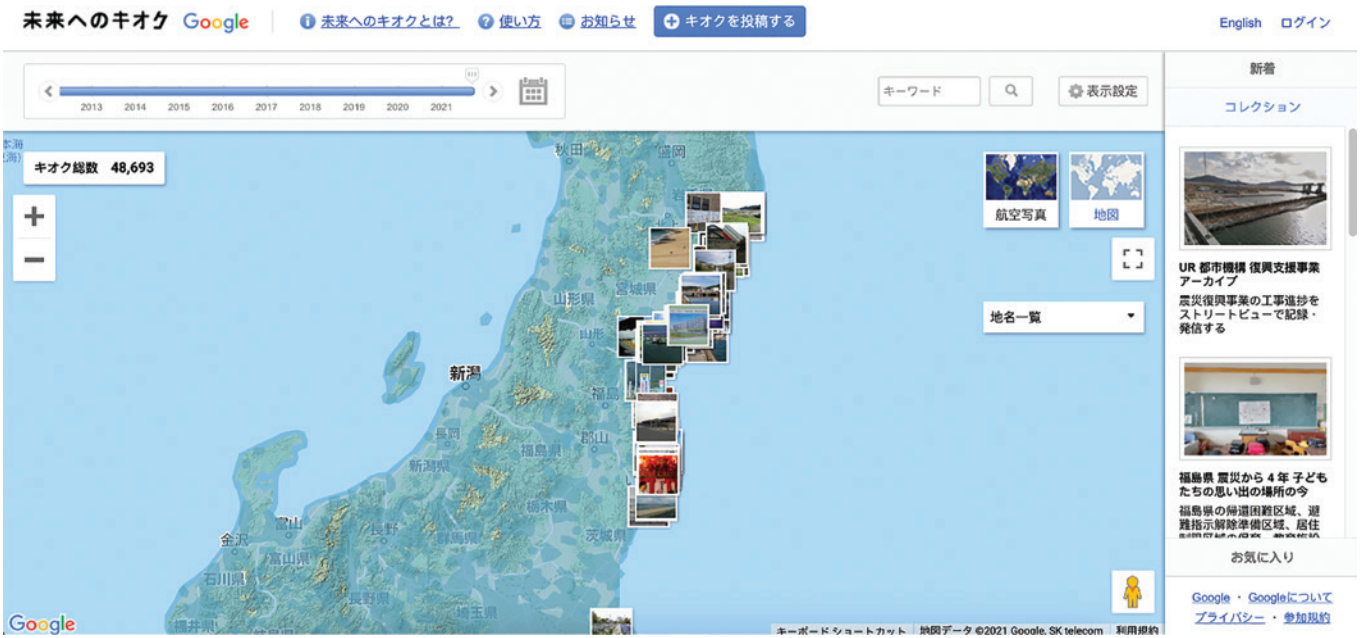

Fig. 6 Homepage of the Memories for the Future Google Street View project.

Fig. 7 Homepage of the Rebuilding Haiti interactive storytelling project.

Another audio guide, made by the students of the Cutelli Lyceum in Catania, presents the protagonists of the Catania reconstruction after 1693: 'The actors of culture and Baroque rebuilding of Catania after 1693[9], telling the story, in first persons thanks to their biographies and works (such as palaces, churches, monasteries), of the people who were able to rebuild the city according to a Late Baroque style (now UNESCO site).
Another Sicilian earthquake has been told on izi.TRAVEL, thanks to the project made with the students of the Primary School of Salaparuta (near Trapani), 'Discovering Salaparuta on the feet of our grandparents…and not only'[10], by collecting the stories on 1968 Belice earthquake, that have been told by the children reporting the words of their parents, just as it was a digital handover of the baton of personal and collective memories through generations.

How to rebuild a hurricane through digital storytelling

A growing trend is to use Internet and platforms to preserve the past by building 'digital memory banks': a great example is the one of the geolocating 'Hurricane digital memory bank'[11] platform, by collecting, preserving and sharing the first-hand stories, images, podcasts from people who were affected by the Katrina and Rita hurricanes. It was launched in 2005, by the George Mason University's Roy Rosenzweig Center for History and New Media and the University of New Orleans, in partnership with the Smithsonian Institutions National Museum of American History and other partners such as the Library of Congress and the Red Cross.

How to tell a terroristic attack through digital storytelling

Active since 2002 and soon included among the permanent digital collections of the Library of Congress and supported among the partners by the Smithsonian Institute thus guaranteeing the long-term digital maintenance of the platform, the '9-11 Digital Archive'[12] collect thousands of documents, photos, images, videos, stories of Americans who want to help preserve the memory of the attacks on the World Trade Centre in New York, Virginia and Pennsylvania, with specific mnestic, identity, values and educative purposes (Farinosi & Micalizzi, 2016). The collections are diversified, between the digital projects carried out by individuals, to the Library of Congress and the Smithsonian institutional ones. This project favoured the construction of collective sensemaking with respect to a story which became global, due to the strong emotional, social and political impact that these events have had on a global scale. The September 11 Digital Archive is a great example of participatory digital storytelling through digital platforms to collect, preserve, and present the history of a community. As declared on the homepage, it "*contains more than 150,000 digital items, a tally that includes more than 40,000 emails and other electronic communications, more than 40,000 first-hand stories, and more than 15,000 digital images*".

Fig. 8 3D character creation of the Captain of Justice character in typical noble dresses from late XVII century, for the Noto 1693: the day of fear immersive VR storytelling project.

Fig. 9 Screenshot of the scene of the emergency meeting for the Noto 1693: the day of fear immersive VR storytelling project.

Conclusions

After introducing these examples of digital storytelling solutions used for preserving digital memories of natural and human disasters, it is necessary to underline the main functions of digital storytelling, to better define the great power of digital storytelling in preserving and disseminating tangible and intangible heritage and individuals and communities stories. By analyzing the functions identified in the political narrative field (Moroni, 2017) and those regarding the management (Salmon, 2008), according to the writer they can be amalgamated with each other, so covering in their definitions the marketing (Mathews & Wacker, 2007), the evolutionary psychology (Gottschall, 2013) and cognitive fields (Bietti et al., 2019). Therefore, they can be readapted, thus describing our proposal about the typical eight functions of digital cultural storytelling (Bonacini, 2020):

- community function: narrative fosters the construction of a community sense;
- referential function: narrative allows the transmission of knowledge;
- empathic function: narrative arouses emotion and involvement;
- mnestic function: narrative allows the individual and collective memories' transmission between generations;
- identity function: narrative allows the identity construction;
- value function: narrative allows the values' transmission; 'springboard' function: narrative allows people to understand what may happen in the future by reading what happened in the past;
- connective function: narrative fosters the connection between institutions and heritage, individuals and collectivities.

All the first seven functions can be activated only when an emotional connection is created and this can only happen by abandoning the oldest methods of knowledge transmission, which are didactic and self-referentiality based, and finding a suitable language and arguments, to arouse willingness to listen and to enjoy cultural content. In this way, we can say that the connective function is the 'umbrella function', covering and including the others.
According to all these functions, all the given examples can finally demonstrate how digital storytelling could be a strong and useful tool for recovering digital memories and for new, more enjoyable and empathic forms of narration.

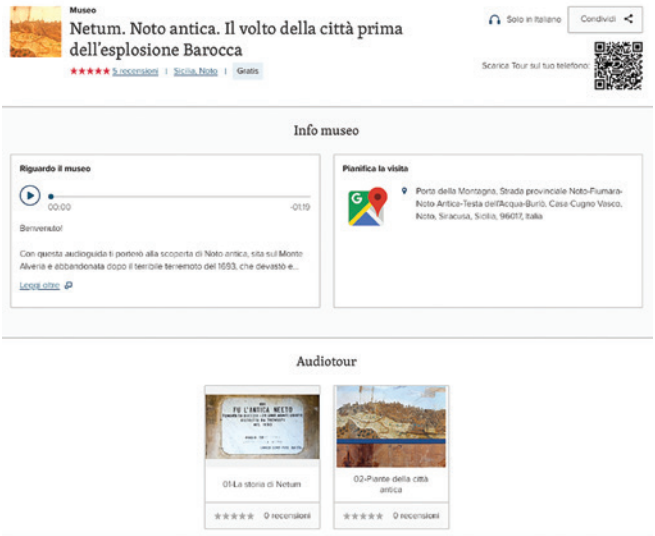

Fig. 10 Homepage on the izi.TRAVEL web platform of the Netum – Ancient Noto. The face of the town before the Baroque explosion multimedia storytelling project through an audio guide.

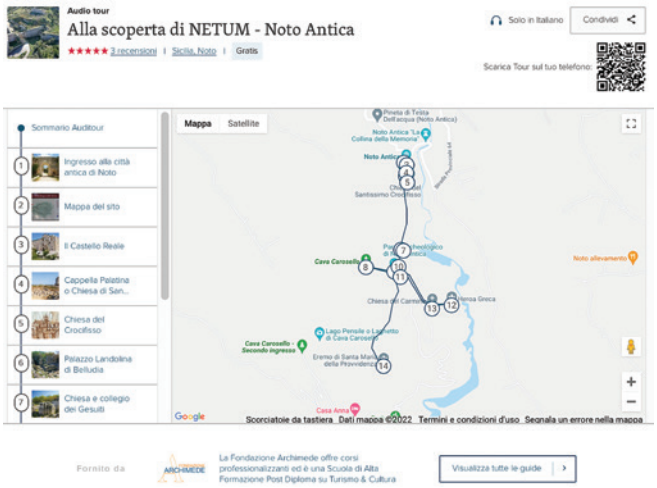

Fig. 11 Homepage on the izi.TRAVEL web platform of the Discovering Netum – The Ancient Noto geo-storytelling project through an audio tour.

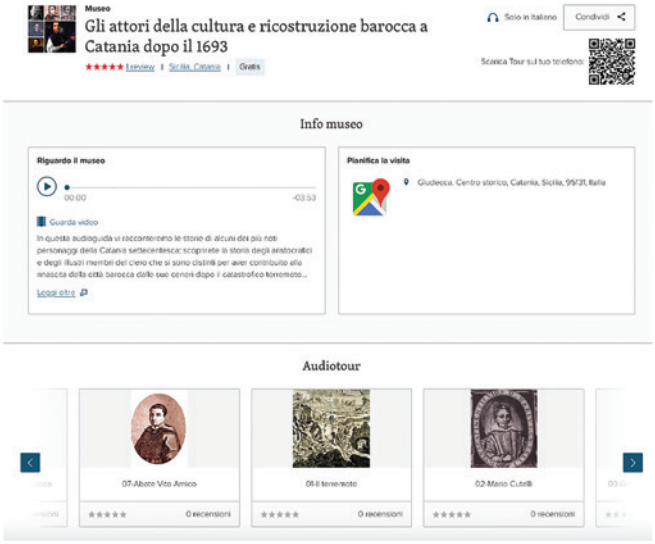

Fig. 12 Homepage on the izi.TRAVEL web platform of the The actors of culture and Baroque rebuilding of Catania after 1693 multimedia storytelling project through an audio guide.

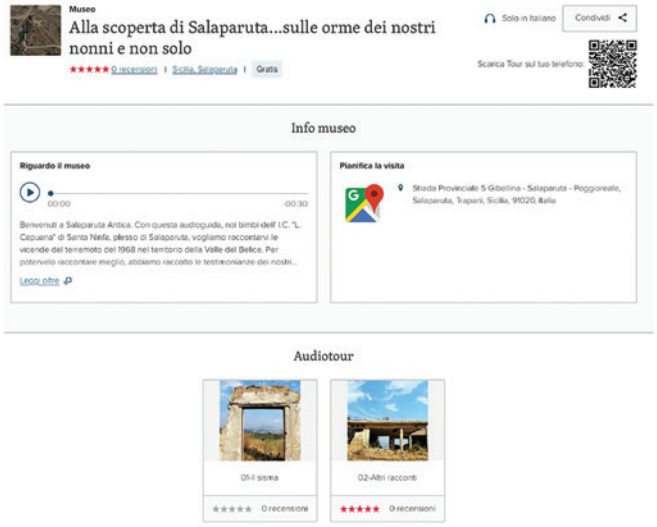

Fig. 13 Homepage on the izi.TRAVEL web platform of the Discovering Salaparuta on the feet of our grandparents…and not only multimedia storytelling project through an audio guide.

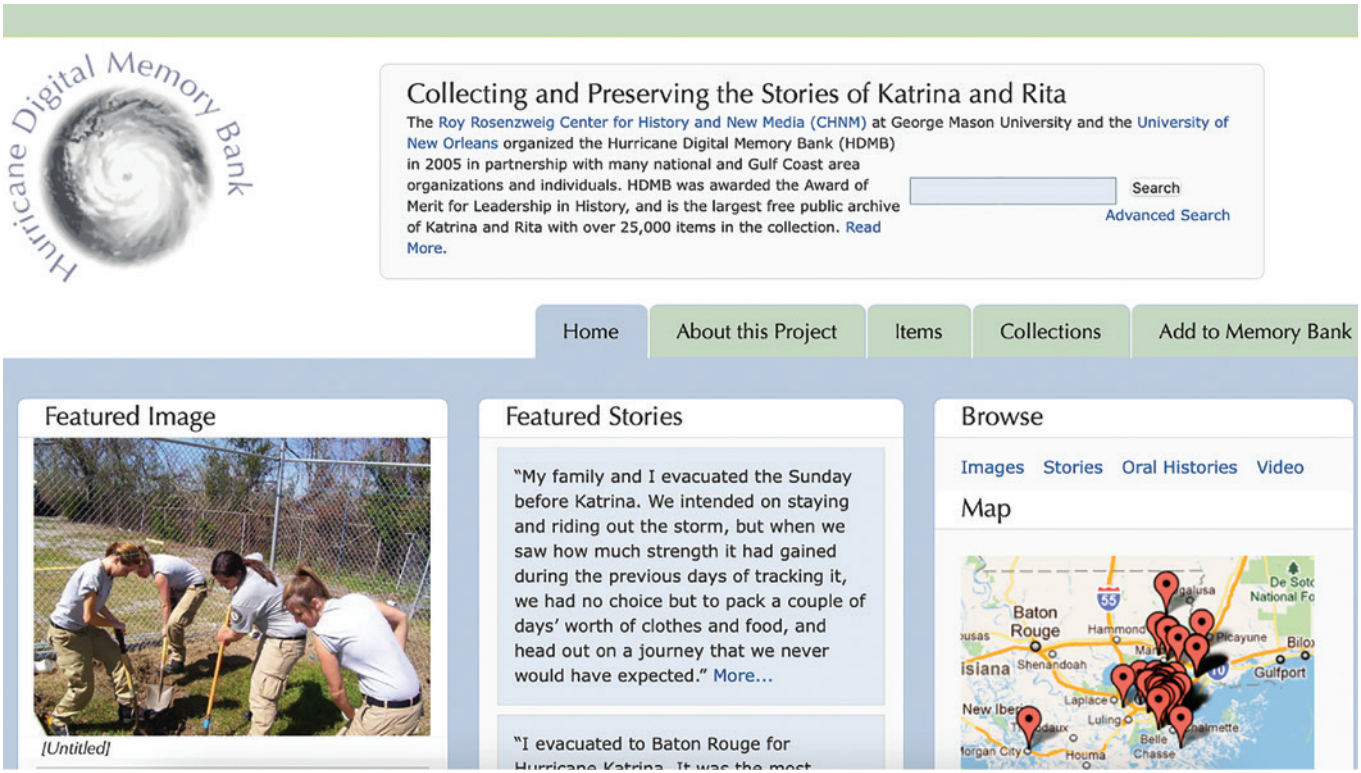

Fig. 14 Homepage of the Hurricane digital memory bank participatory and geo-storytelling project.

Fig. 15 Homepage of the 9-11 Digital Archive participatory storytelling project.

Notes

1 https://www.storycenter.org.
2 http://digitalstorytelling.coe.uh.edu.
3 https://www.sbs.com.au/theboat/.
4 https://www.bbc.com/news/extra/vdb6u1mrrv/the-boat-that-disappeared.
5 https://www.miraikioku.com/streetview/en/about.
6 http://apps.rue89.com/haiti/en/.
7 https://izi.travel/it/76cb-netum-noto-antica-il-volto-della-citta-prima-dell-esplosione-barocca/it.
8 https://izi.travel/it/27e7-alla-scoperta-di-netum-noto-antica/it.
9 https://izi.travel/it/3461-gli-attori-della-cultura-e-ricostruzione-barocca-a-catania-dopo-il-1693/it.
10 https://izi.travel/it/8737-alla-scoperta-di-salaparuta-sulle-orme-dei-nostri-nonni-e-non-solo/it.
11 https://hurricanearchive.org.
12 https://911digitalarchive.org.

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She has joined with internships the Umbrian Cultural realities: Umbrian Museum Pole as Cataloguer (2018), FAI-Umbrian Regional Secretary (2019) as Communication & Event Manager Assistant and Public Library 'G. Carducci' in Spoleto (2020-2021) as Library Assistant. She took part to the Technical-economic feasibility project drafting for a Governance to promote and commercialize the Archaeological Agricultural Park in Aso Valley Ecomuseum (2020).
She is a FAI member (2019): she is content creator for the Spoleto Group's FB page and the Regional Volunteer Trainer.
She adopts historical-artistic and transversal skills in Digital Marketing in developing and understanding the management of Cultural Heritage processes.

Abstract

In the new Digital Ecosystem of the Participatory Age Cultural Institutions are trying to reinvent themselves by redefining their roles and activities, discovering that one of the most effective communication techniques in the museum field is digital storytelling. This is the basis of the Connessioni Museali project: both a real and virtual path for the enhancement of Cultural and Naturalistic Heritage in the Spoleto and Valnerina area (IT), thanks to a mobile app, a serious game, a video-photographic campaign and a social media communication plan. The aim is to catch potential publics, to explore new narrative languages for cultural tourism circuits, to make on-site and remote teaching experiences easier. A broader collaboration is expected with other cultural-digital initiatives to offer a wide and complete SMART tourism in Umbria.

Keywords

Digital ecosystem, Digital storytelling, Connecting museum, Museum network, SMART tourism.

11

Towards a Connecting Museum between Storytelling and New Technologies

The case of Connessioni Museali Project between Spoleto and Valnerina

Digital Ecosystem for Culture and the new Connecting Museum

The traditional communication system for Cultural Places has been changing very deeply in the last few years thanks to cultural, social and technological developments.[1] Cultural Institutions are trying to comply with nowadays Digital Ecosystem for Culture, redefining roles and activities as indicated by a series of documents. Among these, there are national regulations such as the Three - Year Plan for Digitalization and Innovation of Museums[2], or the international acts and conventions such as the Faro Convention[3] and ICOM's indications on the new definition of 'Museum'[4].
In this Digital Cultural Ecosystem[5] communities are made up of museums and cultural institutions; its fundamental element is culture, which must be transmitted to the public according to a specific communication strategy and using technologies to spread it across different channels[6]. Technologies and channels through which the museum must communicate are both directly involved in the museum itself and in part of the district in which 'the museum' is discussed. The institution must also take note and monitor this topic constantly to achieve the audience development, which takes with three important functions: communication, education and marketing (both direct and indirect)[7].
In particular the Digital Ecosystem of Italian Museums provides for a network of public and private entities acting within a framework of open data and common interoperability, according to shared rules, at the center of which the Integration platform of the Museum System is ideally placed. The National Museum System (SMN), based on unified quality standards in agreement with Ministerial Decree n.113 of 21/02/2018, is the guarantor of the interoperability and interchange between every Italian museum at all competence levels and the General Directorate of Museums[8].
Even museums need to fit in the so-called 'Participatory Age', in which everyone can become a content creator for Culture too[9]. In fact, we can talk about a Convergence Culture in which traditional media meet the digital ones, giving birth to trans-medial narrative forms characterized by innovation, convergence, everyday life, interactivity, participation, globality[10].
This is a changing call not only for the biggest international museums, but especially for the smaller ones, both in cities and suburbs, which can find a renewed incentive for a modern and effective cultural communication in network collaboration and in technological adaptation. Summing up, the Museum must be contemporary.
The time is ripe for a new idea of Museum, as turned out by the heated discussion by ICOM's tables. The model of a nineteenth-century Collection Museum, linked to the idea of a museum as a temple, is outdated. The most modern definitions linked to the relational aspect of the museum with its public, such as Forum Museum,

Relational Museum and Community Museum, as well as those ones which declare the different aspects of these relationships, for example Communication Museum, Participatory Museum and Narrative Museum, should be fused together[11]. It is the moment to accomplish a more complete and concise definition of Connecting Museum or Museum of Connected Narration. It is based on storytelling as a connection supportive tool and it is characterized by the emotional and cognitive components with the use of technology. This connection is the one between the institution and its public, mediated by the narration of stories strewed by digital tools[12].
In this scenario, Digital Storytelling is one of the most effective communication techniques with a large potential development for Museums, thanks to its primary connecting function[13]. Storytelling is the art of disseminating contents through telling stories employing digital media in its different expressions: from the ancestral oral form to social media, passing through gaming and Augmented Reality (AR) technologies[14]. Digital Storytelling is used to achieve audience engagement and audience development[15], thus transforming the self-referential museum into a more modern Connecting Museum.

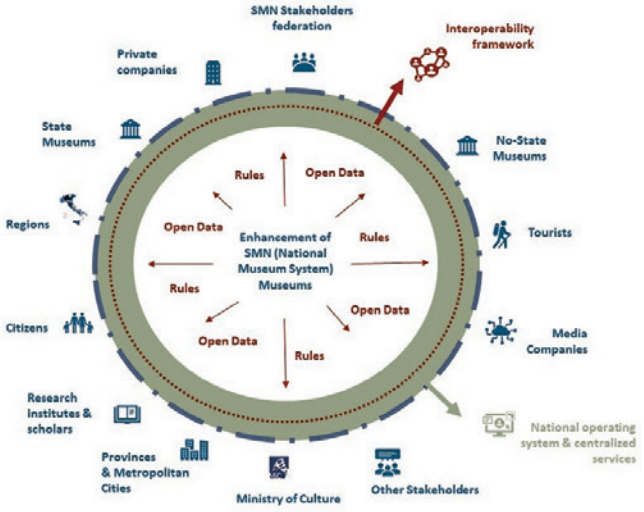


Fig.1 Digital Ecosystem for Culture in Italy due to Ministry of Culture (translate and adaptation from Lampis, A., Orsini, A. (2019) Piano Triennale per la digitalizzazione e l'innovazione dei musei-MiBAC-DG Musei, p. 19).

As is: cultural-digital supply in the Spoleto-Valnerina area

Before describing the *Connessioni Museali* Project as best practice of Digital Strategy for Heritage through Digital Storytelling, a benchmark analysis of the main cultural-digital supplies in the Spoleto and Valnerina Area must be displayed. The analysis is about the storytelling platforms izi.TRAVEL and MySpoleto.
The first one is a native web and app platform which uses digital storytelling and User Generated Contents (UGC) to pursue the mission of democratization and promotion of culture and territories. It consists of a bottom-up system in which citizens can create free contents to be shared with tourists. These UGC are audio guide tours GPS trigged: every place of the narration is geolocated via a GPS trigger-zone linked to a so-called 'point of interest' of the tour, which could be a square, a palace, a church, or an art piece inside a museum[16]. Only few tours of Spoleto made by associations or schools are available there.
The second analyzed platform is MySpoleto web site, which offers a written description of the main attractors of the city divided by types identifiable on Google Maps[17].
The study focuses also on the touristic mobile apps in the area involved available on the main mobile stores:

- Umbria Culture: allows to access the cultural world of the Umbria Region: it is possible to browse the places of culture, the collections and documents owned by libraries and museums[18];
- Cerreto di Spoleto: free app equipped with the iBeacon system[19] to visit the Ciarlatano Museum in Cerreto di Spoleto; information on the area and the main points of interest are provided as well[20];
- Monteluco: free app developed to make the nature

trails of the area of Spoleto easily traceable, enhancing the historical road network[21];
- the Cathedral of Spoleto: allows tourists to live a unique and immersive experience of the entire structure and art works in the Cathedral, entitled to S. Maria Assunta[22];
- Spoleto Tourist App: a digital tourist guide with description and geolocation of the monuments and curiosities about Spoleto, as well as information on the main events. It is not available anymore[23];
- Spoleto Art Today: all the artists and artisans, institutes and associations and cultural initiatives of the city gathered in a single app, as a showcase where they can talk to each other, make themselves known, encouraging comparisons and cultural exchanges[24];
- Vallo di Nera: provides free information on places of interest to visit, sports and food & wine activities, which can be carried out in Vallo di Nera[25];
- the paths in the Olive Range: free app dedicated to the discovery of the Assisi-Spoleto Olive Belt, a heritage of history, art, landscapes and artistic beauties, recognized by MIPAAF (Ministry of Agriculture) as a historical rural landscape and by FAO as an agricultural heritage of world importance[26].

It arises that the game has had no rivals so far, presenting itself as the first example of this kind. The apps have also some of the peculiar characteristics of *Connessioni Museali,* such as outdoor routes, geolocation, use of iBeacon; however, no one of them, manages to reach the completeness and the width of what the project promises to offer.

The main forerunner to deal with is the most recent digital museum project *Dalla Rocca alla Roccia* (2019). Its aim is to lead the visitor through an immersive, innovative, easier and multilingual path, thanks to the creation of a multimedia center inside the Rocca Albornoziana and thematic itineraries with the support of AR[27].

Finally, the results of the ten-year experience in museum networking of Spoleto (Spoleto Card) were examined. Since 2008 this single cumulative ticket allows the access to the cultural network of the city, from ancient times to contemporary events. Services and activities promoted throughout the whole year support an experiential visit. The Spoleto Card is valid for seven days, facilitating the access to city museums and monuments at a special price, including free guided tours aiming to encourage tourists to remain longer in Spoleto, thanks to agreements with local Shops[28].

According to the data provided on sales in the three-year period 2016-2018, a gradual and constant growth in the use of the Card can be highlighted except for 2017, due to the earthquake consequences which hit this area one year before. On the contrary, analyzing sales and entries of the Card for museum sites (tab.1), it is possible to notice the driving role played by the main city museums, such as the National Museum of the Duchy of Spoleto and Rocca Albornoz, the Roman House, the National Archaeological Museum and the Roman Theater. They also provided visibility to the other museums belonging to the tourist-cultural circuit of the Spoleto Card, sharing the attention of public to the latter as well[29].

The Connessioni Museali project

'Connessioni Museali - between valleys and mountains, villages and cities' is both a real and virtual path for the enhancement of Cultural and Naturalistic Heritage in the Spoleto and Valnerina area.

The five Cities involved (Spoleto-Leader, Cerreto di Spoleto, Monteleone di Spoleto, Sant'Anatolia di Narco and Vallo di Nera) and their eleven museum institutions formed a synergistic network thanks to the 2020 Regional Funds, arranged by the Regional Museum System for safeguard and enhancement of the Cultural Heritage. The amount counts approximately €88.000, plus a co - financing of €22.000 added both from the City Governments involved and from the local transport company (Umbria Mobilità)[30].

The project idea, based on the skills acquired in recent years by the Spoleto administration, was born to expand the city museum system linked to the Spoleto Card. The plan was to integrate in the network some of the Valnerina museums, activating a common digital environment capable of raising quality levels of the territories. Overall,

there are eleven museums involved: from archeological to the contemporary art ones, from natural science to ecomuseums. More in details they are:

- Palazzo Collicola - G. Carandente Modern Art Gallery and noble floor (Spoleto) – Project leader;
- Roman house (Spoleto);
- Textile and Costume Museum (Spoleto);
- Natural Sciences Museum (Spoleto);
- Ex Spoleto-Norcia railway Museum (seat of Spoleto);
- Morgnano Mining Museum (Spoleto);
- Hemp Museum (Sant'Anatolia di Narco);
- House of Tales (Vallo di Nera);
- Il Ciarlatano Documentation Center (Cerreto di Spoleto);
- Mummies Museum (Cerreto di Spoleto);
- The Biga Museum (Monteleone di Spoleto).

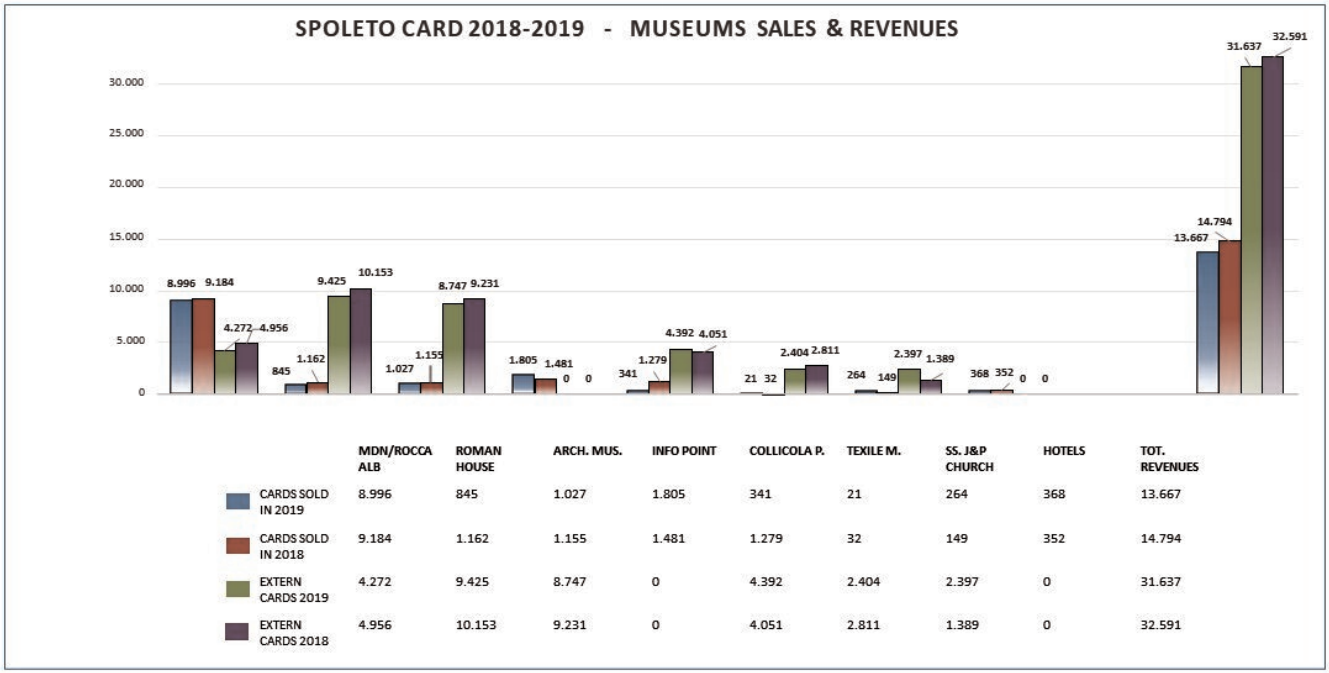
The development of the individual sections of the project can count on the collaboration of other subjects of the local touristic - cultural field, such as foundations and research centers, which made their photographic-documentary repertoires available, fundamental for the contents making of the project[31].

With its various components, the project tries to reach different aims:

- provide the tourist an audio tour support for visiting cities and an audio guide for museums without technological support. This tool is also a particular service for users with motor and/or cognitive disabilities;
- take the museum out to catch new potential audiences;
- stimulate the creation of a unique experience between physical and digital;
- explore the museum's new narrative languages;
- provide new stimuli to circuits linked to cultural tourism;
- make teaching and training experiences easier both onsite and offsite[32].

The outlined project stems from the will of the Institutions to promote and enhance the historical-cultural and natural heritage of the territory thanks to the support of new

Fig. 2 Dalla Rocca alla roccia project poster (©Dalla Rocca alla Roccia).



Tab. 1 Museums sales and revenues of the Spoleto Card in 2018-2019 (translate and adaptation from 2020 report by ©Sistema Museo).

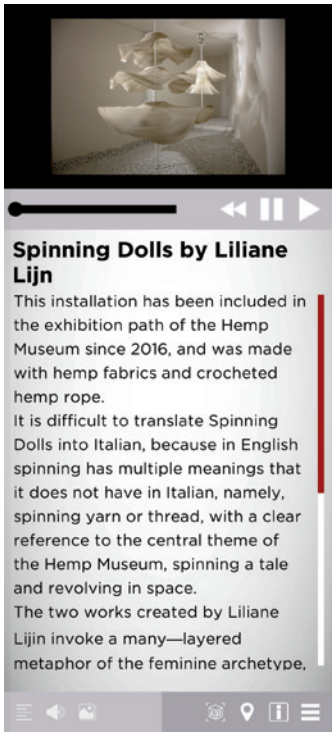
technologies. This is possible thanks to several actions: a mobile app for the use of tourist and Naturalistic attractions (MuDì), an educational-touristic serious game for mobile devices (The Umbrian Chronicles), a video-photographic campaign and an integrated social media communication campaign[33]. Finally, 10 tablets were allocated to museum sites allowing users without mobile devices to use the entire digital cultural offer onsite[34].

MuDì: a mobile app to access the touristic and cultural attractors

Int.Geo.Mod Company, the developer of the Mobile App to access the touristic and cultural attractors, was already known for the previous project *Dalla Rocca alla Roccia*. The *MuDì- Diffused Museum of the Two Valleys* mobile app is identified as a 'geo-storytelling' type, according to the latest classification of storytelling by researchers such as Athena Plus Group and E. Bonacini[35].

This is an advanced audio guide-audio tour, both in a written and oral form with additional multimedia contents. Everyone can use it from their own devices: the app allows the personalization of the visit and overcomes the current pandemic risks caused by the multiple usage of traditional audio guides. In only one mobile app the visitor can manage museum itineraries and outdoor routes at the same time.

When the app gets started, a geo-localized map shows the Points Of Interest (POI) to the user. These are the closer



(Left) Fig. 3 Home screen in MuDì mobile app (©Int.Geo.Mod. S.r.l.); (right) Fig. 4 Example of audio and written guide of a POI in MuDì mobile app (©Int.Geo.Mod. S.r.l.).

attractors or the ones identified on the map (there are 180 of them) and the 8 outdoor paths, located thanks to GPS Triggered Zones. When the user is next to a POI, a notification appears on the app, giving the possibility to use the 'go to' function.
Once the user is inside the museum, the app starts the automatic tour through the iBeacon technology: pointing the device in front of a Point Of Interest, the app recognizes it and shows the options available to try several visual experiences in AR (52 different choices):

- see the historical documentation;
- consult technical sketches or notes relating to its realization or curiosities;
- focus on an isolated detail with overlapping information elements.

At the same time, an audio description of the artwork and a rich archive of additional information are available.
The app will also act as an intermediary for buying tickets to museum sites[36].

The Umbrian Chronicles: the serious game

The serious game The Umbrian Chronicles is developed by Entertainment Game Apps, known for many successful products such as the MiRasna cultural game. The *leitmotif* of the experience is the story of Ponzia Vannozzi, a journalist arrived in Spoleto to write an article on the cultural life of the area. Guided by the local guide Luca Rosati, the lady will visit museums and monuments meeting historical characters and locals, learning about myths and tales, discovering the story of her origins linked to these lands[37].
Based on a personal choice, the user will follow a path discovering the story through steps in a fascinating 'video-playful storytelling'. The Umbrian Chronicles is an educational tool both onsite and offsite, thanks to historical, artistic and environmental contents assembled in the low-poly graphics of the game environment. It is addressed mainly to secondary school children, but it is also proposed as a broader dissemination tool[38].
The EGA launched a monitoring activity to evaluate the knowledge about the local Heritage, willing to understand the actual impact of using the gaming app in the learning process of local school students. They also created a school-working experience with the second class of the Classical High School in Spoleto, testing the guided creation of additional contents for the game.
The main news of the project is the collaboration with the Twitch channel *La bottega della strega*, with weekly streams to preview the developments of the videogame[39].

The Video-Photographic Campaign

Connessioni museali provided for a photographic campaign to make the local Cultural Heritage available not only on the two mobile apps - MuDì and The Umbrian Chronicles - but also on Google art & Culture online free platform[40].
Unfortunately, Google has not answered the request yet[41]. However, the photographic campaign, driven by MaLuDA company, has been necessary for the making of other project activities and it has been carried out according to the guidelines for the digitalization of Cultural Heritage requested by the Italian Cultural Ministry[42].

The Social Media Communication Campaign

Social media must liven up the project story increasing audience engagement and acting as a direct interface in a 'Social Media Storytelling'[43]. To align the communication of all the project stakeholders, the Elog company oversaw developing a coordination program and an organized editorial plan for the communication campaign.

Concerning social networks, the hashtag #Connessionimuseali is used to index the search for all the contents published through the Comune di Spoleto official page (Facebook / Instagram / Twitter / YouTube), while the TiKTok *Connessioni Museali* page was created to reach a younger audience.
The communication strategy also includes the use of paid advertising campaigns (Google Ads and Facebook Ads): from May 3rd to June 3 rd 2021, €400 to allow apps download were invested. Furthermore, three promotional videos about the project contents were produced[44].

First reports and Future Outlooks

Following the launch of the single parts of the project there are already some reports about:

- the AD campaigns contributed to increase the awareness of the project, giving visibility to the two applications. Unfortunately, the iOS update, released shortly before the start of the campaigns, slightly penalized the achievable results, excluding all iOS users with an updated operating system[45];
- MuDì has over 100 downloads on Apple Store and Playstore;

Fig. 5 Ponzia Vannozzi, the main character in 'The Umbrian Chronicles' game (©Entertainment Game Apps Ldt.).

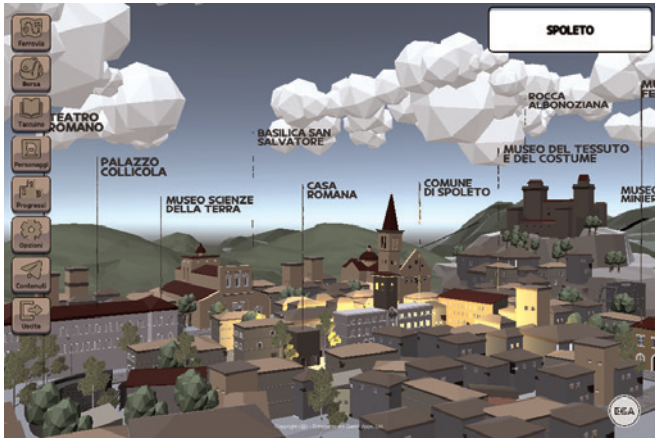


Fig. 6 Low-poly graphic of the Spoleto city center in 'The Umbrian Chronicles' game (©Entertainment Game Apps Ldt.).

- the Umbrian Chronicles counts more than 1.000 installations. With its numbers the gaming app is the most successful part of the project[46];
- the statistic data about Tourism in 2021 in Umbria an in the Spoleto and Valnerina area shows a significant increase of the visitors, especially during the summer (June-August) compared to the previous years (tab. 2, tab. 3)[47];

These reports confirm that Umbria has been chosen as one of the favourite destinations for international tourism and staycation of this year; probably the *Connessioni Museali* Project had played a key role in achieving this goal[48].
Therefore 2020 marked a turning point for museum institutions: they rethought themselves over the new needs of cultural communication[49]. Today, more than ever, the importance of networking across the territory has been understood, especially for the smaller places which base their visibility on inter-museum relations. The Spoleto and Valnerina model, with the excellent proposals of mobile apps, is the most developed experience among the other projects carried out by institutional - cultural networks thanks to the 2020 Regional Museum Funds[50].
These experiences could expand and involve other structure of the cultural - tourism world. Moreover, they could converge in a single digital product for a 'Smart tourism'[51] in the land[52], such as an integrated mobile-based supply able to make tourists and visitors living a fascinating storytelling in the so called 'green heart of Italy'.

The paper is an extract from the final paper of the author written for Cultural Heritage Economics and Management biennial Master at University of Roma Tre (2019-2020) with the supervision of Dr. Elisa Bonacini.

Fig. 7 Example of a Facebook post for the Connessioni Museali project pomotional campaign (©Comune di Spoleto).

Notes

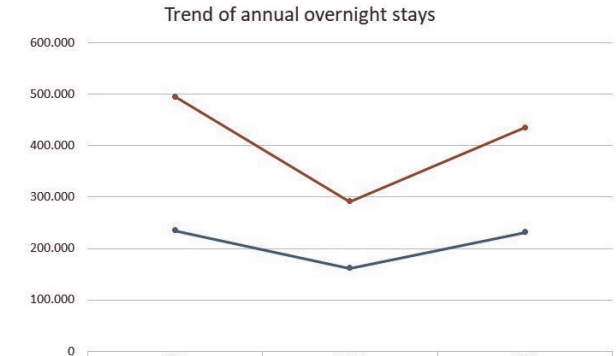
1 Trimarchi, 2020; Bonacini, 2020, pp.15-16; Bonacini, 2012, p. 95.
2 Orsini & Lampis 2019.
3 Council of Europe, Council of Europe Framework Convention on the Value of Cultural Heritage for Society, Council of Europe Treaty Series - No. 199, 201.
4 ICOM: Museum definition, https://icom.museum/en/resources/standards-guidelines/museum-definition/
5 The term 'Digital Ecosystem' is used to indicate a community of subjects who interact with each other, exchanging information to broaden their knowledge, their skills and their contacts, thus trying to best satisfy their own needs and needs within the space delimited by digital techniques.
6 Orsini & Lampis, 2019, pp.18-19.
7 Ayala, Cuenca -Amigo, Cuenca, 2019, pp.7-15.
8 Orsini & Lampis 2019, pp.18-19.
9 Bonacini, 2012, p.95.
10 Jenkins, 2007, p. XXV; Bonacini, 2020, pp.16-17; Simon, 2010.
11 The definitions have been coined respectively: C. Duncan-forum Museum (1971), S. Bodo-Relational Museum (2003), E. Hopper-Greenhill-Communication Museum (2003), N. Simon-Participatory Museum (2010), S. Colazzo-Community Museum (2019) and P. Rosa by Studio Azzurro-Storytelling Museum of (2019).
12 E. Bonacini is the new proposal for a connecting museum or museum of connected narration; Bonacini, 2020, pp. 30-33, p. 274, pp. 277-278.
13 Robin, 2006, pp. 709-716; Brouillard, Loucopoulous & Dierickx, 2015, pp.16-19; Viola & Cassone, 2017, pp 5-18.
14 Salmon, 2008, p.8.
15 Audience engagement concerns the design and implementation of engagement and participation methods which aim to enhance the understanding, satisfaction and personal growth of the public involved in the artistic-cultural experience; Audience development developed by a cultural organization comprising takes the strategic

dimension, the vision, the mission and the objectives that it sets for its public current and potential policy, including the type of participation it seeks to encourage and the impacts that this could produce. Bollo, 2018, pp. 321-330, p. 325; Bonacini, 2020, p.20.

16 Bonacini, 2018, pp.227-273 pp. 230-232; Bonacini, 2013, pp.221-243.

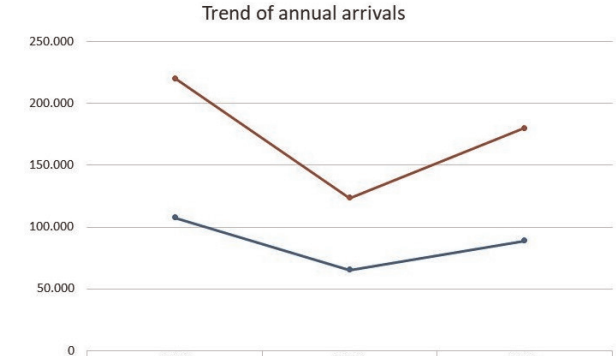
17 My Spoleto: <https://www.myspoleto.it/>.

18 Umbria Cultura: <https://play.google.com/store/apps/details?id=it.sebina.mylib.um1&hl=it&gl=US>.



	2019	2020	2021
Valnerina	261.646	130.698	203.840
Spoleto	233.902	160.500	231.502

Tab. 2 Tourist trend of annual overnight stays in Umbria 2019-2021 (translate and adaptation from 2021 report by ©Regione Umbria).



	2019	2020	2021
Valnerina	112.672	58.297	91.535
Spoleto	107.079	64.974	88.404

Tab. 3 Tourist trend of annual arrivals in Umbria 2019-2021(translate and adaptation from 2021 report by ©Regione Umbria).

19 iBeacon technology allows Mobile Apps (running on both iOS and Android devices) to understand their position on a micro-local scale, and deliver hyper-contextual content to users based on location.

20 Cerreto di Spoleto: <https://play.google.com/store/apps/details?id=it.sesinet.cerretodispoleto&hl=it&gl>.

21 Monteluco:<https://play.google.com/store/apps/details?id=solution.ieeng.spoleto&hl=it&gl=US>.

22 Il Duomo di Spoleto:<https://play.google.com/store/apps/details?id=it.catnic.duomo2&hl=it&gl=US>-

23 Spoleto Tourist App: <https://tuttoggi.info/spoleto-tourist-app-la-nuova-guida-turistica-della-citta/427344/>-

24 Spoleto Art Today: <https://play.google.com/store/apps/details?id=eu.webappstudio.eccellenze.artspoleto&hl=it>-

25 Vallo di Nera: <https://play.google.com/store/apps/details?id=it.vallodinera.app&hl=it>.

26 I sentieri nella fascia olivata: <https://play.google.com/store/apps/details?id=com.app.p5519AC&hl=it>.

27 The project born from the Icaro Network composed of the Umbrian companies of excellence Hyla Nature experience, Int Geo Mod and Link 3C, thanks to the funds of the Umbria Region allocated for the Por Fesr 2014 - 2020 call for Creative Companies.
Dalla Rocca alla roccia, IL PROGETTO: < https://www.dallaroccaallaroccia.it/il-progetto/>.

28 The museums that can be visited, including state, municipal and private ones, are:

- National Museum of the Duchy of Spoleto and Rocca Albornoz;
- National Archaeological Museum and Roman Theater of Spoleto;
- Roman House;
- Palazzo Collicola - Modern Art Gallery and Noble Apartment;
- Textile and Costume Museum;
- Diocesan Museum and Basilica of Sant'Eufemia / Church of Saints John and Paul;
- Temple of Campello sul Clitunno.

As a concessionaire, the Sistema Museo cooperative company carries out technical coordination activities for the Spoleto Card project, management of museum ticket offices and Info Point sales points and associated hotels, administrative and accounting management, coordination of promotional and enhancement related to the project with the super-vision and coordination of the Municipality of Spoleto-leader of the project and all the participating museum institutes.
Spoleto Card: < https://www.spoletocard.it/spoletocard.asp>.

29 Sistema Museo 2020, Allegato A. Report flussi di vendita 2018-2019. In *Spoleto Card- Relazione attività anni 2018-2019*, pp.4-9.

30 Legge regionale 24/2003 *Sistema museale regionale – Salvaguardia e valorizzazione dei beni culturali connessi* e ss. mm. – Programma annuale 2020.

31 The Partners are: ConSpoleto, ANISA, CI-SAM Foundation, CEDRAV, Associazione Amici di Spoleto ONLUS, Italia Langobardorum Association and Officina d'Arte e Tessuti Gallery, The Marignoli di Montecorona Foundation, Casa Menotti Documentation Center Festival Dei Due Mondi, Museum of Rural Life - Pierluigi Fiori.

32 Comune di Spoleto, 2020, pp. 2-3, pp. 13-17.

33 Comune di Spoleto, 2020, pp. 3-13.

34 Comune di Spoleto, Ufficio Cultura- Direzione Sviluppo, *Determinazione Dirigenziale N. 1374 del 15/12/2020 CIG Z252FC1896 Acquisto n. 10 tablet nell'ambito del progetto regionale Connessioni Museali mediante affidamento diretto alla ditta informatica 2013 s.a.s per complessivi 3.400,00 oltre IVA.*

35 Brouillard, Loucopoulous & Dierickx 2015, pp. 35-37; Bonacini, 2020, pp. 244-251.

36 MuDì: https://play.google.com/store/apps/details?id=com.intgeomod.spoleto2&gl=DE

37 EGA-Entertainment Game Apps, Ldt- The Umbrian Chronicles: http://egameapps.com/umbrianchronicles/

38 Comune di Spoleto, 2020, pp. 7-10.

39 EGA-Entertainment Game Apps, Ldt- The Umbrian Chronicles: http://egameapps.com/umbrianchronicles/

40 The giant Google put online a free platform available to cultural institutions that request it, whose goal is to collect and make available to the public high-resolution images of works of art exhibited at many museum sites around the world. The digital offer of the platform ranges from viewing the works in gigapixel format, which allows you to zoom in detail at the level of the brushstroke, to the possibility of taking a virtual tour of the same museums. Bonacini, 2014a, pp. 89-121.

41 For the Umbrian project, the platform would represent a valid tool for the knowledge of the cultural heritage of the territory and its artistic geography, as a support to teachers and students of all levels; at the same time it would operate as an effective means for a wide-ranging dissemination and use of the local cultural heritage.

42 Comune di Spoleto, 2020, p. 7, pp. 10-11.

43 Bonacini, 2020, pp. 213-227.

44 Comune di Spoleto, 2020, pp. 11-13.

The project involves activities to integrated with those already implemented by other institutes and places of the territory culture. The two statal sites of Rocca Albornoziana and National Museum of the Duchy of Spoleto together with the National Archaeological Museum and Roman Theater of Spoleto, the main cultural attractions of the city, shared the general goals of the project, aimed at enhancing a territory considered as a narrative unicum. The enhancement activities of the project may also be integrated with those of the Public Libraries G. Carducci and Carandente of Spoleto. The project also searches the enhancement of naturalistic sites and both tangible and intangible cultural heritage of the territory. In fact, special plans for the involvement and use of the Valnerina Geological Park will be structured, making the numerous areas of geological-environmental value accessible. Comune di Spoleto, Ufficio Cultura- Direzione Sviluppo *(*2020f) *cit.* pp.16-17.

45 Report luglio, 2021 Elog Company for Comune di Spoleto.

46 Playstore report, September 2021.

47 Regione Umbria, *Flussi turistici in Umbria nel mese di ottobre e aggregazione dati 10 mesi 2021*: https://www.regione.umbria.it/turismo-attivita-sportive/statistiche-turismo-2021

48 Thanks also to the promotional campaign by the Regional Government *#UmbriaCuoreVerdedItalia - bella e sicura*, from January to October 1.499.558 tot. arrivals and 4.144.141 tot. overnight stays were traced in the Region with an increase of + 32.1% of arrivals and +36.5% of stays compared to the same time in 2020, and a decrease of -32.0% for the arrivals and -24.9% stays from 2019.

49 Cicerchia, 2020; Minuti, 2020.

50 Comune di Spoleto, 2020, pp.1-3, p. 15. The L.R. 24/2003 about the Regional Museum System with its Annual Program 2020 for Safeguard and enhancement of connected cultural heritage, has in fact also financed other museums digital networking projects:

- The Enchanted Valley. Museums and itineraries for a new experience of beauty;
- Grand Tour Trasimeno;
- HUmbria2O;
- MaPp-Museums App Perugia;
- Umbria BOX;
- RIM-Altotevere Interactive Museum Network;
- MEU - IncontrArti beyond the image;
- Networked museums for the territory;
- MeTu-Museums and North-East Umbria Territories.

51 The notion of Smart Tourism comes out from the European Union's Smart Tourism Directive. The European Capital of Smart Tourism initiative recognizes outstanding achievements by European cities as tourism destinations in four categories: sustainability, accessibility, digitalization as well as cultural heritage and creativity. This EU initiative aims to innovation to strengthen smart destinations in Europe, to enhance tourism offers for visitors and to facilitate new partnerships, networking and the exchange of best practice. It also wants to foster the EU's forward-thinking tourism offer to global audiences and sustainably increase footfall at pioneering destinations that offer unique visitor experiences. The European Commission is implementing the European Capital of Smart Tourism initiative. Currently it is financed under the COSME Program and it is a successor of the Preparatory Action proposed by the European Parliament. European Commission, *European Capitals of Smart Tourism*: https://smart-tourism-capital.ec.europa.eu/index_en

52 Giaccone & Bonacini, 2019, pp. 341-354; Giaccone & Bonacini, 2020; Bonacini, 2014 b, pp. 89-121.

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Google Play: https://play.google.com/store?hl=it [Last access date, 25 January 2022]

I sentieri nella fascia olivata: https://play.google.com/store/apps/details?id=com.app.p5519AC&hl=it [Last access date, 25 January 2022]

Il Duomo di Spoleto:<https://play.google.com/store/apps/details?id=it.catnic.duomo2&hl=it&gl=US> [Last access date, 25 January 2022]

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Spoleto Art Today: <https://play.google.com/store/apps/details?id=eu.webappstudio.eccellenze.artspoleto&hl=it> [Last access date, 25 January 2022]

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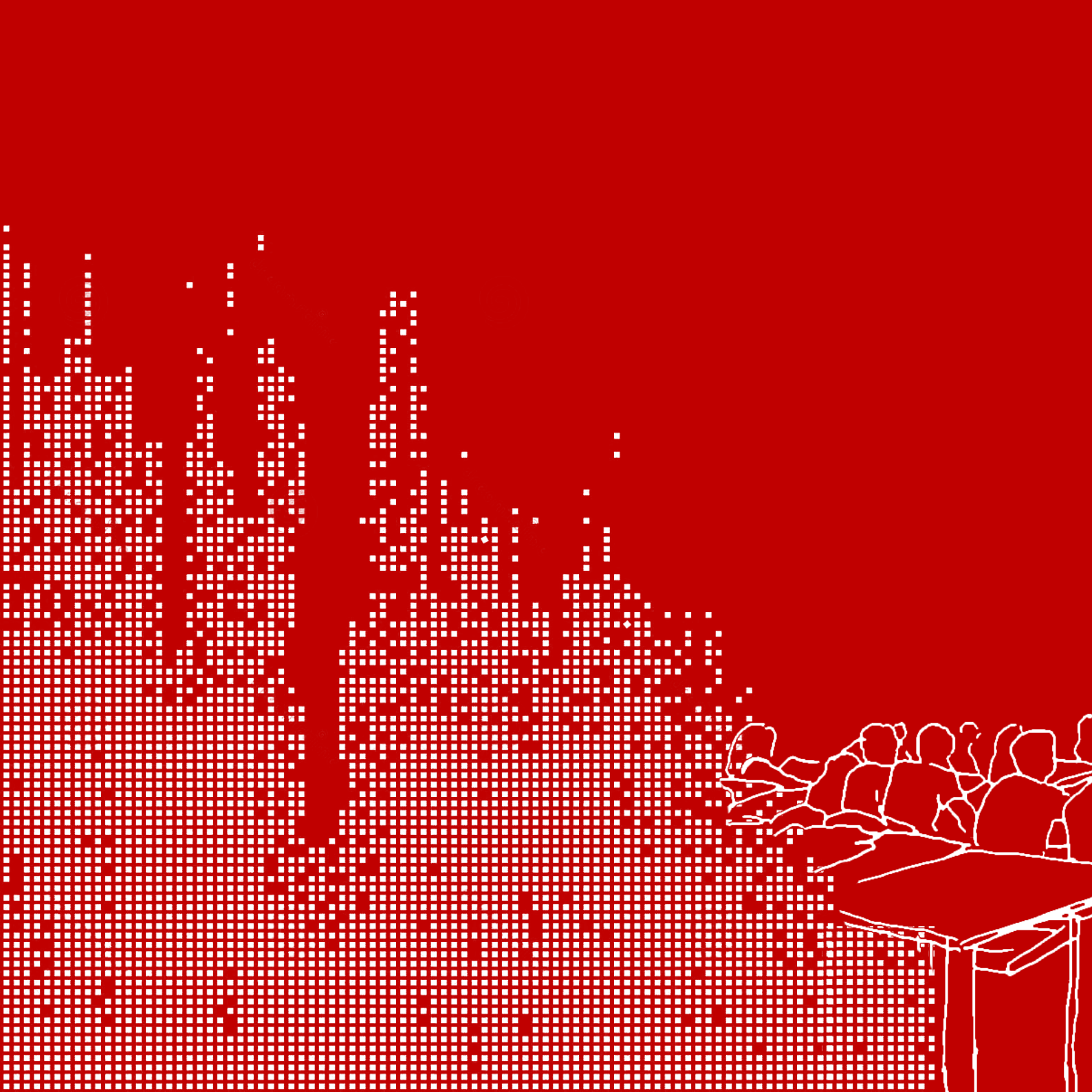
Vallo di Nera:< https://play.google.com/store/apps/details?id=it.vallodinera.app&hl=it> [Last access date, 25 January 2022]



CASE STUDIES ANALYSIS

PARTICIPANTS FINAL ASSIGNMENTS

Forthcoming Interdisciplinary Research and Design on Endangered Heritage: the Results of Summer School 2021

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The organisation of the Summer School by INTERSPECIES network has been conceived since the beginning as a moment of sharing scientific interdisciplinary perspectives towards Endangered Heritage. In this way, it has envisaged a didactic structure with international researchers, students and young researchers both from interdisciplinary fields.
Within the programme structure, the Summer School has aimed to introduce a forthcoming view on the cross-fertilisation of competencies among institutions and partners within the scientific fields (digital survey, numerical computing, structural evaluation, technological intervention, restoration design, visual communication, and service marketing). Its goal has been oriented to improve and involve participants in the creative approach to safety and conservation management for Cultural Heritage, focusing their attention on the proposal of innovative and original project plans, rather than on technical syllabuses. It represents a forthcoming trust in the capabilities of new generations of researchers and professionals, who will succeed, after developing their technical maturity, in translating new original visions into feasible programmes on Cultural Heritage with an encouraging impact through European dynamics.
In the awareness of conducting an experimental action limited to one week, and totally conducted in remote virtual mode (still suffering from the influences of the recent pandemic and the limitations of social exchange and distancing), the Summer School programme has specifically addressed the wider dissemination of research pilots suitable for the scientific complementary transfer on the panorama of Cultural Heritage at risk. The aim has been focused on inspiring creativity and cultural debate on the enhancement of Digital Strategies as non-invasive, widely applicable and disseminable practices, rather than focusing on technical languages and data processing.

The call for participation was launched to welcome PhD students, researchers, professionals, postgraduate, and master's degree candidates from the fields of Architecture, Engineering, Heritage Sciences, Economies and Social Sciences related to Cultural Heritage and Endangered Heritage. Basic knowledge on Cultural Heritage topics has been suggested, as well as basic expertise in digital data, or experiences of involvement in administration policies, promotion practices, and management programs on Heritage sites. The aim has been to encourage the participation of profiles already involved in Cultural Heritage dynamics at different scientific-social levels, but not yet familiar with the wider opportunities for interconnection and exchange between digital applications. The propensity of an academically young audience, characterised by a greater curious and flexible approach to the self-contamination towards the use of 3D and virtual dimension-driven products, was supported.
The skills and knowledge presented by the School were meant to introduce a joint approach to Cultural Heritage, and to implement specific themes regarding emergency

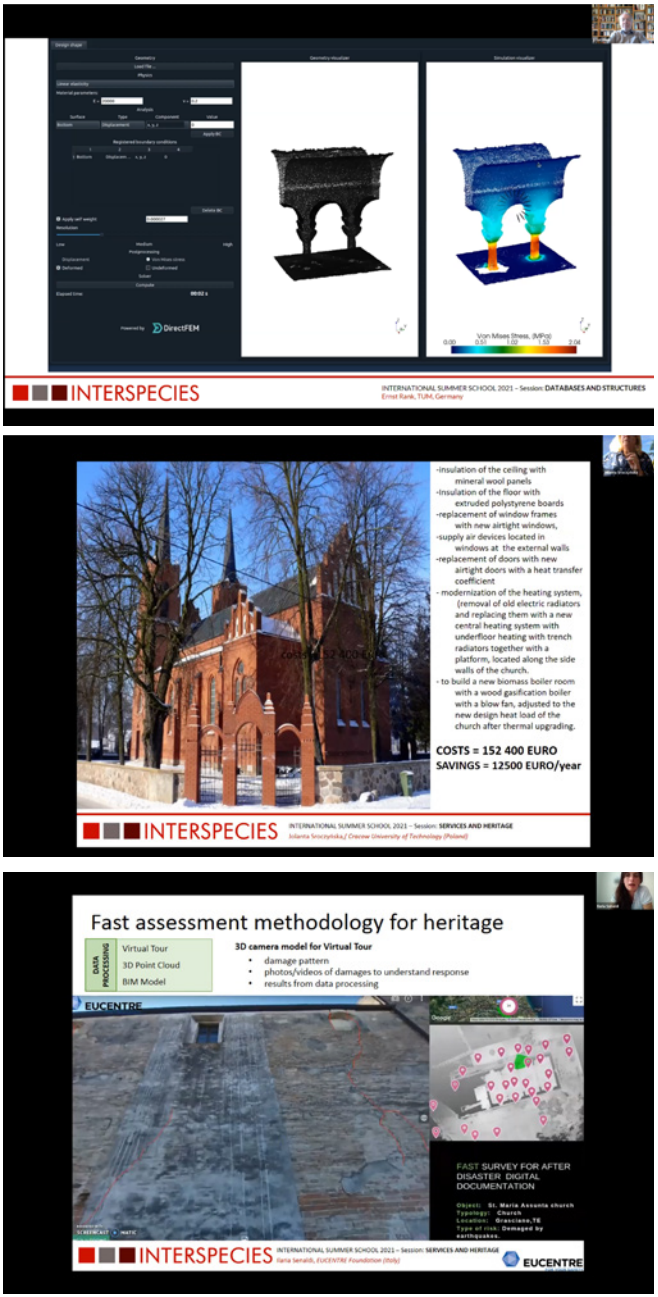


Fig. 1 Theoretical and practical applications presented during the school.

and preservation management. Through the combination of applied science and entrepreneurial knowledge, it offered guidance on strategies of development for digital products and services for cultural, economic, and social benefits.
The School aimed to promote the development of an integrated awareness and interdisciplinary skills among Young Researchers from the shared experiences of European institutions, brought to the school by the international organizing team of Expert Researchers and by the Invited Lecturers. Main contents provided:

- holistic knowledge from the sharing of international best practice cases related to documentation, conservation, and promotion processes for Cultural Heritage, focusing on the centrality of integrated skills and disciplines of Cultural Heritage survey, analysis, and preservation;
- basic skills in integrated technologies, computing methods, tools for the survey and analysis of Cultural Heritage safety, principles of interaction between conservation purposes, and Cultural Heritage social and marketing opportunities based on digital databases and Digital Twins;
- coordination skills, research team building, and the ability to construct opportunities of research integration on monitoring tools and methods for the management and promotion of Cultural Heritage, in particular in expeditious conditions.

For this purpose, the training offer of the School focused on advanced skills on digital platforms and tasks for Cultural Heritage, within the presentation of best practices and technical demonstrations on digital data workflows. The topics have included non-invasive damage mapping from point clouds, information database systems and GIS territorial platforms, policy from Open Access data, on-site restoration experiences and activities in the professional sphere, VR smart fruition for Cultural Heritage, prevention and recognitory activities in emergency sites, crowdsourcing data collection for heritage monitoring by the communities.

The programme of Open Lectures has been structured following the purposes of Thematic Challenges, and

connecting different experiences to reconstruct a critical proposal of workflow from the implication of data collection and their reliability, to their application in the development of analytical technologies and territorial databases, also considering image-learning and geo-reference as an opportunity for their impact on Information Systems and international principles. Considerations from the theory and planning of conservation approaches have faced the aesthetical, technological, and practical choices for restoration and reconstruction in cases of damaged or even lost heritage. Services opportunities from different fields of applications have been included, such as open data sharing and crowdsourcing monitoring, marketing and virtual tourism, risk management and post-event damage assessment, till to the social dimension of storytelling on Heritage disasters through the recovery of digital memories.

The inclusion of a Technical Session, at the end of the lectures, has supported as a milestone between consolidated principles (from experienced researchers) and forthcoming suggestions (from participant students) concerning the research theme, including practical applications of cutting-edge experimentations, processing and on-site recognitions related to the prevention and enhancement of Cultural Heritage at risk. The lecturers, selected between young Ph.Ds. and early-stage researchers, have highlighted how the management of digital data on Cultural Heritage, from the most concentred digitization practices, can support intersectoral purposes of 3D reconstruction of lost heritage, non-invasive structural diagnosis, multi-level risk analyses and digital storytelling for social media communication plans.

The results of the call have collected submissions from the participating countries of Italy, Spain, Poland, Turkey, Tunisia, Syria, Egypt, Iraq, India, and Brazil, widely exceeding the limited number of inscriptions defined for the event. The sending institutions of participants have covered the countries of Italy, Germany, Poland, Spain, and Cyprus from the EU, and also the United Kingdom, Syria, Egypt, India, Tunisia, China, and Brazil, confirming the worldwide attractiveness of the EU initiative.

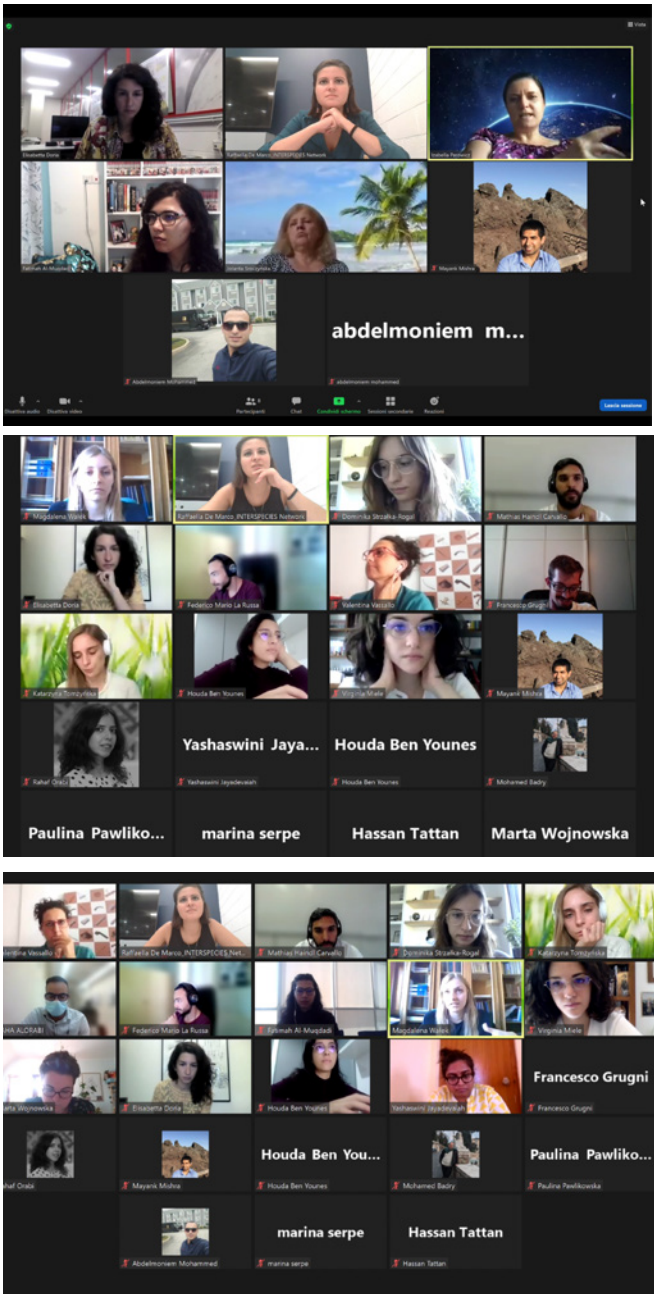


Fig. 2 Moments of dialogue and peer-learning between participants.

Student participation was enthusiastic and showed interest from the very first lecture sessions, where students were immediately primed by curiosity for the applicability of the practices presented towards case studies and actions already addressed in their own experience. The wide range of application of the methodologies presented, as well as the international panorama of impactful and relevant case studies, was an inspiration to the design ideal and impactful perspectives expressed by each participant towards the reality of Cultural Heritage in closer contact between Europe, the Middle East and Asia.
As the didactic objective of the summer school, participants were required to submit a final assignment to reflect the development of the research key points for a Cultural Heritage site, within a presentation including multisource information and elaborates, such as multimedia, digital drawings, 3D models, application of design programs, social and marketing strategies.

In developing the working session activities, the participants have been divided into groups and assigned to an international Cultural Heritage site for the development of a preliminary project draft in the form of a research proposal for the site's safeguard. The

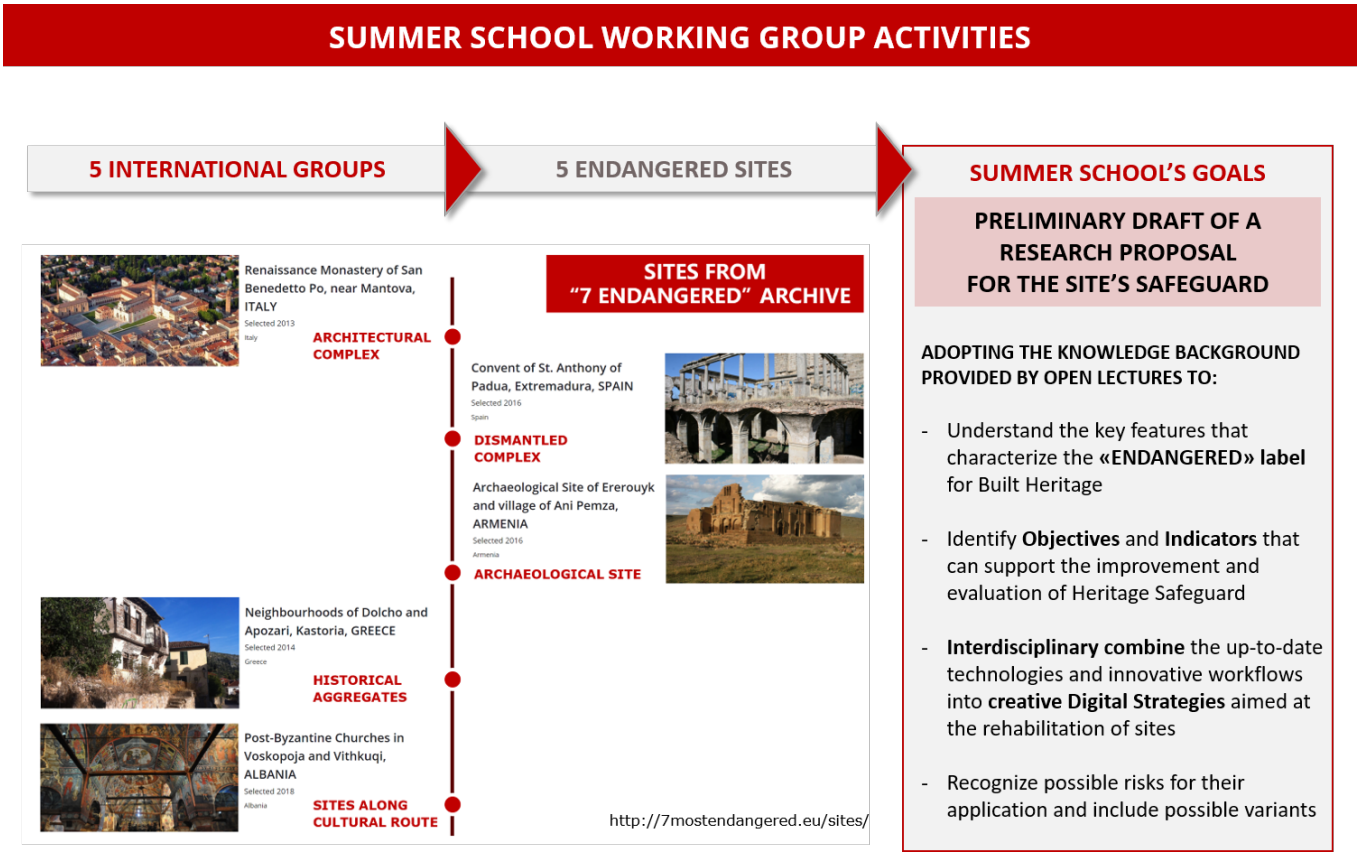


Fig. 3 The selection of sites for the practical activities of working groups, from the list of 7-Most-Endangered program by Europa Nostra.

organisation of the activities considered the conduct of activities remotely, without the possibility of direct contact and discovery of Cultural Heritage sites.
With the aim of promoting Europa Nostra's social and international commitment to Heritage realities at risk reported by local communities, in favour of their neglected cultural impact in major resilience programmes, the choice of case studies was evaluated within its '7-most-endangered' programme. Thanks to the open-web information collected and made available by Europa Nostra, consisting of a Technical Report by the European Investment Bank Institute accompanied by photo galleries and video interviews of social voices, it was possible to engage the participants on the issues of risk and possible enhancement of the sites.
The choice of sites, from the crowd-sourcing activity started in 2013, has focused on contexts still undergoing restoration and enhancement opportunities, varying between scales and types of Heritage objects, with the selection of 5 characteristic dimensions of Endangered Heritage:

- 'Architectural complex', defined by the Reinassance Monastery of San Benedetto Po, near Mantova in Italy, for the predominance of its cultural and traditional impact through the resilience mechanisms

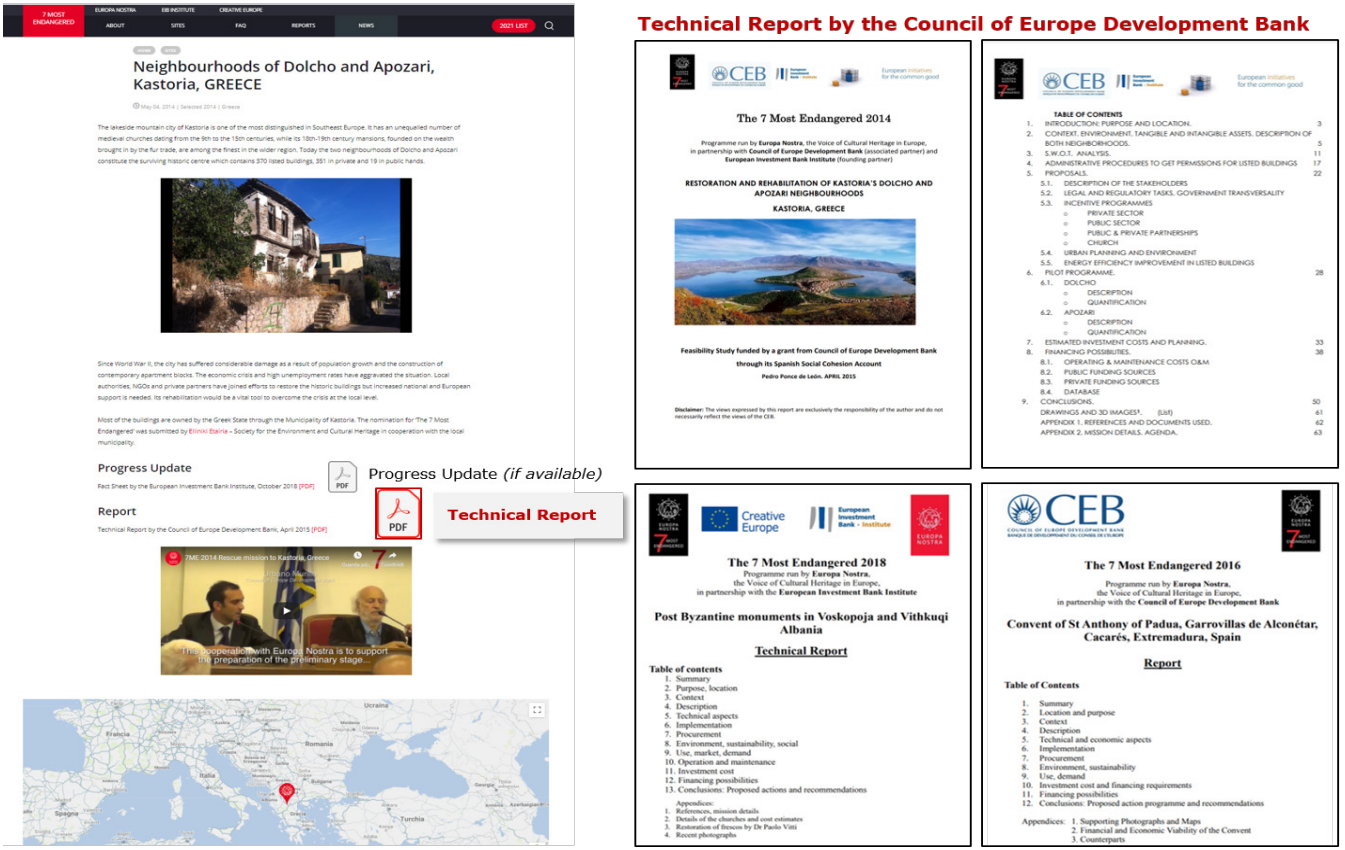


Fig. 4 Sites' presentations and thechnical reports open available from Europa Nostra website, adopted as knowledge basis by the participants for the activities.

Fig. 5 Contents from the final assignments developed by participants.

of the local communities and built area;

- 'Dismantled complex', defined by the Convent of St. Anthony of Padua, in the Extremadura region in Spain, for the enriched value of its ruined structures and architectural features within the values of enhancement and historical renewal of the area;
- 'Archaeological site', defined by the Archaeological site of Ererouyk and village of Ani Pemza, for the characteristic coexistence of archaeological and territorial realities which can support the thematic revitalization of the isolated area;
- 'Historical aggregates', defined by the neighbourhoods of Doicho and Apozari, in Kastoria in Greece, highlight fundamental attention to the monitoring and fulfilment of the communities' needs and protection services while dealing with an urban scale of endangered heritage;
- 'Sites along Cultural Route', defined by the post-byzantine churches in Voskopoja and Vithkuqi, in Albania, characterizing the permeability of widespread heritage and its potential of permeating multiple valorization mechanisms relying on the value of territorial identity.

For each site, key points have been focused within peer-learning sessions and working group activities, regarding:

1. Site analysis and Safeguarding Objectives;
2. Knowledge and Intervention purposes;
3. Methods and application of documentation data within Digital Strategies;
4. Project, conservation, marketing, and social promotion opportunities within EU network.

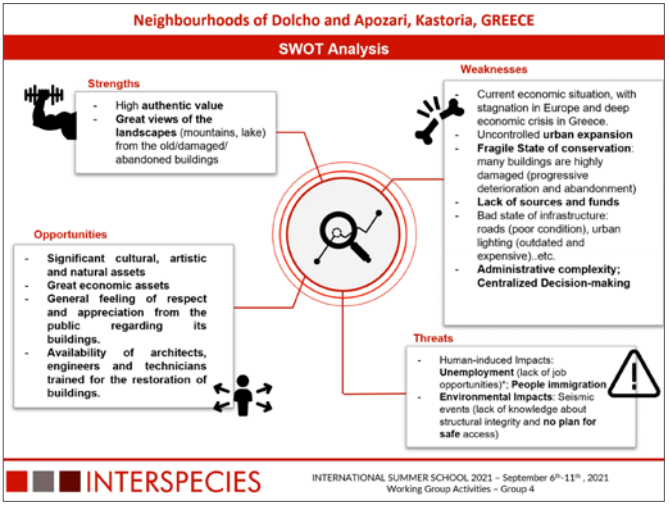
Each participant has been included in an international working group, supporting the overall background with the new skill presented in the Summer School to shape a common experience of Cross-Fertilization of competence to project intervention and preservation measures for Cultural Heritage. Personal knowledge from students, experimentation with technical practices from PhD lecturers, and cutting-edge suggestions presented during School by experienced researchers have been integrated into the scientific

development of assignments by the team working groups. The mechanism of the working sessions was developed through virtual sessions of connection for peer-learnings. In the 2 days of activities, 4 working rooms have been structured, with an introduction of overall peer-learning discussion, including the presentation and organization of final assignment modalities. Each day of working session, in addiction to the overall scientific coordination on the definition of main objectives for site prevention, research on references and purposes of intervention, has foreseen the didactic supervision of 2 tutors from the expert researchers of INTERSPECIES Network. Prof. Sandro Parrinello (University of Pavia, Italy) and prof. Katrin Beyer (École Polytechnique Fédérale de Lausanne, Switzerland) have supervised the working activities on opportunities for data comparison, documentation strategies, and application of digital information through projects' requirements. Prof. Jolanta Sroczynska (Cracow University of Technology, Poland) and prof. Izabella Parowicz (European University Viadrina, Germany) have supervised the foreseen groups' strategies regarding marketing and conservation outputs, and the integration of projects in EU/worldwide programmes for the safeguarding of Heritage.

Reviewing the development of the working sessions, a great communicative enthusiasm is observed manifested by the participants, made even stronger by the willingness to knowledge sharing due to their belonging to different disciplinary fields. The discovery of similarities and parallels between sectoral languages on Cultural Heritage is often conceived as very distant lexicons between Social Humanities and Information Technologies. In this case, it was reinforced by the openness manifested by the young participants, and by their enthusiasm to contribute with their ideas to a debate on a broad scale with respect to both the INTERSPECIES network and the European arena.
The presentations produced by the groups to show the developed project proposal, and subsequently extended in the chapter version of this volume, highlight powerfully perceived opportunities for multi-interactive information

Fig. 6 Contents from the final assignments developed by participants.

Fig. 7 Contents from the final assignments developed by the participants. Interdisciplinary integration of different sectors knowledge and experience has been pursued.



use on Endangered Heritage sites, aimed to reach 3D digital over-structures for tangible management thereby offering value in organizing and reusing Cultural Heritage repositories of data. Firstly, the participants have been guided in learning how to recognize, manage, and plan intervention in a complementary scientific awareness on the assigned Endangered Cultural Heritage site, from the identification and qualification of assets to the actualization of related EU safeguard plans.
Through the review of data management strategies and opportunities of digital elaboration, domain prospects from Cultural Heritage visualization have been foreseen to interconnect awareness and access at European policy-logic workflows, to centralize all the potentials of knowledge and market provision on Cultural Heritage conservation towards their usability by future operators, customers, managers, and stakeholders. This strategy has oriented the design activity on the analysis and synthesis of interdisciplinary and intersectoral Endangered Cultural Heritage research data, boostering the interoperability of cross-related features from theoretical models in a plan of adaptability of wider digital strategies from technical and social studies.

INTERSPECIES Summer School has shown the opportunity of didactics and interdisciplinary training on digital skills to achieve key values for youth generations, acting on

1. the impact of accurate operations of digitisation in Cultural Heritage sphere;
2. primary methodological approaches to the connection of wide amounts of dimensional and information source data;
3. establishing fundamental basis and critical parameters for Endangered Cultural Heritage critical documentation, about endangered features of physical constructions and sites;
4. considering safety conditions, conservation quality and valorisation frameworks in delivering services and public interaction.

Their pursuit has to be implemented through the coordination of goals coming from the identified Thematic Challenges:

1. spatial and morphological coordination of data to derive safety knowledge frameworks of damage, instabilities and reinforcement solutions on the stability of Endangered Cultural Heritage sites and buffer contexts, which affects the safeguard of Cultural Heritage and surrounding infrastructures (Thematic Challenge 1);
2. semantic and parametric connection between geometric and informative data to attain conservation technical workflows, applicable to schedule resources and processes in the intervention management of Endangered Heritage structures and surrounding sites (Thematic Challenge 2);
3. visual and interactive correspondence of data to connect immersive repositories for valorisation into participatory social and marketing strategies that recall service providers and public impact (Thematic Challenge 3).

Considering the expectance of Cultural Heritage within the '2030 Agenda', it comes from the 'World Heritage Sustainable Development Policy' (UNESCO, 2015) the call to orient concepts and enhance the thematic strength of Cultural Heritage disciplines, providing evidence-based results and informing policies. The main expected indicators concern relying on existing data sources, assessing qualitative/quantitative joint data; developing instruments to measure, verify and prioritize capacities/proposals across institutions, and reflecting the aspiration to a Results-Based normative assessment (Culture|2030 indicators).
It is from the future generation of professionals and researchers that society expects competence, passion and initiative to realise these goals. In this way, the dissemination of educational initiatives aimed at exposing dynamic and creative mindsets, centrally oriented on the research study theme of Endangered Heritage, is encouragingly foreseen, to foster scientific careers, societal innovations and resilience horizons for the EU.

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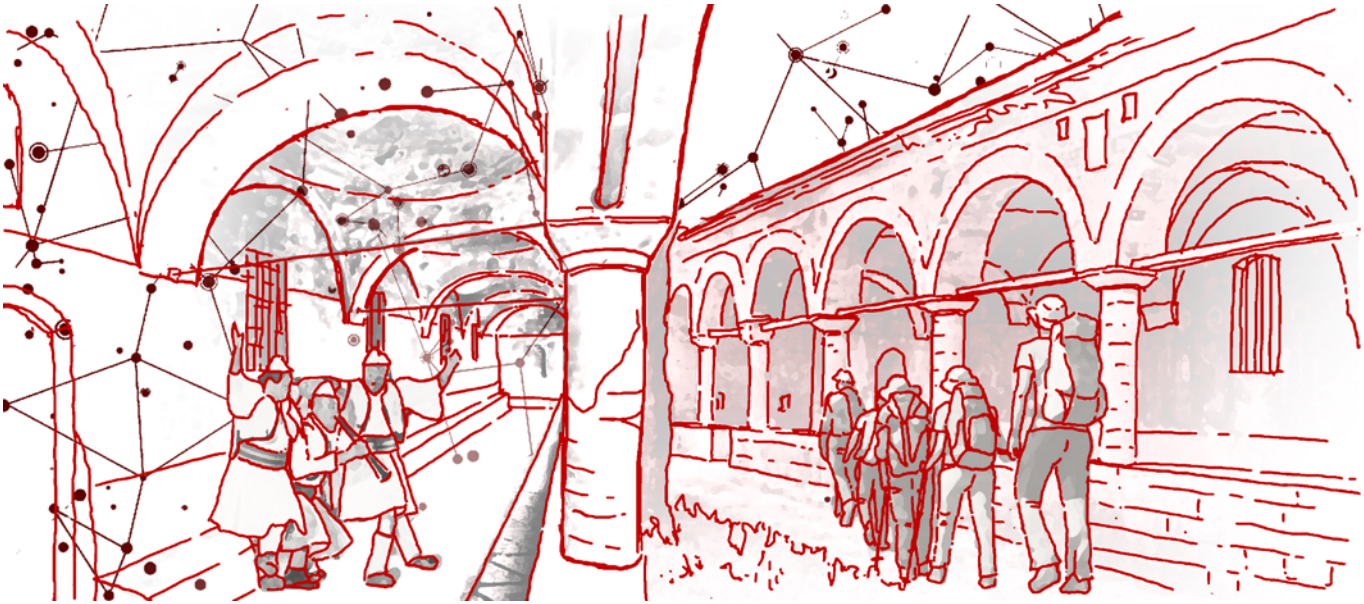
Intern at many scientific facilities including conservation internship at 14th century castle in Chissey-en-Morvan, France and scientific internship at University of Cassino and Southern Lazio, Italy. Architect at WHAT Architecture, London till 2016 and PLUS8 Architekci, Zabrze till now. Speaker at International Conference on Metrology for Archaeology and Cultural Heritage and author of a speech during Seminar organized by Polish Academy of Sciences titled "Medieval castles in H-BIM ontology model". Author of scientific papers about applications of digital tools for protection of Architectural Heritage.

C1

"The Path of the Ancient": Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania



Abstract
Topic of this research is restoration of twelve religious buildings dating from 14th to 18th that are located in or close to the villages of Voskopoja and Vithkuqi in Korca region in south-east Albania. They are a unique piece of architecture and an example of extraordinary art in the background of Europe. The study area is located at a crossroads in the Balkans which has undergone many political and religious transformations throughout history. The monuments identified in the project are unusual and rather unique buildings with historical relevance, religious significance and high artistic value. Preliminary research has been done for those objects however there is no general plan for the region and together with its history and unique natural conditions it is an example of Cultural Landscape. Therefore the purpose of this study is to propose a strategy for the Korca and some promotional solutions to revitalise this part of Albania, the churches and their interiors.

Keywords
Cultural heritage, Artificial intelligence, Byzantine architecture, Religious architecture, Digital strategy.

Introduction

Topic of this research is restoration of twelve religious buildings dating from 14th to 18th that are located in or close to the villages of Voskopoja and Vithkuqi in Korca region in South-East Albania. These churches are unusual in that they were built under the Muslim Ottoman regime by Christians living in an isolated rural area which at the time was highly populated and prosperous. One of the main features that make them unique are the iconographic paintings inside the churches (Rousseva, 2018). Due to the unusual natural landscape and complex history of the churches, the region may be called a cultural landscape and should be treated as such. Most of the buildings are around 250 years old and have not been modified significantly since they were built. Preliminary research has been done for those.

The Ministry of Culture has been also involved in the restoration of those churches especially in the starting process. Most of the twelve buildings underwent essential protective restoration works. In the Europa Nostra Report (Bond & Abando, 2018) we can find general information about the architecture and the history of the churches and the region. Some financial analysis has been carried as well and the basic technical and safety issues have been discussed.

However there is no general plan for the region and very few publications even considered the surrounding of the churches. Even the Europa Nostra Report (Bond & Abando, 2018) mentions that the proposed first action should be creating *"Strategic Review and the establishment of an Overall Programme"*. The document also contains information about financial problems. *"Funding and resources have been limited and the works carried out seem to have been fitted in as the resources became available rather than forming part of structured long-term programme"*, notes the report.

The purpose of this study was to (in a remote way) find the strong points of the whole region and come up with the strategy for revitalization of the Korca. It also suggests special programmes and funding sources that could potentially become helpful in restoring the region.

Case study

Historical Background

The study area is located at a crossroads in the Balkans which has undergone many political and religious transformations throughout history. The historical events that characterised the area from 1417-1479 onwards were the fulcrum of the transformation of the area from an architectural and urbanistic point of view. One of the churches (Holy Trinity Church, Lavdar - Kisha and Shën Triadhës në Lavdar) was built by one of the three ruling families of Albania during the Skanderbeg revolt on Ottoman expansion: The Muzaka. A family that went from being Vassals of the Ottoman Empire to rioters and later to exiles.

Albania found itself in 1432 to be dominated by the Ottoman Empire in the form of the vassalage of the three Albanian noble families: the Castrota, the Arianiti and the Muzakaj (Muzaka). The Muzaka family participated alongside Skenderbeg, an Albanian national hero, in 1444 in the rebellions against the Ottoman Empire. The rebellion led to the Empire's withdrawal from Albania, guaranteeing a period of independence that lasted from 1444 to 1450 with the Ottomans taking Albania (İnalcık, 1978).

With the submission back to Ottoman rule, many of the Albanian noble families converted to Islam. Here stands one of the curious components of the studio site: Kisha and Shën Triadhës në Lavdar was finished building in 1470, proving to be one of the last churches built in this area during the Ottoman expansion. However, the fate of the family is destined to break away from that of the landed possessions following the ascent to the throne of Mehmet II (which took place in 1478) since in 1479

Gjon Muzaka, one of the exponents of the family, fights in Siege of Shkodra against the sultan undergoing a heavy defeat resulting in exile in Italy. Following this exile, churches were no longer built in the area until the 17th - 18th century with the construction of the other 11 churches under study using a style that is not too opulent from the outside (Inalcık, 1978).
The churches were abandoned and started to be recovered in the early 21th century.

1. Church of the Archangels Michael and Gabriel, Voskopoja, 18th century;
2. Church of the Dormition of the Virgin, Voskopoja, 18th century;
3. Church of St. Nicholas, Voskopoja, 18th century;
4. Church of St. Athanasius, Voskopoja, 18th century;
5. Church of St. George, Shipcka, 17th century;
6. Church of Monastery of Apostles Peter and Paul, and chapel. Vithkuqi, 18th century;
7. Church of the Archangels Gabriel and Michael, Vithkuqi, 17th century;
8. Church of the Prophet Elijah, Voskopoja, 18th century;
9. Church of St. George, Vithkuqi, 18th century;
10. Church of the Monastery St. John the Forerunner (Prodromos), Voskopoja, 17th century;
11. Church of St. Mary, Vithkuqi, 16th century;
12. Church of the Holy Trinity, Lavdar, 14th century.

Fig.1 Aerial photo of the Moscopole area.

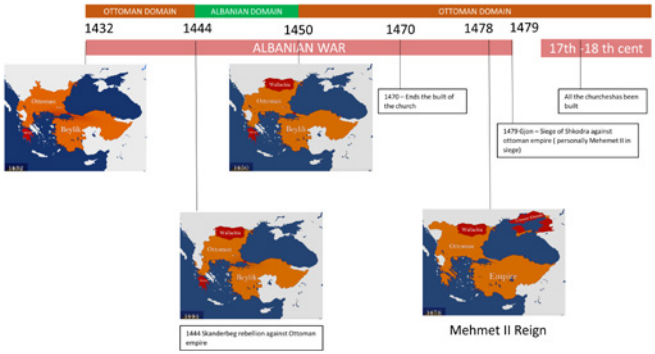


Fig. 2 Historical timeline of the Albanian war.

Architectural Heritage

The churches are mostly basilicas with a principal nave. Most of them are on the rectangular plan with not very significant height. In some cases a bell tower is added. The churches have also some later additions such as porticos and situating narthex at the west end. The construction is made with local stone with lime mortar (Bilgin, 2015). The exteriors are modest as mentioned earlier due to Ottoman Muslim regime at the time (İnalcık, 1978).

In opposition to the modest exteriors the special feature of these churches is their interior decoration. All the interiors are decorated with mural paintings in the 'fresco' technique. According to the Europa Nostra Report (Bond & Abando, 2018) there is no similar fresco work in the Balkans Region considering the concentration and quality of the paintings.

Unfortunately this example of Cultural Heritage is in great danger because of many inconveniences. Due to the fact that Albania is situated at the interface of major tectonic plates the seismic risk is classified as 'high'. Two earthquakes of great impact happened in 1960 and 1967 which caused significant damages. Some parts of the buildings have major structural stability problems and in the effect were abandoned. This has partially contributed to the problems with controlling the water ingress. Bad ventilation and a high level of humidity are a great challenge especially when it comes to protecting the paintings. The last general problem is a security risk. Because the churches belong to the Orthodox Church the owners prefer them to be constantly open to the public. This state led to many cases of robbery so far and is still an on-going process. Unprotected objects are slowly disappearing.

State of art and reference projects

This research is based mostly on the Europa Nostra Technical Report (Bond & Abando, 2018) because it presents the topic most transversely. It is also mostly a first-hand description of the technical state of all the objects. A very comprehensive source dealing with the typology of the churches is given by Bilgin in 2015. The paper presents the main typology for all the objects taking into consideration mostly morphological features. Most of the research such as carried out by Palushi in 2014 and Dhimgjini in 2018 is concentrated around the problem of a chosen church such as the one in Shipcka and dealing with general technical state and conservation issues. A big concern are the frescos with a few publications but one outstanding piece done by Rousseva in 2018 treating at large about the iconographic characteristics of all the churches.

Due to the main aims of this research project we have decided to choose two reference projects picturing a database style and the second one proving the touristic potential of such regions. Both could be useful in formulating the main strategy. Very interesting reference project which should be taken into consideration is H2020 Prometheus. It proposes an interesting methodological approach and offers a structured database. The research project develops an Informative 3D system, multidisciplinary and implementable, that represents the preparatory step for the management, maintenance and valorisation of Cultural Heritage Routes over European committees and administrations (Parrinello et al., 2019). Second reference example represents the touristic potential in such objects laying especially in a unique natural landscape. The colourful Orthodox churches of

Fig. 3 Photographs of the various churches in the area of Moscopole, Vitkuqi and Lavdar.

Fig. 4 Frescos in Church of St. George, Shipcka.

Podlasie are the pride of the region. Blue, green, brown or yellow attract attention from afar. Wooden Orthodox churches are real architectural gems on the map of Poland. The colours of the churches are not meaningless. Each of them carries a certain intention. Blue churches are dedicated to the Mother of God or Archangel Michael. Green is connected to the Holy Spirit, while brown commemorates martyrs. Yellow or rather gold facades are dedicated to Christ or holy apostles and bishops[1].

Main strategy and the objectives

The monuments identified in the project are unusual and rather unique buildings with historical relevance, religious significance and high artistic value. They are potentially an important tourist attraction and could assist regional

Fig. 5 H2020 Reference project Prometheus (on the left) and colourful churches of Podlasie, Poland (on the right).

development with positive impacts on employment. This potential is now being recognised after years of neglect and action is now needed to capitalise on it. The main goal of the project is revitalization of the region of Voskopoja and Vithkuqi villages. It also has four general aims: scientific, popularisation, restoration and educational aim. Scientific aim focuses on the enhancement of knowledge of the region and its architecture. Popularisation aim is based around building promotion strategies for the region which are one of the most important aspects for the further development. Restoration aims focused on restoring twelve religious buildings, comprising ten churches and two monasteries dating from the late 14th century and the rest dating from the 17th – 18th century located in or close to Voskopoja and Vithkuqi in Albania. Educational aim preserves the memory of the Albanian's revolution in the Ottoman period and history of Byzantine Churches.

Because the revitalization is a complex process the objectives have been divided into five categories: revitalization of the region, restoration of the churches, infrastructure enhancement, promotion and post restoration plan.

Social Actors

The area is lucky to have an attractive potential on different scales (local, national and international) and in different areas of focus. Because of that it also has several possible fund sources available which can support the revitalisation of the region.

At the international level there is mainly an interest in the development of infrastructures and connections in addition to the international interest given to the lost alphabet by the Embassy of Kosovo and by the US. Department of state, by the EU itself and by the Ministry of Culture of Albania.

Another very important interest concerns the restoration of churches and frescoes, the subject of this study. This type of intervention is of interest to the EU, the Orthodox Church, the Albanian Ministry of Culture, and the local communities.

The last three interests concern the legacy of the Muzaka family, shared by the heirs of the same family. Finally, the interest of sport, tourism and agriculture find a wide interest in the economic development of the region (also demonstrated by the presence of the '100 Village Program' plan and by his words: *"An important aspect of this program is also the combination of tourist and agritourism potentials, the cultural and historic heritage and natural beauties, making them all accessible to tourists"*[2].
The '100 Village Program' plan in addition to the 'Routes of Faith' that's a communication route with mediaeval origin that connected Venice to Thessalonica up to Constantinople. The Route of Faith together with the network of museums across Albania become the main drivers of economic development as shown by the Europa Nostra report: *"Also relevant to this church restoration project is an initiative by the Ministry of Culture to organise" Routes of Faith "to encourage visitors to explore off the beaten track. In addition, the Ministry of Culture has a decentralised network of museums across Albania and, as has been noted elsewhere, Korça has the most extensive Icon exhibition centre in the country housed in the National Museum of Mediaeval Art"* (Bond & Abando, 2018).

Methods and Digital applications

Artificial Intelligence

To better establish how to operate in the area and the community, it is essential to understand the functioning of

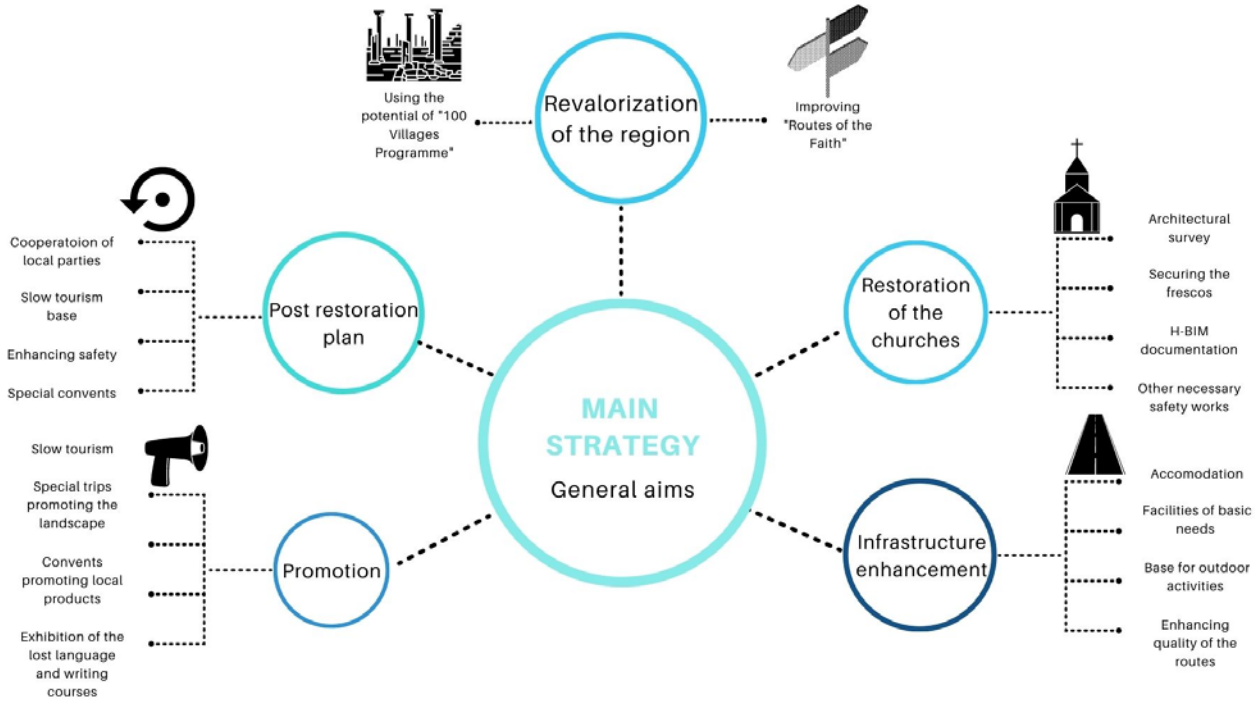


Fig. 6 Diagram with the steps of the main strategy.

existing local communities. Since we cannot have direct access to the study area, we have opted for the use of Artificial Intelligence. This method turns out to be the best compared to other practices as it allows to analyse a greater amount of data and information per unit of time from different sources, to be able to have more levels of data extraction (explicit and implicit), access to generalised knowledge spread by the community (defects and forces of the community extracted through newspaper, image, sentiment analysis). All this aggregate information leads to a fairly complete cognitive picture of the community for the profile of the analysis that is required (analysis of news, the way of life of locals and tourists, events, characteristic cultural elements, and growth potential).
The method used for a reading of the existing community, social levers, habits, etc. is Artificial Intelligence (Object Recognition) for the extraction of the characteristics of a community. This method, disseminated in several articles and texts (Zhou et al., 2014), it is integrated with other image reading and feature extraction algorithms. The final model used is built on three main components.

1. The construction of the dataset: the dataset was built using social media and the internet as sources. This dataset was collected using the 'core' that unites the various churches (Moscopoli, Lavdar and Vithkuq) as a common point. In total, 1,200 photos were collected (500 Moscopoli, 500 Vithkuq and 200 Lavdar) with an annual coverage for each subject under examination;
2. the second fundamental point is the Object Recognition conducted on an NVIDIA Titan X. The main purpose of this phase is the use of the SIFT (Scale-Invariant Feature Transform) system and the Lowe method (Lowe, 1999), the Spatial Pyramid Planning strategy (Lin et al., 2017), and the SSD model (Liu et al., 2016) for object recognition based on a pre-trailed performance data set on the MS-COCO Data, Cityscapes Data and PASCAL VOC datasets for the current recognition of over 10,000 \ Label objects in English;
3. once the objects in the photos have been recognized, the various 'characteristics' are extracted and collected in the form of a dataset and graphically represented to highlight the 'characteristic' elements most present and recognized on the total of the photos collected.

Using this method many interesting features emerge such as the fact that Moscopoli is a city strongly characterised by the presence of churches. In addition, the city has strong natural and sporting characters.
Vithquk, on the other hand, brought to the attention that an ancient language was recently discovered in that area that had been lost and forgotten throughout history. This new find has received a great deal of attention from the American embassy, bringing its discoverer to very strong media attention.

Results

Development Strategies

The development strategies are divided into three main development layouts: Cultural, Turistic/Sport, Agricultural. These three layouts were decided on the basis of the interests of the social actors (able to facilitate development), the characteristics of the communities (actual and potential) and the restoration or maintenance needs of the churches.
The first level, the Cultural one, also called 'Path of the Ancients' or 'Path of Byzantines', is placed in direct connection with the 'Route of Faith' between Venice and Constantinople with the city of Korca and the National Museum of Medieval Art as the first pole of attraction for frescoes and icons. In the second phase the route develops from Korca to Moscopoli to continue to Vithkuq as regards the frescoes but also to reach the second international attraction pole (The Lost Alphabet). Finally, once tourists have reached the pole of the dispersed alphabet, visitors can continue to Lavdar to discover the legacy of the Muzaka and the history of the region and their historical heroes. Furthermore, this type of tourist/ cultural income allows the Public Administration

or social actors involved to invest in technologies for seismic and anti-theft control solving the main problem, before the restoration process.
The second layout, the Touristic/Sports one, is based on a continuous path with an 'Eight' development in order to guarantee a touristic/sporting continuity. The route adds to indispensable cultural stops, the Pond and the mountain Mal Ostrovicë of 2323 m. These two additional subjects help to increase sporting interest in the area.
The whole path is designed to have three types of approach (Terrestrial, Marine and Mountain). The land allows tourists to use the 'Eight' path with the quad, MountainBike (MTB), Cross or walking. The activity at the lake would allow the use of kayaks and finally in Mal Ostrovicë visitors can do climbing or paragliding.
The third strategic layout implements some types of mountain tourism used for example also in Livigno (Italy) and other famous locations over Alps. This type of tourism concerns the 'Farmer for a day' programs or the possibility of horseback riding allowing tourists to immerse themselves in nature and in the context of development of the area.

Impact

The urgent need for restoration calls for immediate action. Interventions shall require not only highly qualified workmanship-namely specialised conservators but also

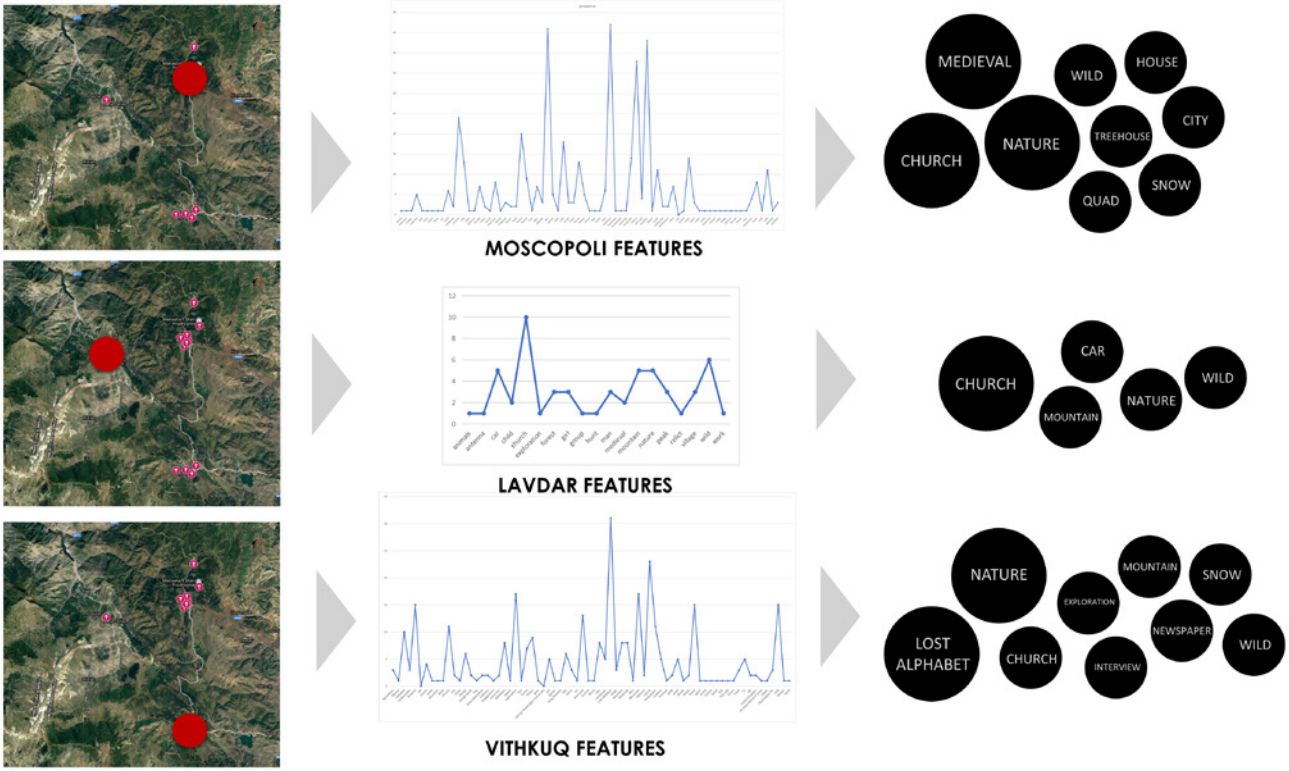


Fig. 7 'Features' extracted from Artificial Intelligence in each study area.

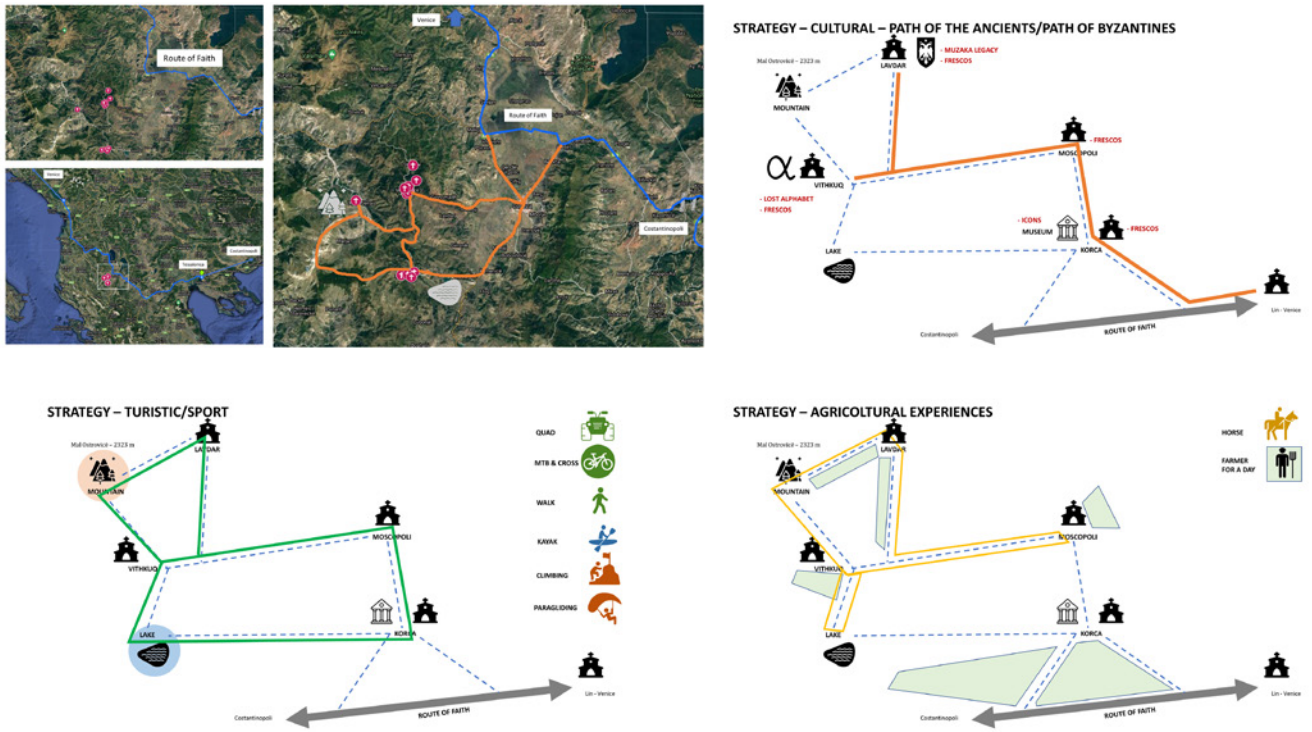


Fig. 8 Strategies for the enhancement of the territory, culture and economic activities.

a wider interdisciplinary approach. Most appropriate procedures and techniques should be carefully planned and executed. The process should consider short term and long term goals.

For the short term result it would be necessary to restore the churches and the frescos. To finish this process the local experts should be trained properly within different fields and have connections with international professionals. Also promotion of the site is a very important aspect. It may lead to participation of the locals and raising awareness and most importantly to digital documentation of the site for current and future works.

The expected long term result is creating and sustaining a place for agro tourism and slow tourism. Bringing the churches back to use may also lead to the reviving of the region because they are an important aspect of the local culture. To fulfil all the expected results developing a regulations plan for the region and the site is necessary.

Conclusions

In conclusion, the area has shown a strong presence and historical importance, it has a strong connection in a very important moment of Albanian history and induced in this state of art by the historical events of the region. The area has a potential for infrastructural, economic and tourist development at national and international level.

The use of Artificial Intelligence has allowed us to have a general picture of the dynamics of the community from the point of view of tourism and its inhabitants.

The development of layer strategies allows a dynamic area development capable of orienting investments, when present, towards the areas of interest that need the most or with a higher economic return profile. Since they are all "sustainable" strategies, they do not create any environmental impact but are found to be of help to the ecosystem of the region (as poland churches).
Understanding the hidden story behind a development site, through surveys and analysis we can find many sustainable ways to develop projects of a certain size, reducing the waste of money and time as much as possible. Furthermore, the use of tools like Artificial Intelligence (Zhou et al., 2014) can be of support in the part of decision making, community understanding, and project planning.

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1 *https://*zabytek.pl/[Last date access, March 2022].
2 *https://kryeministria.al/* [Last date access, December 2021].

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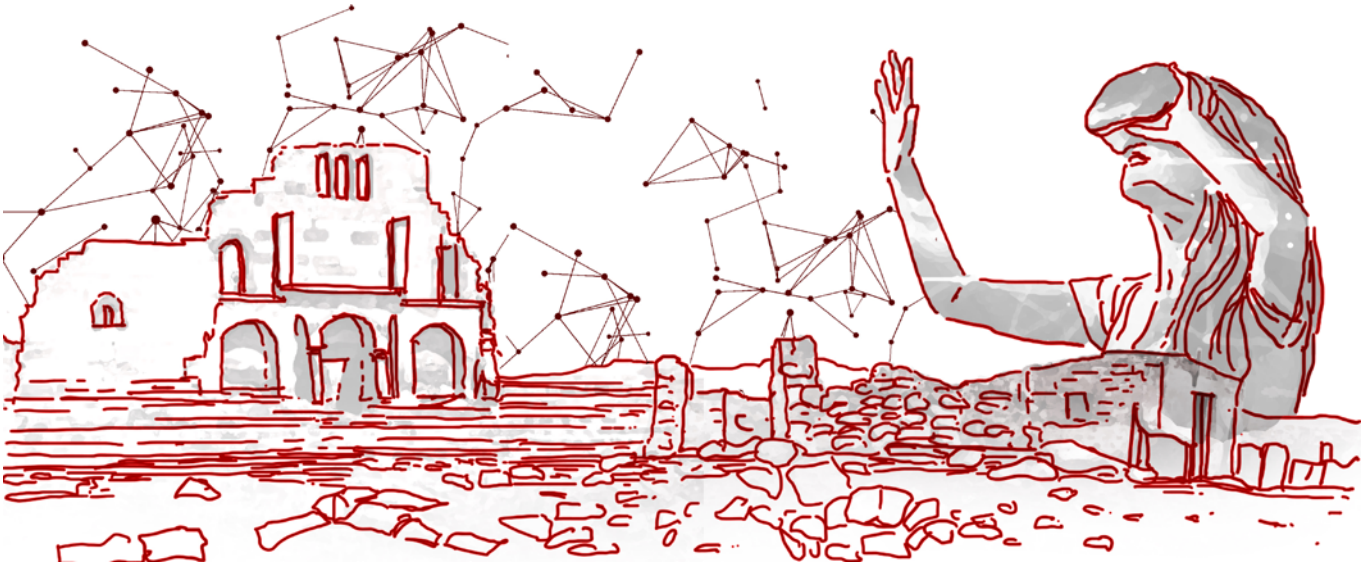
Between Surviving and Sustaining: Archaeological Site of Ererouyk and Village of Anipemza, Armenia



Abstract

This article imbibes planning and discussion of a trial proposal for the endangered archaeological site of Ererouyk and the village of Anipemza within the Armenia border. The site is famous as one of the most prominent Armenia sites with a 5th CE basilica remains with overlapped remains of many historical periods and prominently Soviet Era industrial settlement. The proposal identifies two significant themes considering site remains – religious and Industrial heritage. The trial proposal structure briefly discusses the site context and condition, objectives, intended intervention considering the site condition and needs; digital interventions; a work plan with the execution schedule. Further, the proposal looks into aligning the site interventions to sustain the site through local population engagement and impact assessment followed by the outcomes of the proposed actions, along with the creation of possible state-of-the-art case examples through the intervention execution.

Keywords

Endangered heritage, Digital cultural heritage, Preservation of historical sites, Soviet-era industrial settlement, Notional proposal, Site and sustainability.

Introduction

"Armenia is a country with a long history, and much of its Cultural Heritage is also symbolic of the identity of the Armenian people. For that reason, the government positions Cultural Heritage protection as a vital national policy and is actively engaged in related activities"[1].

The Archaeological Site of Ererouyk and the neighboring village of Anipemza are located in Armenia, Northwest of Yerevan, next to the Akhourian River and the Turkish border. Yererouk or Ererouk means quivering in the Armenian language. According to the popular narrative, the basilica's name was derived from its unique architectural solution of the structure, which seems to quiver on its six columns when viewed from a distance (Wikipedia, 2021). The site is famous for the ruins of the basilica dating to the 5th century, which is considered one of the most prominent monuments of Armenia (Augelli & Marcone, 2020) is on the UNESCO World Heritage tentative list, remains highly endangered (Europa Nostra, 2017). At its construction, the church was surrounded by thick walls, surrounding buildings, underground rooms, and a water reservoir. The church was possibly the center of a developed residential community and was one of the earliest examples of the basilica style of Armenian church buildings constructed on pillars. The site also contains other archaeological remains from different historical periods (Augelli & Marcone, 2020). During the Middle Ages, Ererouyk was strongly linked with the Armenian capital city of Ani, located only a few kilometers away (Europa Nostra, 2016), which is presently part of the Turkish territory.
The village of Anipemza was a product of industrialization during the Soviet period. It was possibly designed by the famous Armenian architect Alexander Tamanyan (Augelli & Marcone, 2020) and established in 1926 and expanded in 1936 (Aymerich & Clausse, 2017) as a residence for workers in the nearby lump pumice stone's quarry (Augelli & Marcone, 2020). After the quarry's closure in 1994, the village of Anipemza lost many of its inhabitants, who sought employment abroad (Aymerich & Clausse, 2017). The site and the village were enlisted on the '7 most endangered heritage sites in Europe', 2016.
With the initial introduction to the site, it is evident that it offers various appeals as a tourist destination. It compasses archaeological remains from various historical periods, a famous ancient religious monument, remnants of industrial soviet heritage designed by an Armenian star architect with an urban fabric and architecture that reflects the soviet period. As a learning exercise, we relied on the lectures delivered during the Summer School as well as the previous rehabilitation details on the site following its nomination on the list of endangered monuments.

Objectives and Main Strategy

As part of the INTERSPECIES Summer School 2021, our team was tasked with developing a conservation and revitalization strategy for the site that is centered around truistic and sustainable development opportunities. As our physical interaction with the site is none, our proposal for the site's rejuvenation is solely understood and formed based on secondary sources of information and literature about the site. Therefore, our write-up is a trial proposal on the site's possible rejuvenation, which would further need a detailed evaluation and revision before applying any proposed strategies and activities.
Based on an initial SWOT analysis and examination of the previous studies of the site, we begin to draft the main objectives for the conservation and revitalization plan. A major report prepared by the European Investment Bank Institution (EIBI) (Aymerich & Clausse, 2017) served as the skeleton on which we modeled our objectives and work plan. Therefore, our strategy centered on developing and

building on the reports approach through digital technology and tools that provide innovative approaches and results.

The work plan proposed by the EIBI (Aymerich & Clausse, 2017) addressed the revitalization and conservation of the site on four fronts. The first action concerned with understanding the structural components of the site by conducting scientific studies on both the archaeological remains and the buildings in the village, site cleaning, structural stability, archaeological excavations, sedimentology analysis, seismic and physical analysis, as well as an environmental feasibility analysis (Aymerich & Clausse, 2017). The second action concerned the reconstruction works necessary to preserve, conserve, and rehabilitate the site and its infrastructure (Aymerich & Clausse, 2017). The third action suggested creating two museums (one archaeological and the other for the Soviet heritage) to serve the site's visitors (Aymerich & Clausse, 2017). The final action addressed information dissemination through communication and advertisements concerning the site through publications leaflets and conferences (Aymerich & Clausse, 2017).

The group envisaged designing its plan in line with the already suggested actions. However, our approach emphasizes the inclusion of digital tools and strategies to enhance the effectiveness of the existing/proposed actions and intervention implementation. Moreover, our strategy is inclusive of dedicated digital documentation as an objective, as it is the foundation layer upon which each of the following steps is executed further. Therefore, our objectives for the conservation and renovation of the site include:

1. providing adequate digital documentation for the archaeological site of Ererouyk and its constituents

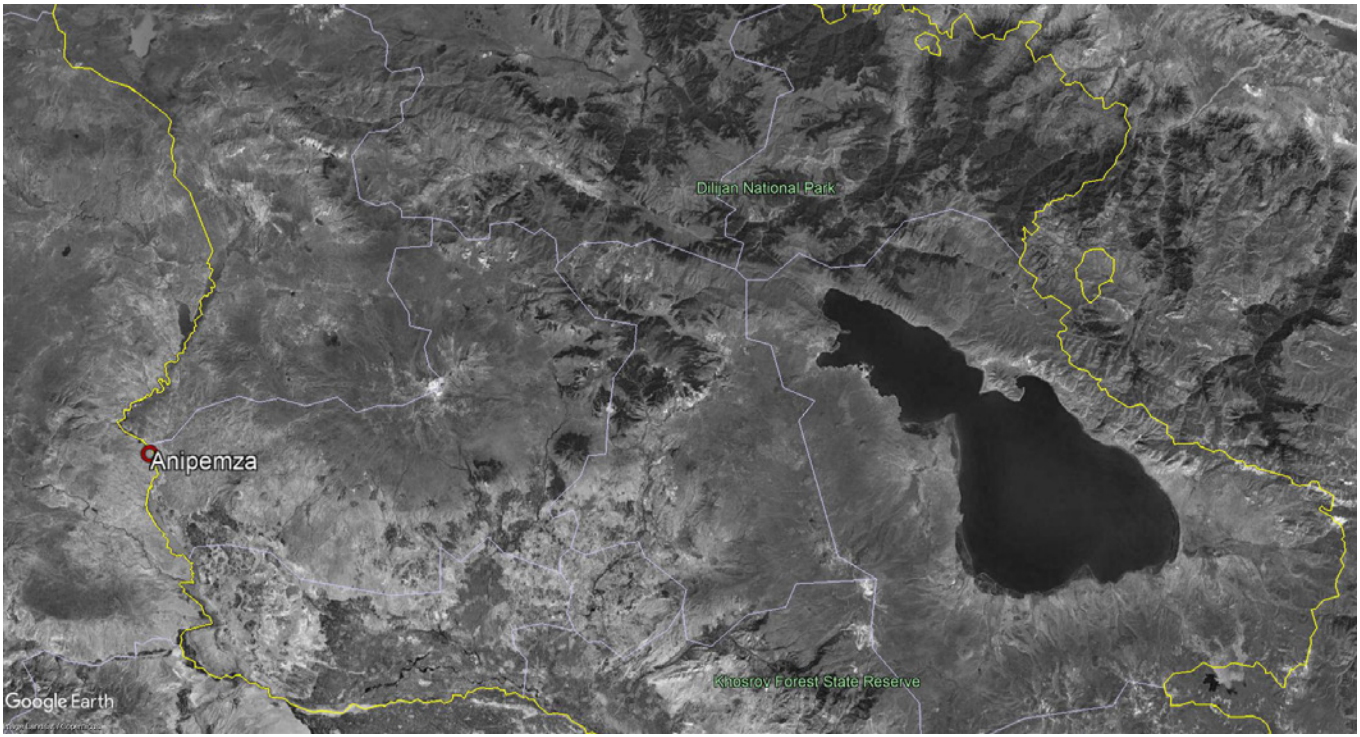


Fig. 1 The location of the site on the border between Armenia and Turkey from Google Earth Pro.

using a combination of digital technologies and tools to provide 3D models with different resolutions and details required to serve other later objectives;
2. continuing digital studies to design interventions aimed to arrest the further deterioration of the existing remains of the basilica and define conservation measures and plans to ensure its safety and continued existence;
3. fostering research, interpretation, and dissemination of the historical context and heritage of the site to enhance its cultural association and significance;
4. tourism planning and facilities creation and implementing cutting-edge (Virtual Reality/ Augmented Reality) technologies for promoting and strengthening the public understanding of the site and its components. This constitutes a steppening stone towards transforming the dissemination and marketing of the site in the digital realm. Since the development of heritage sciences and the growing

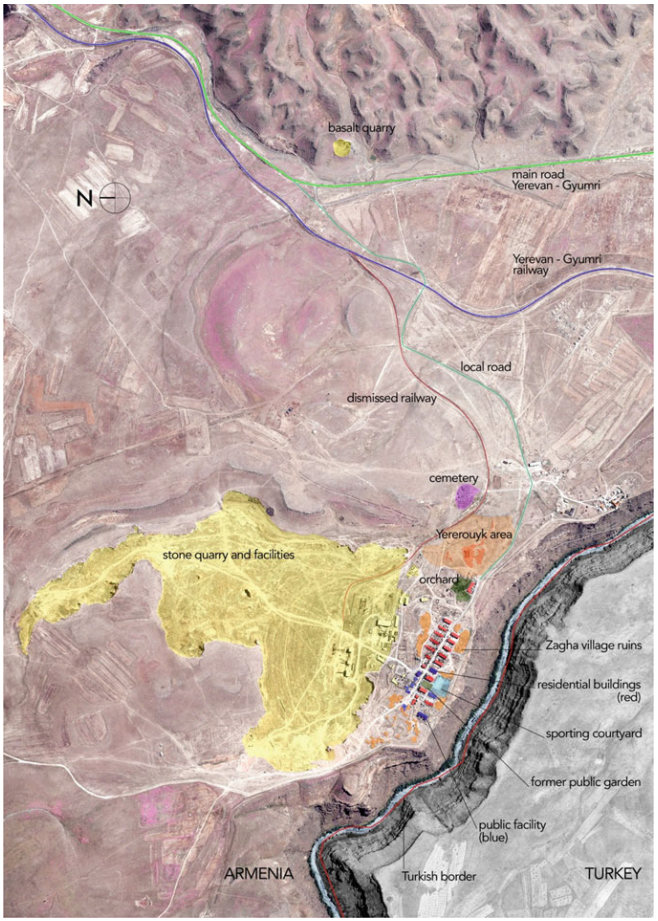


Fig. 2 The Anipemza Village as it appears from satellite (2015): territory, connections, morphology, facilities. Source Augelli & Rigamonti, Anipemza Village's Adaptive Reuse Design, 2020, p. 72.

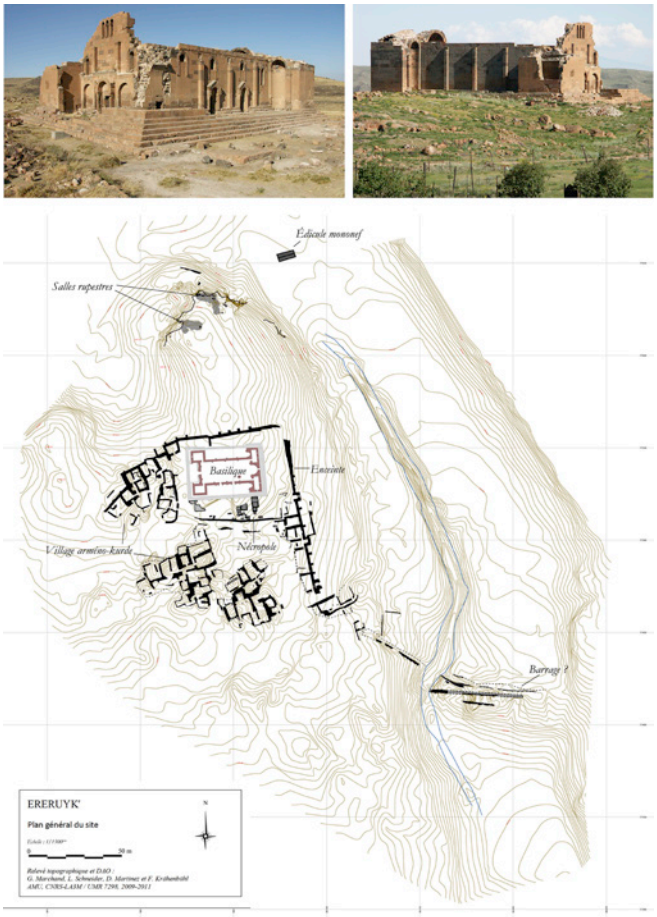


Fig. 3 The plan of the historical site and views of the basilica. Sources Donabédian, 2021.

importance of Cultural Heritage as a national identity, at first and then as part of the collective human civilization, the term heritage 'market' was coined (Peacock & Rizzo, 2008), which regards the cultural products as a revenue-generating commodity. Our approach, hence, aims to take a step towards digitizing that heritage 'market'.

Methods and Digital Applications

Our methodology was inspired by our experiences in the field and the series of lectures that we attended in the INTERSPECIES Summer School that illustrated the use of multiple digital data sets and their use for different analysis workflows of historical monuments and sites, especially for endangered elements of the site and structural heritage and the necessity of slow tourism (Bolognesi, 2021) and catering the visitors (Parowicz, 2021). They offer the opportunity to analyze the structural integrity (Rank, 2021), risk possibilities (Sroczynska, 2021) as well as potential seismic threats (Beyer, 2021), which are highly relevant in the case of Ererouyk and Anipemza.

Hence, the methodology focuses on utilizing technological advancement to document, analyze, and disseminate the site and its surroundings. Digital tools that we suggest employing are LIDAR (Light Detection and Ranging), Multi-Spectral Imaging, Virtual Reality, Virtual Reconstruction, and digital simulation. This is followed by an assessment of the quality and accuracy of the digital survey and the resulting 3D model to validate their reliability when implemented in the different activities of the project. But, we strongly recommend a bottom-up approach for the methodology to be effective, inclusive, and sustainable. This essentially includes assessing and understanding the site and its historical and socio-cultural context. A review of the historical and scientific literature on the one hand and the interest and involvement of the local community and local experts in the intervention process and activities is needed. This can be done through interviews, surveys, and group discussions to understand and align the priorities of the locals. Along with understanding how they relate to the site. And how would they communicate it to the rest of the world?

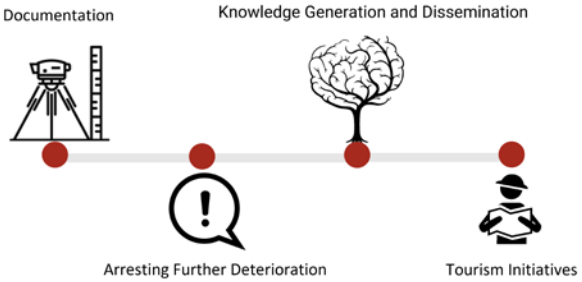


Fig. 4 The suggested objectives adapted to the workplan proposed by (Aymerich & Clausse, 2017), Group 2.

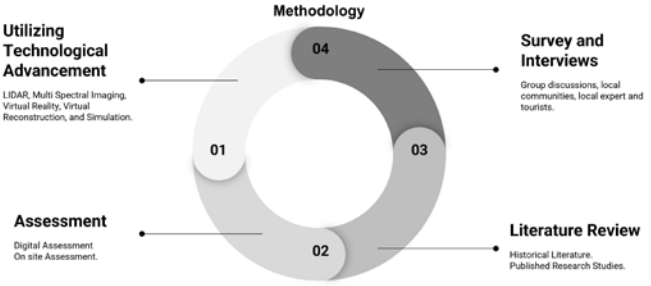


Fig. 5 A schematic of the proposed methodology.

Activities of the Workplan

The suggested activities of the groups' workplan are designed with the objectives in mind. The four objectives are divided into focused activities to expand on the methods applied to achieve each objective and facilitate their implementation on the workplan. The activities are proposed for a timeline of two years which, if needed, will be furthered.

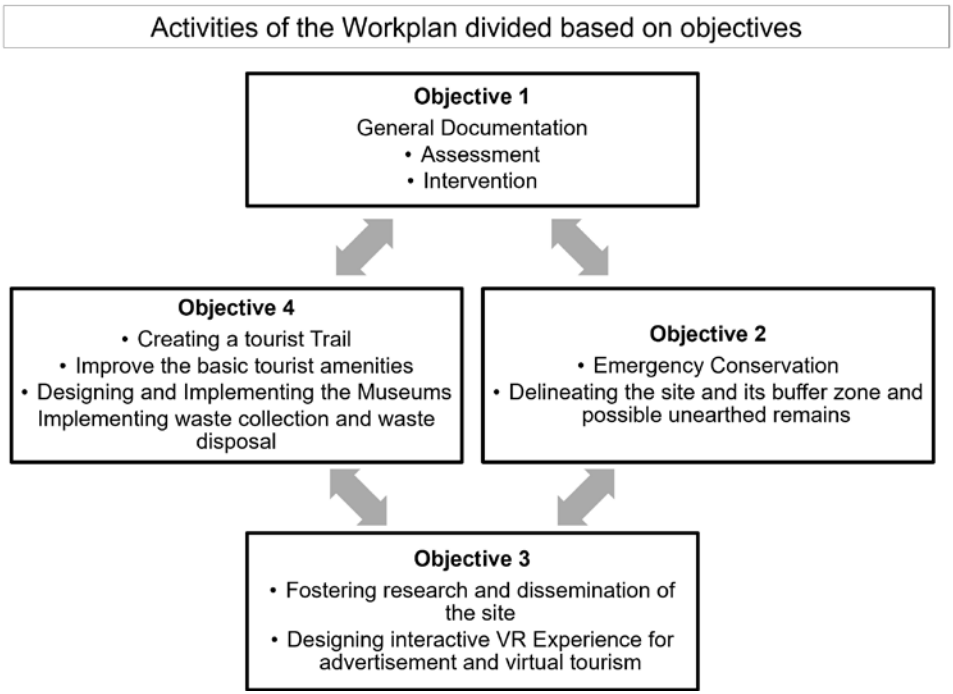


Fig. 6 Activities of the Workplan divided based on objectives proposed by Group 2.

Activities	1st quarter	2nd quarter	3rd quarter	4th quarter	5th quarter	6th quarter	7th quarter	8th quarter
Documentation								
Assessment								
Intervention								
Analysis and Interpretation								
Fostering research, interpretation and dissemination of historical context								
Tourism planning and facilities creation								

Fig. 7 The timeline of the proposed activities.

The activities for the first objective concern general documentation, assessment, and intervention. For the general documentation, we suggest using Close-range Aerial LIDAR, multispectral imaging, thermal cameras mounted on UAVs (Unmanned Aerial vehicles) to observe anomalies to identify unearthed archaeological remains without the need for physical excavations. This can lower the project's overall budget as prioritization of excavation spots can be made, and the buried remains stay protected from weathering and degradation. While at the same time, complementing the digital data sets with models of higher resolution by combining LIDAR and TLS (Terrestrial Laser Scanning) in the acquisition process to identify hitherto unknown archaeological remains.

Dr. Raffaella De Marco, for the group, prepared an illustration of the planned distribution of the different types of data collection equipment throughout the digital survey based on the accuracy required for each section of the site (Fig. 8). For example, laser scanning is concentrated within the archaeological complex, while the entire area is surveyed with UAVs. The general documentation can also facilitate a historical reconstruction of the basilica, as the original form and style of the church have not yet been determined.

The assessment activities, on the other hand, are divided into four categories:

1. structural assessment to examine the structural integrity and risk assessment for the basilica and the village buildings to decide on structural interventions and regular monitoring;
2. architectural assessment to evaluate the non-structural condition of the non-archaeological buildings to facilitate the rehabilitation and reuse of those spaces by the tourism and environmental goals;
3. archaeological assessment to identify the state of conservation of the exposed remains and evaluate the amount and the nature of the unexcavated remains. This assessment evaluates the profitability of physical excavation and its contribution to the valorization of the site and its historical and touristic appeal;
4. risk assessment to evaluate natural and man-made risks. Natural risks include seismic and climate change. Virtual simulations are proposed to understand, assess and prepare for future seismic threats to the archaeological complex and the village. Environmental simulation evaluates the effects of climate change and weathering. Occurred and possible man-made threats, including vandalism, neglect, and accidents, are studied to develop preventive and post-occurrence strategies in the case of occurrence.

The final set of activities to serve the first objective includes four activities:

1. debris clearance, cleaning the site and its remains of biological and environmental agents;
2. design a structural intervention to strengthen the basilica remains in addition to the architectural restoration of the basilica and other prioritized remains;
3. landscaping the site with local and relevant plantation and vegetation;
4. documenting the suggested intervention for analysis and facilitating future studies and interventions.

Among these proposed activities from the above section, a few activities were already implemented in 2018 following the report of the EIBI with Europa Nostra -2017 funding. The cleaning of the site and improvement of roads along with fundraising activities to fund future actions (Fact Sheet by the European Investment Bank Institute, 2018).

The second objective focuses on employing the results of the previous activities for the protection and emergency conservation and restoration of the site components. As well as identifying and defining the archaeological site and its buffer zone expanse and facilitating the application, storage, and access creation of the collected data for further research and interpretation.

The third objective focuses on research, interpretation, and dissemination of the two major historical narratives and the site's context – an ancient city with historical and religious significance and a Soviet Industrial site. Two activities are proposed under this objective, considering both these narratives. Each design will be referenced and wetted thoroughly by consulting and

reviewing the historical documents concerning the site and its monuments, documented inscriptions, and existing interpretations.

1. Creating a 3D reconstruction of the basilica as it was at its complete construction in the 6th century CE by comparing the 3D model of the initial configuration of the site with the 3D model of the actual configuration along using available historical documents and photos. The produced virtual reconstruction is further used to embed in a VR environment to advertise and disseminate the site information;
2. creation and development of an interactive VR experience exhibiting the day-to-day life of the industrial site of the soviet period focused on industrial activities like mines and their workers.

The fourth objective focuses on activities concerning tourism planning and facilities creation. Activities surround four actions concerning the fourth objective. Three activities center around the current site requirements; therefore, the 'Intra site' context and one activity discuss the site association possibilities with other tourist destinations, therefore the 'Inter site' context.

Intra Site Interventions

1. Designing and creating Tourist trails with viewpoints and information spots focusing on the two narratives. Firstly, as an ancient city with historical and religious significance; secondly, Soviet Industrial site.
2. Tourist Amenities estimation and Creation
   a. Identify the areas within and outside the defined site expanse that suit and fulfill the requirements to create required tourist amenities;
   b. improve and further construct basic tourist amenities in harmony with the site and local texture - restrooms (toilets), drinking water facilities, cafeterias, and restaurants;
   c. tourist souvenir shops that will include site-related souvenirs and any local craft, artistic, or/ and unique products. The availability of these products in and around the site area needs to be surveyed and mapped before integrating into tourist souvenir shops.

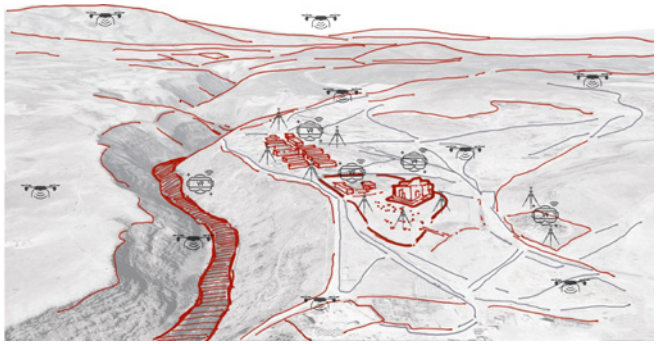


Fig. 8 Distribution of the different equipment of data collection throughout the digital survey based on the accuracy required for each section of the site.

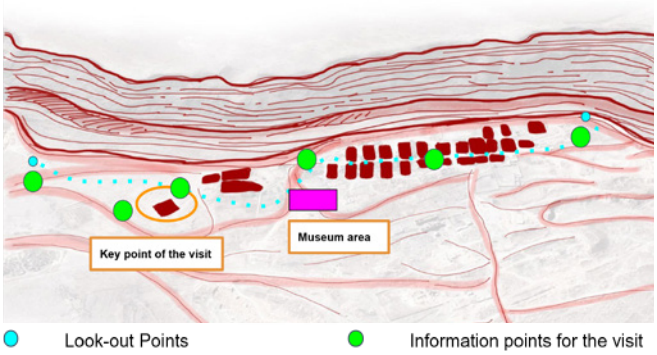


Fig. 9 Schematics for the tourist trail and main attractions.

3. Environment-friendly waste collection and sustainable in situ management - identifying the location, designing the waste management process, building, and managing the facility in harmony with the environment.

Inter Site Intervention

Identifying and contextually locating and associating the site with other sites in Armenia based on the two thematic narratives, namely the site as an ancient city with historical and religious significance and a Soviet Industrial site. Utilize the possibilities to develop and take steps to systematically associate the site with its unique heritage components and narratives into tourist circuits connecting to similar heritage sites in Armenia.

Value and Novelty Assessment

This section will discuss plans and activities intended to be the State-Of-Art contributions that the site and its remains can serve to create.

1. Creation of the archaeological/natural park.

Aymerich & Clausse in 2017 proposes the possibility to position the site and its premise as able to support the creation of the archaeological as well as national park that not just research, conserve and displays the present site's archaeological and natural heritage but also envisages as being a nodal center that engages in an exemplary work of studying and integrating the Armenian archaeological and natural heritage with continued research in many sites across Armenian border. Through this, the center can serve and offer a state-of-art example of the Armenian heritage and sites.

2. Immersive and interactive audio, visual, and virtual experience.

The site and the activities mentioned will produce a considerable amount of visual data, which can be curated and integrated into the display at the tourist interpretation center with an aim to communicate conservation and research activities at the site. Use technology to combine storytelling and Virtual Reality in the tourist trail-related narratives. These activities and the data storage, use, and accessibility facilities for scientifically captured visual data need to be initiated. These serve as a unique state-of-the-art example for the other heritages and heritage sites in the Armenian context. Similar approaches have been shown to be successful as a learning tool facilitating local participation and integration (Economou & Tost, 2011).

3. Site promotion strategies.

The intervention's third and last crucial state-of-the-art contribution would be to devise effective strategies for the site's promotion considering its uniqueness, identity, location, and resource. We recommend four focus areas for state-of-the-art site promotion strategies. They are:

a. social media;
b. representing the site as heritage compendium;
c. target population - young and adults;
d. positioning the site as an Open-Air Museum.

Site and Sustainability

The recent debates propose to include culture as the fourth pillar of sustainability. Positioning the Culture as the fourth component of sustainability puts Cultural Heritage as a cross-cutting domain cable to touch the standard three components, namely the economic, ecological, and social, along with the fourth component of culture. This positions Cultural Heritage sites at the center of sustainability effectiveness, especially at the community and site level. Though one can follow established procedures to assess, strategize, implement and evaluate the site and community sustainability, it is better to adopt a holistic framework based on the site's life cycle.

We propose a simple framework for the present site that needs further research and revision. Three non-negotiable focus areas that are considered for the current framework are:

1. understand the site's entire tangible components with utmost sensitivity for its historical events and composition;
2. arrest further deterioration of the monuments and remains with responsible and sustainable interventions;
3. making the site a viable heritage for the local community and visitors.

Six stages are presently proposed considering these primary focus areas. Wherein the interaction between the stages is non-linear and, therefore, reciprocal as each of these stages and the collected information can impact other stages, causing revisions in strategy and methods of implementation and impact evaluations.

Expected Results and Impacts

1. An account of the Histographic development of the site across centuries based on archaeological and monumental remains;
2. creating and disseminating site heritage to reach out to

the target population through social and other media;
3. documentation dossier on the site interventions, including their outcomes;
4. improved footfall of the tourists to the site owing to improved amenities and disseminated heritage of the site;
5. conserved site, monuments, and remains;
6. improved opportunities for the local community to participate and utilize the opportunities created through increased tourist flow;
7. intervention would enable and facilitate possibilities for future actions.

Conclusions

The archaeological site of Ererouyk and the village of Anipemza in Armenia are battling their survival and hope they sustain their heritage and the community. To achieve this objective, we unison to represent the site as a combined heritage of historical, architectural, and Soviet period Industrial Hub positioning the site as a strong contender for targeted visitor's attention. The proposed interventions and actions can serve as a case study to initiate the possibilities for the Armenian cultural heritage field to look at the cultural heritage sites as a compendium of varied cultural expressions with layers of history facilitating and embracing each site's wholistic potential along with non-religious uniqueness. The site has the potential to create economic opportunities and a sense of belongingness among the local community towards the site and its heritage. As the site stands testimony to pan Europe's shared history (in all its positive and negative glory) through its industrial heritage provides a contemporary cultural context to acknowledge and recognize the multi-layered interactions.

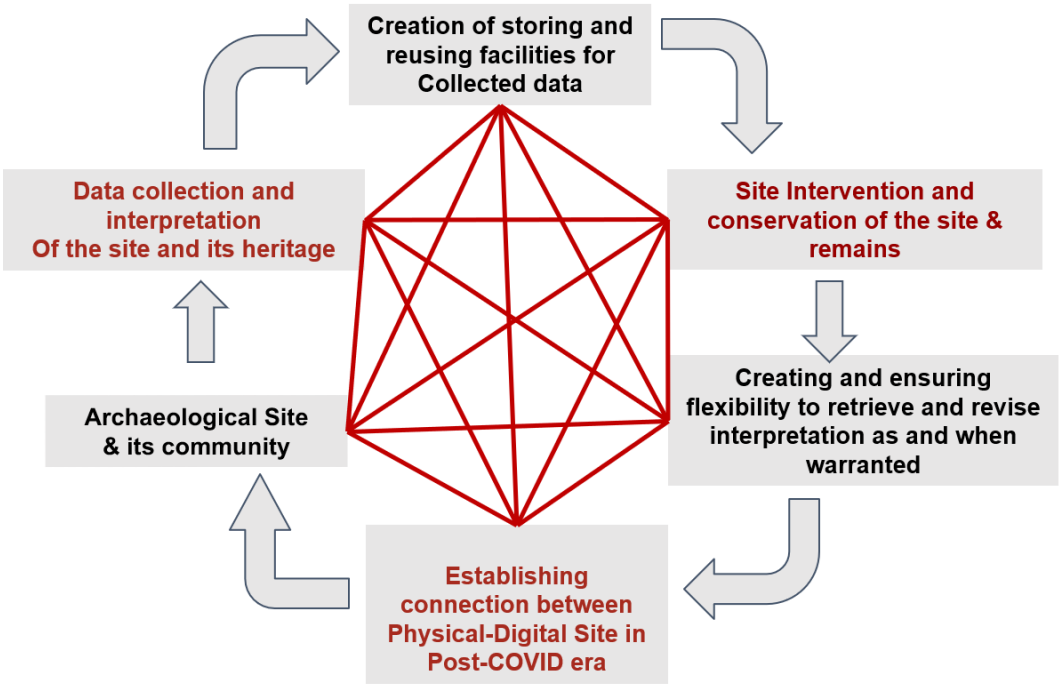


Fig. 10 The non-linear interaction between the stages of intervention.

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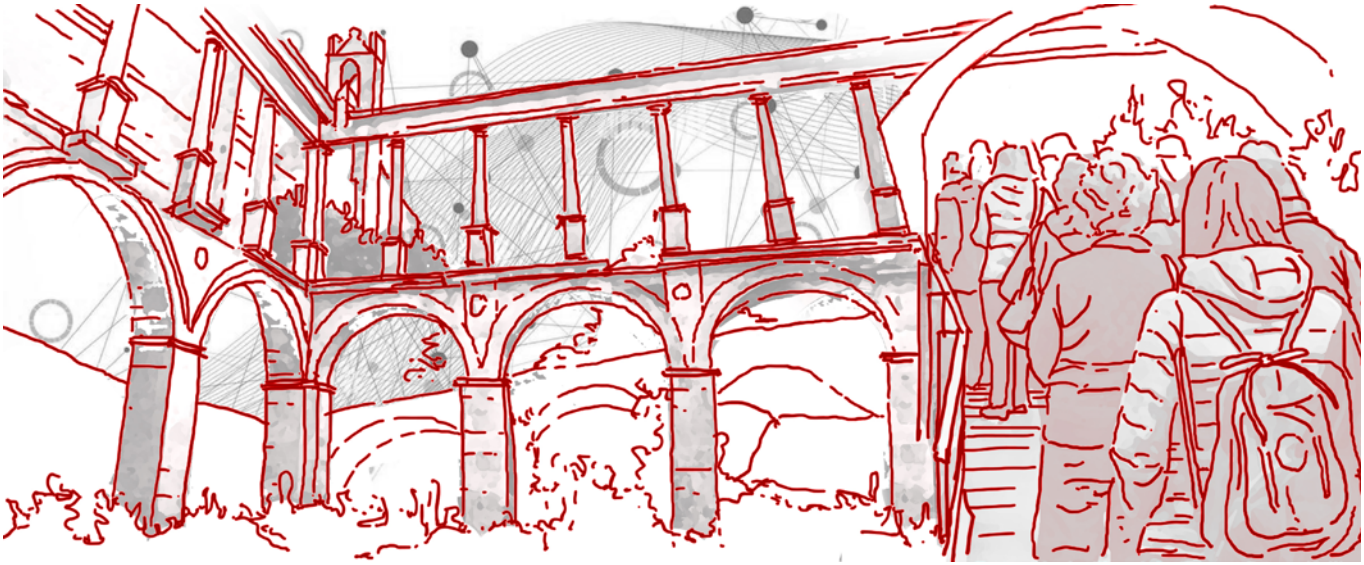
Integrated Multidisciplinary Approach for Restoration and Valorisation. The Convent of St. Anthony of Padua in Extremadura, Spain



Abstract

The rehabilitation of Cultural Heritage at risk needs integrated processes of managing and planning intervention. The following project proposes to establish an integrated methodology for the recovery of the Convent of Saint Anthony of Padua and the surrounding area, Garrovillas de Alconétar (Extremadura, Spain).

The current proposal is conceived and developed as a possible future regeneration project for the ancient architecture, subject to abandonment, and its circumjacent area. A multidisciplinary methodology, combining several fields of studies such as archaeology, history and architecture, digital analysis, visualization tools, and economic strategies, is at the basis of the project. In the methodological pipeline, helpful support in the rehabilitation and restoration of the asset and its area is provided by the employment of 3D digital technologies, which can be valuable tools for diagnostic investigation and provide a transparent approach to the analysis of the architectures. Moreover, digital tools can be used for visualisations and reconstructions aimed at the valorisation of cultural assets.

Keywords

Endangered cultural heritage, Multidisciplinarity, Digital technologies, Rehabilitation, Sustainability.

Introduction

Cultural Heritage must communicate our past, and at the same time, it should be integrated into the present, looking towards the future. It must communicate with the space and those who live in that space and consequently contribute to their well-being. In this context, the cultural asset has a historical-cultural value, an expressive and emotional capacity to communicate the history of a place, helping to create a sense of belonging of the inhabitants to the space and its history. It also acts as a social rehabilitator and economic attractor for underdeveloped areas. Suppose that monument is left to time degradation, neglected by its owners or institutions responsible for its protection, and by the locals' oblivion. In that case, a situation of instability in an area's delicate social and economic balance is easy to happen.

The paper presented here is the result of a multidisciplinary collaboration for developing a project dedicated to the rehabilitation of endangered Cultural Heritage.

The subject of the rehabilitation research proposal is a building of high interest in the history of Extremadura in Spain: the Convent of Saint Anthony of Padua. Its importance in the area as a religious and cultural landmark through the centuries suddenly declined. In 1991, the building, owned by the Regional Government of Extremadura and private citizens, was classified as a Monument of Cultural Interest. Nevertheless, it is now abandoned and in a state of neglect. Therefore, the current project is conceived as a proposal for a possible future regeneration masterplan of the neglected ancient architecture and its surrounding area, worth to be enhanced.

The endangered Cultural Heritage under study has been analysed from different perspectives. The multidisciplinary cooperation has allowed the design of a restoration and valorisation project developed on different levels of detail: from the micro - represented by the building and its components- to the macro - consisting of the adjacent area and expanding towards the region and the country.

The case study

The Franciscan Convent of Saint Anthony of Padua is located in the suburbs of the town of Garrovillas de Alconétar, in the region of Extremadura. The area is one of the largest of Spain's Autonomous Communities, but also the country's poorest region in terms of 'Purchasing Power Parity (PPP)'. Garrovillas is itself a relatively poor and small town. However, it has a long history and highborn connections. Prehistoric and historic structures surround the broader area of the site of the Convent, mainly consisting of ecclesiastical buildings. The area also presents interesting geological and geographical features, including a local river and a lake system.

The Convent of St. Anthony of Padua is a complex structure, built in a variety of architectural styles, using a range of building techniques and materials above approximately 300 years. The Convent, founded in 1476, underwent three main development phases (Campbell, 2017):

1. in the mid-16th century, the Chapel was expanded to create its actual plan, with the addition of a Chapter House and religious offices on the South;
2. in the mid-17th century, a further side Chapel was added to the main Chapel and reconfigured towards the South. Here, double-level cloisters and cells for the nuns were constructed;
3. the last phase of the building is dated back to the first half of the 18th century: a new entrance on a new South wing was set up, which included additional cells for the nuns, and an extension to the South of the cloisters to allocate a refectory and infirmary. During this period, the Side Chapel was dedicated to Cristo de las Injurias, with the addition of richer decorations in the interior.

The Convent was eventually deconsecrated in the early 19th century and then sold. Successively, the building was used for various artisanal and industrial purposes: it was even employed as a sheep shearing facility, weaving

shed and forge. That state of abandonment, still persistent, has naturally brought to parts' collapse, despoliation of the building and looting of several decorated elements and materials for reuse in other edifices.

From an architectural and historical point of view, the main Chapel and the double-height cloisters are the most valuable elements. Over time the structures were modified or built without regard for the historical or architectural value of the original asset. Fortunately, as verified by the report conducted by the delegation of Europa Nostra in partnership with the Council of Europe Development Bank (Campbell, 2017), the main structure of the Chapel and a large part of the cloisters are still standing. The ribbed,

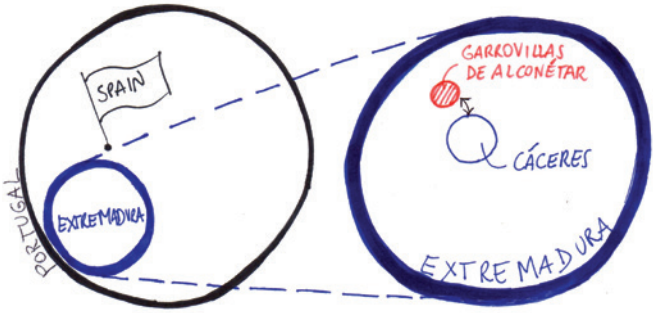


Fig. 2 Schematic representation of the proposed project and its multi-level approach.

Fig. 1 The Convent of Saint Anthony of Padua and its current situation (copyright © 2014-2021 Dirección General de Turismo).

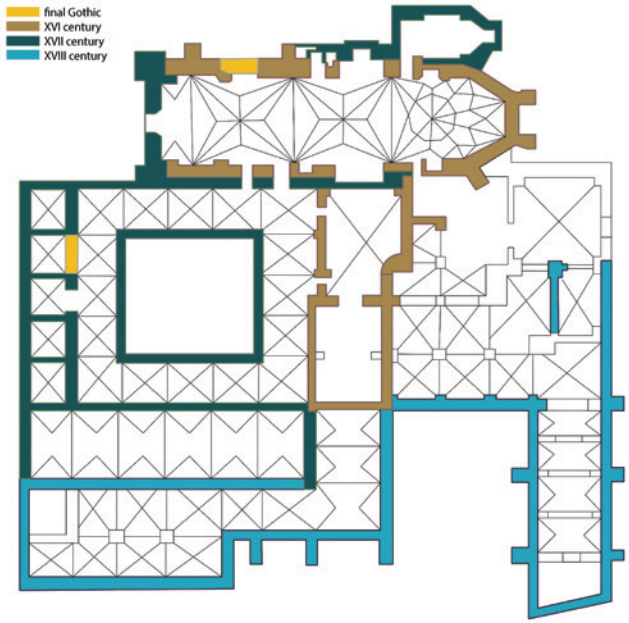


Fig. 3 The main constructive phases of the Convent of Saint Anthony of Padua (graphic re-elaboration from Campbell 2017).

Fig. 4 The ribbed and fan-vaulted ceiling of the Chapel (copyright © José Luis Díaz) https://arteenruinas.com/convento-san-antonio-padua-garrovillas-alconetar/.

fan-vaulted ceiling of the Chapel is largely complete and it can be stabilised and maintained. The actual roof of the church was looted in the second half of the 19th century, exposing the ceiling. Therefore a high priority should be given to the protection and reconstruction of the vault.
The two levels designed in different architectural styles make the cloister valuable and unique of its kind. Although the inner ring of columns is still standing, only the west wall on the upper levels remains. The lower cloister has vaulted ceilings to support the upper floor. The overall structure is becoming unsteady, and especially the western walls are at high risk of collapsing. Therefore, also the cloisters have high priority for the site's rehabilitation, and the consolidation works are very urgent.

State of the art in the field

A literature review addressing past and ongoing projects, as well as scientific papers, was carried out. Similar examples of neglected monasteries rehabilitated and reconstructed for different purposes were considered for the development of the current proposal.
An interesting project of restoration and rehabilitation of an ancient religious building is the case of Ptuj Monastery. The Monastery, located in Ptuj (Slovenia), has been renovated several times, and transformed from a hospital to a museum. The last restoration highlighted its historical value while maintaining the Baroque monastery's use. This renovation led to a design that did not bring major invasive interventions but kept the original structure[1]. The new project maintains the old church's functions since they are similar to the new performance centre's needs. The main entrance in the old cloister space allows circulation through the structure, and it also functions as the central node to all paths of the building. On the opposite side of the enclosed courtyard, the converted nave hosts the main event hall. The integration of the historic white walls and vaulted ceilings into the modern restored complex is a synthesis of the past and the present.
Another valuable case study is the restoration of a religious monument located in Spain. The project of the Monastery of

San Juan in Burgos is particularly interesting because it shows a different approach to the renovation and preservation of an architectural complex in ruins[2]. Although the structure needed very extensive reconstructions, these were done in a way that did not revolutionise its essence. The solution adopted in the case of the Monastery of San Juan tried to restore the ancient monument using modern materials for a new roof and giving back the perception of the interior space. The new design established a dialogue with the ancient architecture, without physical contact with the ancient walls.

A recent, ongoing project is the one carried out at the Mediaeval monastery of Ayia Napa (Cyprus), promoted by the Bishopric of Constantia and Famagusta in collaboration with the Freïe University of Berlin and the Department of Antiquities of Cyprus[3]. This is a very interesting project since the work foresees several results for the rehabilitation of the Cultural Heritage asset. For instance, archaeological excavations of some parts of the monastery are undergoing in order to bring to light the ancient and long history of the building. The restoration of the ancient monastery for the parts still dedicated to the cult are aimed at the conservation of their original use destination while the rehabilitation of other areas (e.g., the cells) are aimed at their re-use and for musealization purposes (Schrade, 2021)[4]. As an essential step, a database for the building survey, bibliography, and document collection, is created and continuously updated to make it accessible to the project researchers, local stakeholders and construction specialists. From that, a website for the museum, a 3D video projection and a museum app are to be developed later. The overall operation is especially important also because the rehabilitation of the ancient building will help to re-qualify as 'cultural' an area instead dedicated to mass tourism.

The previous examples are informative for what concerns the different approaches to restoring ancient religious buildings with traditional techniques. Nevertheless, there is a vast literature on the use of 3D documentation and 3D reconstructions for several purposes, such as management and planning, analysis, conservation, valorisation and restoration.

For instance, the case of St. Agatha Chapel in Pisa used 3D survey techniques for the architectural restoration of the monument (Bevilacqua et al., 2017). In that specific case, the combined use of photogrammetry and laser scanner techniques produced 3D models that are great

Fig. 5 The two-level cloister, designed in different architectural styles (copyright © 2014-2021 Dirección General de Turismo) https://www.turismoextremadura.com/en/explora/Convent-of-San-Antonio-de-Padua/.

Fig. 6 The two-level cloister from the inside space (copyright Arte en ruinas) https://arteenruinas.com/convento-san-antonio-padua-garrovillas-alconetar/.

Fig. 7 Renovation of a former Dominican monastery to a performance centre in Ptuj, Slovenia (copyright Miran Kambic) https://www.archdaily.com/431421/ptuj-performance-center-enota.

instruments for the analysis of the structure. The 3D model of the Chapel, providing a high resolution and precise outcome, is used to identify all the elements required for the analysis of the current state, the exact identification and position of degradation elements, and damages both of the constituent materials and their decorations.

Fig. 8. Modern reconstruction for the preservation of the ancient ruin: a new roof for the Monastery of San Juan in Burgos, Spain (copyright Santiago Escribano Martínez) https://www.archdaily.com/783820/cubierta-monasterio-de-san-juan-bsa.

Therefore, the use of 3D documentation provides useful support for preservation and conservation.

A similar project using 3D documentation techniques (laser scanner and photogrammetry) for planned conservation and restoration purposes is carried out at the former church and convent of Sant'Agostino in Bergamo. This case study is valuable because it shows how 3D models are useful for documentation and restoration aims and are the critical element for creating multimedia data-sharing platforms for communication and enhancement of Cultural Heritage assets. Moreover, the development of a web portal provided access to two different modalities of interrogation of the 3D model: a diachronic one, dedicated to the history of the building based on a specific timeline and including the function assumed by the former church over time; and an analytic one, which examines the architectural and decorative structures considering their state of conservation (Cardaci et al., 2019).

Beyond the cases of restoration and promotion, other studies in the survey and rehabilitation field focus on the need for emergency protocols based on structural knowledge and

documentation for the protection and intervention on the heritage at risk. For instance, the structural documentation applied to the Pokcha Church in Russia proposes the integration of the 3D survey products into Reality-Based Models, organising data through phases and controlling the quality of the components. The 3D polygonal models are intended to be used in computational platforms for information on tensional behaviour, analysis and calculation of risks (Parrinello & De Marco, 2019).
Similarly, the project 'PROMETHEUS - PROtocols for information Models librariEs Tested on HEritage of Upper Kama Sites', focusing on the Upper Kama region and the Cultural Heritage of its territory, aims at defining, through interdisciplinary collaborations, protocols for the development of methodologies and tools (e.g., H-BIM) for the documentation and management of the architectural heritage and the consequent interventions on the endangered ones (Parrinello et al., 2020).
An important aspect is, therefore, the one of preventive conservation and preservation. For instance, regarding Cultural Heritage conservation, preservation and valorisation (also through digital technologies) an EU funded project has been working on the preventive steps of the process. Specifically, the 4CH project[5] aims to set up the methodological, procedural, and organisational framework of a Competence Centre able to smoothly and continuously work with a network of Cultural Institutions, both local and national, providing them with guidelines, advice, support, and services aimed at the preservation and conservation of cultural assets (Maietti et al., 2021).
That is an essential step in the future of the preservation and valorisation of Cultural Heritage since the results of this effort will help to draw good practices and guidelines that institutions and countries will be able to refer to, train on the topic and facilitate the preservation and conservation of Cultural Heritage also through successful case studies.

Main Strategy and Objectives

The previous case studies are paradigmatic for the main aim of the proposed project, that is the rehabilitation of the Convent of Saint Anthony of Padua and the area of Garrovillas de Alconétar. The Convent has a great interest because of its importance both at religious, cultural and historical level. Moreover, the quality of the original construction, the peculiarity of the different styles belonging to the renovations and additions, and the majesty of its dimensions make the Convent worth preserving and becoming an attraction for a quite unknown part of Spain as Garrovillas de Alconétar.
In the rehabilitation of a historic structure, searching for new purposes represents a strategic model to support the economic development of the surrounding area or the revitalisation of abandoned territories. Nevertheless, the repurposing of

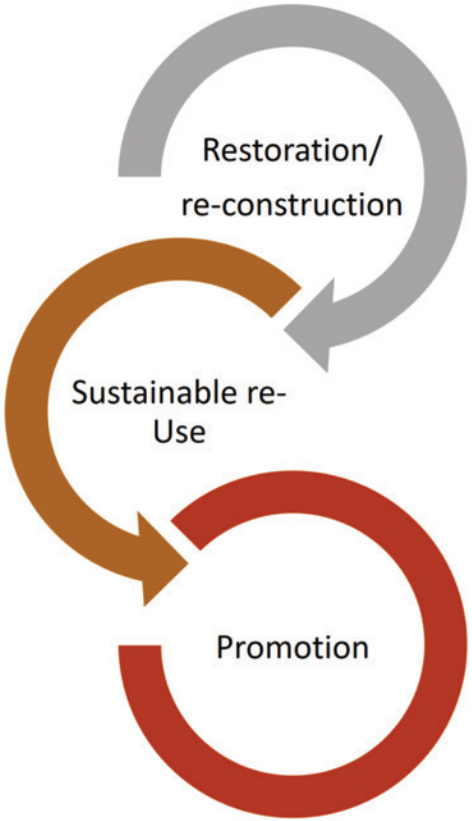


Fig. 9 The strategy for the rehabilitation of endangered Cultural Heritage.

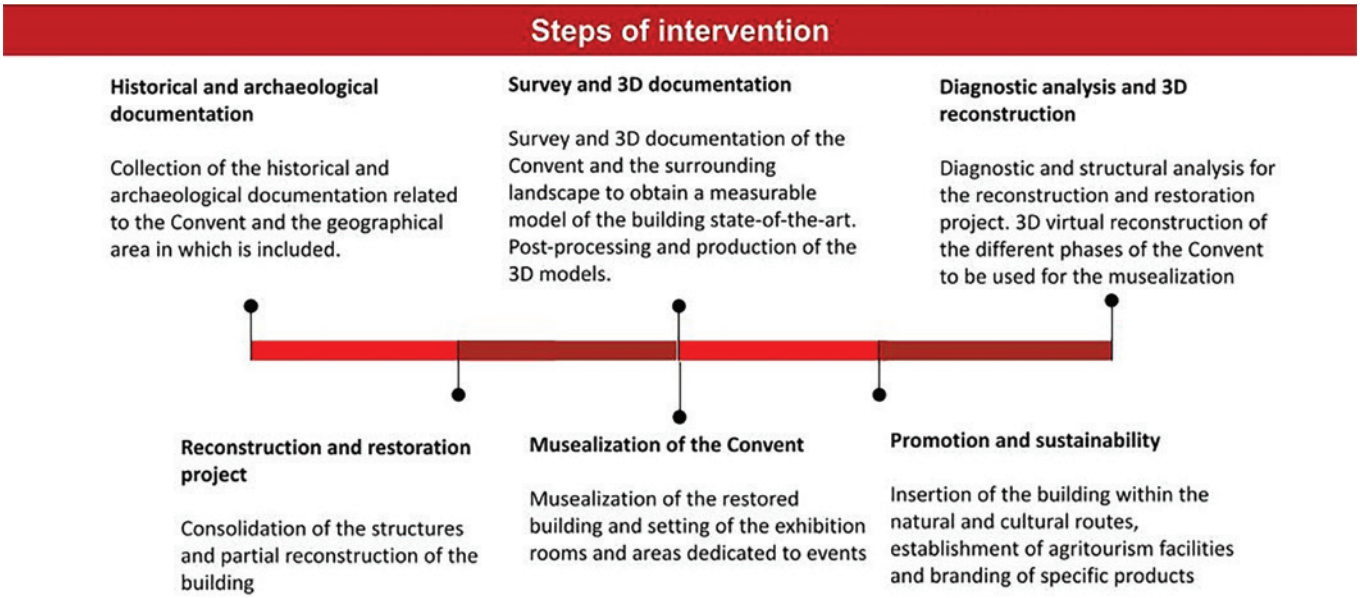


Fig. 10 Steps of the methodological pipeline.

the historical buildings should take into consideration the geographical and social context and not to overturn their original nature. Currently, not-impacting changes at the local level have already started. Indeed, some historical and religious buildings of the area have been restored and put at disposal of the community.

For instance, some resident cultural groups have organised an anthropological museum dedicated to local life. In parallel, activities to support tourism with small scale accommodations have been initiated. In this vein, the strategy developed for the case study consists of three main objectives, focusing the intervention on creating a program that will keep the monastery in use both in daylight and at night and throughout the year. The first objective consists of the restoration and partial reconstruction of the building. The reconstruction/ restoration project will proceed along and be integrated with the sustainable re-use of the convent, the second objective of the rehabilitation strategy, highlighting its historical value and avoiding invasive interventions. The third objective, the promotion, will start from the initial phase of the project and consists of the musealization of the restored convent and the insertion of the rehabilitated asset in a touristic and marketing programme of the area.

The general confidence, also shared by the Commune and Autonomous Community, is that the use of the cultural and natural history of the region can act as motors of regeneration, and tourism might bring an important development in the local economy, providing new opportunities to the growth of the entire area. To do so, besides the intervention of the Convent, some actions need to be undertaken for making Garrovillas de Alconétar reachable and attractive for the community at a local level and for foreign tourists as well.

These actions should improve the transport system. There is only one airport in Extremadura, in Badajoz (124 km to Garrovillas). Nevertheless, for foreign tourists, although the country road system is good, at least half a day by car or public transportation from Madrid or Lisbon is needed. Moreover, language skills should be developed and hospitality and accommodation services be implemented. Finally, a platform should be designed showing the 'attractions system' and

providing a comprehensive and broad network between them. The rehabilitated Convent will be put in relation with the existing museum and the other historic structures, and inserted in the naturalistic attractions system of the region in order to develop tourism in the area. The addition of further products such as agro-tourism, mountain biking paths, and speciality food providers would increase the tourist offer in the area.
The presence in the Extremadura of the European Regional Development Funds programme Via de la Plata, a route based on an old Roman road used as one of the pilgrimage routes to Santiago de Compostela, is another important element in the establishment of a touristic system. Indeed, the route already connects several rehabilitated historic buildings and accommodations and passes close to Garrovillas: the Convent and the surrounding area well suit the existing cultural and religious touristic system.

Methods and Digital applications

The variety of expertises in the field of archeology/digital heritage, architecture and urban planning made it possible to analyse the endangered Convent from different points of view in order to create an integrated multidisciplinary project of restoration and valorisation. The combination and integration of several fields, such as history and archaeology, architecture, digital analysis and visualisation, and tourism/economy allowed analysing the cultural asset in all its components and understanding its needs and those of the community living around it, and consequently to plan effective strategies for its conservation, development and valorisation.
The presence of a methodology at the basis of a project is very important to guarantee the correctness of the final result. It is possible to scientifically integrate all the steps and ensure their correct sequence through its development, anticipating possible bottlenecks during the process. It has to be underlined that all the steps depend on each other, and some are developed parallel. Such a methodology designs the rehabilitation project according to two different levels of detail. The first one consists of a micro level, represented by the building and its components; the second one involves the enhancement of the adjacent area, expanding the relations towards the region and the country. Specifically, the multidisciplinary methodology was developed and organised in six steps:

1. historical and archaeological documentation;
2. digital data documentation;
3. three-dimensional reconstruction and diagnostic analysis;
4. reconstruction and restoration;
5. musealization of the asset;
6. promotion and sustainability.

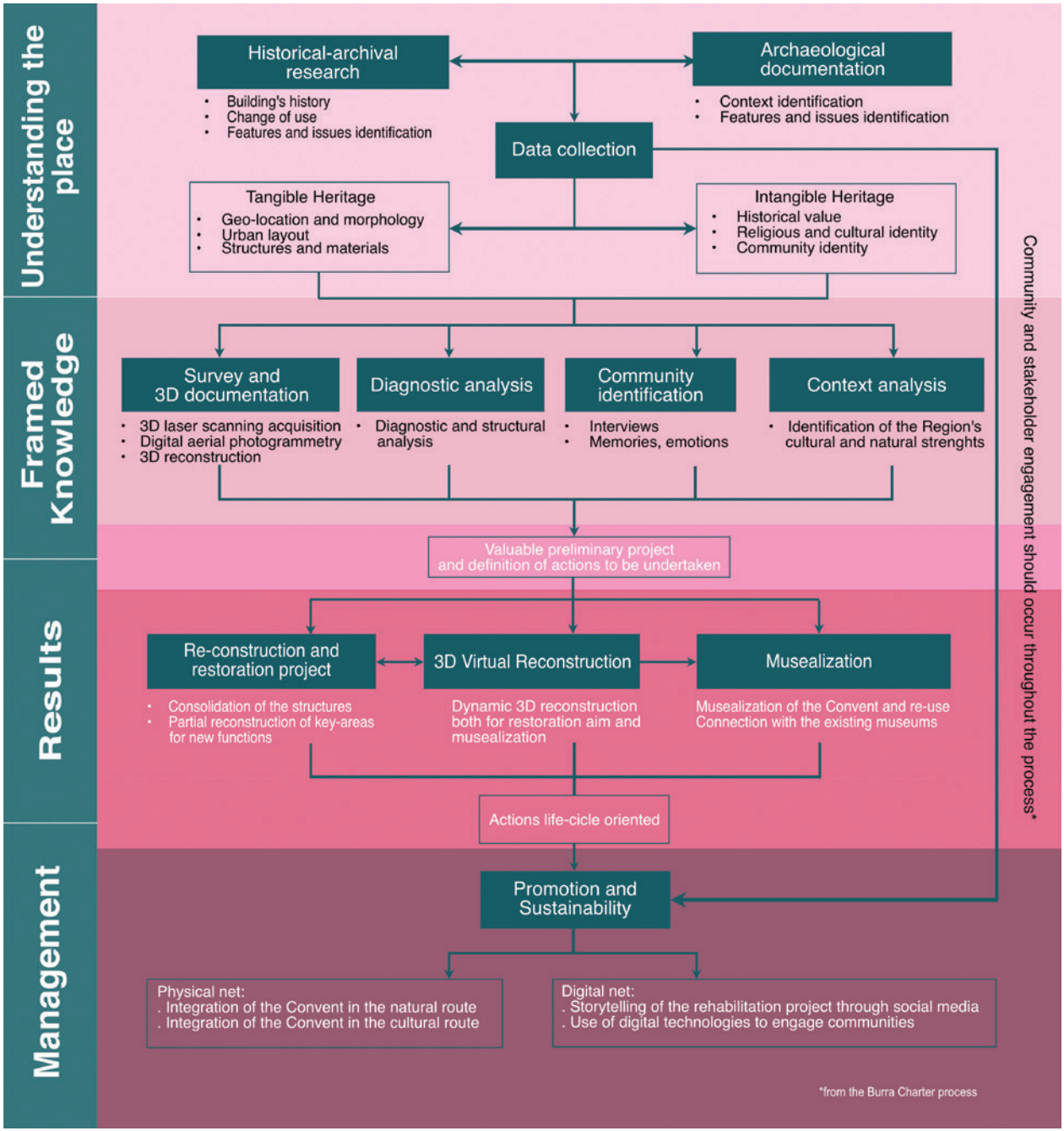
Following, each step of the methodology is described in detail. Moreover, a conceptual flowchart that relates the interventions and their sub-actions to pursue the proposed objectives is provided.

1. Historical and archaeological documentation.

This step consists of gathering all the historical and archaeological documentation related to the Convent and the geographical area in which it is included. That is a fundamental passage since the collection of information about the case study is able to frame the asset in the historical and geographical background, knowing about the changes that occurred through time and having a clear knowledge of its current situation. Detailed knowledge of the Cultural Heritage under study is at the basis of all the successive processes of analysis, interpretation and communication. Ancient texts, bibliographic references, archive data, and plans provide a useful starting point for the subsequent operations.

2. Survey and 3D documentation.

In this methodological pipeline, helpful support in the rehabilitation and restoration of the asset and its area is provided by the employment of 3D digital technologies, which can be useful tools for visualisation and diagnostic and provide a transparent approach to the analysis of the architectures. Complex geometries and shapes characterise Cultural Heritage assets; they are the result of successive stratifications and increasingly require the application of integrated survey techniques for documenting them. Recent studies have focused on the combination of the traditional survey with digital technologies such as laser


Understanding the place
Framed Knowledge
Results
Management
Historical-archival research
Building's history
Change of use
Features and issues identification
Archaeological documentation
Context identification
Features and issues identification
Data collection
Tangible Heritage
Geo-location and morphology
Urban layout
Structures and materials
Intangible Heritage
Historical value
Religious and cultural identity
Community identity
Survey and 3D documentation
3D laser scanning acquisition
Digital aerial photogrammetry
3D reconstruction
Diagnostic analysis
Diagnostic and structural analysis
Community identification
Interviews
Memories, emotions
Context analysis
Identification of the Region's cultural and natural strenghts
Valuable preliminary project and definition of actions to be undertaken
Re-construction and restoration project
Consolidation of the structures
Partial reconstruction of key-areas for new functions
3D Virtual Reconstruction
Dynamic 3D reconstruction both for restoration aim and musealization
Musealization
Musealization of the Convent and re-use Connection with the existing museums
Actions life-cicle oriented
Promotion and Sustainability
Physical net:
. Integration of the Convent in the natural route
. Integration of the Convent in the cultural route
Digital net:
. Storytelling of the rehabilitation project through social media
. Use of digital technologies to engage communities
*from the Burra Charter process
Community and stakeholder engagement should occur throughout the process*

scanners and close-range or aerial photogrammetry by underlying the need to define a common reference system to which the different acquisitions should be connected for a shared data access and work interoperability (Croce et al., 2019).

Survey and 3D documentation of the Convent and the surrounding landscape[6] are useful to obtain a measurable model of the building's state-of-the-art. Those investigations are also the fundamental basis for the post-processing and production of the 3D models.

Integrated geomatics survey techniques, suitable means for the representation of the shape and geometry of existing elements, constitute a fundamental resource to be used as a basis for the analyses of restoration, conservation and maintenance of the Cultural Heritage asset (Bitelli et al., 2019, Ebolese et al., 2019).

In this context, digital surveys and digital reconstructions can be useful in forecasting the promotion and the musealization of the architectural object.

3. Diagnostic analysis and 3D reconstruction.

Diagnostic and structural analysis for the reconstruction and restoration project. The documentation of the Convent remains an essential step for the next reconstructive project. The creation of 3D digital models allows the possibility of developing 3D reconstructions useful to analyse and simulate preventive actions and test the constructive rules and the static logic (Thravalou et al., 2021, Kudela et al., 2019). The 3D virtual reconstruction of the different phases of the Convent to be used for the musealization. The digital data acquisition generates a high-resolution 3D model characterised by high precision and accuracy of a few millimetres, both for what concerns the building and part of the landscape which it insists on.

4. Reconstruction and restoration project.

After the documentation/3D reconstruction and virtual simulation, the restoration of the Convent can start. Particularly, the consolidation of the structures and the partial reconstruction of some areas of the building will be carried out. After the preliminary analysis of the remains, the consolidation of the cloister seems to be the best solution for some of the project's final goals. Other areas of the Convent will be partially re-constructed in order to host the musealization service.

5. Musealization of the Convent.

This phase consists of the musealization of the restored building and the setting of the exhibition rooms and areas dedicated to events. In this renovated context, 3D reconstructions, previously developed for diagnostic analysis, can also be used for developing virtual applications aimed at storytelling the past of the Convent and acting as attractors within a systematic project of rehabilitation and sustainable economic development of the areas (Bonacini, 2020).

6. Promotion and sustainability.

The last phase of the pipeline consists of the insertion of the building within the natural and cultural routes through the establishment of facilities and branding of specific local products.

Fig. 11 Project conceptual flowchart of interventions.

Expected results and Impact

Several expected results, impacts on multiple levels (e.g., site, local community, European community) and added values have been foreseen by the establishment and development of this project, and that will help to prove the significance of this study for the conservation and valorisation of the ancient building and its surrounding area. The rehabilitation of the Convent will offer a positive economic and financial return for the local community and the surroundings. In order to obtain this aim, the following results and impacts will be expected.

- Creation of a Cultural and Natural Heritage Atlas

a. Result: the creation of an Atlas that includes natural and cultural routes and positions the building within it will bring benefits on the micro-level. The village of Garrovillas de Alconétar will be connected with its surroundings, the amenities and other attractions of the area[7]. Moreover, the Cultural and Natural Heritage Atlas will create macro connections with the bigger cities of the surrounding area, such as Madrid, Salamanca, and

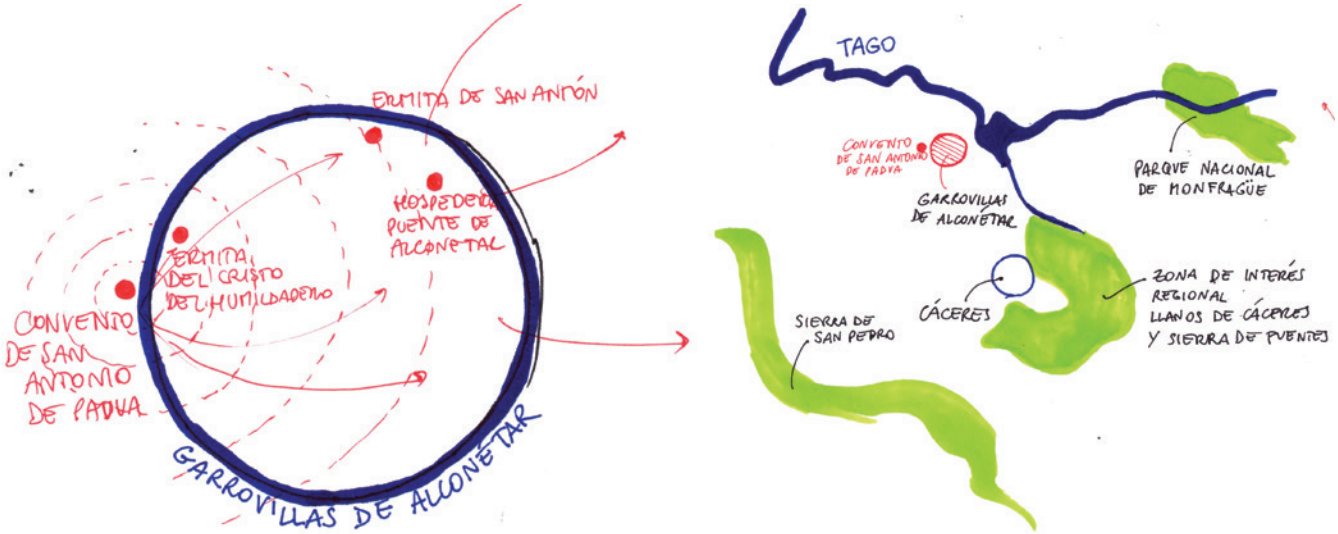


Fig. 12 Schemes for the integration of the Convent in the cultural and natural routes.

Toledo in Spain and Evora in Portugal.

b. Impact: the creation of an Atlas, together with the rehabilitation of the Convent/village and its inclusion within the tourism routes, will bring a light impact on the area in order not to change its rural identity and make the best use of its resources.

- Partial reconstruction of the Convent

a. Result: the reconstruction and restoration of the ancient building will give back to the community its Cultural Heritage.

b. Impact: the restored and reconstructed Convent will again be part of the identity of the community of Garrovillas, bringing new job opportunities, both during the restoration process and during the successive exploitation of the asset.

- Musealization of the building

a. Result: in the restored rooms, the 3D models - previously created for technical purposes (analysis and diagnosis) - can be shown and reused for a diachronic visualisation of the ancient structure and other multimedia solutions. Therefore, the reconstructed part will be dedicated to the musealization of the convent to present the history and archaeology of the building and the area (e.g., Via de la Plata and Roman sites, from Roman to modern times). The new cultural asset/museum will be an attraction to be inserted in the historical and archaeological route of Extremadura.

b. Impact: the musealization of the building enhances the sense of identity of the citizens and their belonging to that culture/area.

- Inclusion in the Astro-tourism route

a. Result: after stabilising the Convent ruins from a static point of view, the building will be included in the 'Red de Miradores'[8] of the night sky list within the Astro-tourism tour.

b. Impact: the insertion of the Convent as a new spot of the network of Miradores will intensify the route, attracting another niche of tourists, particularly photographers, during the night, implementing slow tourism and increasing the request for accommodation in the area. This increase of passages during the night will also drive people to use the accommodation facilities of the Convent neighborhood.

- Creation of an agritourism system

a. Result: at a local level, the involvement of farms and locals is forecasted to improve hospitality while the agricultural areas will be implemented for branding and selling the products of the area, such as olive oil and Porto wine.

b. Impact: the creation of the agritourism system will push ahead of the area's economy without changing its traditional activities since ever dedicated to agriculture. Also, in this case, the inclusion in an agritourism network will enhance slow tourism, not changing the essence of the area. In general, all these expected results will positively impact the local community.

The remaining structures on the site are not sustainable in the long term: they will need to be repaired, reinforced, and protected. This stabilisation work should have a positive environmental impact and create a secure site for visitors. The Convent can be a Cultural Heritage asset and an instrument of social redevelopment: converting the existing structures into usable

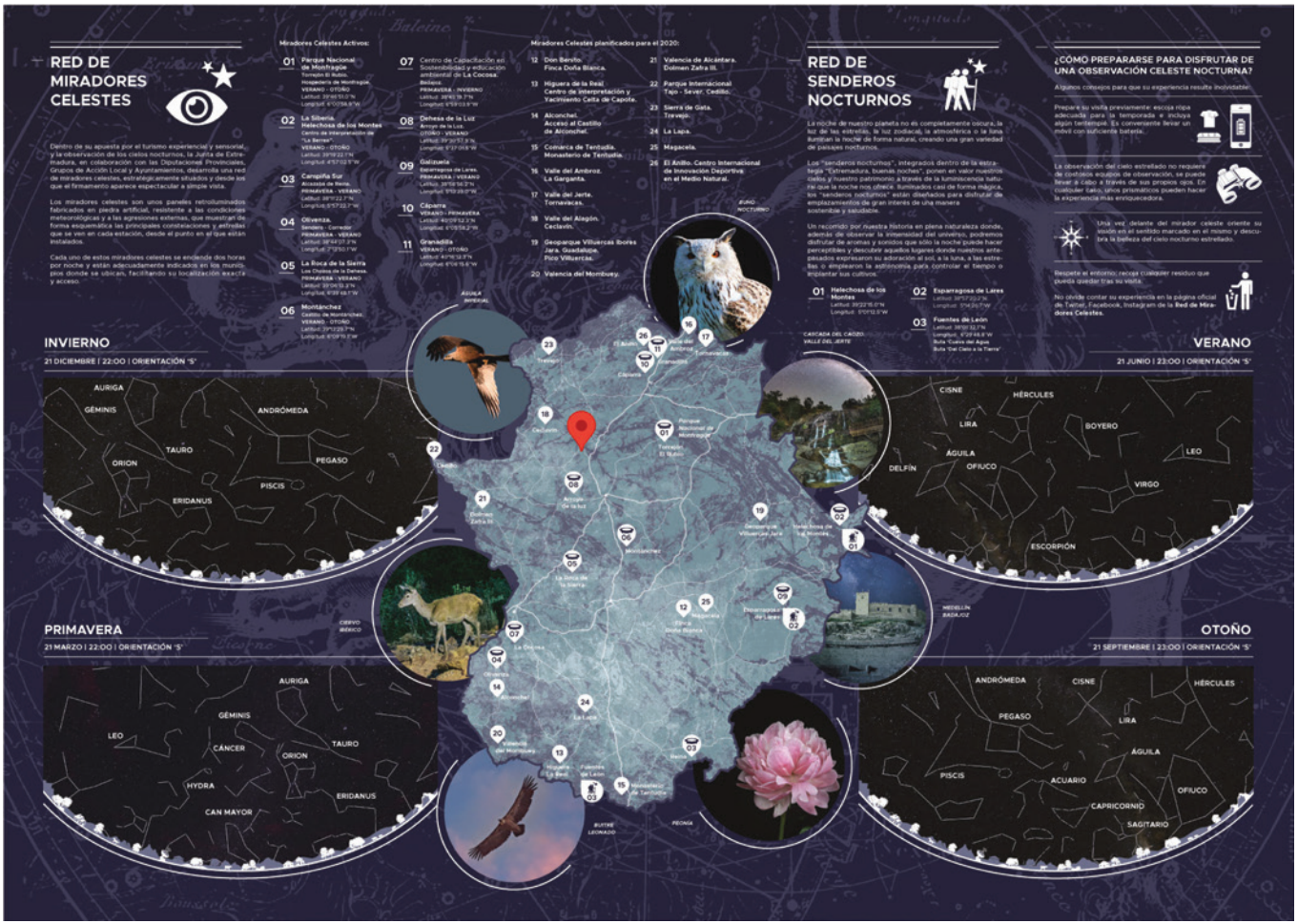


Fig. 13 Red de Miradores: insertion of the Convent (redpoint) in the existing network.

spaces could have a strong positive social impact. Garrovillas de Alconétar is at risk, like many other relatively remote Spanish villages. The Commune sees the region's cultural and social heritage as potential draws for visitors, who will put money into the local economy and arrest its financial and social decline. Moreover, at the European level, the exploitation of a poor area as Garrovillas de Alconétar will stimulate tourism and local productions to create jobs and economic growth.

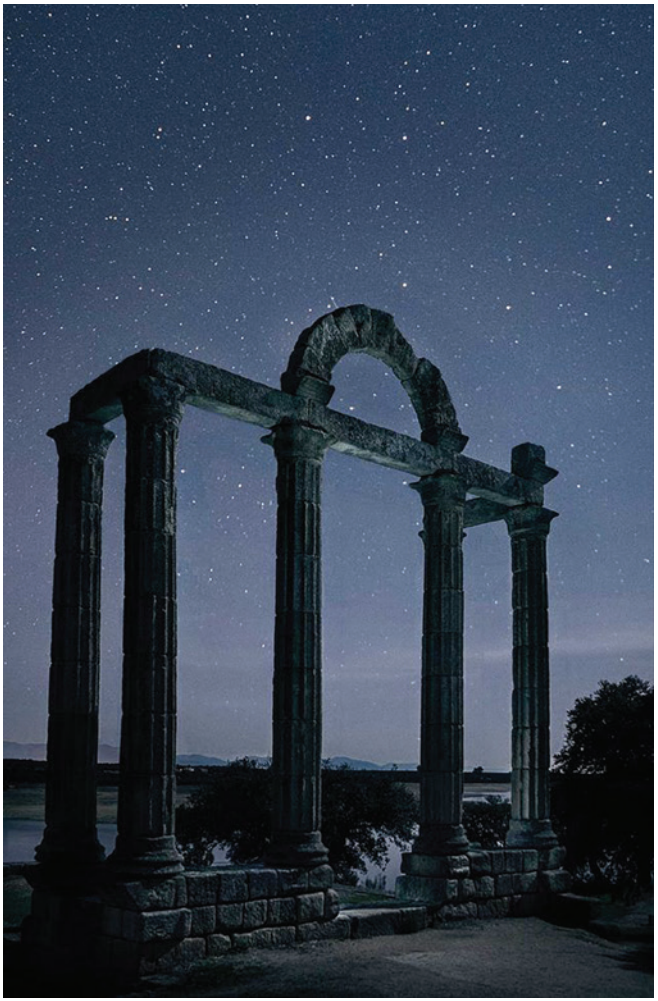


Fig. 14 Mirador celeste (Copyright © 2014-2022 Dirección General de Turismo).

Conclusions

Although Extremadura is one of the poorest cities economically and the least densely populated, it is clear that the presence of the Convent of Saint Anthony of Padua is a vital source for tourism and attracting visitors. The restoration project of this monastery will be an excellent solution for many problems of this city, as it will save the building from collapse and preserve its historical and architectural importance. As stated by Della Torre, *"planned conservation is an innovative procedure, stepping from restoration as an event, to preservation as a long-term process"* (Della Torre, 2010). In this vein, the restored Convent will shed light on the region, bringing an influx of visitors, increasing tourism, and providing job opportunities. The project will lead to a rise in the region's economy. The favourable climate and natural environment of Extremadura, together with its cultural attractions, will be the scenario for attracting continuous tourism throughout the year. In this context, digital technologies and digitisation processes play a key role in developing new multimedia museum attractions and enhanced interpretations of our collective Cultural Heritage while contributing to sustainable economic growth.

Conservation is an indispensable tool for Cultural Heritage protection and preservation since a 'healthy' cultural asset acts as a well-being producer of the area to which it belongs and contributes to the cultural growth of its inhabitants. Moreover, the logic of valorisation of the cultural asset must always be taken into consideration for the purpose of producing an economic circuit. The recovery of the asset takes place not only as cultural enrichment but also as a new economic resource for its surrounding area (Moro et al., 2007).

Notes

1 Ptuj Monastery, Performance centre (https://www.enota.si/projects/2016052609014817/).
2 'Monastery of San Juan Cover / BSA' [Cubierta Monasterio de San Juan / BSA] 17 Mar 2016. ArchDaily. Accessed 6 Dec 2021. <https://www.archdaily.com/783820/cubierta-monasterio-de-san-juan-bsa>. ISSN 0719-8884.
3 Since that is an ongoing work, there are no published results and bibliographic references yet.
4 https://www.geisteswissenschaften.fu-berlin.de/we02/griechisch/byzantinistik/projekte/zypernprojekt/index.html.
5 https://www.4ch-project.eu/.
6 Beyond the 3D documentation of the landscape, this step might also involve the use of a geophysical survey aimed at its archaeological investigation (Clark 1996; Gaffney & Gater 2003; Witten 2006).
7 Beyond the historic structures on the Via de la Plata already mentioned, there are: Plaza de la Constituciòn; Iglesia de San Pedro Apostol – 15th Century gothic church; Convento de Nuestra Señora de la Salud – small convent particular for architectural features; Iglesia de Santa Maria de la Consolaciòn – very early 15th Century church, well restored; Ermita de San Anton – a small restored chapel close to the centre of town; Museo Etnografico – presenting a substantial collection of artefacts based on the different trades of the town and locality; Hospederia Puente de Alconétar – former palace of the Dukes of Alba, now a hotel.
8 https://extremadurabuenasnoches.com/miradores-celestes/la-red-de-miradores/.

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C4

An Intervention and Marketing Proposal for the Monastery of San Benedetto Po in Polirone, Italy

Abstract

The contribution illustrates intervention and proposals for the San Benedetto in Polirone Monastery in San Benedetto Po, Italy. The primary aim of this project is to structure a proposal for the protection and enhancement of the Monastery and the town of San Benedetto Po starting from the state of the art of the Monastery's current condition.

The project aims to suggest cultural valorization, restoration, structural and marketing interventions for local and global visitors. The methodology is the multi - layer cultural analysis, in which several intervention methods are proposed to continue past efforts as well as producing a parametric historic building information model (HBIM) to serve as a global archive. Furthermore, seismic and microclimate monitoring using sensors is suggested to aid the longevity of the historic building, reduce risks, and proactively prepare for future disasters. These enhancement suggestions could provide opportunities for the development of the promotion of local activities, the increase of site knowledge, and the development of tourism systems.

Keywords

Maintenance, Prevention, Cultural heritage, HBIM, San Benedetto Po.

Introduction

Preservation of heritage sites is paramount for their prolonged service life. Unfortunately, many heritage sites face extinction due to a shortage of funds needed to repair and are ultimately left to ruins. Therefore, it is preferred to create a sustainable mechanism that will allow heritage sites a flow of funds, which can be used for their restoration and create a sustainable model that would benefit, and preserve the structure in the long run. One such case study of a Monastery in Italy is being analyzed in this article and ways to preserve it and make it a tourist attraction are analysed. There are several such case studies where a heritage site is being used for works apart from the tourist purpose. For example, the Palace of the Dukes of Braganza in Guimarães, Portugal, is used as a conference organisation venue situated in front of the University of Minho to raise some resources apart from providing sightseeing tours. Another example of Shiv Niwas Palace, located in Udaipur, India, being used as a movie shooting place for Hollywood movies to expose it to other tourism-related activities. A sustainable refurbishment strategy concerning an existing building shall be focused on an adequate preliminary evaluation of the possible impact of the new function or the impact of the spatial and technological changes due to the necessity to adequate the existing building to the users' needs (Morandotti, 2018). This kind of predictive evaluation shall take place in a very preliminary design phase, as only after this assessment design choices aware of the existing building resilience may be deepened (Besana et al., 2018).
The primary objective was to develop the historical and architectural knowledge of the Monastery to structure a proposal for the enhancement and protection.

Historical information

The monastery of Polirone is made up of numerous buildings that were originally intended for the various activities carried out by the monks. The Monastery is part of the list of the 7 Most Endangered Sites of 2013 drawn up by Europa Nostra, The European Voice of Civil Society committed to Cultural Heritage (Europa Nostra, 2013). The Monastery's foundation is due to Mantua Tedaldo di Canossa's count in 1007 a.C. and was dedicated to himself and his wife Willa of Hucpoldingi. The foundation took place thanks to an important donation from the Benedictine monks. They donated a portion of the land between the Po river and the Lirone river, which has now disappeared due to reclamation. From this donation comes the name of the locality, Polirone, which was strategic for the control of river navigation.
The Monastery was a spiritual centre highly significant despite the fact that it was initially formed by a nucleus of 7 monks. The original church, of which few traces remain today, dates back to the mid-11th century when Bonifacio di Canossa, lord of the territory, took care of the construction. Together with the church, Bonifacio had the oratory of Santa Maria built, which still exists today (Museo Civico Polironiano website). The central nucleus is articulated around the cloisters of the Secolari and S. Simeone. The planimetric configuration is irregular, as many spaces have been annexed over the centuries and are owned differently from the municipal one. In a median position with respect to the two cloisters is the church, with the sacristy and the small church of Santa Maria. To this first part are added other autonomous buildings such as the Canossian Convent, two buildings intended for residence, the Refectory and the parish house. These are characterised by a regular longitudinal planimetric layout. The volumes are clearly diversified, both for the presence in some cases of a basement in others of a third level and for the evident dimensional differences between the various buildings. Currently, only three

cloisters remain built and visible: the large refectory, the new infirmary, and the large cloister of the basilica. The small church of Santa Maria remains from the mediaeval period, with a floor mosaic dated 1151. The main reconstruction was made in the 16th century by the architect Giulio Romano, mainly famous for beautiful palaces in Mantova as Palazzo Te. In addition to the reconstructions by Giulio Romano, numerous other valuable elements were added, including a wooden door at the entrance to the complex in 1547, the wooden choir carved by Vincenzo Rovetta (1550), terracotta statues made by Begarelli and some pictorial decorations. The paintings are the fresco on the refectory, which is attributed to Correggio, and a version of the Last Supper made by Girolamo Bonsignori.

The inhabited centre develops on the right bank of the Po river and the buildings nowadays incorporate, and surround the structure of the Monastery. The river and the monastery have played an essential role in the economic importance of the community for centuries. The Monastery has played a religious, political, and cultural role of primary importance in the national history of monasticism, playing a central role in Italy. The Monastery had this role until 1797, when Napoleon Bonaparte suppressed it (Museo Civico Polironiano). From 2006 to 2012, the architectural complex of San Polirone underwent a conservative and functional restoration. Unfortunately, a few months before the ending of the restoration works, an earthquake seriously damaged all the buildings of the monastery (Belmondo, 2018).

Fig. 1 In the image: location of San Benedetto Po in Polirone and the Abbey. The monastic complex occupies the center of the town and defines the main square.

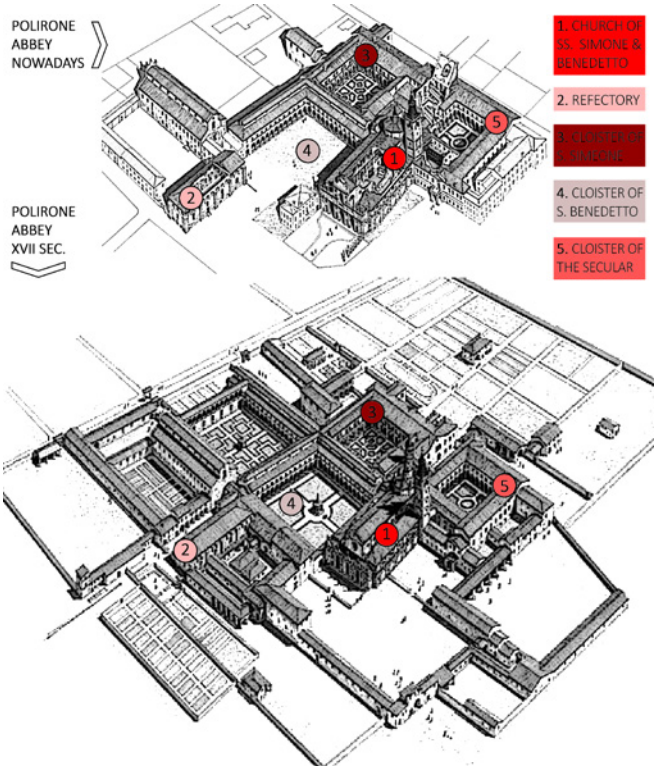


Fig. 2. The abbey is made up of numerous areas that differ from each other in terms of construction period, primary function and restoration work carried out. The current conformation is the result of the last important restoration intervention carried out by the famous Italian architect Giulio Romano (1499-1546) (Confortini).

State of the art: past interventions and restorations

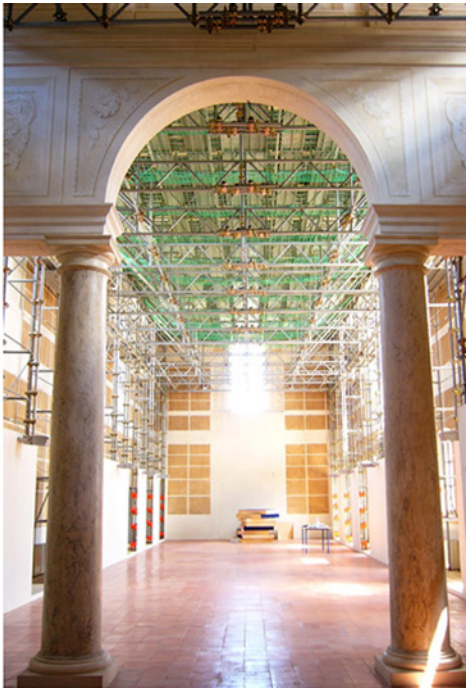
The territory and the architecture of the Monastery were heavily damaged during an earthquake that occurred in May 2012. Starting in the following years, a series of initiatives aimed at securing the complex began, but given the dimension of the Monastery and the extensive damage, the restoration was complex. Today the various buildings that make up the Monastery of San Benedetto Po are largely strictly interconnected but nevertheless are the responsibility of three distinct owners, which have made the interventions more complex:

- state authorities - external damage with risk to the public;
- parish of San Benedetto Po - internal damage to the Basilica and Oratory;
- municipality of San Benedetto Po - internal damage to the remaining buildings.

The municipality has activated interventions that have as a priority the completion of the restoration of the museum and the refectory, to reopen for tourists (Europa Nostra, 2013). Since 2013, renovation and seismic consolidation works have been activated with an opening in 2015. The rest of the complex underwent restoration in the years 2015 and 2016. In 2016, the complex suffered further damage following another earthquake. Despite the critical situation, the Monastery remains a cultural place of identity of the territory. An ordinance of the Lombardy Region (D.Lg. 12677 - 29/10/2020) made it possible to obtain funds to proceed with the structural and restoration works. The works were divided into two parts: the first relates to the structural works and the second to the consolidation of the decorations (Berlucchi & De Vito, 2014). The first involves several steps, including the restoration of wall continuity, the repair of cracks, the encircling of the spire and the floor above the lower vault, the consolidation with tie rods of the angular pillar at the base of the bell tower. The second foresees the consolidation of the terracotta elements and the cleaning of the exposed brick facings. In addition to conservative restoration operations, works aimed at securing and extraordinary maintenance of the technical and technological elements, and the metal structure of the belfry (Europa Nostra, 2013). The current situation of the Monastery can benefit from a promotion and enhancement plan, which not only focuses on

(Right, above) Fig. 3 View of the main facade of the monastery church with, on the right, detail of the rich decorations that adorn the interiors.

(Right, belowe) Fig 4 Interventions administered after the earthquake of 2012 (Images taken from the Berlucchi & De Vito, 2014).



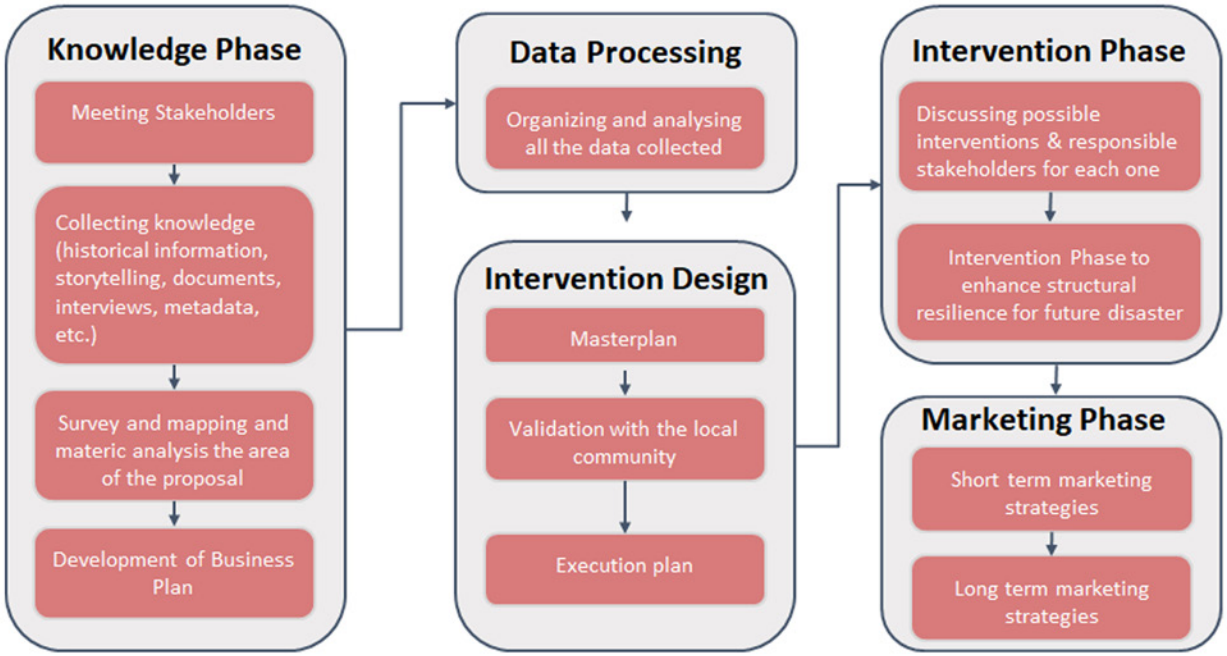


Fig. 5 Method followed to carry out the activities of enhancement and new functionalization of the Monastery.

building interventions but is aimed at activating a tourist and cultural flow for the benefit of the entire territory. The project-based on the current state of the art aims to integrate research methodologies for the proposal of intersectoral strategies for the conservation of Cultural Heritage through digital practices.

Objectives and main strategy

A thorough historical review of San Benedetto Po Monastery implies many significant challenges that the complex continues to endure since its early history to this day. Some challenges are natural given the monastery's context. On the urban level, the complex covers a large area of a small town with a low population density which imposes financial and resource constraints. On the regional level, the small town is close to Mantua and lies between well-known cities such as Venice, Padua, Bologna, and Milan. Thus, it is understandable that the town gets such little recognition as compared to those cities. Other challenges are a result of circumstances such as natural disasters. Earthquakes have severely damaged the complex. As such, intervention work is required to increase the complex's resistance to future earthquakes.
This unique combination of circumstances creates a complex environment to work in. Stabilising the complex seems to be the priority, but the context and overall enhancement of the cultural assets and their respective context are also significant. Thus, the general aim of this proposal is to aid in transforming San Benedetto Po Monastery into a visible attraction for local and international visitors. This aim is planned to be achieved through Condition assessment of the building post-earthquake and after intervention - to

increase earthquake resistance; Production of Digital Model (HBIM) as an archive of all intervention (past and future), to overcome current difficulties in managing the stakeholders and the site, real-time monitoring of assets to proactively solve issues on-site and plan in case of future crises; and to device Marketing strategies for short and long terms.

Methodology and Digital applications

Multi-level Cultural Analysis

Since its conception in 1007, the Monastery has undergone many changes. From its redesign by Giulio Romano in 1540 to its suppression in 1797, the site was a vital centre for religion, culture, and art (Belmondo, 2018). The complex held strategic importance because it used to dominate the course of the river Po. A look at the current map shows that the current river is far from the town, which indicates a change of its natural course. Furthermore, the ratio of the complex area to the small town illustrates how dominating it is within the context. Thus, it seems crucial to focus not only on the Monastery but also on the multi-levels it lies within, these levels are:

- the individual assets of the complex, and the relationships between them;
- the municipal relationship between the complex and the town of San Benedetto Po;
- the provincial relationship between San Benedetto Po and surrounding towns;
- the regional relationship between the town and surrounding large cities.

These relationships are crucial to shaping strategies with positive outcomes on the complex and its context. The individual assets interact with each other using pathways, luscious gardens, and intersection spaces, each with a story to tell. The municipality (population 7,700) is among the sparsely populated areas in rural Italy where the population has decreased since the end of the Second World War (Europa Nostra, 2013). This could reflect a unique relationship between

Fig. 6 Map illustrating the current San Benedetto Po municipality's relationship with the river Po, mains street and urban context.

a small society and a site that interchangeably affects each other. This relationship is hard to wholly grasp by exterior observers, as local, empathetic experience is essential to provide sensible interventions.

The next level is between San Benedetto Po town and the other towns around it such as Mantua, Suzzara, Pegognaga, and Revere, Borgo Mantovano. These towns could be later empowered and joined together in ventures that market them as significant sites in the Italian cultural scene. The last level is between the town and large cities in the region such as Bologna, Padua, Venice, and Milan. These cities receive extraordinary tourism which could negatively affect their heritage. As such, enhancing small towns such as San Benedetto Po could aid in the sustainable distribution of tourism within this region.

Earthquake Damages

Historic structures, especially which can create employment through museum visits and other related activities, should be thoroughly evaluated, and reliable damage assessments should be performed to carry out proper intervention solutions. Failure to undertake a

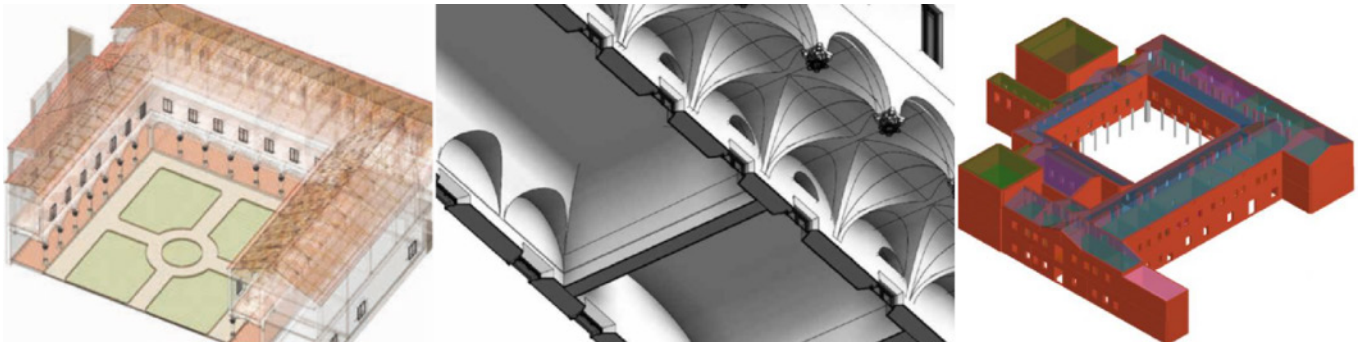


Fig. 7 An example of a BIM system and three-dimensional modeling achievable for the Monastery of San Polirone (Belmondo, 2018).

correct-time diagnostic may reduce the cultural value of historical buildings, affecting people's livelihoods and the cultural identity of people and towns linked with these structures. The site under consideration is such a structure, which was damaged owing to a recent earthquake event. In general, the intervention process in ancient historic structure is always cumbersome owing to uncertainty at various levels such as establishing the mechanical properties of materials, connection details, structural elements and their heterogeneous constructions over a period of time, rather than in one go, that is the case of our modern constructions. The site was hit by a recent earthquake in May 2012, that led to the damages in the structure and the damages to artwork including, frescos, ceiling, and wall paintings. The damages pose a threat to the integrity of the monastery complex If not intervened might lead to the collapse of some parts of the monastery, thus permanent access to building parts. Furthermore, the earthquake caused risks that could lead to walls being detached from the vaults, even the vaults stability is compromised and the loosening of tie-wall connections in the corridors. Soon after the earthquakes of 20th and 29th May 2021, the various damages in the San Simeone, which is the first-floor headquarters of the Polironiano museum, were categorised. Main inspections were carried out for ceilings and walls as the ceiling frescoes are attached to wooden vaulted structures with the following observations (Europa Nostra, 2013):

- the stability of the wooden vaulted structure assessment showed 70% minor damage and 30% major damages;
- several cracks in the vaults, frescoed and aisle walls were observed on the Church of Santa Maria. The entry staircase leading to the Polironiano Museum had some detached fragments of the statues and in-depth sessions between the ceiling and the wall structure. On the east side wall, a severe crack was observed;
- the crack in the ground floor vault was also caused due to the earthquake and posed some risk to paintings. The cracks need to be catalougued according to their severity and classified from very thin to severe cracks as this is essential for the damage diagnosis to be performed;
- museum offices were also diagnosed with cracks at the beams supporting the ceiling panels;
- the inspection results recommended several interventions and suggestions, such as solving the problem of water infiltration in the masonry of San Simeone Cloister;

The end results of the inspections were to make the structure safe and to prevent its further damage. It was decided to make the structure safe in accordance with current European earthquake provisions (EN-1998), for which €1.8 million was financed.

HBIM

Building Information Modelling (BIM) is often implemented to satisfy collaboration needs in simple and complex projects. This becomes useful in heritage buildings, where key stakeholders could include owners, operators, state, municipality, national, international bodies, and more. In the case of San Benedetto Po Monastery, ownership falls under three separate owners: the State, the Municipality, and the Parish, which created considerable challenges to restoration projects (Europa Nostra, 2013). Furthermore, ownership and control over these assets are adjoining or mixed in certain areas, which blurs the interaction between the three entities. Europa Nostra reported significant schedule and cost overruns due to disputes over access rights, responsibilities, and ownerships. Thus, the usage of Heritage BIM (HBIM) here is suggested not just as a set of digital tools, but also as the overall process to manage information, roles and ownerships carefully during the project and operational phase.

HBIM is a set of standards, processes, and tools that manage both graphical and non-graphical information often obtained from site visits, research, archives, and entities or individuals who control, inhibit, or own the site (Stober et al., 2018). These individuals are often multi-disciplinary including architects, historians, archaeologists, managers, and owners, who play key roles in providing, managing, and analysing heritage information. Scientific literature has encouraged working with an HBIM framework to improve the gathering, documentation, and implementation of heritage information (Jordan-Palomar et al., 2018). In addition to technical tools, HBIM provides a framework of high transparency and clarity that could coordinate complex responsibilities and authority levels of a project such as San Benedetto Po Monastery. In this context, HBIM would provide two main purposes:

a. Process Purposes: given the considerable disputes and delays in the past restoration projects, a change of approach is needed to minimise conflicts focusing on collaborative teamwork, transparency, and interoperability. In this project, where various stakeholders engage with the complex in various levels of authority, interest, and responsibility, introducing a Common Data Environment (CDE) could provide significant benefits. CDE is a central platform where all project information is hosted, the content of the CDE includes documents, graphical models, non-graphical information, and more (NBS, 2016). Using this platform as a single source of truth with clear reporting lines, approvals, and authorization cycles should enhance team collaboration, reduce mistakes and duplications. Furthermore, HBIM ensures stakeholders' engagement through interoperability operations, software such as ArchiCAD and Revit have exporting features that could transform captured data into more conventional formats such as excel sheets (Moyano et al., 2020). In addition, the emergence of Industry Foundation Classes (IFCs) as a 3D open exchange format further reinforces the interoperability of the HBIM approach. Such features aid in the engagement of team members even if they are not from the Architecture, Engineering, and Construction (AEC) industry. This is crucial since San Benedetto Po holds architectural, artistic, movable, and immovable heritage, which needs an interdisciplinary management approach. As such, the proposed system is a holistic approach using 3D models that are saved in both native and IFC formats, open-code protocols, and a CDE to link all the databases together, thus allowing adequate management.

b. Technical Purposes: in principle, the concept of HBIM revolves around reverse-engineering the geometrical aspects of the asset through major data capturing using modern technologies (Yilmaz et al., 2007). Following this process, the model is enriched with non-graphical data representing a crucial part of the asset's history, properties, and significance. The levels of detail and information depend on the model's intended use. In the case of the Monastery of San Benedetto Po, this process should be oriented not only towards documentation but also for the operation of the complex.

Considering future risks, the resulting model could be used for preventative risk management and informed decision-making. Furthermore, the resulting model could also be used for the site's overall marketing using Virtual Reality tours and immersive experiences.

Conservation Work

The previous conservation works carried out on the San Benedetto Po were mainly focussed on improving the existing structure's load-carrying capacity and making it earthquake resistant to some capacity. The priority of the conservation works aimed to secure the structure from further damages and deterioration that might lead to the collapse/weakening of some parts in the future. Several conservations were carried out as listed below:

- as discussed in section 'Earthquakes Damages', after the earthquake crack survey was carried out in which severe cracks were identified during the inspection. To arrest the propagation of these cracks post-earthquake, consolidating mortar was injected throughout the several cracks to stop their further growth;
- the material filling the sides of vaults was removed and replaced with lightweight material;
- the mechanical behaviour was also improved with the insertion of new steel ties;
- all wooden architraves have been verified and replaced;
- some pillars behind the altar have already had to be underpinned by a series of micropiles to a depth of 10m to prevent further sinking of the north side of the nave that had already sunk several centimetres.

Although several works are carried out, there is a need for the conservation work that is permanent in some instances. Some of the conservation works hinder visitors' passage, such as the wooden braces (A-shape) to strengthen the structure and are not aesthetically pleasing.

Monitoring

Monitoring microclimate plays a vital role in the longevity of the assets of a historical building such as museums where important artifacts are preserved. In this regard, monitoring microclimate (mainly relative humidity and temperature) is essential to safeguard the assets for long periods. Long-term deterioration in historic buildings is caused by a mix of elements, including internal climatic factors such as relative humidity, temperature, fire, moisture intrusion, pests, and UV radiation. The degradation process of assets such as books and ancient manuscripts is accelerated for the historical buildings, owing to excessively high temperatures. Several researchers have carried out research works in this area, and some of the investigations were carried out in the present case study. In their review paper, Mishra et al. (2021) summarised the monitoring works carried out in the Cultural Heritage sites using Internet of Things (IoT)-based sensors. For example, Tse et al. (2020) monitored parameters such as the internal temperature, humidity, and air quality inside a museum in Portugal. The authors deployed a self-adaptive system, whose sensors switched off when they were not in use and when the museum was closed to the public. Other researchers, for example, Sanchez et al. (2020), deployed a system named PlusCare for the library of the University of Salamanca, integrating IoT technology, 360-degree images of monuments, and laser scan data. The PlusCare system monitors 27 such parameters through sensor hotspots, which display real-time values on a structural health monitoring system. Maksimovic et al. (2019) deployed a structural health monitoring system with numerous sensors each measuring a church's various climatic and vibration characteristics to improve the microclimate within the church. A Church in Spain was monitored for temperature and relative humidity values by Perles et al. (2018) to identify objects inside the monument that could be affected by adverse values of monitored parameters. Owing to the recent advancements in microclimate monitoring, it is suggested that Library in the San Simeone Cloister could be preserved by online monitoring of assets using the aforementioned sensor nodes.

Curto & Grimoldi (2006) surveyed San Benedetto Monastery for three years to collect data on the thermal

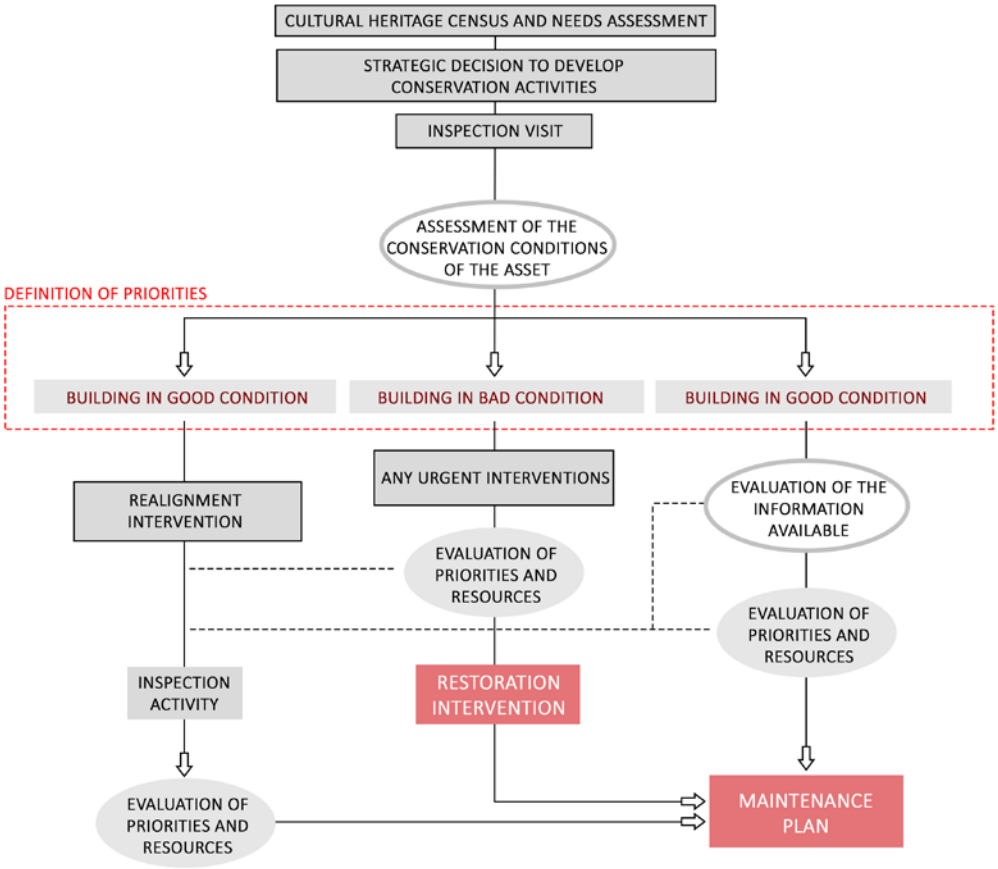


Fig. 8 The maintenance and conservation program of the built heritage follows different approaches based on the initial conditions of the object in question. The diagram shows some possible steps for the action method. The steps have been developed following the indications of the Italian regulations (Gasparoli, 2012).

gradients between the masonry and microclimate for damage diagnosis. The study aims to identify the areas where water seepage is dominant and thus reduce the number of core sampling tests throughout the masonry. It was found out from the water level diagrams that the excessive moisture is confined to a maximum of 70 cm height from the ground surface. Hence, based on the previous works also, it could be recommended to solve the problem of water infiltration in the masonry of San Simeone Cloister to avoid any further damage. The same intervention solution that worked for the basilica can be regarded as a promising intervention where an impermeable membrane was laid beneath the terracotta tiles to prevent water infiltration. Hence, long-term benefits under sustainability criteria can be obtained by inserting impermeable membranes under the roof tiles. Furthermore, several non destructive state-of-the art technologies that have been adopted

for various historic structures before, such as laser scanning (Armesto-González et al., 2010, Napolitano et al., 2019), ultrasonic pulse velocity (Akoglu et al., 2020), displacement transducers and thermo-hygrometers (Blanco et al., 2018), ground penetrating radar (Ludeno et al., 2020), unmanned aerial vehicles (Germanese et al., 2018) and photogrammetry (Jahanshahi & Masri, 2013) can be deployed for the damaged location within the Monastery.

Marketing Strategy

When discussing marketing strategies for the site, the challenge changes from merely preserving the value and transforming that value into a resource. The difference between the two is that value is preserved because of its importance for future generations, while a resource is a value being used to generate benefits while conserving its original essence (Zetti, 2010). As such, the strategy proposes merging technical efforts with local participation to produce sustainable strategies. Thanks to the development of immersive technologies, it has become possible to discover heritage within digital environments that represent it with a high level of detail and information (Lee et al., 2019). Thus, the produced HBIM data could be tailored and made available for users to interact using devices such as joysticks or touch displays. This type of experience favours progressive discovery and transforms the HBIM model from a research product to a means of marketing the complex to the public even before visiting (Banfi, 2021). Engagement Methods such as community discussions, collective surveys,

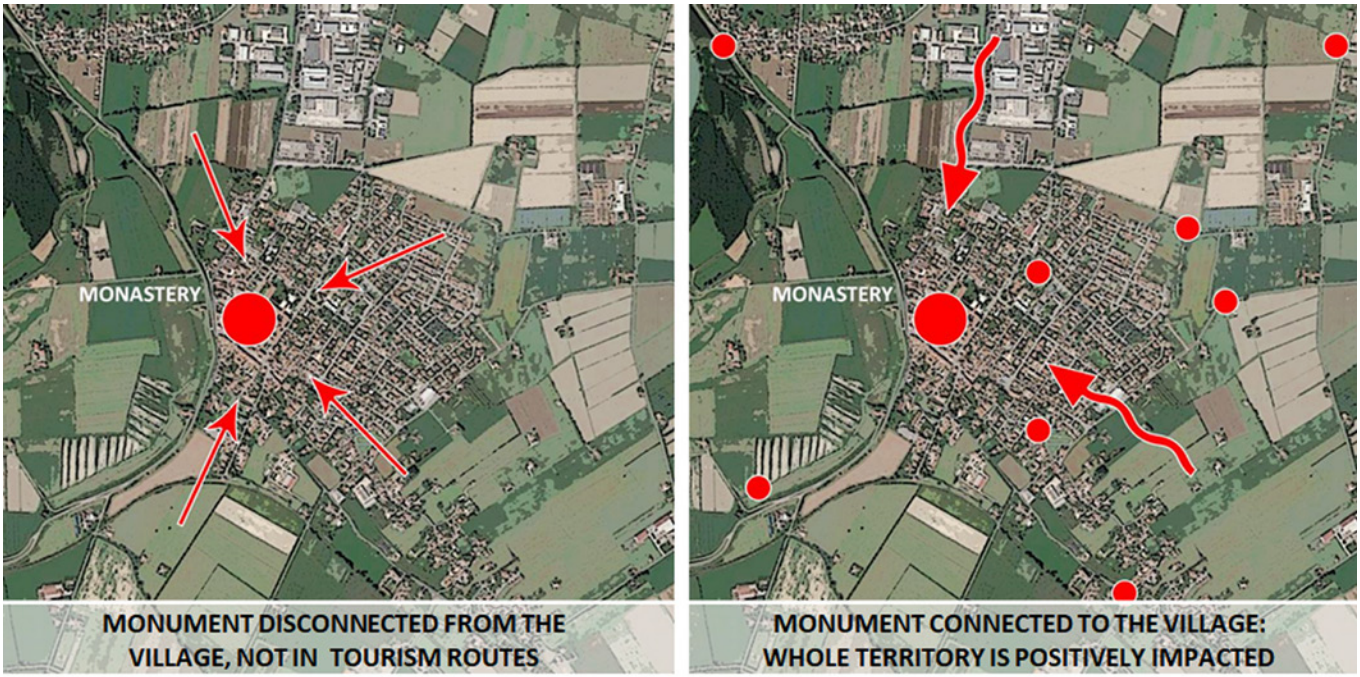


Fig. 9 The current situation of the Monastery can benefit from a promotion and enhancement plan, which not only focuses on building interventions but which is aimed at activating a tourist and cultural flow for the benefit of the entire territory.

collection of local tales and memories would enrich the marketing strategy and ensure social inclusivity. Thus, marketing strategy could be devised as follows:

1. SHORT TERM
- Coordinating with the three stakeholders to use suitable spaces to host events such as weddings, celebrations, or scientific conferences organised by close Universities (such as the University of Pavia in Mantova);
- using the HBIM model to provide VR and mixed reality experiences to enable remote visits;
- the inclusion of the local community by holding educational workshops, summer schools, and seminars;
- use of social media to increase the visibility of the Monastery and town.

2. LONG TERM
- Organising annual festivals celebrating the Monastery. It could start on 9 March as this is the date Napoleon suppressed the monastery in 1797 to resemble the site's resilience;
- enrich the visiting experience by celebrating historical figures who are linked to the site like Giulio Romano, Matilde the great countess, and Benedetto Fontanini;
- inscription on national and international heritage lists, possibly representing the site and all the small towns around it as one world heritage site.

Expected results and impact

The valorization of built Cultural Heritage is necessarily connected to the policies and practices of use, fruition, and protection. These activities are sanctioned by the Italian Constitution, which indicates implementation by ensuring the conservation of the heritage and promoting its public use (Gasparoli, 2012). The practice of architectural conservation can start from the diagnosis of the state of conservation of cultural assets, considered inseparably within their context, anticipating the need for a procedural and systemic vision of the problems (Cecchi, 2006). The broad and varied definitions of valorisation both in the state of the art of literature and in the legislative context of the Italian territory are complex to define a complete and standardised synthesis.
Valorization can be the primary goal of the conservation process of Cultural Heritage and as a set of actions defined and coordinated in time (intervention schedule), which aim to increase the quality and identity of the individual heritage. These enhancement processes are opportunities for the development of the promotion of local activities, the increase of data and knowledge and the development of tourism systems (Montella, 2009). The realisation of these projects requires multidisciplinary contributions, with economic and managerial evaluations and with participation policies that involve local populations in the processes of recognition of values and development opportunities (Della Torre, 2008).
Starting from these assumptions, the project proposal was conducted to enhance the architectural site and create a tourist and cultural flow that can experience the Monastery and also the village of San Benedetto Po in Polirone at different times the day and year by activating an extended enhancement. The short term results and goals concern different scientific and disciplinary fields:
- architectural field: activate structural safety systems of the building as monitoring of the structures in the event of future earthquakes;
- preventive management and maintenance field: activation of a real-time monitoring system for damage control and recovery management; creation of an HBIM information system for scheduling maintenance and recovery actions.

Based on the activities structured in the action methodology, long-term objectives have also been structured, such as:
- enhancement of the cultural heritage: monastic complex as an aggregating place of culture that interacts deeply with its community; development of widespread and sustainable tourism in the area;
- San Benedetto Monastery as an attraction for local and international visitors: the town will benefit from the financial income generated by visitors,

events, and public use of its assets; creation of job opportunities for the local community; linking San Benedetto to the Italian cultural scene as a cultural central area on the territory.

Conclusions

The valorization and scheduled maintenance activities require a distinction between the goals and the tools necessary to achieve them. Therefore, it is necessary to clarify that the purpose of this project is to propose a course of action to limit the single and unrelated actions over time, to promote building maintenance and touristic valorization as a daily and constant activity over time. This study analysed the Monastery from individual and urban levels to draw sensible enhancement strategies that preserve the site's essence and celebrate it within its unique context. Careful examination of past literature illustrates the various challenges the site undertakes. From natural disasters to managerial disputes, interventions were often delayed and reactive. This project sought to design proactive interventions that aided the asset in future crises. Furthermore, interventions should not hamper the movement of tourists and should be sought as permanent solutions instead of temporary ones. Preservation of assets and increasing their longevity through micro-climate monitoring and choosing the appropriate temperatures and relative humidity environments will aid in increasing the service life of these non-structural assets, although important in terms of Cultural Heritage preservation.
Furthermore, this proposal went beyond physical intervention and suggested process changes that could aid in clarifying authority, responsibilities and minimise disputes. Although preserving the complex is crucial, cultural enhancement is also significant to provide financial and awareness support for the small town. Marketing strategies were drawn both in the short and long term to celebrate the complex and acknowledge its incredible value. Future research could focus on the actual impact of this strategy and tailor it further using local community input.

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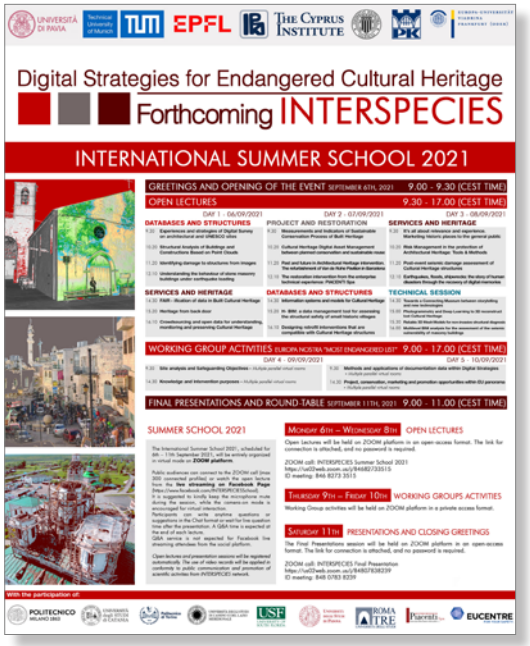
Summer School Structure

PROGRAM AND REPORT OF THE SUMMER SCHOOL

STRUCTURE OF THE EVENT



The International Summer School 2021, scheduled for 6th – 11th September 2021, will be entirely organized in virtual mode on **ZOOM platform**.

Public audiences can connect to the ZOOM call (max 300 connected profiles) or watch the open lecture from the **live streaming on Facebook Page** (https://www.facebook.com/INTERSPECIESSchool).
It is suggested to kindly keep the microphone mute during the session, while the camera-on mode is encouraged for virtual interaction.
Participants can write anytime questions or suggestions in the Chat format or wait for live question time after the presentation. A Q&A time is expected at the end of each lecture.
Q&A service is not expected for Facebook live streaming attendees from the social platform.

MONDAY 6TH SEPTEMBER 2021 — DAY 1

Morning Session — **DATABASES AND STRUCTURES**

9.30 - 10.20 — **Experiences and strategies of Digital Survey on architectural and UNESCO sites**
Sandro Parrinello
University of Pavia (Italy)

10.20 - 11.10 — **Structural Analysis of Buildings and Constructions Based on Point Clouds**
Ernst Rank, Laszlo Kudela, Stefan Kollmannsberger
Technical University of Munich (Germany)

Break

11.20 - 12.10 — **Identifying damage to structures from images**
Bryan Pantoja Rosero
Ecole Polytechnique Fédérale de Lausanne (Switzerland)

12.10 - 13.00 — **Understanding the behaviour of stone masonry buildings under earthquake loading**
Katrin Beyer
Ecole Polytechnique Fédérale de Lausanne (Switzerland)

Afternoon Session — **SERVICES AND HERITAGE**

14.30 - 15.20 — **FAIR - ification of data in Built Cultural Heritage**
Sorin Hermon
The Cyprus Institute (Cyprus)

15.20 - 16.10 — **Heritage from back door**
Cecilia Bolognesi
Politecnico di Milano (Italy)

16.10 - 17.00 — **Crowdsourcing and open data for understanding, monitoring and preserving Cultural Heritage**
Cettina Santagati
University of Catania (Italy)

17.00 - 17.15 — **Roundtable and closing of day 1**

TUESDAY 7TH SEPTEMBER 2021 — DAY 2

Morning Session — PROJECT AND RESTORATION

9.30 - 10.20 **Measurements and Indicators of Sustainable Conservation process of Built Heritage**
Jolanta Sroczynska
Cracow University of Technology (Poland)

10.20 - 11.10 **Cultural Heritage Digital Asset Management between planned conservation and sustainable reuse**
Marco Morandotti
University of Pavia (Italy)

Break

11.20 - 12.10 **Past and future in Architectural Heritage intervention. The refurbishment of the Mies Van de Rohe Pavilion in Barcelona**
Luis Manuel Palmero Iglesias
Universitat Politècnica de València (Spain)

12.10 - 13.00 **The restoration intervention from the enterprise technical experience: PIACENTI Spa international projects**
Giammarco Piacenti
Piacenti SpA (Italy)

Afternoon Session — DATABASES AND STRUCTURES

14.30 - 15.20 **Information systems and models for Cultural Heritage**
Maurizio Marco Bocconcino
Politecnico di Torino (Italy)

15.20 - 16.10 **H- BIM: a data management tool for assessing the structural safety of small historic villages**
Assunta Pelliccio
University of Cassino and Southern Lazio (Italy)

16.10 - 17.00 **Designing retrofit interventions that are compatible with Cultural Heritage structures**
Savvas Saloustros
Ecole Polytechnique Fédérale de Lausanne (Switzerland)

17.00 - 17.15 **Roundtable and closing of day 2**

WEDNESDAY 8TH SEPTEMBER 2021 — DAY 3

Morning Session — **SERVICES AND HERITAGE**

9.30 - 10.20 — **It's all about relevance and experience. Marketing historic places to the general public**
Izabella Parowicz
Europa-Universität Viadrina (Germany)

10.20 - 11.10 — **Risk Management in the protection of Architectural Heritage: Tools & Methods**
Jolanta Sroczynska
Cracow University of Technology (Poland)

Break

11.20 - 12.10 — **Post-event seismic damage assessment of Cultural Heritage structures**
Ilaria Senaldi
EUCENTRE Foundation (Italy)

12.10 - 13.00 — **Earthquakes, floods, shipwrecks: the story of human disasters through the recovery of digital memories**
Elisa Bonacini
IDEx, University of South Florida (U.S.A.)

Afternoon — **TECHNICAL SESSION**

Interdisciplinary and creative applications of Digital Strategies on Heritage

14.30 - 15.00 — **Towards a Connecting Museum between storytelling and new technologies. The 'Connessioni Museali' Project between Spoleto and Valnerina.**
Giulia Bassetti
University of "Roma Tre" (Italy)

15.00 - 15.30 — **Photogrammetry and Deep Learning to 3D reconstruct lost Cultural Heritage: extracting 3D metric information from historical images**
Francesca Condorelli
University of Padova (Italy)

15.30 - 16.00 — **Reliable 3D Mesh Models for non-invasive structural diagnosis: certification and applications for structural risk purposes on Built Heritage**
Raffaella De Marco
University of Pavia (Italy)

16.00 - 16.30 — **Multilevel BIM analysis for the assessment of the seismic vulnerability of masonry buildings**
Marco Saccucci
University of Cassino and Southern Lazio (Italy)

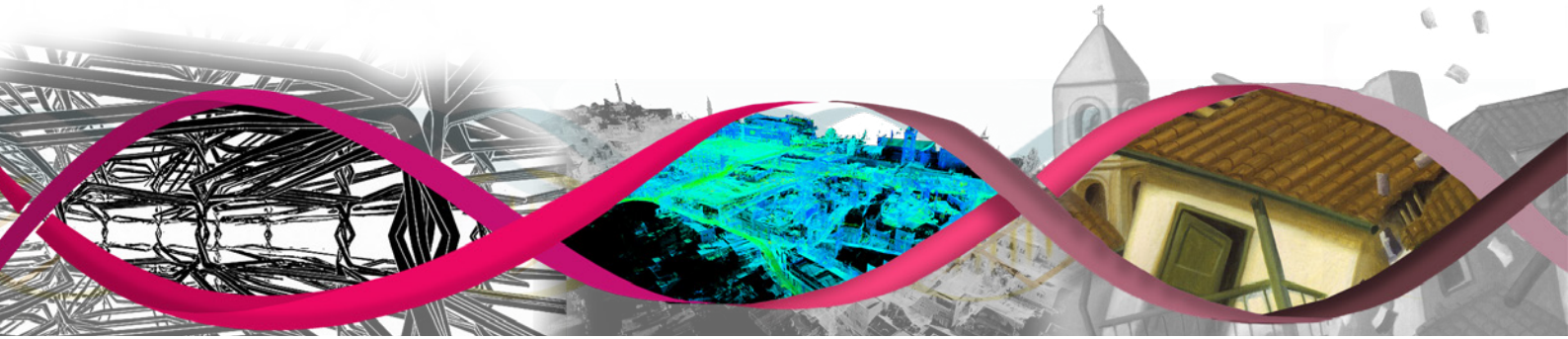
THURSDAY 9TH SEPTEMBER 2021 — DAY 4

MORNING — Site analysis and Safeguarding Objectives

9.30 - 10.30	**Peer-learning discussion**
10.30 - 11.15	**Presentation and organization of Final Assignment modalities**
11.30 - 13.00	**Working groups activities** Virtual rooms for group discussion: presentation of participants and assignment of MAIN THEME and CROSS-FERTILIZING THEMES
Closing goal	**Assignment and contextualization of the Case Study for each group**

AFTERNOON — Knowledge and Intervention purposes

14.30 - 15.30	**Peer-learning discussion**
15.45 - 17.00	**Working groups activities** Virtual rooms for group discussion: definition of main objectives for site prevention, research on references and purposes of intervention
Closing goal	**Definition of Cross-disciplinary Frameworks to support strategic aims**



FRIDAY 10TH SEPTEMBER 2021 — DAY 5

MORNING — Methods and applications of documentation data within Digital Strategies

9.30 - 10.30	**Peer-learning discussion**
11.30 - 13.00	**Working groups activities** Virtual rooms for group discussion: comparison on data, documentation strategies, application of data, necessary information, project requirements.
Closing goal	**Flowcharts of Interdisciplinary data correlations**

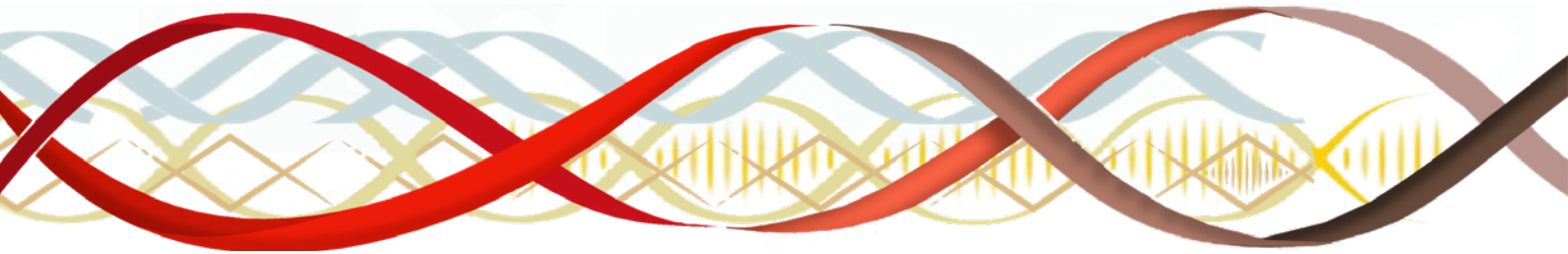
AFTERNOON — Project, conservation, marketing and promotion opportunities within EU panorama

14.30 - 15.30	**Peer-learning discussion**
15.45 - 17.00	**Working groups activities** Virtual rooms for group discussion: marketing and conservation outputs, strategy of intergration in EU/Worldwide programmes for Safeguarding objectives (reconnection with starting themes of the school)
Closing goal	**Foreseen applications and results of the proposed strategies** **Review of presentations for the Final Assessment**

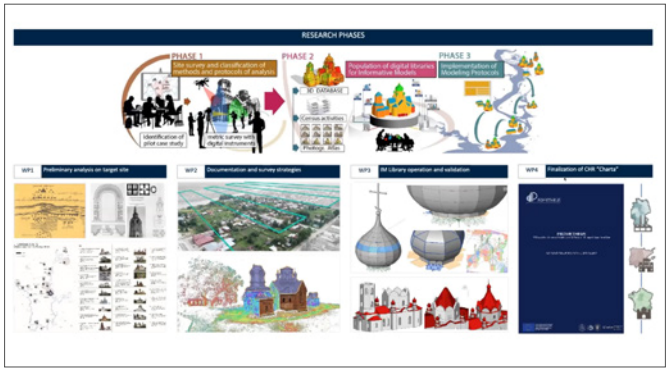
SATURDAY 11TH SEPTEMBER 2021 9.30 - 12.00 **Presentations and Closing Greetings** — DAY 6

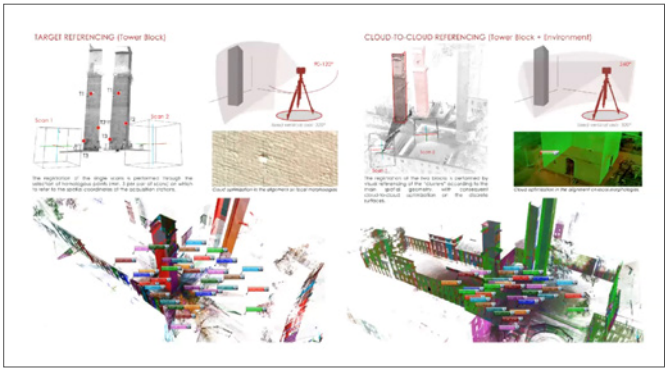
Open Lectures

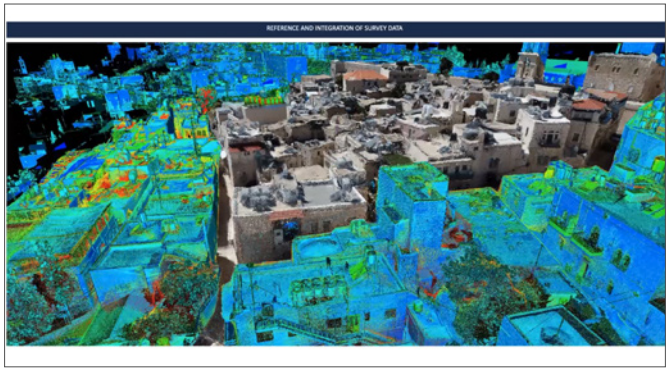
Abstracts

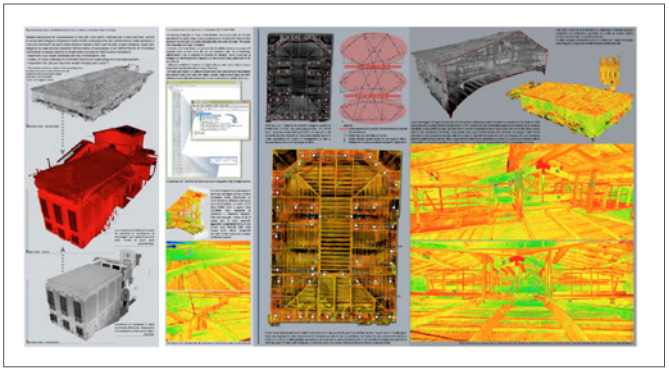


Experiences and Strategies of Digital Survey on Architectural and UNESCO sites









Sandro Parrinello

University of Pavia, Pavia (Italy)

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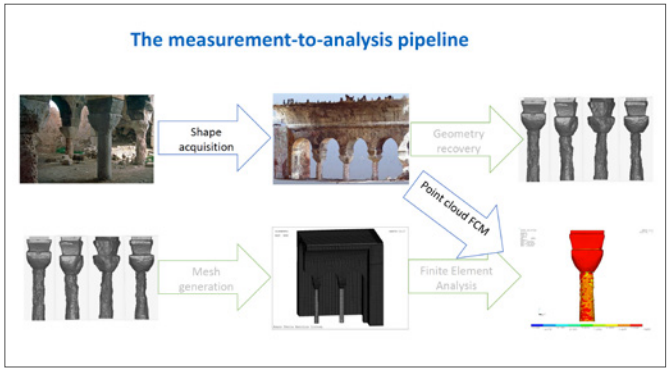
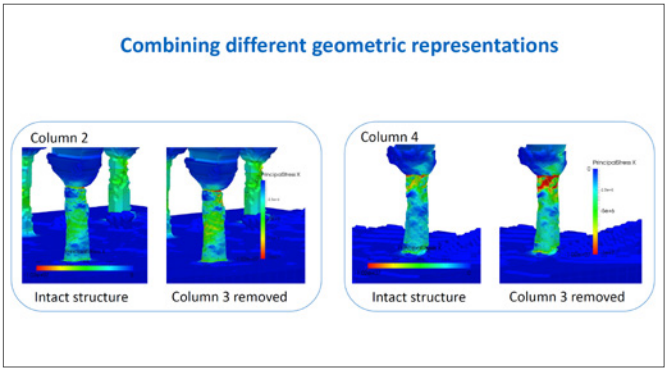
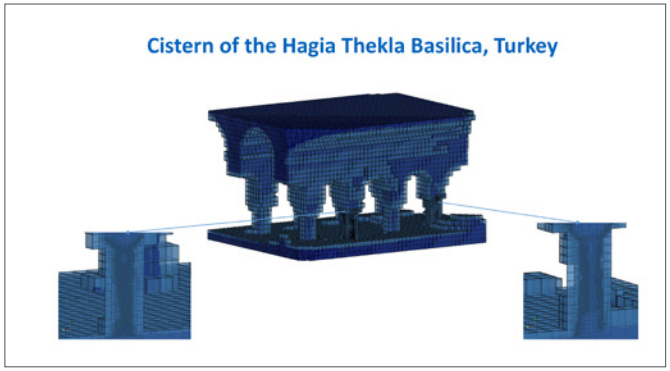
Abstract

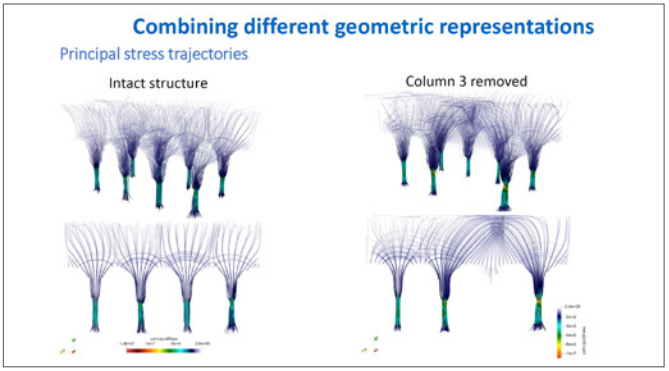
The documentation of Cultural Heritage concerns the construction of digital archives and databases able to classify and interact with a multitude of information that characterizes the digital identity of the documentation objects. These data describe both physical characteristics and constructive qualities, to support the understanding of the history and life cycle of the specific heritage object. The digital replica must interconnect with other databases and repository systems by standardizing certain media languages to assert their own digital identity. Thus, with the purpose of certificating analysis tools for the management and enhancement of Endangered Heritage, the digital representation and transposition of the artifact become the privileged means for the development of protection and preservation initiatives on Cultural Heritage.

Structural Analysis of Buildings and Constructions based on Point Clouds









Ernst Rank, Laszlo Kudela, Stefan Kollmannsberger

Technical University of Munich, Munich (Germany)

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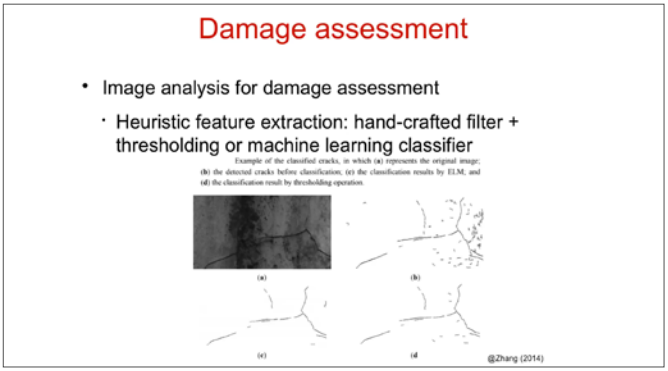
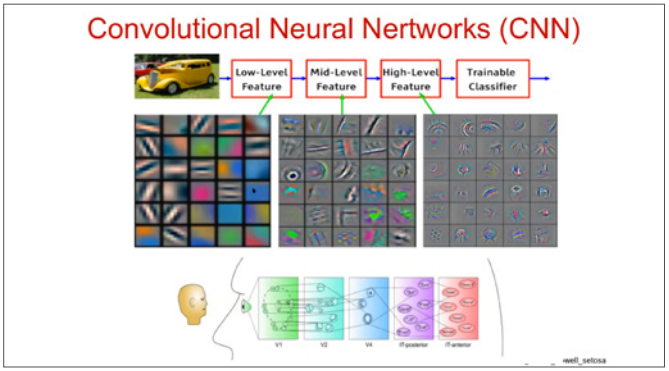
Abstract

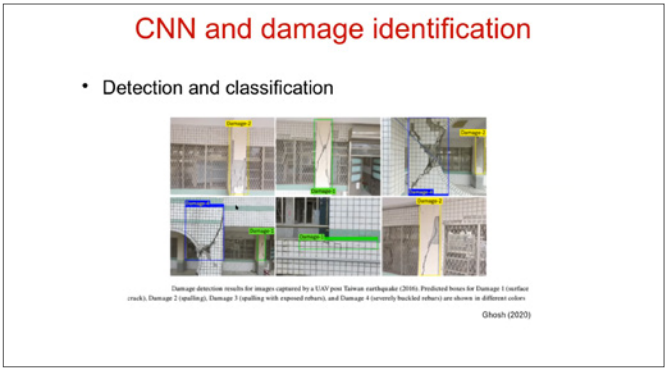
The protection and restoration of historic monuments often requires a thorough condition analysis including the assessment of the structure's stability.

This lecture will introduce a workflow starting from a geometric reconstruction of the surface of a structural artifact based on point clouds from laser scans or photographic images. From the obtained geometric model a structural analysis is then initiated. A brief introduction will be given into the basics of numerical methods, supporting fast and efficient structural assessment even for irregularly shaped and partially damaged constructions.

Identyfing Damage to Structures from Images







Bryan Pantoja Rosero

École Polytechnique Fédérale de Lausanne, Lausanne (Switzerland)

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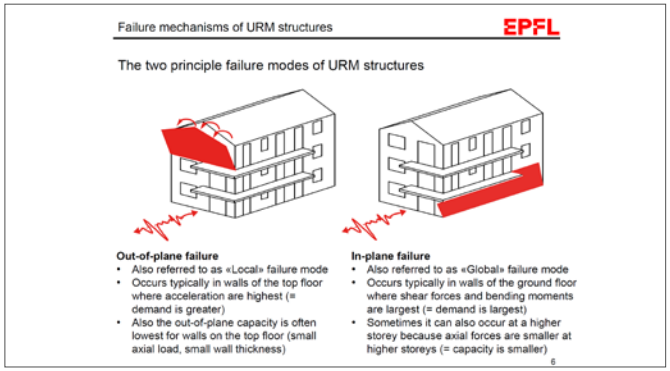
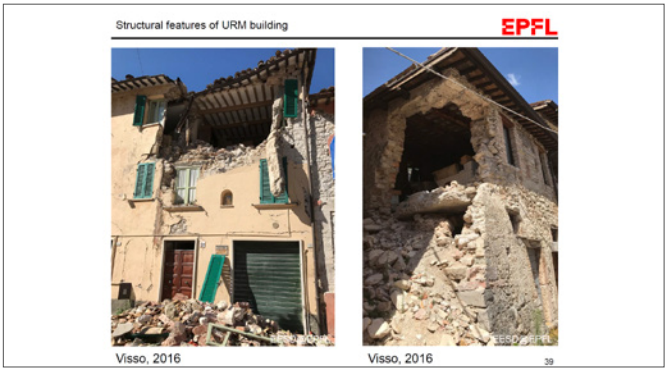
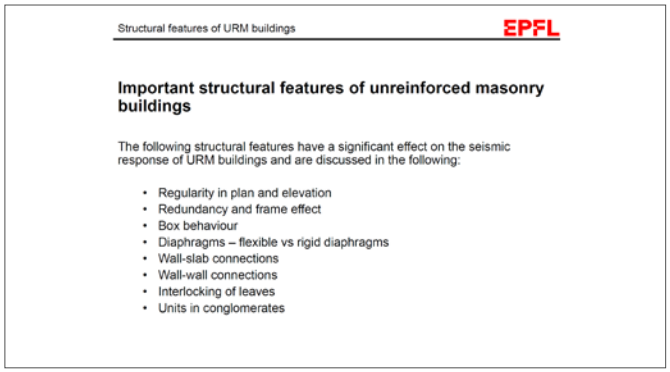
Abstract

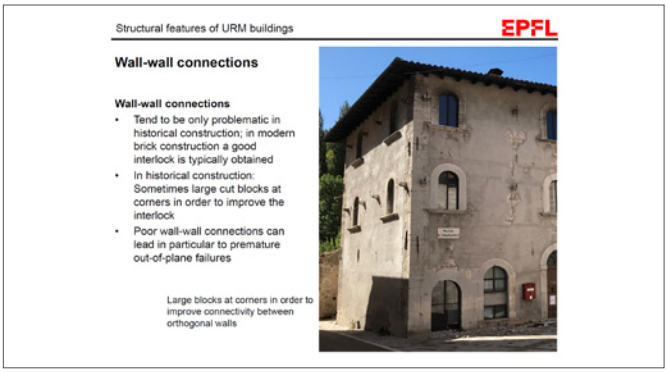
The settlement, overloading, extreme weather events, floods, and earthquakes are just some of the factors that put our cultural heritage structures at risk. As a result, ongoing maintenance and inspection of these structures for potential damage is becoming increasingly important. With significant advancements in drone and optical measurement technologies, as well as rapid improvements in artificial intelligence, we can monitor and inspect our cultural heritage structures in a timely, cost-effective, and efficient manner. This contribute introduces the concept of image-based inspections of historical structures using computer vision and machine learning methods, providing participants with cutting-edge technologies required for reliable and trustworthy AI-based pipelines.

Understanding the Behaviour of Stone Masonry Buildings under Earthquake Loading









Katrin Beyer

École Polytechnique Fédérale de Lausanne, Lausanne (Switzerland)

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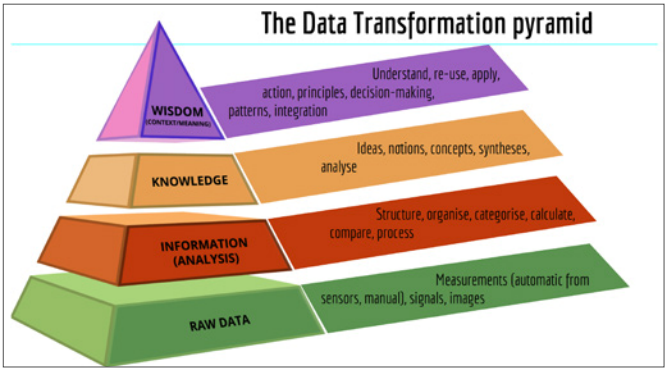
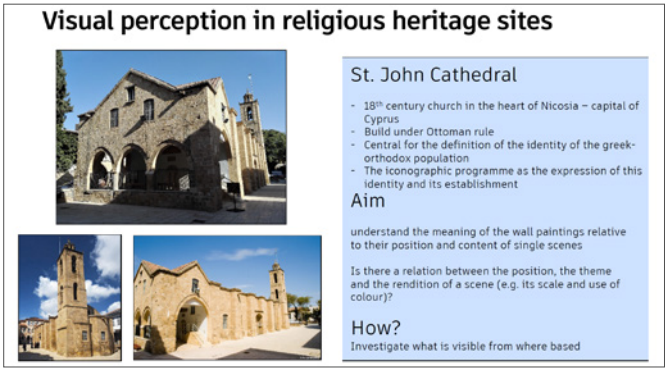
Abstract

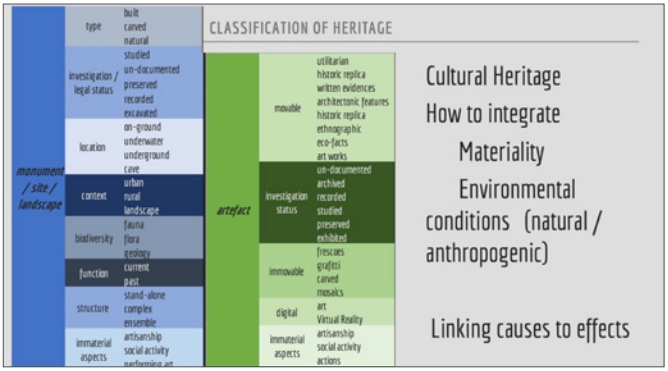
Many buildings and churches but also city walls and bridges that belong to the cultural heritage are made from stone masonry. Due to the large weight of the stones, the low strength of the mortar and the poor interlock of natural stones, stone masonry structures are particular vulnerable to seismic action.

Next to the properties of the stone masonry material also other structural configurations of the building are important for its seismic response, such as, for example the floor stiffness and the wall-floor connection. This lecture introduces the material stone masonry in general and discusses in particular the response of stone masonry buildings under earthquake loading.

FAIR - IFICATION OF DATA IN BUILT CULTURAL HERITAGE







SORIN HERMON

The Cyprus Institute, Nicosia (Cyprus)

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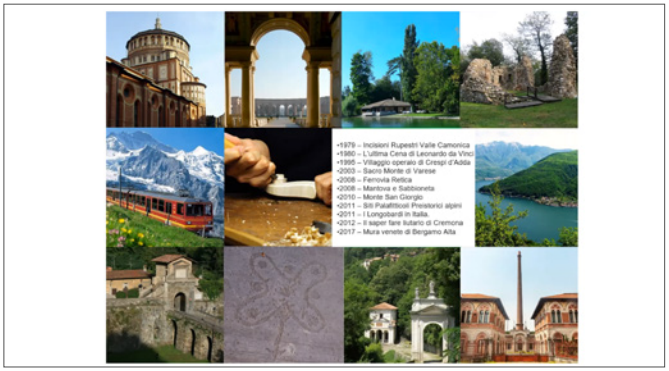
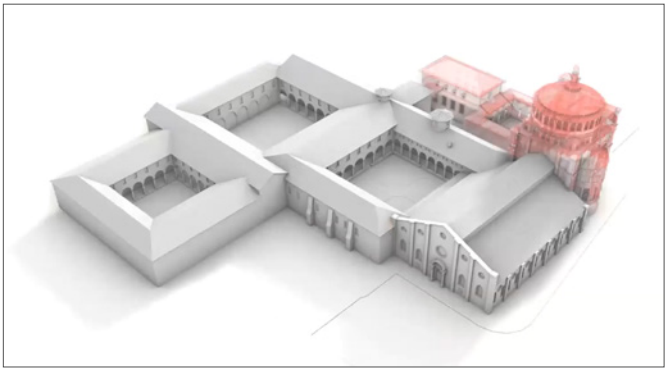
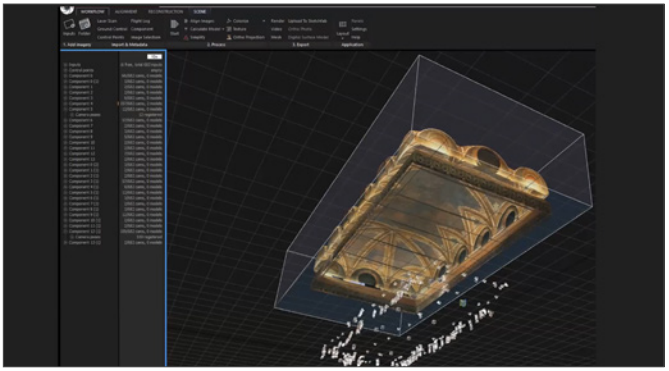
Abstract

The lecture will focus on issues related to challenges facing when addressing the EU directives on Open Science and Data Sharing. In particular, the lecture will detail types of data used in Built Cultural Heritage and Heritage at Risk, data provenance and data quality.

Heritage from Back Door







Cecilia Bolognesi

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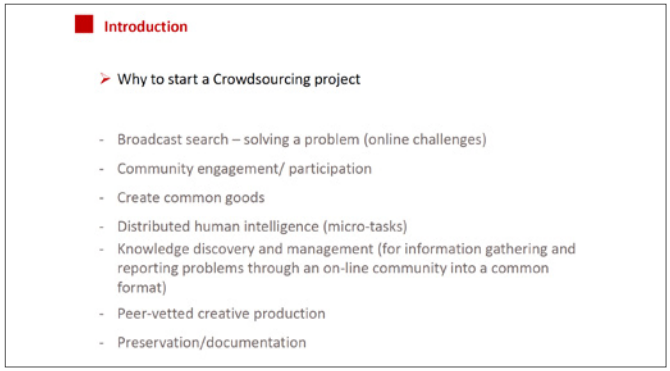
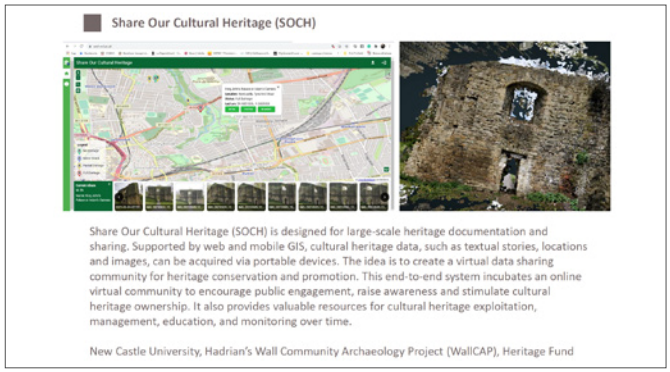
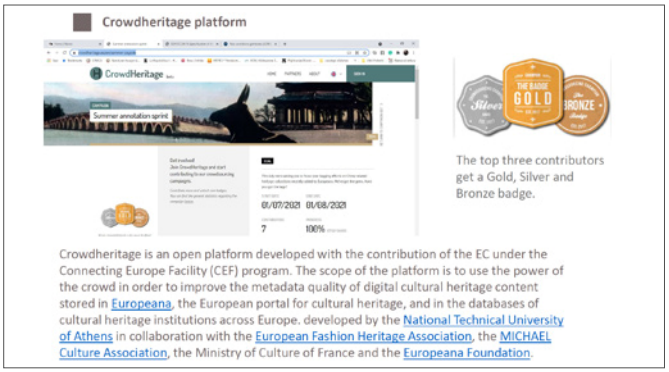
Abstract

The richness of the Italian heritage has favored mass tourism phenomena, desertifying areas that, abandoned to themselves, risk being forgotten or, even worse, transformed. Unesco heritage sites and abandoned places are sometimes just a few kilometers away. The attention to the diffused art and to a slower tourism has the possibility to bring back in vogue paths and routes that assume a new value in the post-pandemic era. Digitalization, smart visit, immersive and augmented reality can become the best promotion of Cultural Heritage in a crowded future.

Crowdsourcing and open data for understanding, monitoring and preserving Cultural Heritage







Cettina Santagati

University of Catania, Catania (Italy)

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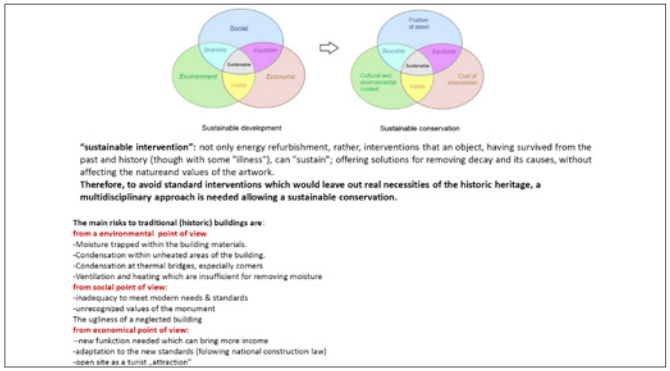
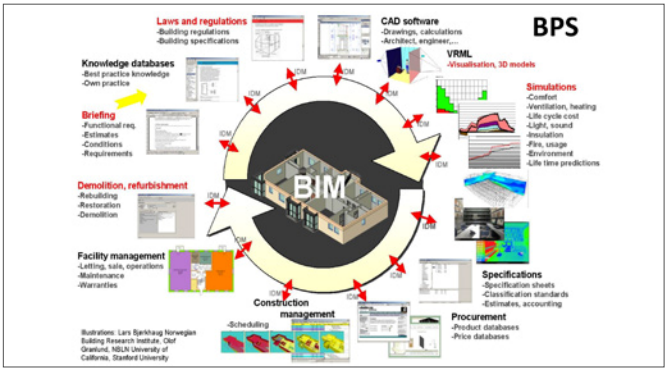
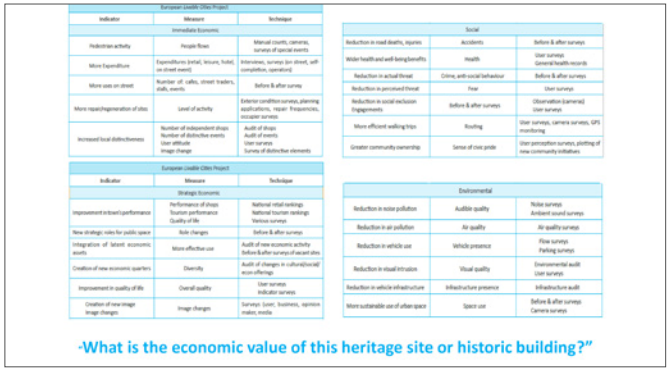
Abstract

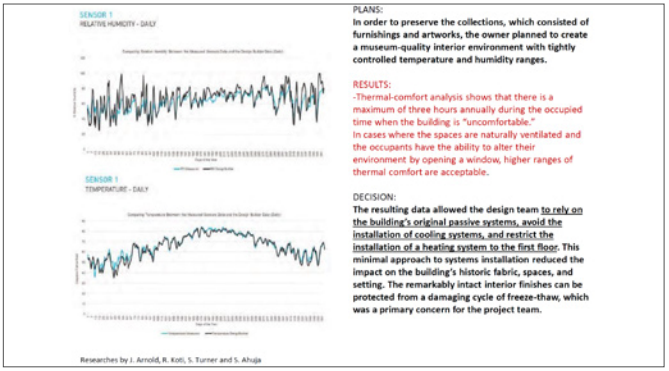
Cultural heritage is constantly under threat by anthropic actions and natural hazards. 3D acquisition and modeling play a pivotal role for monitoring and preserving the legacy of the past. However, the high costs related to documentation task both in terms of time and resources requested have prevented a constantly and massive documentation activity. Crowdsourcing activities that directly involve groups of citizens can significantly speed up survey, elaboration and monitoring procedures as well as contribute to the creation of heritage communities as stated by the Faro Convention. Moreover, these actions combined with the adoption and use of open data (i.e. OpenStreetMap) allow for an expeditious mapping and 3D modeling of Cultural Heritage and Historical Cities for documentation, monitoring and preservation purposes.

Measurements and Indicators of Sustainable Conservation process of Built Heritage









Jolanta Sroczynskai

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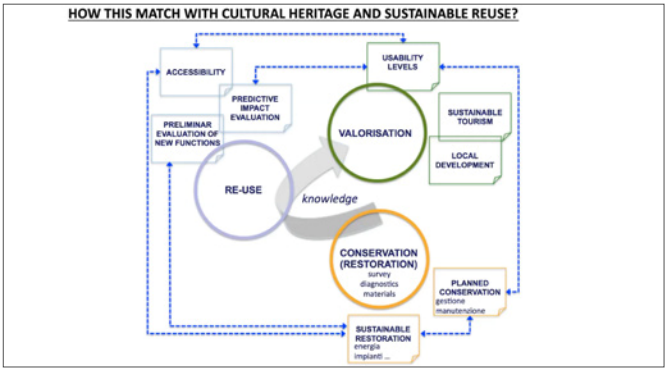
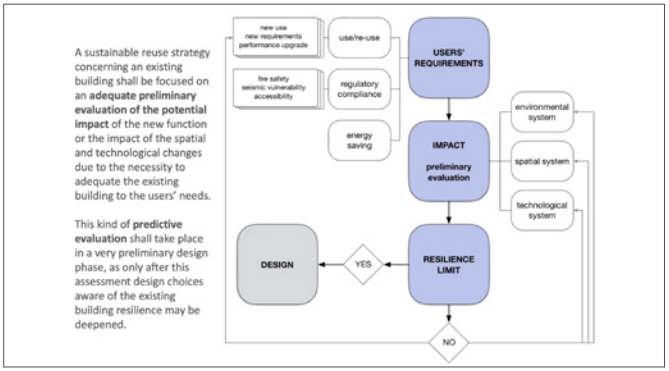
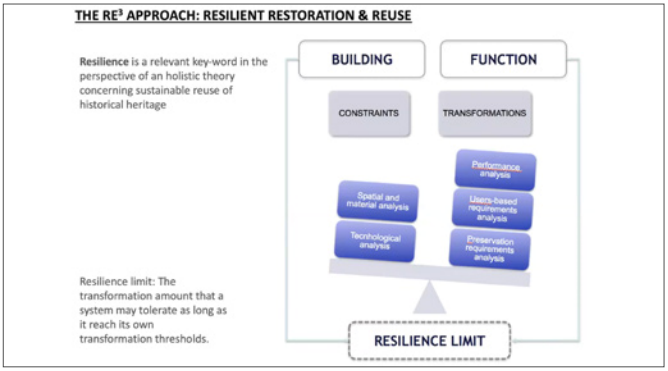
Abstract

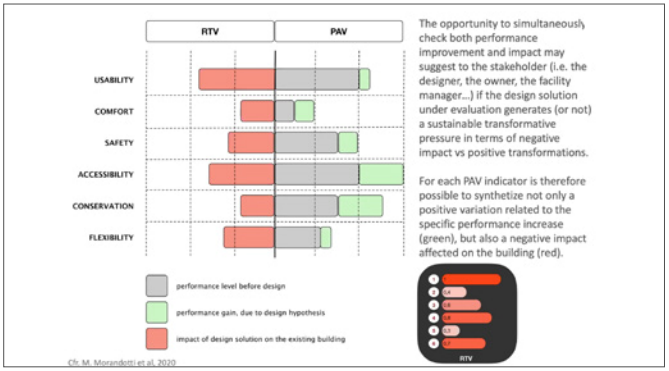
Restoration of historic buildings is a process related not only to the need to protect their historic value but also to the need to adapt them to modern standards and policies of human environmental protection. Ensuring the comfort of use, reduction of Co2 emissions, energy efficiency, regulation of moisture problems in the building are just a few issues having a direct impact on the positive public perception of the built heritage. The lecture discusses the controversial solutions used in the restoration of historical buildings adapted to the contemporary needs of users.

Cultural Heritage Digital Asset Management between Planned Conservation and Sustainable Reuse









Marco Morandotti

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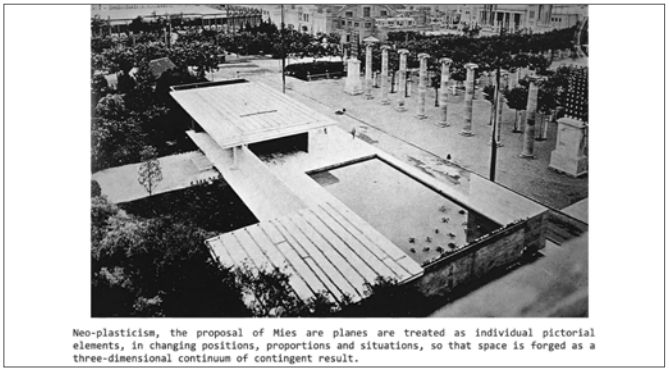
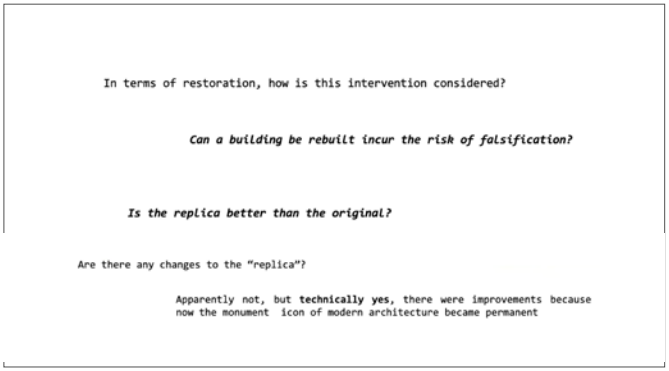
Abstract

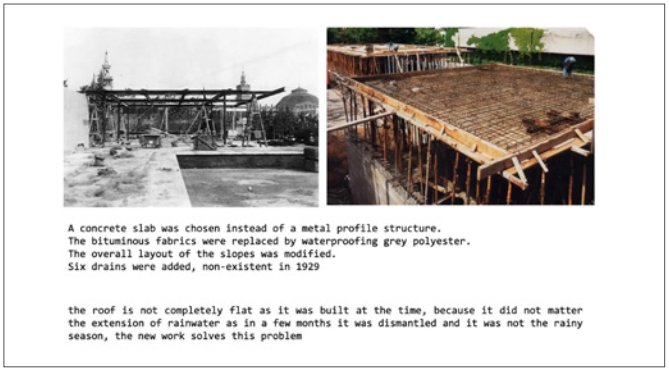
General aim of Asset Management is to achieve the organizational objectives through balancing risk, opportunities and costs. It has become more relevant both for producing value through management of the built environment and for supporting the sustainability strategies. Its relevance may become even greater considering Cultural Heritage assets, due to the more crucial balancing among historical values, improvements requirements and conservation constraints. The increasing adoption of Information Technologies pushes for a transition to the digital Asset Management. This happens by means of the integration among different digital technologies, from survey and documentation, to modelling, to management of existing structures, including planned conservation strategies and resilience planning tool through sustainable adaptive reuse.

Past and future in Architectural Heritage Intervention The Refurbishment of Mies Van de Rohe Pavilion



Neo-plasticism, the proposal of Mies are planes are treated as individual pictorial elements, in changing positions, proportions and situations, so that space is forged as a three-dimensional continuum of contingent result.





Luis Manuel Palmero Iglesias

Universitat Politècnica de València, Valencia (Spain)

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Abstract

Historical international networks have demonstrated the technical advances and progress of countries through architectural and engineering examples. In most cases, architectural projects have shown the new technological advances and the industrial and social image of countries and communities also abroad. The case of Mies Van der Rohe Pavillon in The Barcelona International Exposition (1929) has been a decisive case of social impact. As a result of the architectural project, different influences have been attributed to it, even if after the closing of the Exposition the Pavilion was dismantled in 1930. Its reconstruction in 1986 on its original site has followed a debate on the originality in the use of materials regarding the balance of novelty and modernity, the rigor of geometry, the precision and clarity of parts assembly.

The Restoration Intervention from the Enterprise Technical Experience: PIACENTI International Projects


Restoration of the wooden boards

Mosaics restoration

Giammarco Piacenti

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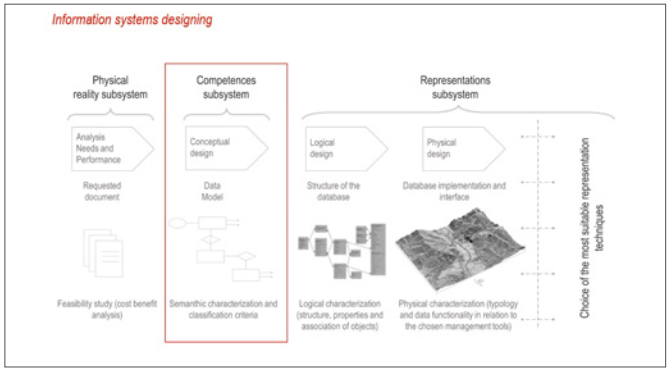
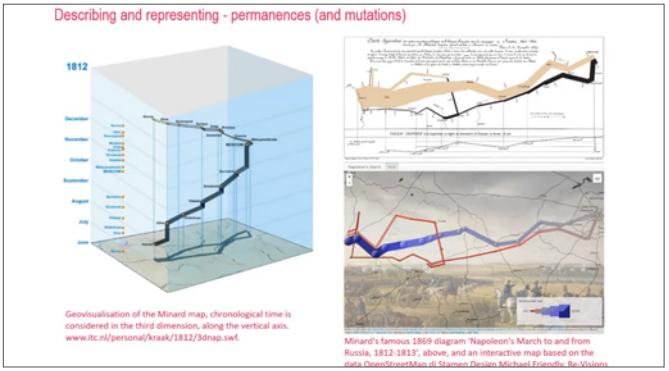
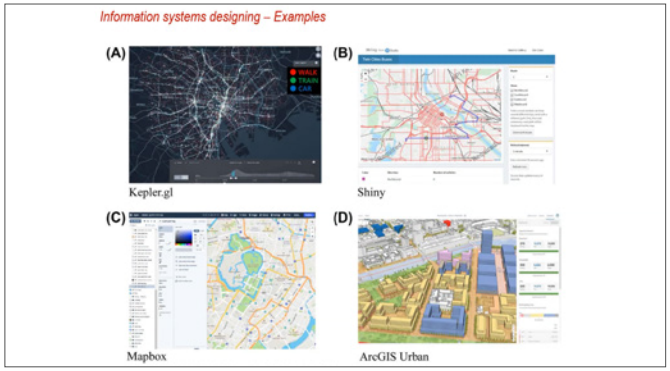
Abstract

The design and conservation practice aimed at enhancing Cultural Heritage requires knowledge and in-depth study. The cultural basis presented by the theories of restoration is combined with technique, scientific updates, and quality standards for the management of the construction sites, as well as with the manual skills brought within the professional ability of individual operators. The international experience of Piacenti SpA, a historic company in the tradition of Italian restoration, presents a panorama of know-how in the field of recovery and conservation of historic works, highlighting the functionality of the intervention chain from documentation to design and restoration.

Information Systems and Models for Cultural Heritage







Maurizio Marco Bocconcino

Politecnico di Torino, Turin (Italy)

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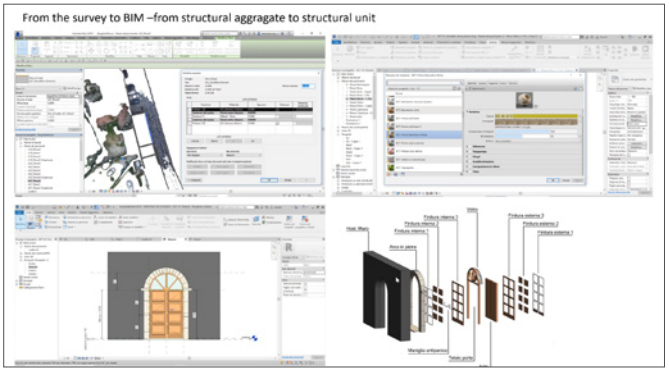
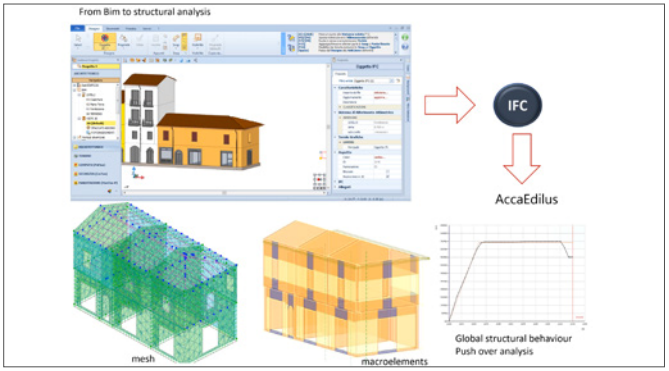
Abstract

Brief critical review of methods and tools for the management and representation of data and information in the cultural heritage field. Data formats and consistency of interchange flows (criteria, methods and techniques for designing and setting up interdisciplinary and multiscalar information systems and models).

Methods and tools for the representation of conceptual, logical and physical models and schemes related to complex geodatabases. Use of graphic information for technical and non-technical communication. Examples, case studies applied to representative categories.

H- BIM: A Data Management Tool for Assessing the Structural Safety of Small Historic Villages





Assunta Pelliccio

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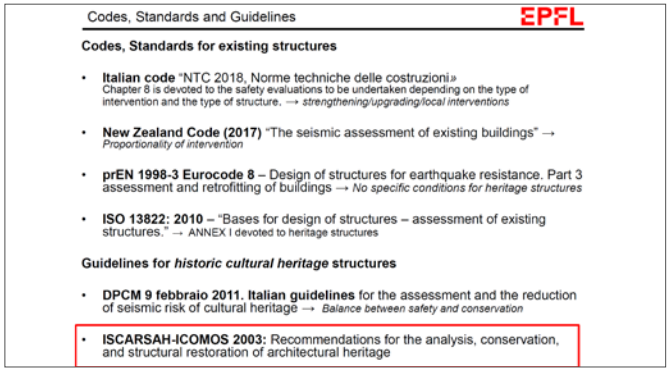
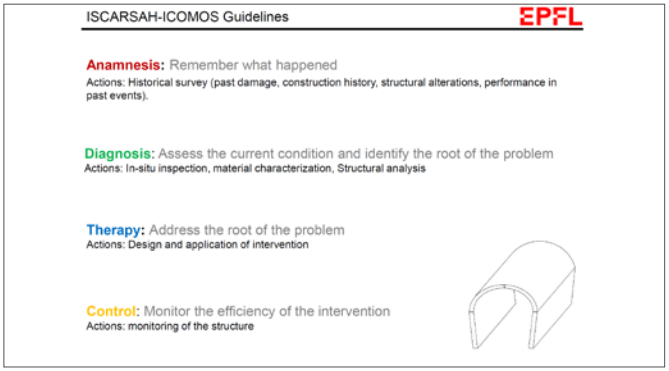
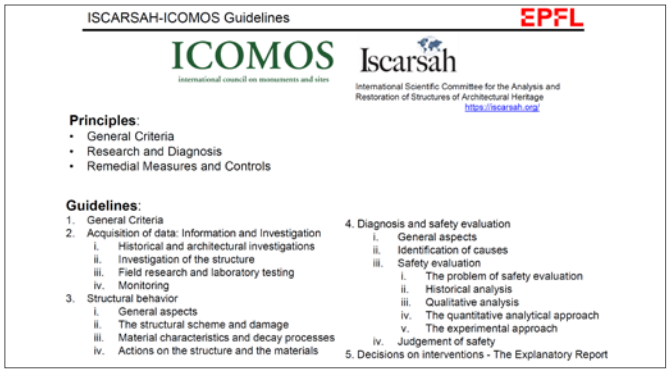
Abstract

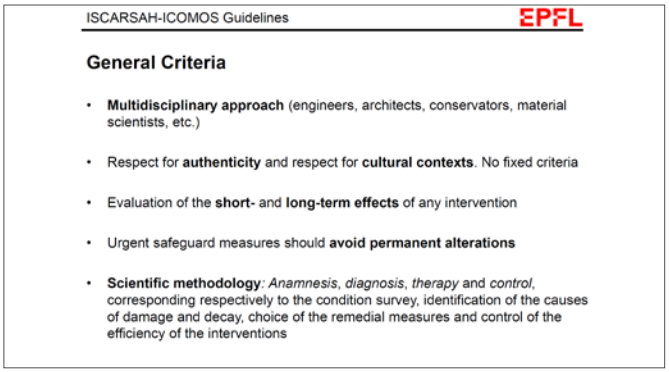
In Italy, historic villages (Charter of Krakow, 2000) are particularly vulnerable since most of them are located in the Apennines, which is the area with the highest seismic risk. The conservation process of these sites, composed of complex structural aggregates, requires tools capable of acquiring and managing the multitude of heterogeneous data and interfacing with software capable of analysing their structural evaluation. H-BIM is a suitable tool for this purpose. H-BIM, in fact, can return digital models based on "knowledge levels" according to the methods of analysis introduced by the National Technical Construction Standards (NTC 2018 – chap. 8).

Designing Retrofit Interventions that are Compatible with Cultural Heritage Structures









Savvas Saloustros

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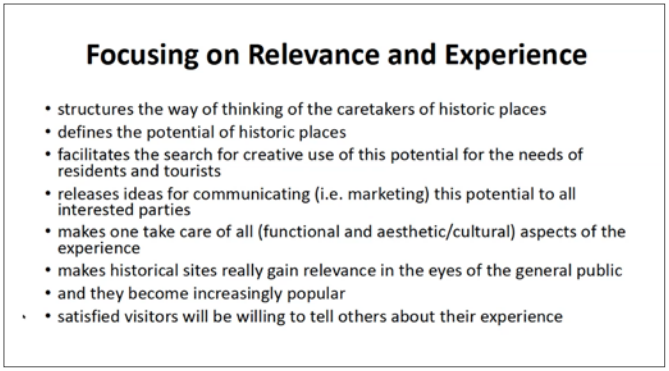
Abstract

The design of retrofit interventions in cultural heritage structures should ensure structural safety and preserve at the same time the cultural value. In this lecture, we will discuss the general principles and guidelines for retrofit in heritage structures, aside with current retrofit practices. In the first half of the lecture we will overview current international guidelines for interventions in heritage structures, such as the ISCARSAH-ICOMOS principles. In the second part, we will see specific interventions currently used for the retrofit of historic masonry structures. The aim of this lecture is to present a conceptual framework for the design of retrofit interventions by engineers, architects and conservators.

It's All About Relevance and Experience Marketing Historic Places to the General Public



Izabella Parowicz

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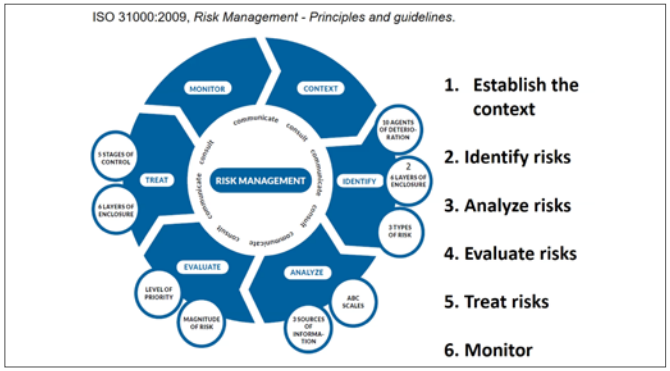
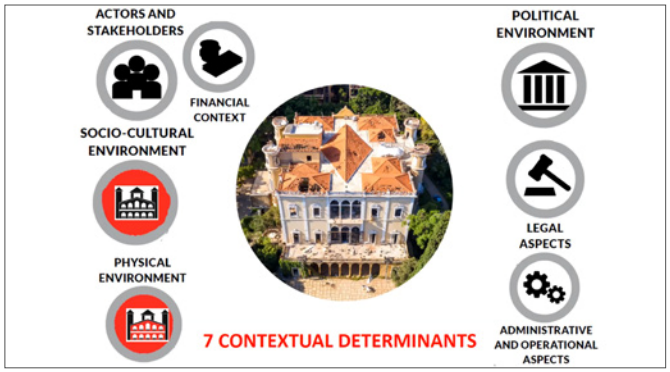
Abstract

While some historic sites enjoy tremendous popularity, others – albeit not necessarily less interesting or less valuable – are not as appreciated by the general public and sometimes even fall into oblivion, which is often reflected in their poor state of preservation. Historic site managers around the world are wondering how to attract public attention to such places. My lecture will focus on two factors that can make a difference – emphasizing the relevance of a given historic site and caring about the experience of those who visit or interact with it in any way, even if only perceptually.

Risk Management in the Protection of Architectural Heritage: Tools & Methods





Jolanta Sroczynska

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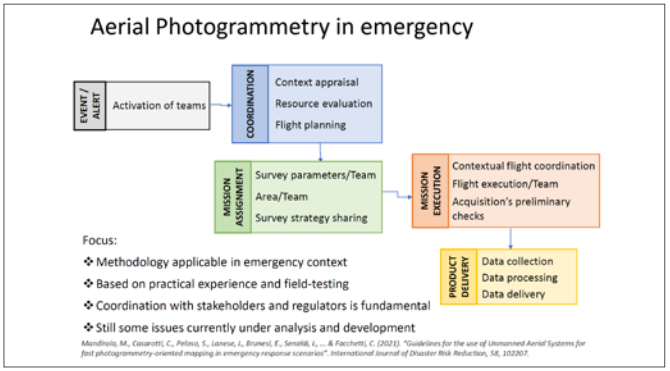
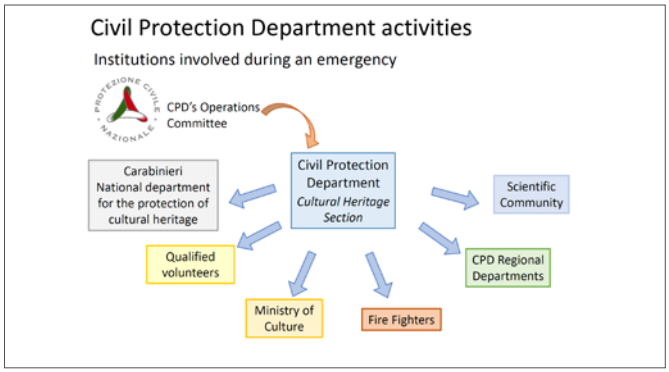
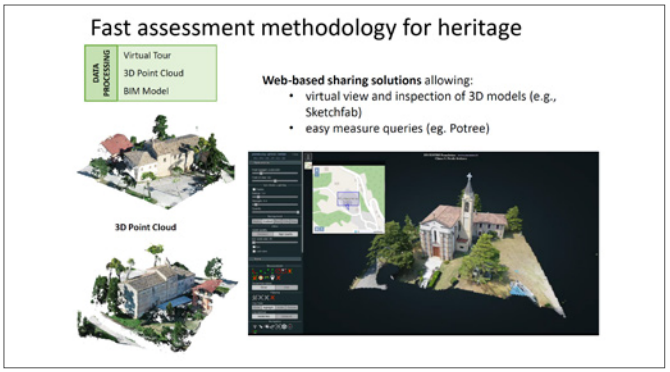
Abstract

Risk management in conservation projects and the restoration process provides tools and methodologies to improve the protection and conservation of culture heritage buildings. Early risk identification and reduction are based on the calculation of risk as a function of hazard, exposure and strength of the historic building. The lecture signals the most common types of risks, starting from the first inventory and research works carried out in a historic building, through the preparation of the project, its restoration, and ending with the final use, taking into account (as well) the progressive climate changes. The presented examples of the implementation of appropriate measures are to convince of the essence of risk analysis as an integral part of the process of heritage protection and to make clear the need for appropriate adaptation of the monument in order to make it more resistant and reduce potential losses.

Post-event Seismic Damage Assessment of Cultural Heritage Structures







Ilaria Senaldi

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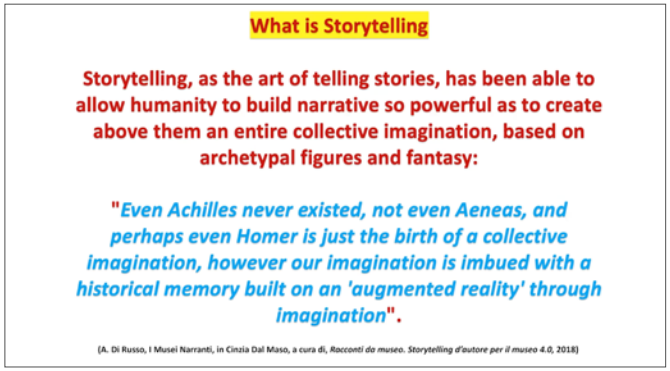
Abstract

The damage assessment of monumental structures after several seismic events in different countries has systematically highlighted the vulnerability of heritage buildings, in particular churches and palaces, and the importance of reducing the risk to preserve their cultural value. Multi-disciplinary procedures for the post-event damage reconnaissance, based on the use of digital technologies, are currently applied by Eucentre in support of the Italian Civil Protection Department for the preservation of cultural heritage through the realization of effective provisional interventions.

Earthquakes, Floods, Shipwrecks: the Story of Human Disasters through the Recovery of Digital Memories



Elisa Bonacini

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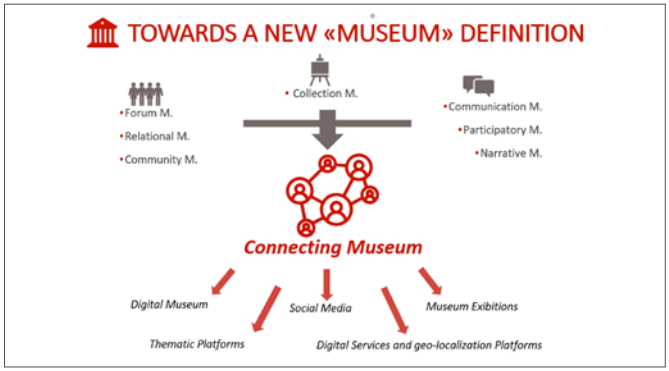
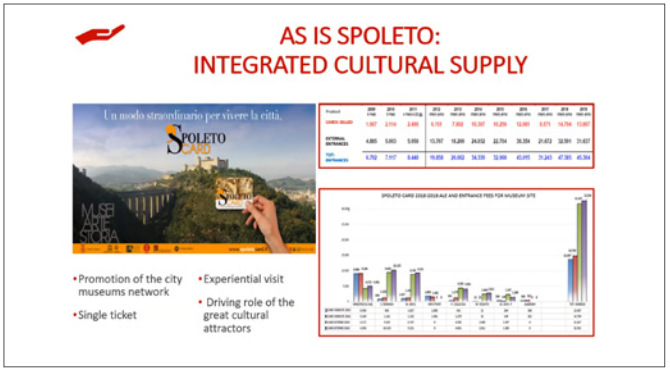
Abstract

This lecture will highlight on how new technologies can allow to safe the "digital memory" of human disasters, thanks to digital storytelling: how a tornado is digitally told? How a destroyed urban landscape could be digitally reconstructed in its digital memory? How a shipwreck or an earthquake could be told from the point of view of the protagonists of those tragedies? Digital storytelling offers numerous examples of how these tragedies can be told, in the attempt of a "digital recovery" of the memories of individuals and communities.

Towards a Connecting Museum between Storytelling and New Technologies. The 'Connessioni Museali' Project





Giulia Bassetti

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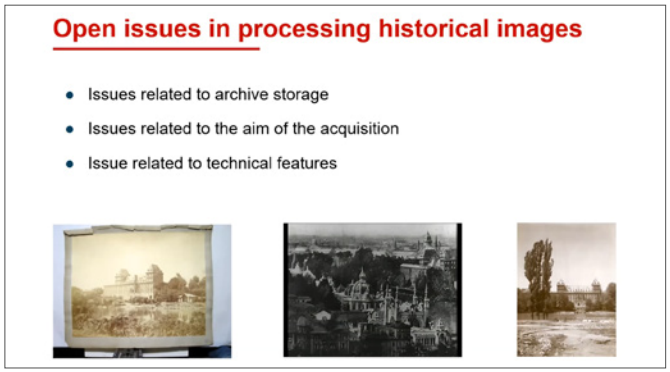
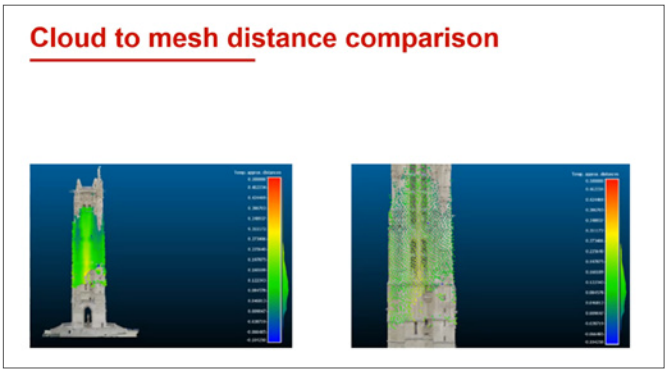
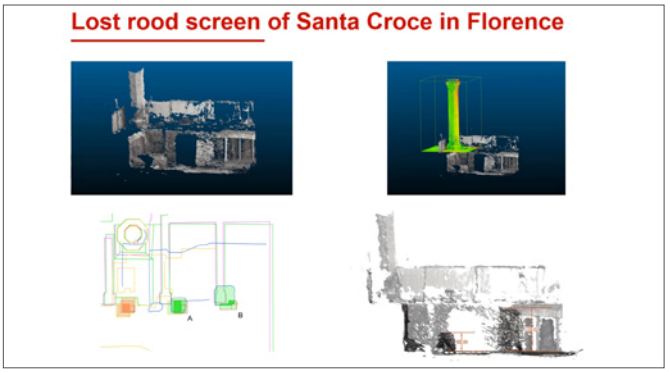
Abstract

The Digital Storytelling is the basis of the 'Connessioni Museali' project: both a real and virtual path for the enhancement of Cultural and Naturalistic Heritage in the Spoleto and Valnerina area, thanks to a mobile app, a serious game, a video-photographic campaign and a social media communication plan. The aim is to catch potential publics, to explore new narrative languages for cultural tourism circuits, to make on-site and remote teaching experiences easier. A wider collaboration is expected with other cultural-digital initiatives to offer a wide and complete SMART tourism in Umbria.

Photogrammetry and Deep Learning to 3D Reconstruct Lost Cultural Heritage







Francesca Condorelli

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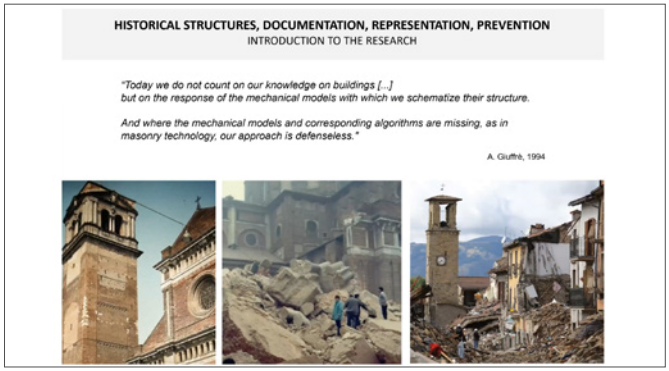
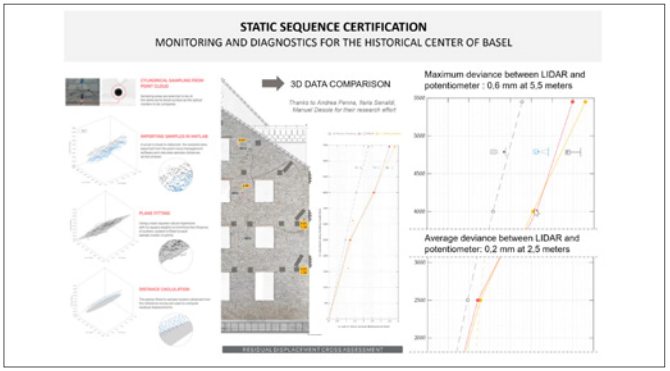
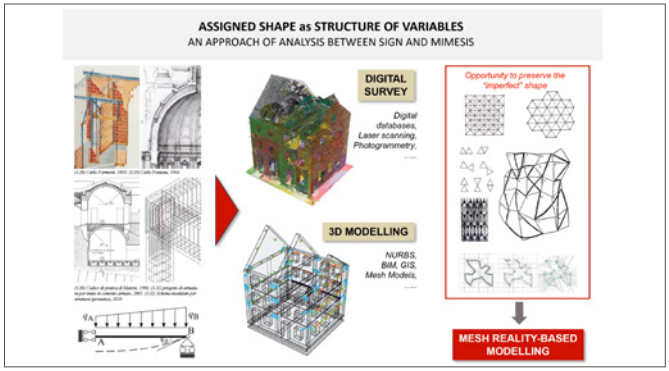
Abstract

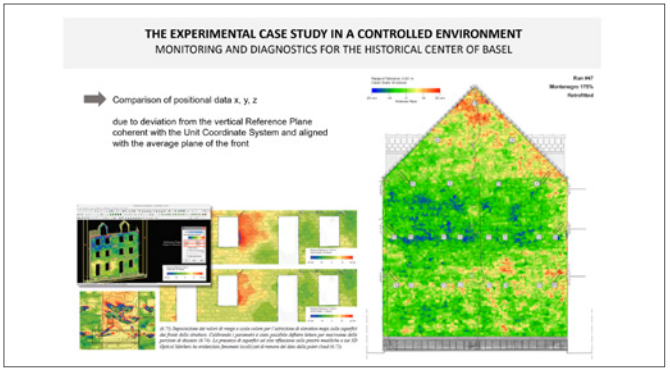
Historical photographs and film footage, which have survived over time because they are stored in historical archives, are in many cases the only traces of monuments that no longer exist. Thanks to Photogrammetry and Artificial Intelligence, applied to these sources, it is possible to document and to 3D virtually reconstruct lost architecture in order to preserve their historical memory. The presentation aims to give an analysis and assessment through the extraction of metric information from historical images and to experiment with its potentialities in the heritage field with the purpose of valorising historical iconographical documentation.

Reliable 3D Mesh Models for Non-invasive Structural Diagnosis: Certification and Applications on Built Heritage









Raffaella De Marco

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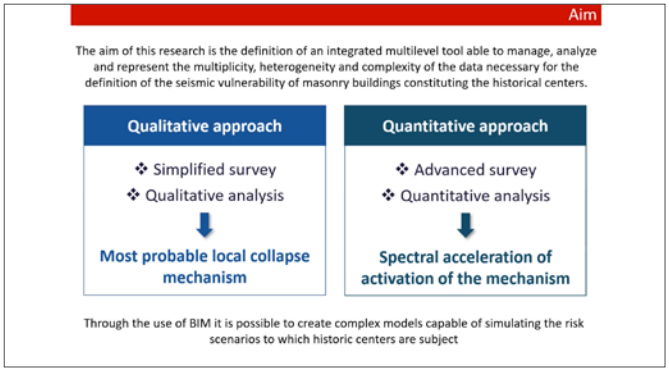
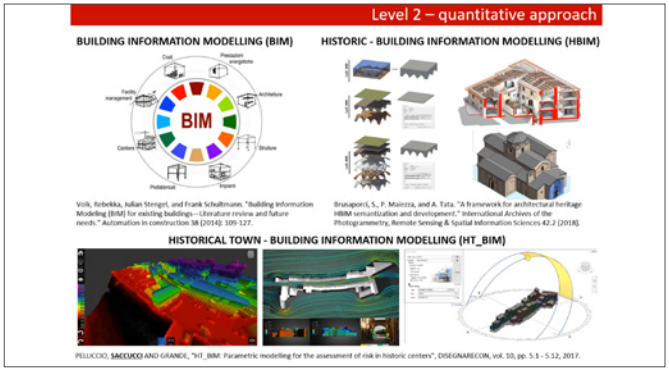
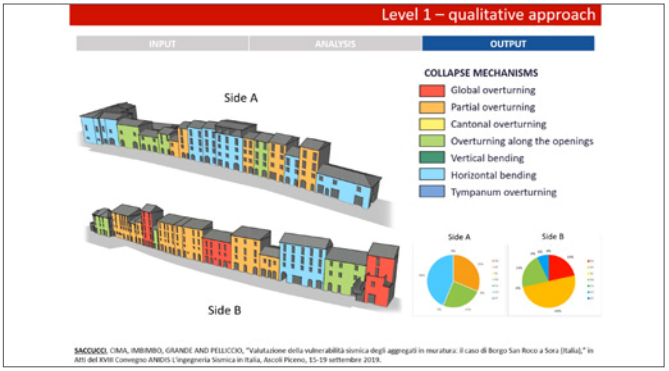
Abstract

Close-range 3D digital survey methods (e.g., LiDAR, photogrammetry) offer the opportunity to collect a wide amount of morpho-metric data on Built Heritage without invasive actions. Their detection ensures an high level of detail, till to permit the analysis of the shape of single constructive components and masonries. The increased resolution of point clouds databases can be preserved within 3D high-poly mesh models. Developing studies of shape reliability on damages, there application is tested within multi-scale case studies of structural systems, to assess risk conditions and intervention opportunities.

Multilevel BIM Analysis for the Assessment of the Seismic Vulnerability of Masonry Buildings







Marco Saccucci

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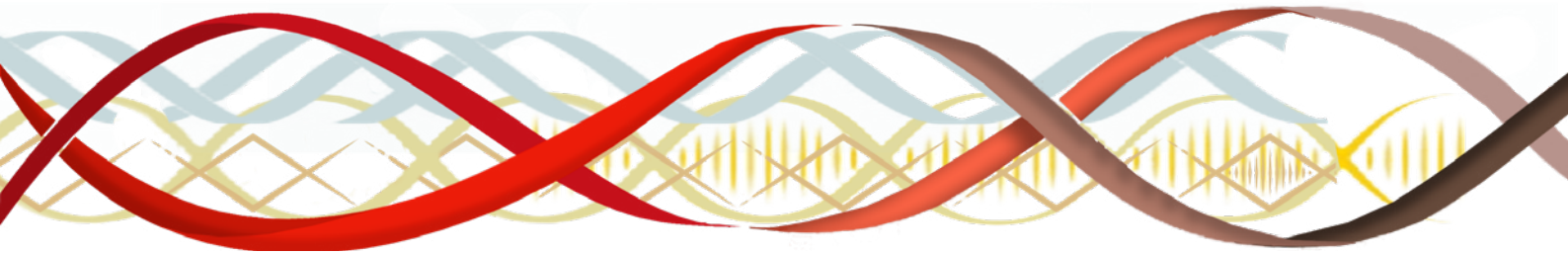
Abstract

Italy is characterized by very heterogeneous historical centers which, due to their geographical position, are exposed to a high seismic risk. The research work shows an innovative integrated multilevel tool capable to manage, analyze and represent the multiplicity, heterogeneity and complexity of the data necessary for the evaluation of the seismic vulnerability of masonry buildings constituting the historic centers through the use of BIM. The methodology is tested on a case study: San Rocco Village in Sora (FR).

Final Presentations

Participants, Assignments and Results of Working Sessions



Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania "The Path of the Ancient"

Discover the site!

GROUP 1

Francesco Grugni
University of Pavia, Pavia (Italy)

Paulina Pawlikowska
Rzeszów University of Technology (Poland)

Magdalena Wałek
Silesian University of Technology (Poland)

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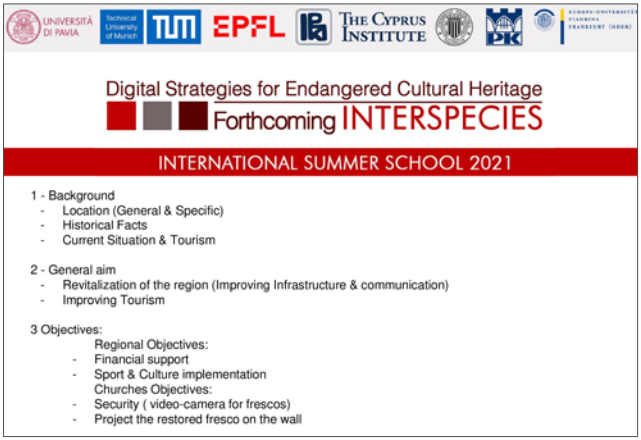

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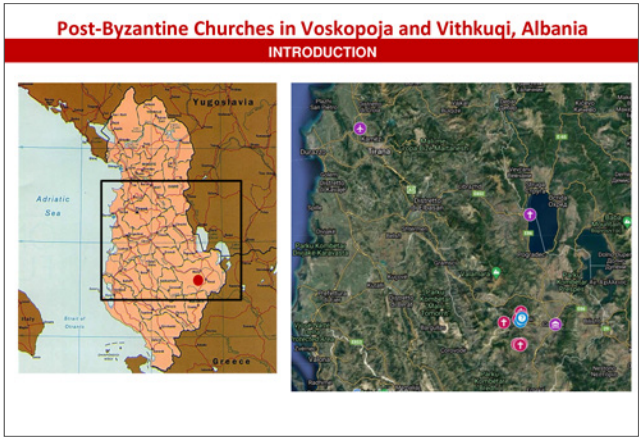

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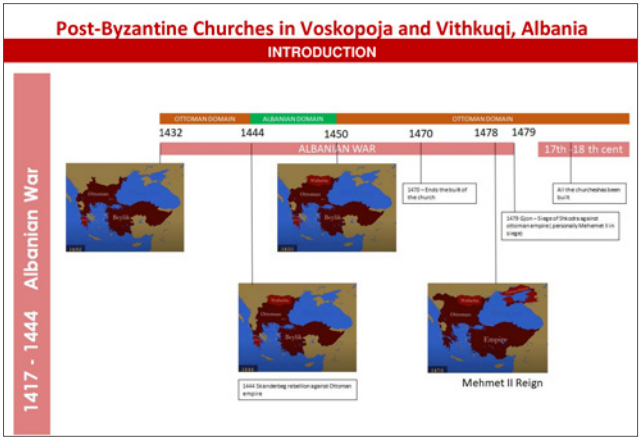

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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

INTRODUCTION

ARTIFICIAL INTELLIGENCE FOR COMMUNITY FEATURES EXTRACTION

Zhou, Bolei & Liu, Liu & Oliva, Aude & Torralba, Antonio. (2014). Recognizing City Identity via Attribute Analysis of Geo-tagged Images. 10.1007/978-3-319-10578-9_34.

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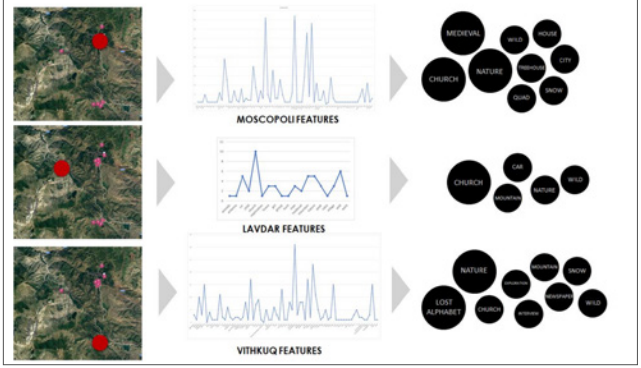
Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

INTRODUCTION



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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

INTRODUCTION

8

Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

INTRODUCTION

9

Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

INTRODUCTION

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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

GENERAL AIM / RATIONALE

General aim: Revitalization of the region of Voskopoja and Vithkuqi villages

These **churches** are exceptional by their history and form and contain very remarkable works of art which merit to be restored as cultural heritage ex. **Vithkuqi lost language** and for potential tourism benefits to this underdeveloped region.

Scientific aim: enhancement of knowledge
Popularization aim: making the site more popular
Restoration aim: the restoration of twelve religious buildings, comprising 10 churches and 2 monasteries dating from late 14th century and most dating from 17th - 18th century located in or close to Voskopoja and Vithkuqi in Albania
Educational aim: preserving the memory of the Albanian's revolution in the Ottoman period and history of Byzantine Churches

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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

OBJECTIVES

Revalorization of the region	Restoration of the churches	Infrastructure enhancement	Promotion	Post restoration plan
1.Improving "Routes of the Faith" 2. Using the potential "100 Villages program"	1. Architectural survey 2. Securing the frescos 3. H-BIM documentation 4. Other necessary safety works	1. Providing any sort of accommodation 2. Enhancing facilities of basic needs 3. Providing places as a base for outdoor activities 4. Enhancing quality of the routes	1. Promoting slow tourism 2. Organizing special trips for promoting the landscape 3. Organizing convents promoting local products (food etc.) 4. Exhibition of the lost language and writing courses in Vithkuq	1. Cooperation between different local parties 2. Keeping slow tourism base with outdoor activities 3. Enhancing safety of the churches 4. Possibilities for organizing special convents on the site

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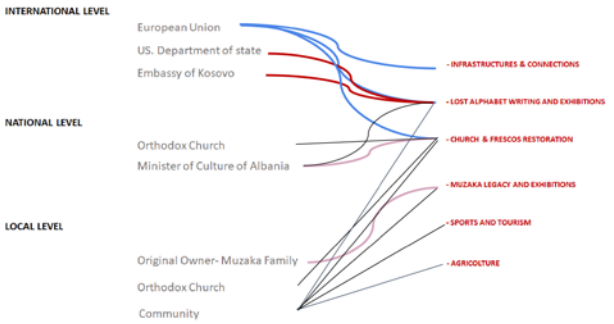
Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

POTENTIAL SOCIAL ACTORS



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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

PROFILES'EXPERIENCES

Project Manager	Timetable & Head of Project
Community Manager	Keep contacts between Community and Project manager
Data analyst & collector	Tourism Survey
Urban Planner	Urban Survey
Transport Planner	Mobility & Transportation Project
Cultural Heritage Specialists	Valorization of the site Digital survey Conservational guideline
Qualified Contractor	Contractor of the project under supervision of CHS

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Post-Byzantine Churches in Voskopoja and Vithkuqi, Albania

REFERENCES AND RELATION WITH THE STATE-OF-ART

Colorful churches of Podlasie in Poland

https://www.celwpodrozy.pl/2020/05/10-kolorowych-cerkwi-na-magicznym-podlasiu.html

Livigno Community - Italy

http://www.hotelangelica.it/

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

ATLAS AND DATABASES ON SITES AND TERRITORY
HISTORICAL AND TYPOLOGICAL INFORMATIONS
INTEGRATION WITHIN SERVICES AND PRODUCTION

ENHANCEMENT OF SITES FROM AND TOWARDS THE TERRITORY

Reference to H2020-MSCA-RISE "PROMETHEUS" project

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

DIGITAL RECONSTRUCTION OF THE FRESCOS

REVIVAL OF THE SITE

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

WIDER OFFER OF ACTIVITIES

PROMOTION OF SLOW TOURISM

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

STRATEGY DRIVERS

An important aspect of this program is also the combination of tourist and agritourism potentials, the cultural and historic heritage and natural beauties, making them all accessible to tourists.

- «100 Village Program»

Also relevant to this church restoration project is an initiative by the Ministry of Culture to organise "Routes of Faith" to encourage visitors to explore off the beaten track. In addition, the Ministry of Culture has a decentralised network of museums across Albania and, as has been noted elsewhere, Korça has the most extensive Icon exhibition centre in the country housed in the National Museum of Medieval Art.

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

STRATEGY – MAIN PATH – ROUTES OF FAITH

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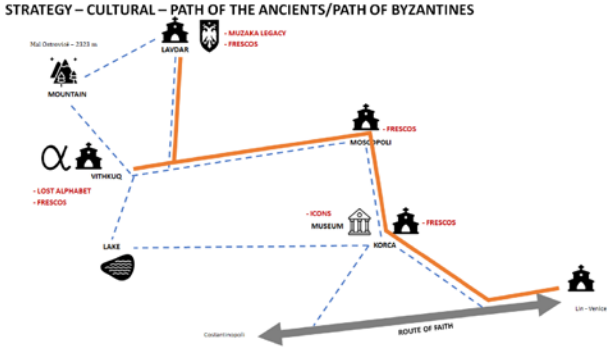
Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

STRATEGY – CULTURAL – PATH OF THE ANCIENTS/PATH OF BYZANTINES



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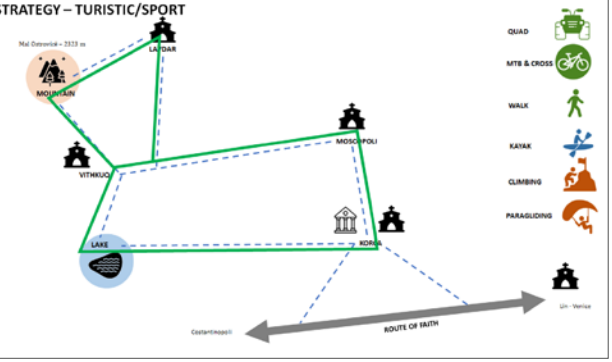
Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

STRATEGY – TURISTIC/SPORT



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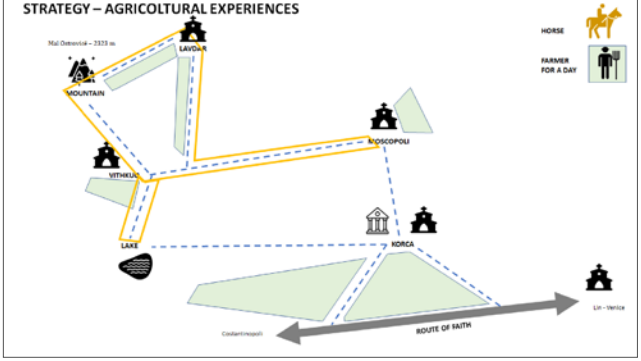
Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

STRATEGY – AGRICOLTURAL EXPERIENCES



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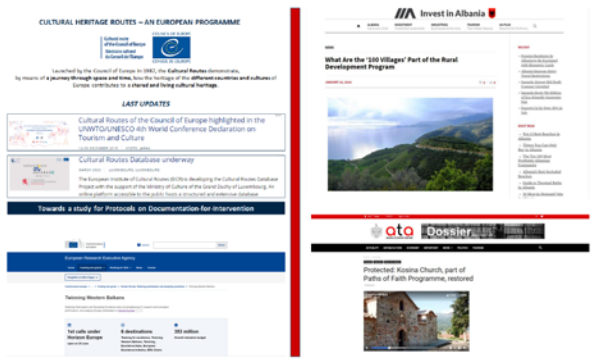
Taking in action Endangered Cultural Heritage Sites

FUTURE PERSPECTIVES TOWARDS INTERNATIONAL OPPORTUNITIES



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Taking in action Endangered Cultural Heritage Sites

WORKPLAN

1. **Protect the sites** (Security camera, Sensors, and monitoring the sites)
2. **Restore The churches** (Vithkuqi) - Cause it's most attractive for the Lost Alphabet
3. **Upgrade Infrastructures** - (Routes of Faith) (Salonicco - Scutari) or (Salonicco - Venice)
4. **Increase Connections** between Korca & Route of Faith (Streets)
5. **Restore The churches** (Lavdar) - Cause extend the path of the Ancient with Muzaka Legacy
6. **Increase the sports activity and agrotourism** connected to the Path of the Ancients
7. **Promotion of the Site** (Agrotourism & Sports Activity & Lost Alphabet Exhibitions and Courses
8. **Restore the Churches** (Moscopoli) - to complete the Path

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First Step: Keep the site secure

The report shows thieves are the main problem the site suffers in this moment

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

SHORT TERM

- **Restoration** of the churches and frescos
- Trained **local experts** within different fields and connections with international professionals
- **Promote** the sites
- **Participation** of the locals and raising awareness
- **Digital documentation** of the site for current and future works

LONG TERM

- Create and sustain a place for **agrotourism and slow tourism**
- Bring **churches** back to use
- **Revive** the region
- Developing a **plan regulations** for the region and the site

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Taking in action Endangered Cultural Heritage Sites

CONCLUSIONS

Understanding the **hidden story behind a development site**, through surveys and analysis we can find many sustainable ways to develop projects of a certain size, reducing the **waste of money** and **time** as much as possible

Furthermore, the use of tools like **Artificial Intelligence** can be of support in the part of decision making, Community understanding, and project planning

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Digital Strategies for Endangered Cultural Heritage

Forthcoming INTERSPECIES

INTERNATIONAL SUMMER SCHOOL 2021

THANK YOU FOR ATTENTION!

Francesco Grugni, Paulina Pawlikowska, Magdalena Wałek

Between Surviving and Sustaining: Archaeological Site of Erերouyk and the village of Ani Pemza, Armenia

Discover the site!

GROUP 2

Yashaswini Jayadevaiah
Indian Institute of Technology Kampur (India)

Rahaf Orabi
Pázmány Péter Catholic University (Hungary)
The Cyprus Institute (Cyprus)

Marina Serpe
Silesian University of Technology (Poland)

Marta Wojnowska
Jagiellonian University (Poland)

1

Digital Strategies for Endangered Cultural Heritage
Forthcoming INTERSPECIES

INTERNATIONAL SUMMER SCHOOL 2021

**Between Surviving and Sustaining:
Archaeological Site of Erերouyk and the village of Ani Pemza, Armenia**

by

Y Jayadevaiah, R Orabi, M Serpe, M Wojnowska

2

Archaeological Site of Erերouyk

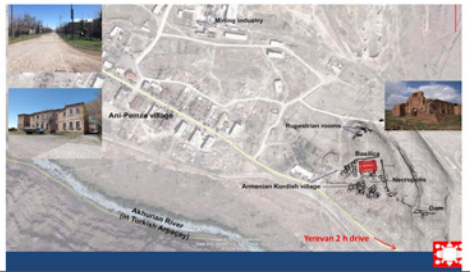
Prelude to the Proposal

3

Archaeological Site of Erերouyk

GENERAL AIM / RATIONALE

Armenia is a country with a long history, and much of its cultural heritage is also symbolic of the identity of the Armenian people. For that reason, the government positions cultural heritage protection as a vital national policy, and is actively engaged in related activities - *2010, Survey Report on the Protection of Cultural Heritage in the Republic of Armenia by Japan Consortium for International Cooperation in Cultural Heritage*



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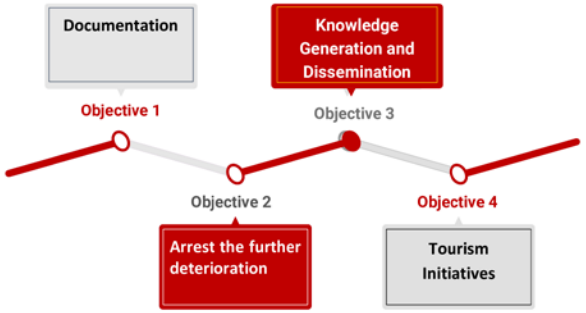
Archaeological Site of Erերouyk

OBJECTIVES



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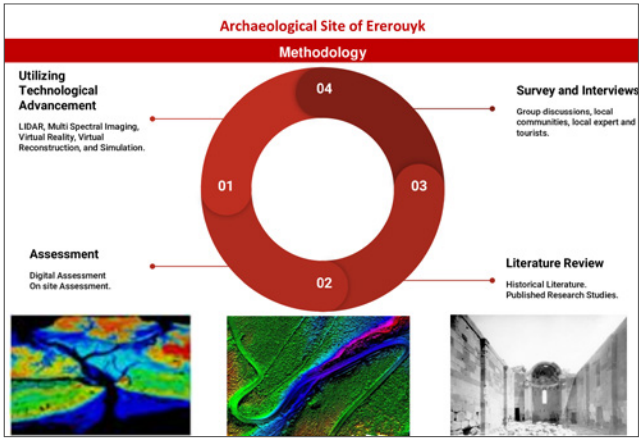
Archaeological Site of Ererouyk
Methodology
Utilizing Technological Advancement
LIDAR, Multi Spectral Imaging, Virtual Reality, Virtual Reconstruction, and Simulation.
04
Survey and Interviews
Group discussions, local communities, local expert and tourists.
01
03
Assessment
Digital Assessment
On site Assessment.
02
Literature Review
Historical Literature.
Published Research Studies.

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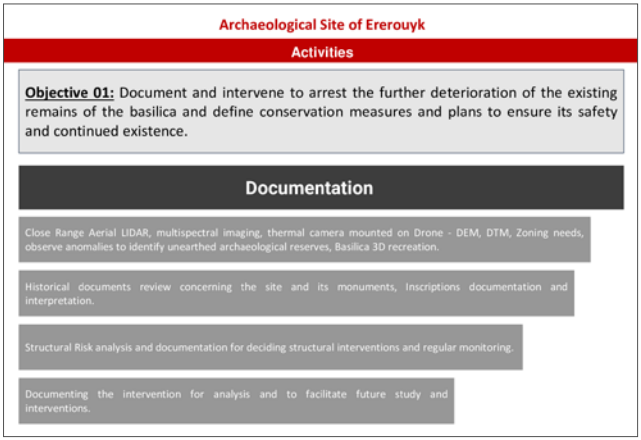
Archaeological Site of Ererouyk
Activities
Objective 01: Document and intervene to arrest the further deterioration of the existing remains of the basilica and define conservation measures and plans to ensure its safety and continued existence.
Documentation
Close Range Aerial LIDAR, multispectral imaging, thermal camera mounted on Drone - DEM, DTM, Zoning needs, observe anomalies to identify unearthed archaeological reserves, Basilica 3D recreation.
Historical documents review concerning the site and its monuments, Inscriptions documentation and interpretation.
Structural Risk analysis and documentation for deciding structural interventions and regular monitoring.
Documenting the intervention for analysis and to facilitate future study and interventions.

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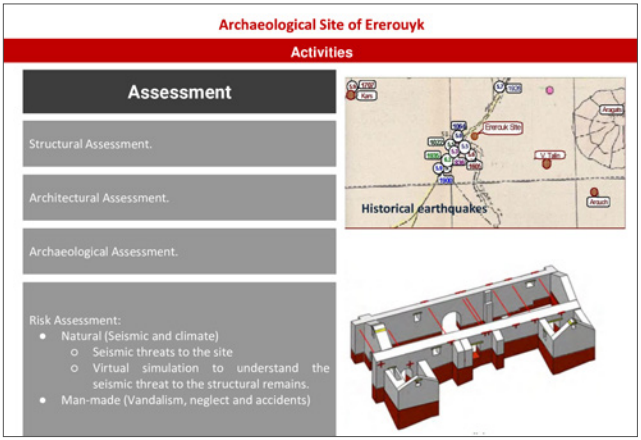
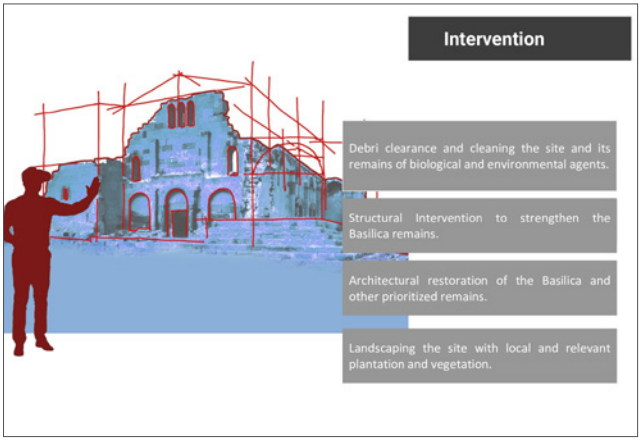

Archaeological Site of Ererouyk
Activities
Assessment
Structural Assessment.
Architectural Assessment.
Archaeological Assessment.
Risk Assessment:
Natural (Seismic and climate)
Seismic threats to the site
Virtual simulation to understand the seismic threat to the structural remains.
Man-made (Vandalism, neglect and accidents)
Historical earthquakes

8


Intervention
Debri clearance and cleaning the site and its remains of biological and environmental agents.
Structural Intervention to strengthen the Basilica remains.
Architectural restoration of the Basilica and other prioritized remains.
Landscaping the site with local and relevant plantation and vegetation.

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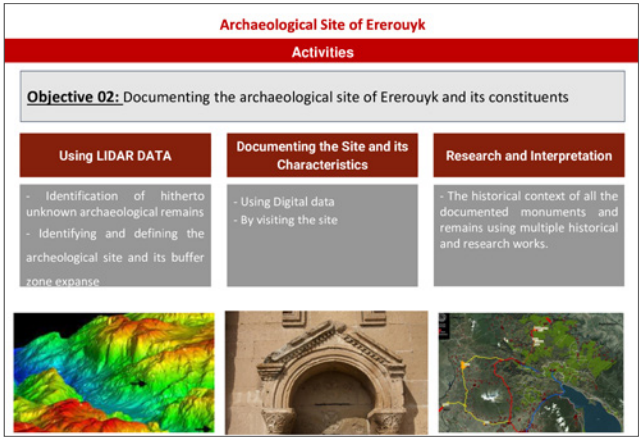
Archaeological Site of Ererouyk
Activities
Objective 02: Documenting the archaeological site of Ererouyk and its constituents
Using LIDAR DATA
- Identification of hitherto unknown archaeological remains
- Identifying and defining the archeological site and its buffer zone expanse
Documenting the Site and its Characteristics
- Using Digital data
- By visiting the site
Research and Interpretation
- The historical context of all the documented monuments and remains using multiple historical and research works.

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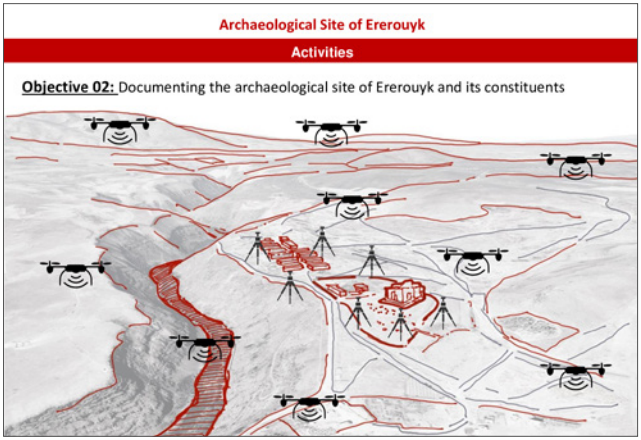
Archaeological Site of Ererouyk
Activities
Objective 02: Documenting the archaeological site of Ererouyk and its constituents

11

Archaeological Site of Ererouyk

Activities

Objective 03: Fostering research, interpretation and dissemination of historical context and heritage of the site to increase its cultural significance.

Conducting 3D reconstruction of the structure of the Basilica in the 6th century.

Utilizing that reconstruction in VR environments to advertise and disseminate the site.

Comparing the 3Ds model of the initial configuration of the site with the 3D model of the actual configuration using historical documents, photos, etc...

Designing an interactive virtual experience during the soviet times.

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Archaeological Site of Ererouyk

Activities

Objective 04: Tourism planning and facilities creation

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- Identify the areas within and outside the defined site expanse that fits and fulfill the requirements to create required tourist amenities
- Improve and further create basic tourist amenities - Restrooms (toilets), drinking water facilities, cafeterias and restaurants
- Environment friendly waste collection and in situ disposal management

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- Tourist interpretation center with an aim to communicate conservation and research activities at the site

- Providing Immersive audio - visual experience using technology to combine storytelling and virtual reality coupled with tourist trial

- Tourist souvenir shops which will include site related souvenir as well as any local craft, artistic or/and unique products. The availability of these products in and around the site area needs to be surveyed and mapped before integrating them into tourist souvenir shops.

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Archaeological Site of Ererouyk

REFERENCES AND RELATION WITH THE STATE-OF-ART

- Social media
- Representing Site as Heritage Compendium
- Targeting young and adult Population
- Positioning site as an open air museum

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Taking in action Endangered Cultural Heritage Sites

Steps of intervention: WORKPLAN

Activities	1st quarter	2nd quarter	3rd quarter	4th quarter	5th quarter	6th quarter	7th quarter	8th quarter
Documentation								
Assessment								
Intervention								
Analysis and Interpretation								
Fostering research, interpretation and dissemination of historical context								
Tourism planning and facilities creation								

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Archaeological Site of Ererouyk

PROFILES' and EXPERIENCES

Marta Wojnowska
Specialization - Art Historian
Education - Post Graduation, Art History and Preservation of Cultural Heritage, Jagiellonian University

Have expertise in monitoring and evaluating architectural interventions. Presently working as Inspector of architectural monuments working in MWUOZ Delegation in Tarnów

Marina Serpe
Specialization - Structural
Education - Post Graduation

Civil engineer with an interest in the conservation of historical heritage. During the master's thesis I analyzed the Ninfeo Ponari through a FEM analysis of soil-structure interaction to simulate the stress history of the system. The goal was to understand the current state of the structure and evaluate, in a completely preliminary way, possible recovery interventions.

Rahaf Orabi
Specialization- Architecture
Education- Post Graduation, Digital Architecture, Digital Cultural Heritage

PhD candidate in PPKE, Hungary, working on the Digital Reconstruction of the Historical Morphology of the Old City of Aleppo in the Medieval Period. Architect in the DGAM, Syria, with experience in laser scanning and photogrammetry for damaged and endangered heritage.

Yashaswini Jayadevaiah
Specialization - Archaeology
Education - Post Graduation, PhD Researcher

Archaeology and cultural heritage enthusiast pursuing PhD in 'Archaeology and technology practice and its theorization' with a practice based approach at IIT Kanpur, India. Expertise include Digital and computational archaeology, Ancient science & technology, theoretical archaeology and its epistemological implications

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

- An account of Histographic development of the site across centuries based on archaeological and monumental remains.
- Creating and disseminating site heritage to reach out to target population through social and other media.
- Documentation dossier on the site interventions including their outcomes
- Improved footfall of the tourists to the site owing to improved amenities and disseminated heritage of the site.
- Conserved site, monuments and remains.
- Improved opportunities for the local community to participate and utilize the opportunities created through increased tourist flow.
- Intervention would enable and facilitate possibilities for future actions.

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

- Every nation in Europe from historical time's had reciprocally influenced each others socio, political and cultural arenas. Acknowledging them through recognising these multilayered interactions (positive and negative) can be well represented through cultural heritage and history of such sites.

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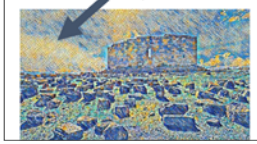
Taking in action Endangered Cultural Heritage Sites

SUSTAINABILITY

Understand site's all tangible components with an utmost sensitivity for its historical events and composition.



Arrest further deterioration of the monuments & remains with responsible and sustainable interventions.

Making site a viable heritage for the local community and its visitors.

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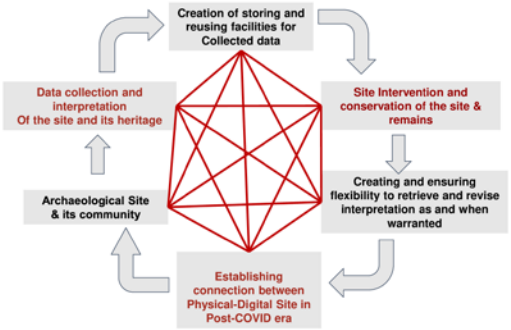
Taking in action Endangered Cultural Heritage Sites

SUSTAINABILITY



Proposal for Restoration and Valorization of the Convent of St. Anthony of Padua in the Region of Extremadura, Spain

Discover the site!

GROUP 3

Taha Alorabi
University of Pavia (Italy)

Virginia Miele
Silesian University of Technology (Poland)

Dominika Strzałka-Rogal
Cracow University of Technology (Poland)

Valentina Vassallo
The Cyprus Institute (Cyprus)

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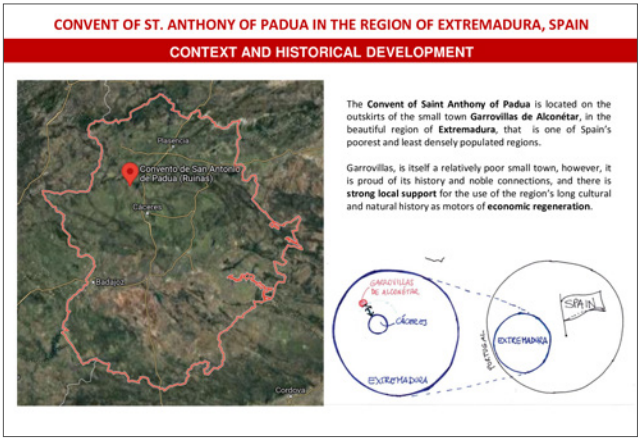

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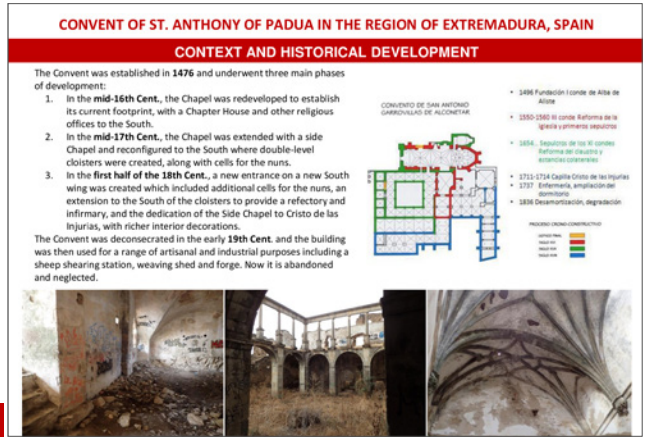

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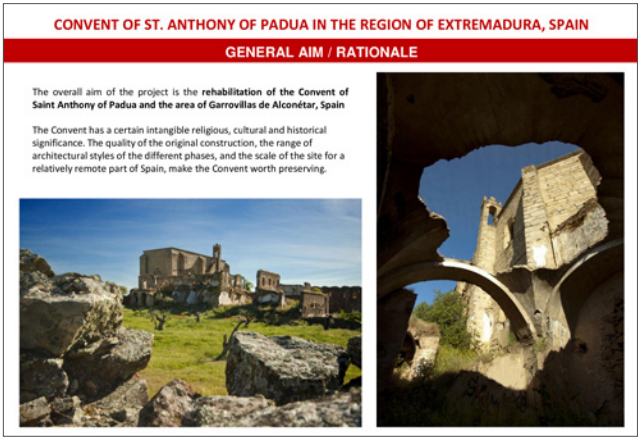

CONVENT OF ST. ANTHONY OF PADUA IN THE REGION OF EXTREMADURA, SPAIN

OBJECTIVES

OBJECTIVES

1. **Restoration/ Partially re-construction project**
2. **Sustainable re-Use**
3. **Promotion**

Actions for Restoration and reconstruction:
- Archaeological survey and historical documentation/analysis
- Digital documentation of the cultural asset
- Structural analysis and diagnostic

Actions for sustainable re-use
- 3D models - digitalization of "memory"
- Musealization and cooperation with the other museum in the area
- Temporary exhibition and events
- Landscape design and creation of a "Physic Garden" would provide additional attraction for potential visitors.

Actions for Promotion and Sustainability
- Reuse of rural infrastructures for promoting internal landscape
- Integration in existing Cultural and Natural trails
- Connection with facilities provided by local community for accomodation (Air b&b, restaurants and so on)
- Astro-tourism
- Valorization and branding of typical local products

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CONVENT OF ST. ANTHONY OF PADUA IN THE REGION OF EXTREMADURA, SPAIN

REFERENCES AND RELATION WITH THE STATE-OF-ART

State-of- the-art:
similar examples of neglected monasteries rehabilitated and reconstructed for different purposes.

The Medieval Monastery in Ayia Napa
Current works of re-storation and re-use of the Medieval Monastery in Ayia Napa. Digging of the ancient remains and re-use of the monastery cells as museum rooms.

Ptuj Monastery, Slovenia
The building has to be adapted to its future use without major invasive interventions, which would damage its historical structure.

Roof for the ruins of the Monastery of San Juan in Burgos
The project sought to elegantly preserve an important monument in the city of Burgos in the north of Spain. Thanks to conservation efforts in the latter half of the 20th-century, the ruin, though exposed was in relatively good condition.

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CONVENT OF ST. ANTHONY OF PADUA IN THE REGION OF EXTREMADURA, SPAIN

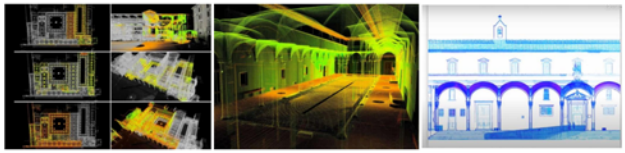
REFERENCES AND RELATION WITH THE STATE-OF-ART

State-of- the-art:
example of 3D documentation and 3D reconstruction projects for several purposes

Inception Projects

INCEPTION realises innovation in 3D modelling of cultural heritage through an inclusive approach for **time-dynamic 3D reconstruction** of artefacts, built and social environments.

INCEPTION methods and tools will result in 3D models that are easily accessible for **all user groups** and **interoperable** for use by different hardware and software.



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CONVENT OF ST. ANTHONY OF PADUA IN THE REGION OF EXTREMADURA, SPAIN

PROFILES'EXPERIENCES

Valentina Vassallo is a Dual PhD candidate in Science and Technology in Cultural Heritage at the Cyprus Institute (Cyprus) and in Classical Archaeology and Ancient History at Lund University (Sweden), focusing her research on the development of a 3D digital approach, based both on geometric and semantic aspects, for the study and interpretation of archaeological material. She earned a B.A. and M.A. in Conservation of Cultural Heritage - Archaeology) and an M.A. in Conservation and management of Cultural Heritage with a major in digital methodologies and technologies. Valentina was formerly a Fellowship Researcher at the Institute of Technologies Applied to Cultural Heritage of the Italian National Research Council (Itabc - CNR) focusing her research activities on 2D/3D archaeological documentation, Geographical Information Systems, and Virtual Museums.

Virginia Miele is a doctoral student in the Department of Architecture and Urban Planning at the Silesian University of Technology, in Gliwice. The scientific aim of the Ph.D. thesis is to define the characteristics of the post-Industrial heritage, through the analysis of selected Italian and Polish cases of study, in order to prescribe recommendations for the process of revitalization of the Valley of Liri, in the region of Lazio. She earned a Master Degree in Restoration of Architecture at the University of Ferrara with the Master thesis: "Fragmented Urban Organisms. Studies for reintegration of an urban gap".

Dominika Strzałka-Rogal graduated from Cracow University of Technology. She earned a Master Degree in Chair of History of Architecture and Monument Preservation with Master Thesis "Miedzianka, the story of disappearing", focusing her research on post-industrial heritage connected with social needs.

Taha Alcrabi, Architecture master student in the university of Pavia. He is working on thesis in survey and restoration of culture heritage .

8

Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

Atlas: creation of an Atlas that includes **natural and cultural routes** and position the building within it, going from **macro connections** with bigger cities (such as Madrid, Salamanca, Toledo in Spain and Evora in Portugal) to the **micro level** (the village of Garrovillas de Alconétar and its surroundings).

To obtain this aim, the following results and outcomes will be expected.

Partial reconstruction of the Convent: The reconstruction/restoration will affect the areas more stable and that not need a complete makeover, given some exception (see technical report).

Musealization of the building: the reconstructed part will be dedicated to the musealisation of the convent to present the building itself and the history and archaeology of the area (e.g., **Via de la Plata** and **Roman sites**, from Roman to modern times). In the rooms of the museum the 3D models - also acquired for the technical purposes (analysis and diagnosis)- can be shown and reused for a diachronic visualisation of the building + other multimedia solutions). The new cultural asset/museum will be an attraction to be inserted in the historical and **archaeological route of the Extremadura**.

Consolidation of other parts of the building: those parts of the Convent requesting a heavy reconstruction and intervention will not be reconstructed but only stabilised to be used as Miradores within the **Astro-tourism tour**.

Creation of an agritourism system: at a local level the involvement of farms and locals to create hospitality -e.g., agricultural area will be achieved (branding and selling of products produced in the area, e.g. oil, Porto wine).

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Taking in action Endangered Cultural Heritage Sites

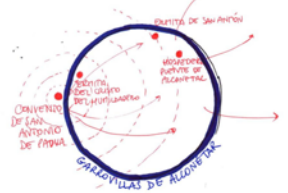
EXPECTED RESULTS / OUTCOMES

Historical and Cultural Attractions of Garrovillas de Alconétar

The rehabilitation of the Convent will offer a positive economic and financial return also for the local community and the surroundings. Beyond the historical structures on the Via de la Plata already mentioned, there are:

- **Plaza de la Constitución** – large and beautifully colonnaded town square;
- **Iglesia de San Pedro Apostol** – 15th Century gothic church in a striking setting;
- **Convento de Nuestra Señora de la Salud** – small convent with some particular architectural features;
- **Iglesia de Santa María de la Consolación** – very early 15th Century church, well restored and with one of only three fully operational church organs in the world from the period;
- **Ermita de San Anton** – slightly misleading name: a small restored chapel close to the centre of town;
- **Museo Etnografico** – well presented and substantial collection of artefacts based by theme on the different trades of the town and locality.
- **Hospederia Puente de Alconétar** – former palace of the Dukes of Alba, now a hotel.

The historic city of Alcàntara is only 30 km away



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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

Astrotourism route: the stabilised ruins of the Convent will be included in the list of the Miradores of the night sky

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Taking in action Endangered Cultural Heritage Sites

Steps of intervention: WORKPLAN

Historical and archaeological documentation

Collection of the historical and archaeological documentation related to the Convent and the geographical area in which is included.

Diagnostic analysis and 3D reconstruction

Diagnostic and structural analysis for the reconstruction and restoration project. 3D virtual reconstruction of the different phases of the Convent to be used for the musealization

Jan 2022 — March — March-Apr — May 2022 - May 2023

Survey and 3D documentation

Survey and 3D documentation of the Convent and the surrounding landscape to obtain a measurable model of the building state-of-the-art. Post-processing and production of the 3D models.

Promotion and sustainability

Insertion of the building within the natural and cultural routes, establishment of agritourism facilities and branding of specific products

Reconstruction and restoration project

Consolidation of the structures and partial reconstruction of the building

Musealization of the Convent

Musealization of the restored building and setting of the exhibition rooms and areas dedicated to events

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

Atlas: rehabilitation of the Convent/village and its inclusion within the tourism routes, but with a light change on the area in order not to change its rural identity and make the best use of its resources.

Musealization of the building: enhance the sense of identity of the citizens and their belonging to that culture/area.

Creation of an agritourism system: pushing the economy without changing the traditional activities of the area

EU point of view: exploitation of a poor area stimulating the tourism and local productions in order to create jobs and an economical growth

Local community: The remaining structures on the site are not sustainable in the long term: sooner or later, the Convent will collapse. If the remaining structures are to be sustainable, then they will need to be repaired, reinforced and protected. This work of stabilisation should have a positive environmental impact and create a secure site for visitors. To see the Convent not only as a cultural heritage asset, but also as an instrument of social redevelopment: converting the existing structures into usable spaces, either incrementally or in a single act, could have a strongly positive social impact. Garrovillas de Alconétar is at risk, like many other relatively remote Spanish villages. The Commune sees the region's cultural and social heritage as potential draws for visitors, who will put money into the local economy and arrest its economic and social decline.

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Taking in action Endangered Cultural Heritage Sites

SUSTAINABILITY

*"**Sustainable reuse**, like adaptive reuse, is based upon the assumption that buildings, areas, districts, and sites are not static entities. They are not designed simply for one single use during their life cycle. It consists of the practice of introducing new content in an existing site, paying particular attention to the needs of society, and following the principle of **maximum conservation and minimum transformation**."*

Cfr. Marco Morandotti, *"Cultural Heritage digital asset management - between planned conservation and sustainable reuse"*

"Ready Citizen One" Towards Heritage Knowledge Accessibility & Conservation in Dolcho and Apozari, Kastoria, Greece

Discover the site!

GROUP 4

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Houda Ben Younes
Sapienza University of Rome (Italy)

Mathias Haindl
École Polytechnique Fédérale de Lausanne (Switzerland)

Federico Mario La Russa
University of Catania (Italy)

Katarzyna Tomzynska
Cracow University of Technology (Poland)

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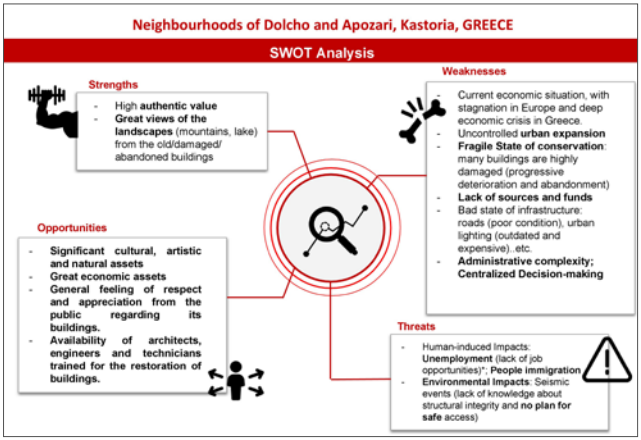

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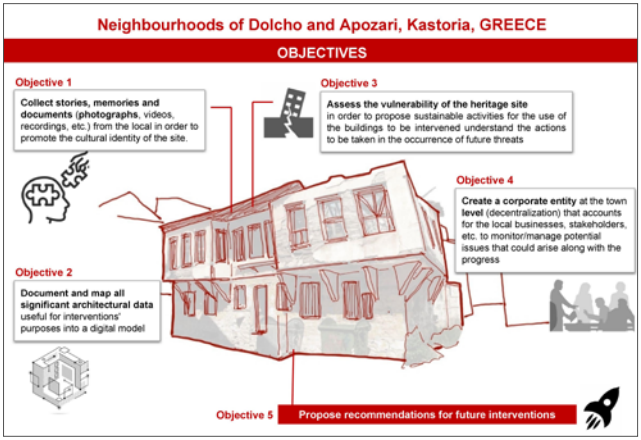

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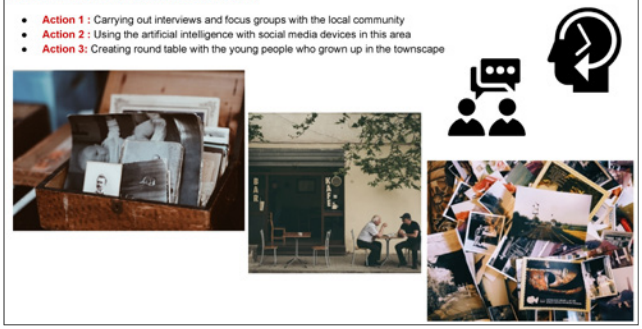
Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

OBJECTIVE 1 - Scan the Cultural Identity

Collect stories, memories and documents (photographs, videos, recordings, etc.) from the local in order to promote the cultural identity of the site.

- **Action 1 :** Carrying out interviews and focus groups with the local community
- **Action 2 :** Using the artificial intelligence with social media devices in this area
- **Action 3:** Creating round table with the young people who grown up in the townscape



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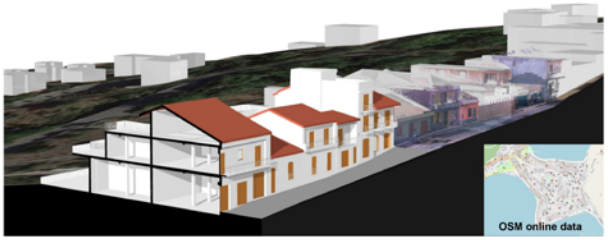
Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

OBJECTIVE 2 - Digital Urban Survey and City Information Modeling

Document and map all significant architectural data useful for interventions' purposes into a digital model:

- **Action 1:** Performing architectural digital survey campaigns of the site
- **Action 2:** Designing a responsive 3D city database by merging acquired survey data and open-data available online
- **Action 3:** Preparing the 3D city database for the enrichment with all architectural and cultural metadata



La Russa F. M., Genovese G. (2021), *City Information Modeling and seismic risk: integrated H-BIM approaches for the management of post-earthquake scenarios*, . In: (eds.) Bolognesi C. and Santagati C., Dienne – Building Information Modeling, Data & Semantics, 8, pp. 71 – 82

7

Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

OBJECTIVE 3 - Vulnerability Assessment

Assess the vulnerability of the neighbourhoods and propose sustainable activities for the use of the buildings to be intervened, and proposing immediate actions in the occurrence of future threats (seismic, landslide, climate change, etc.)

- **Action 1:** Overlapping of map with the identification and distribution of most vulnerable buildings with hazard map for the site of study (seismic, landslide, etc.)
- **Action 2:** Identification of risks associated with primary services (hospitals, schools, etc.) in order to mitigate the consequences for the community in case of severe damage
- **Action 3:** Strengthening proposal by preserving the building's architectural and historical value
- **Action 4:** Create safety routes to visit the areas where the most vulnerable buildings are located
- **Action 5:** Generate an operational plan in the case of an earthquake to keep the community in a safe condition

Giardini, D., J. Woessner, L. Danciu (2014) Mapping Europe's Seismic Hazard. EOS, 95(29): 261-262. www.efehr.org/en/Documentation/specific-hazard-models/europe/overview/

I. D. Bantisiotou, T. M. Tsapanos, V. N. Margaris, P. M. Hatzidimitriou. Estimation of the seismic hazard parameters for various sites in Greece using a probabilistic approach. Natural Hazards and Earth System Sciences

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Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

OBJECTIVE 4 - CORPORATE Entity

Creating a corporate entity at the town level (decentralization) that accounts for local businesses, stakeholders, etc. in order to manage potential issues that could arise along with the progress

- **Action 1:** Creating a committee composed of management specialists and economic experts
- **Action 2:** Organizing regular meetings with governmental authorities, local community and other stakeholders.

Adopted after Burra Charter for Cultural Significance (Version 2013)

1- Hamrouni, I.B.O. & Amer, M. (2021), Siwa Oasis: a Forgotten Heritage under Threat. In S. Doempke, L. Tournillon & M. Turne (eds), World Heritage Watch Report 2021. Berlin: World Heritage Watch, 122 – 126.

2- Management Plan - UNESCO World Heritage Site "Old Town of Regensburg with Stadtamhof" - www.regensburg.de/sixcms/media.php/464/STADT_RGBG_MANAGEMENTPLAN_WELTERB_E_GB_screen.pdf

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Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

OBJECTIVE 5 - Recommendations

Propose recommendations for the future interventions

- **Action 1:** Propose standards and guidelines for a strategic site management
- **Action 2:** Propose an economic planning based on the site's assets
- **Action 3:** Propose a visitor's experience management and interpretation

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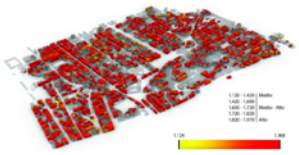
Taking in action Endangered Cultural Heritage Sites

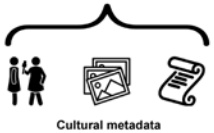
EXPECTED RESULTS / OUTCOMES

1 - Development of an open-access City Information Model (CIM) where locals, tourists and investors can find and interact with:

1.1 Data related to nowadays state of conservation of the building units coming from survey campaigns.

1.2 Metadata uploaded from community members and interested parts such as interviews, historical photos and documents.





La Russa F. M., (2021), *AI for AEC: Open Data and VPL Approach for Urban Seismic Vulnerability*. In: (eds.) Giordano A., Russo M., Spallone R., REPRESENTATION CHALLENGES - Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain, pp 383 - 387

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

2 - Taking action to start with restoration works and safety plan (identification and prioritization of the most deteriorated buildings and areas)

Revitalized historic building in Dolcho: Poulopoulos Mansion
http://7mostendangered.eu/sites/neighbourhoods-of-dolcho-and-apozari-kastoria-greece/

Revitalized historic building in Kastoria: Skoutari's Mansion
http://www.kurovelegkos.org/wp-content/uploads/2016/11/7ME-2014-Greece-Kastoria-Report.pdf

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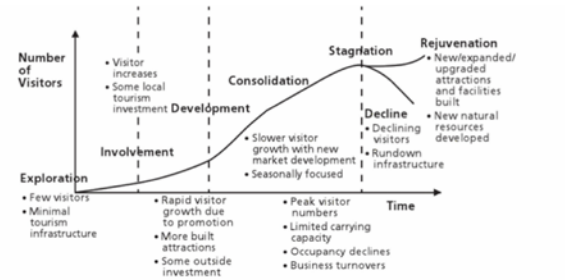
Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

3 - Taking action to start with restoration works and safety plan



Morrison, A. M. (2013). Marketing and Managing Tourism Destinations. New York: Routledge, p.71, fig. 3.2.

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

4 - Elaborating a functional guidelines for the future adaptive uses for buildings and public spaces

Dolcho. Museum of the Macedonian Struggle
http://7mostendangered.eu/sites/neighbourhoods-of-dolcho-and-apozari-kastoria-greece/

UNESCO, 2016. *Culture: Urban Future. Global Report on Culture for Sustainable Urban Development*. Paris. UNESCO.

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

MID-TERM IMPACTS

- Train locals and professionals on how to **use and enrich the database with their own data along the time**
- Promote the sites' values along with the conservation process in parallel in order to **raise awareness among the local community.**
- Emancipate the level of the local community involvement (engagement of community)
- Regularize the development plan of the town, taking into account the landscape (to address/pause the "chaotic" urban expansion)
- Develop a mobile app for various types of users (visitors, tour guides, local community, authorities, check, show the evolution of the restoration progress…….)

LONG-TERM IMPACTS

- Revive the neighborhoods of Dolcho and Apozari
- Create/develop/enhance **sustainable cultural tourism**
- Attract **various tourism segmentations** (environment explorers, scholars..etc)
- Adapt the buildings to their new uses (creating summer school activities, elaborating adaptive-reuse of buildings, etc), and bringing a new life to the site
- Generate thematic events (e.g. events for archaeologists, city walks for historians, etc.)

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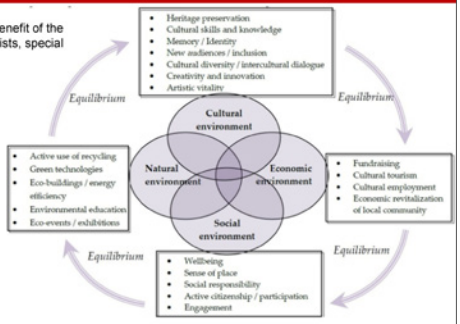
Taking in action Endangered Cultural Heritage Sites

SUSTAINABILITY

Future potential use and benefit of the site to anyone (locals, tourists, special group of interest



Luiza Pop, I. & Borza, A. (2016), Factors Influencing Museum Sustainability and Indicators for Museum Sustainability Measurement. Sustainability 8(1), 101 - 122 (Fig. 1 - adapted after: Stylianou-Lambert, T.; Boukas, N.; Christodoulou-Yerali, M. Museums and cultural sustainability: Stakeholders, forces, and cultural policies. Int. J. Cult. Policy 2014, 20, 566–587)

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Neighbourhoods of Dolcho and Apozari, Kastoria, GREECE

PROFILES'EXPERIENCES

Mohamed Amer, M.A.
Heritage Site Management Professional; HeritageForAll Initiative Founder; Ph.D. student in Heritage Marketing and Sustainable Cultural Tourism at Roma Tre University (developing a people-based heritage branding model); M.A. in Heritage Conservation and Site Management (BTU-Cottbus Senftenberg, 2015); ICOMOS-ICTC Member.
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Architect, researcher and member of the scientific and technical committee whose purpose is to inscribe the island of Djerba (Tunisia) on the World Heritage List. I published in diverse topics such as; Ibadite Architecture in the Maghreb, Berber domestic Architecture in Djerba, Demmer and Nafusa mountains, Heritage conservation policies in the island of Djerba and the M'Zab valley.
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Katarzyna Tomżyńska, MSc. Arch.
Architect, conservator of monuments and inspector of the Provincial Office for the Protection of Monuments, Ph.D. student at Cracow University of Technology at the Faculty of Architecture. Interested on the method of valorization of risk management in historic manor complexes in Małopolska (Poland).
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Mathias Haindl, Ph.D. Student
Civil engineer. Currently researching at the Earthquake Engineering and Structural Dynamics Laboratory at EPFL on the quantification of several sources of uncertainty embedded in post-earthquake assessments of masonry structures, and recognizing the structural vulnerabilities for subsequent decision-making.
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Federico Mario La Russa, Ph.D. Student
Civil engineer and architect. Since 2019 Ph.D. student in "Evaluation and mitigation of urban and land risks" at the Department of Civil Engineering and Architecture - University of Catania. Currently working on a PhD thesis that deals with City and District Information Modeling for expeditious seismic vulnerability assessment.
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An Intervention and Marketing Proposal for the Monastero di San Benedetto Po in Polirone, Italy

Discover the site!

GROUP 5

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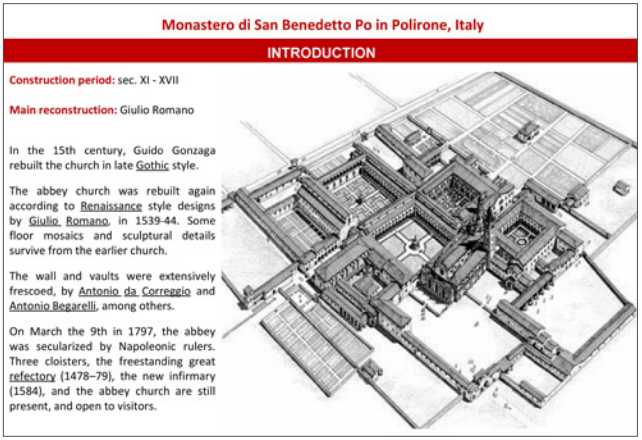

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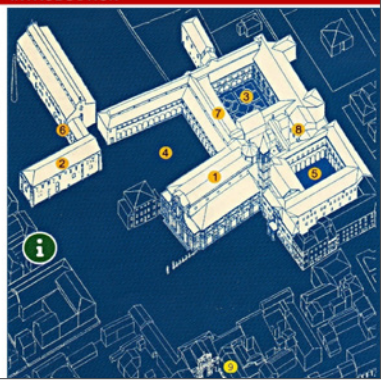
Monastero di San Benedetto Po in Polirone, Italy

INTRODUCTION

Responsibility of three separate authorities:
State Authorities - External damage with risk to the public
Parish of San Benedetto Po - Internal damage to the Basilica and Oratory
Municipality of San Benedetto Po - Internal damage to the remaining buildings.

Includes:

1. Church of SS. Benedetto and Simone
2. Refectory of the Abbey of Polirone
3. Cloister of S. Simeone of the Abbey of Polirone
4. Cloister of S. Benedetto
5. Cloister of the Secular
6. Cellars and Infirmary
7. Monumental rooms
8. Polironiano Museum of Material Culture
9. Ancient entrance door



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Monastero di San Benedetto Po in Polirone, Italy

INTRODUCTION

7

Monastero di San Benedetto Po in Polirone, Italy

INTRODUCTION

8

Monastero di San Benedetto Po in Polirone, Italy

INTRODUCTION

9

Monastero di San Benedetto Po in Polirone, Italy

AIMS and OBJECTIVES

AIM: To aid the transformation of San Benedetto to a visible attraction for local and international visitors.

Objectives:

1. Overall Marketing of the site and all of its assets;
1. Condition assessment of the building post-earthquake and after intervention - ways to make it earthquake resistant;
1. Production of Digital Model (H-BIM) as an archive of all intervention (past and future), to overcome current difficulties in managing the stakeholders and the site;
1. Real-time monitoring of assets to proactively solve issues on-site and plan in case of future crises.

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Monastero di San Benedetto Po in Polirone, Italy

REFERENCES AND RELATION WITH THE STATE-OF-ART

The search for literature regarding the site was conducted **online** in September 2021 in both English and Italian to identify previous work and research conducted, the findings could be summarised as:

References

Previous Interventions

Restoration works 2000 - 2012: some monastery buildings and frescoes were restored.

STUDIO BERLUCCHI 2012 - 2015: relief conservation, architectural design (preliminary, definitive, executive),work supervision, safety coordination plan during execution.

Reports

Technical-Descriptive Report of the Project Interventions - San Benedetto - February 2013

Seismic Report and Evaluation - San Benedetto - February 2013

Repair, Seismic Improvement - Cloisters of San Simeone - 8th August 2013

Europa Nostra Technical Report 2015: proposes an action programme for the monastery subsequent to the 2012 earthquake damage.

Scientific Research

Thermo - Hygrometrical Surveyings and Microclimate Monitoring at the San Benedetto Po Abbey (Del Curto and Grimoldi 2006):

the Aim was to develop IRT procedures for the monitoring of thermo – hygrometrical conditions of ancient buildings and surveillance of risk areas.

Other Sources

Brochures and Articles:

Youtube Videos:

Google Street tours

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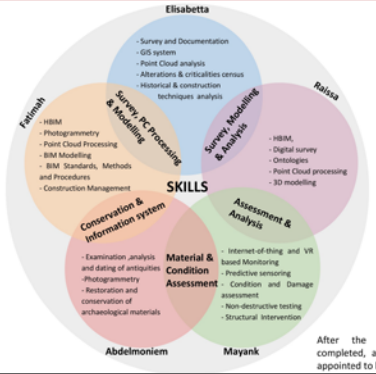
Monastero di San Benedetto Po in Polirone, Italy

PROFILES' EXPERIENCES



After the technical Intervention is completed, a **Marketing Expert** shall be appointed to lead the marketing campaign.

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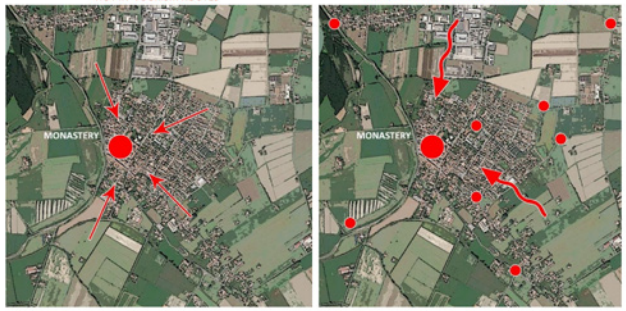
Monastero di San Benedetto Po in Polirone, Italy

METHODOLOGY STARTING POINT

MONUMENT DISCONNECTED FROM THE VILLAGE, NOT IN TOURISM ROUTES

MONUMENT CONNECTED TO THE VILLAGE: WHOLE TERRITORY IS POSITIVELY IMPACTED



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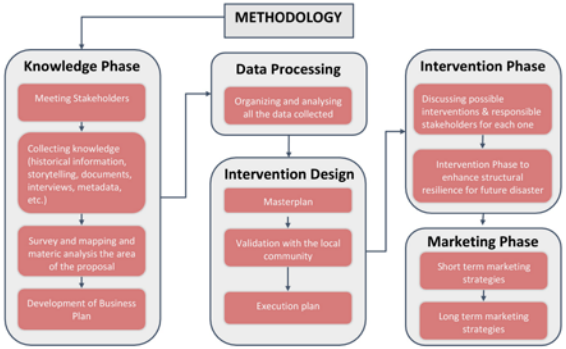
Monastero di San Benedetto Po in Polirone, Italy

METHODOLOGY AND TOOLS



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Monastero di San Benedetto Po in Polirone, Italy

METHODS

Chronology of Monastery restoration works after earthquake

- San Simeone – first floor head-quarters of Polironiano Museum (earthquake damages categorised)
- Future costs involve €6.3 million out of which €1.8 million financed to make structure safe in accordance with current european earthquake codes
- Library – San Simeone Cloister - could be preserved by online monitoring of assets
- Recommended to solve problem of water infiltration in masonry of San Simeone Cloister
- North and West wings: Central longitudinal walls on the first floor were not perfectly aligned vertically above those of the ground floor - no problem as it pre existing defect !
- Damages due to alteration of first floor owing to building functional use for various purposes - Cracks and fissures
- Basilica - good intervention - impermeable membrane was laid beneath the terracotta tiles to prevent water infiltration
- Some pillars behind the altar have already had to be underpinned by a series of micropiles to a depth of 10m- north side of the nave has sunk several centimetres
- Ceilings and Walls- ceiling frescoes are attached to wooden vaulted structures - stability of wood structure needs to be assessed (show 70% minor damage; 30% major damages)
- Long term benefits under sustainability: for example by inserting impermeable membranes under the roof tiles

Priority should be given to external parts first; then San Simone as it generates employment

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Monastero di San Benedetto Po in Polirone, Italy

PROPOSED INTERVENTIONS

Understanding damages due to earthquake and current temporary interventions

Outer part first, then go with inner (museum etc)

Decide several long term solutions to increase earthquake resistance and monitoring of assets

Inspection and diagnosis Identify causes of damage → Assessment of safety level and prioritising repair areas → Decision for Intervention

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Monastero di San Benedetto Po in Polirone, Italy

METHODS: PROPOSED INTERVENTIONS

After Earthquake proposed permanent interventions - to increase service life time of monument

Using compatible lime-based mortar in retrofitting interventions of large areas of low thickness

Interventions to improve the connections (walls – floors)

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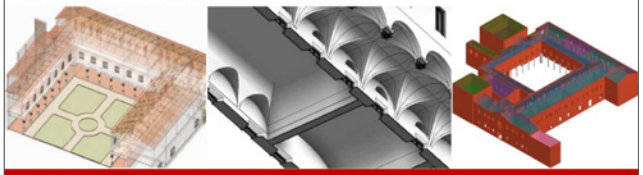
Monastero di San Benedetto Po in Polirone, Italy

METHODS: Scan to H-BIM

Process of documentation that forms an archive of all interventions on site



Placing focus not only on H-BIM as an end product but also as a Process of Collaboration

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Monastero di San Benedetto Po in Polirone, Italy

METHODS: Conservation

conservation process

The previous interventions aimed mostly to an overall re-functionalization and a seismic improvement of the bearing structures

1)the first priority was to secure the structures from further decay and collapse

2)consolidating mortar was injected through the crack

3)the material filling the sides of vaults was removed and replaced with lightweight material

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Monastero di San Benedetto Po in Polirone, Italy

METHODS: Conservation

4)mechanical behaviour was also improved with the insertion of new ties

5)All wooden architraves have been verified and replaced

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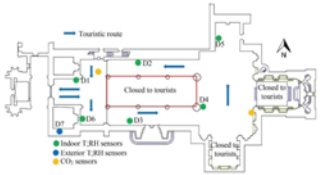
Taking in action Endangered Cultural Heritage Sites

Steps of intervention: sensors and monitoring

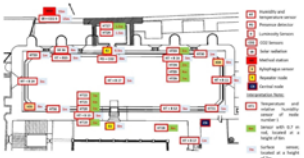
Library – San Simeone Cloister - only part that provide **employment**

- It could be preserved by online monitoring of assets
- Already one micro-climate assessment - carried out

Target People of Interest: Researchers



Jeronimos Monastery in Lisbon (Portugal) (Silva et al. 2020)



Sensors in Historical Library of Salamanca (Spain) (Mora et al. 2021)

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Taking in action Endangered Cultural Heritage Sites

Steps of intervention: Monitoring vibration

For monitoring vibrations IoT + UAV + VR assisted system can be used

Target People of Interest: Researchers

Unmanned aerial vehicle can be used for capturing geometry and then sensors can be viewed in VR interface (Mastio di Matilde in the old fortress (Leghorn) (Bacoo et al. (2020))
VR Tool: http://moscardo.isti.cnr.it/

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Taking in action Endangered Cultural Heritage Sites

MARKETING PHASE

SHORT TERM

- Coordinating with the 3 stakeholders to use some of the site's spaces commercially to host events such as weddings, celebrations or conferences organized by nearby universities (such as the University of Pavia);
- Use of the large central cloister as a stage for summer theater events;
- Using the H-BIM model to provide VR and mixed reality experiences to further enhance the site's attraction;
- The inclusion of the local community in the operation and maintenance process of the site by holding educational workshops, summer schools and seminars;
- Use of social media to increase the visibility of the village and the Monastery.

LONG TERM

- Organizing an annual festival celebrating the long history of the site, and the town around it. It could start on 9 March as this is the date Napoleon suppressed the monastery in 1797 to resemble the site's resilience;
- Enrich the visiting experience by adding **immersive experiences** that celebrate all historical figures who are linked to the site like Giulio Romano, Matilde the great countess, Caravaggio, and Benedetto Fontanini;
- Inscription on national and international heritage lists, possibly representing the site along with all the small towns around it as one world

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Taking in action Endangered Cultural Heritage Sites

EXPECTED RESULTS / OUTCOMES

- Increased structural safety of the building for future earthquakes;
- Activation of a real-time monitoring system for damage control and restoration management;
- Enhancement of a heritage site that is rarely visited today;
- Monastic complex as an aggregating place of culture that interacts deeply with its community;
- Development of widespread and sustainable tourism in the area;

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Taking in action Endangered Cultural Heritage Sites

EXPECTED IMPACT / ADDED VALUE(S) ON THE SITE, COMMUNITY AND EU

- San Benedetto as an attraction for local and international visitors;
- The town will benefit from the financial income generated by visitors, events and public use of its assets;
- The creation of job opportunities for the local community;
- Linking San Benedetto to the Italian cultural scene (particularly with the small towns around it like Mantua);
- New cultural central place on the territory.

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REFERENCES

1. Silva, H. E., Coelho, G. B., & Henriques, F. M. (2020). Climate monitoring in World Heritage List buildings with low-cost data loggers: The case of the Jerónimos Monastery in Lisbon (Portugal). Journal of Building Engineering, 28, 101029.
2. Mora, R., Sánchez-Aparicio, L. J., Maté-González, M. Á., García-Álvarez, J., Sanchez-Aparicio, M., & Gonzalez-Aguilera, D. (2021). An historical building information modelling approach for the preventive conservation of historical constructions: Application to the Historical Library of Salamanca. Automation in Construction, 121, 103449.
3. Bertocci, S. (2020). Digital survey and documentation of two Franciscan convents in Umbria, Italy. Franciscan Landscapes: the Observance between Italy, Portugal and Spain. Architecture of the Souls. 24-25 Sept. 2020
4. Monastero di San Benedetto Po in Polirone, Italy Technical Report, The 7 Most Endangered 2013 Europa Nostra.
5. Cosentino, A. (2014). Panoramic infrared reflectography. Technical recommendations. *International Journal of Conservation Science*, 5(1) ,p51.
6. Thoury, M., Elias, M., Frigerio, J. M., & Barthou, C. (2007). Nondestructive varnish identification by ultraviolet fluorescence spectroscopy. Applied spectroscopy, 61(12), p1275.
7. Micelli, Alessia; Morandotti, Marco; Parrinello, Sandro. 3D survey and semantic analysis for the documentation of built heritage. The case study of Palazzo Centrale of Pavia University. VITRUVIO - International Journal of Architectural Technology and Sustainability,
8. YouTube Videos.
9. http://7mostendangered.eu/sites/renaissance-monastery-of-san-benedetto-po-near-mantova-italy/
10. https://guideturistichemantova.it/monastero-di-s-benedetto-po/
11. https://www.lombardiabeniculturali.it/architetture/schede/MNZ40-00019/
12. https://www.turismosanbenedettopo.it/servizi/notizie/notizie_homepage.aspx

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Socials and Media

FACEBOOK

@INTERSPECIESSchool
https://www.facebook.com/INTERSPECIESSchool

INSTAGRAM

IG Profile: interspecies_school

WEB SITE

URL: https://interspecies-school.unipv.it/

CONTACTS

interspecies.school@gmail.com

INTERSPECIES SCHOOL

SOCIALS HASHTAGS

#INTERSPECIES
#internationalsummerschool
#culturalheritage #culturalheritageindigitalage
#endangeredheritage

#TCH1
#databases #structures #3dmodelling

#TCH2
#project #restoration #buildingtechnologies

#TCH3
#heritage #services #chmarketingservices #vr

#heritage #digitalheritage #heritageprotection
#heritagevalorization #heritagepolicy

The INTERSPECIES network has launched a series of channels and socials profiles for the active dissemination of the project, the partners' research experiences, and the scientific purpose of the summer school. In particular, a Facebook page, an Instagram profile and a Web site have been shared, related to a contact address.
The identification of keywords and hashtags, related to the significant Thematic Challenges of the themes of reflection and intervention on Endangered Heritage, was initiated for a quick and effective search of posts and news related to the activities, participants and developments of the research topics.
The website and social channels provide an opportunity to follow up on the progress of the school, the results and insights from the lectures, and future conference and workshop activities. They are meant to become a reference for the representation of the network.

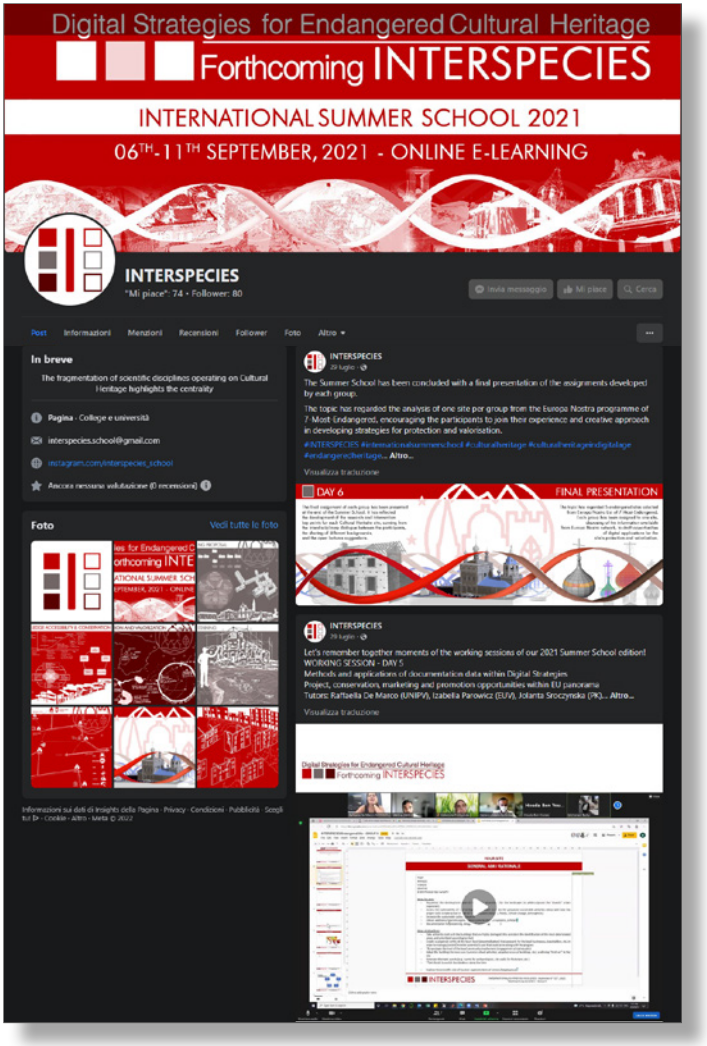
Facebook Page

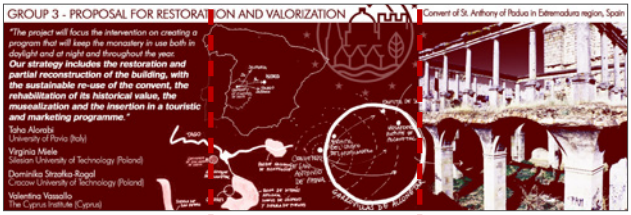
Instagram Profile

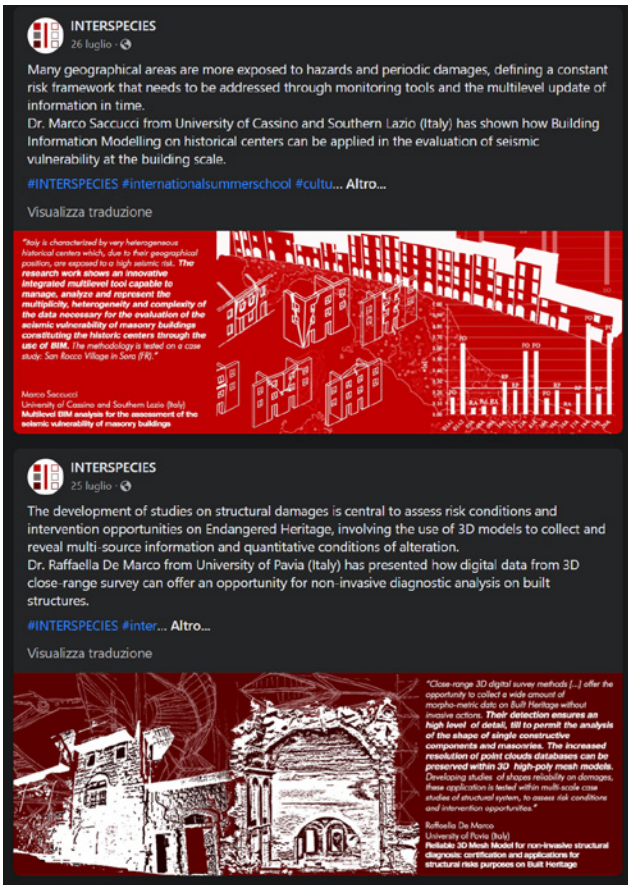
Web Site

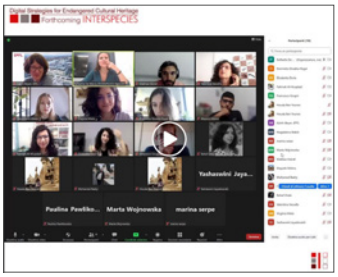
FACEBOOK PAGE

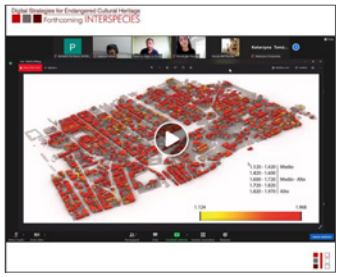
The page launched the call to the Summer School 2021, promoting lecturers, contents and results of activities. It collects posts, original graphics, multimedia and video of lectures. The graphic design included the creative project of the individual posts, which were designed on an adaptable format for other socials.





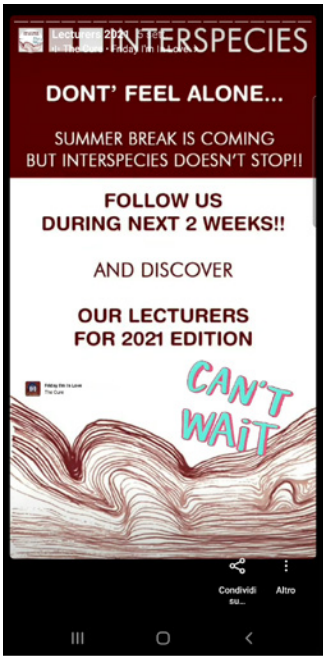


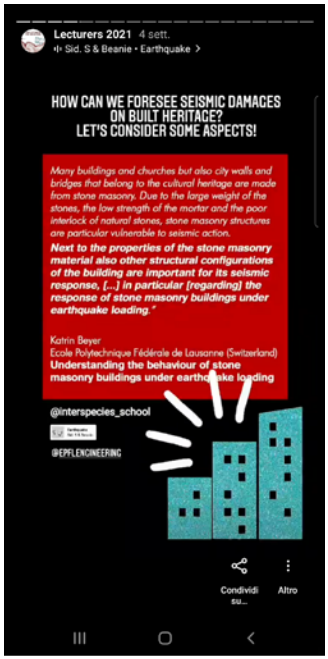




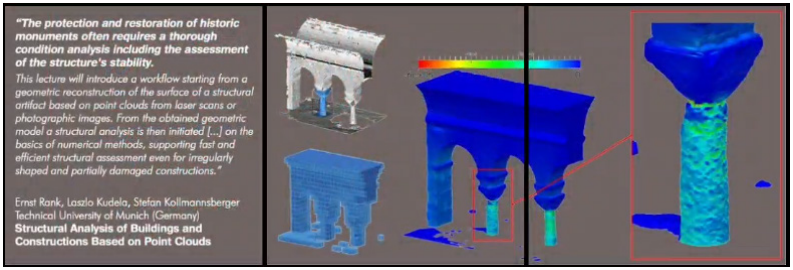
INSTAGRAM PROFILE

The profile adapted the branding of the network (geometry and colour palette) in the promotion of partner institutions, people, participants and Endangered Heritage sites at the centre of the Summer School activities. The graphic layout of the posts is significant both individually and in the overall visual reading and scrolling scheme of the profile.

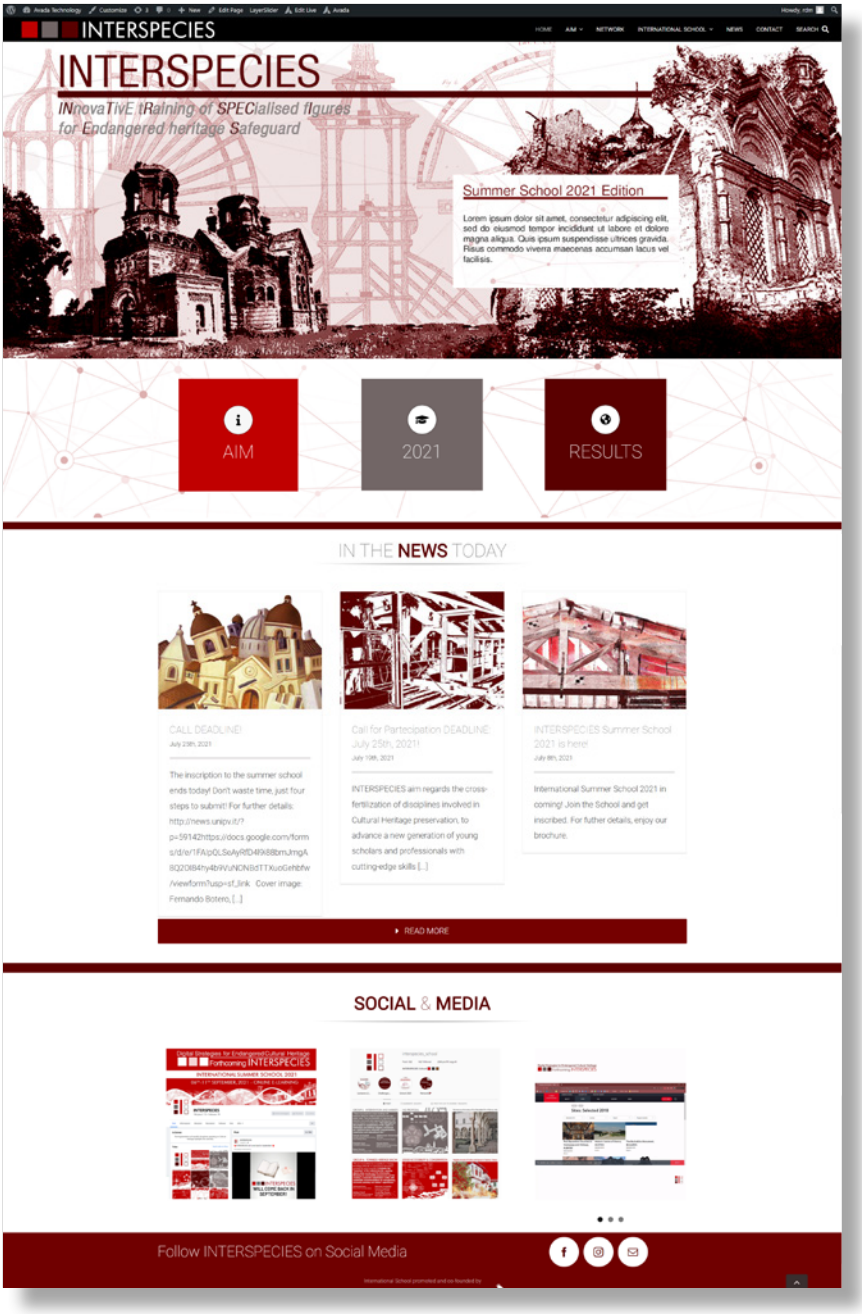




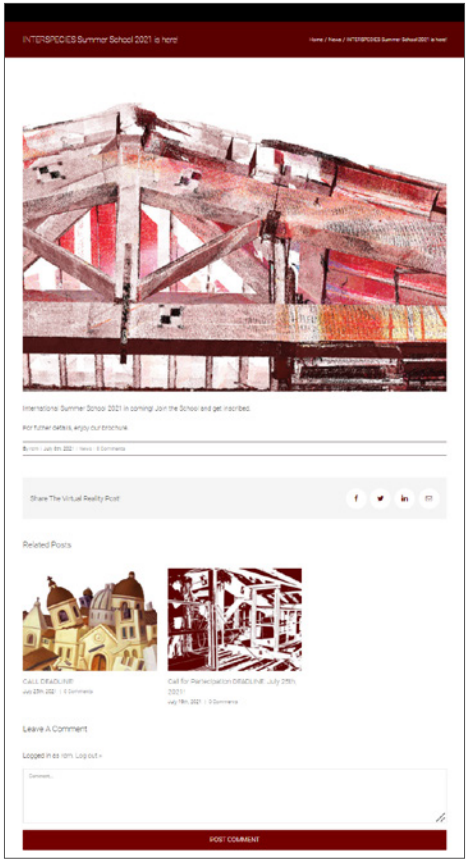
The profile included a social media campaign to involve followers and promote the lecturers of the Summer School, with dedicated audio-visual stories and references to researchers and institutions involved in the multi-disciplinary programme.

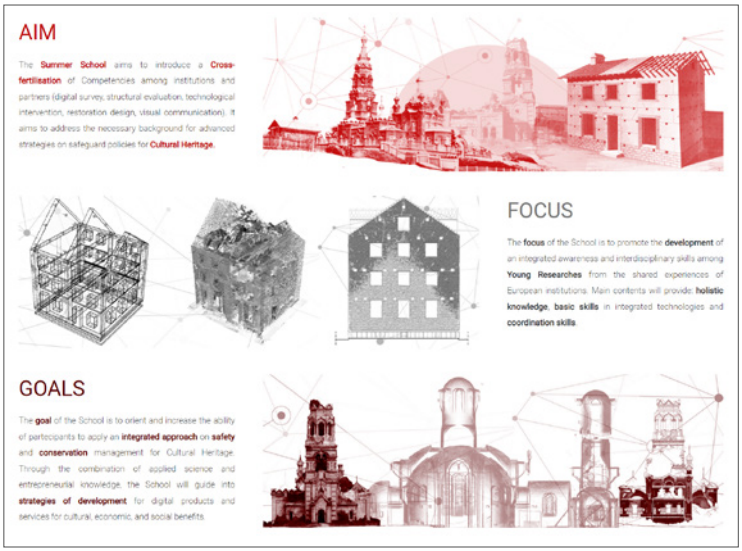


WEB SITE

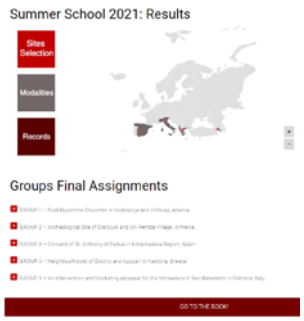


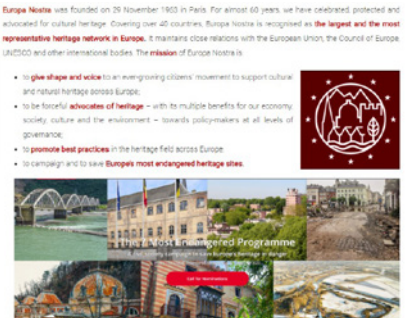
The website was designed on the graphic layout set up for socials, with the aim of constituting an extended narrative and descriptive channel of the aim, challenges and results of the INTERSPECIES network within the different annual activities.
The News collection traces the phases of organisation, membership and activities of the Summer School, with updates for future editions. The School's development themes, as well as the lecturers involved and the lectures presented, are listed and structured according to the representative Thematic Challenges.
References to Socials and Media are included.



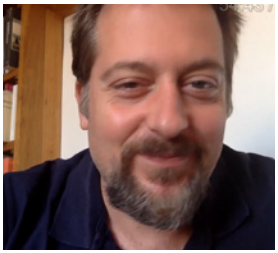


The results produced during the Working Sessions of the Summer School are collected, with reference to the participants and professional profiles involved. For each working group, the location of the Endangered Heritage site can be found, together with the link to the dedicated section on the Europa Nostra portal, in the '7-most-endangered' programme.
The material produced by participants is available, including the presentation and recording of the last day of the event on the project proposal for site conservation and enhancement. Further information on the contents can be found in the extended version of the chapter in this proceedings volume.

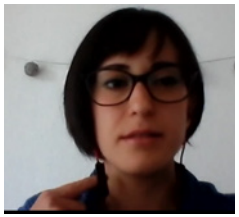


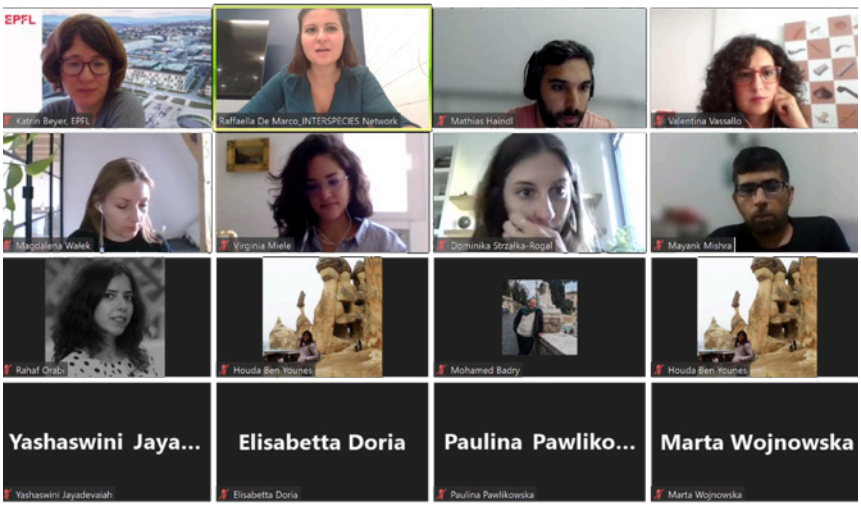


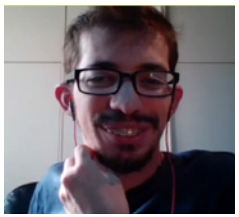
Photographic Gallery of the Event





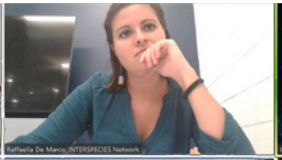





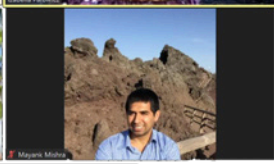


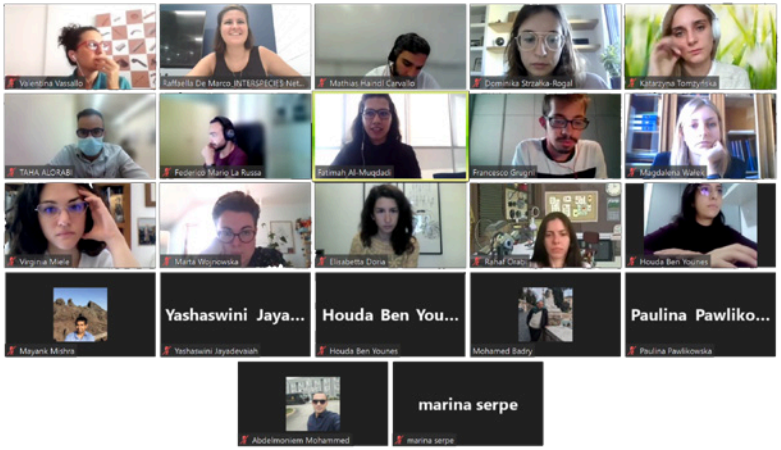






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Paulina Pawliko...
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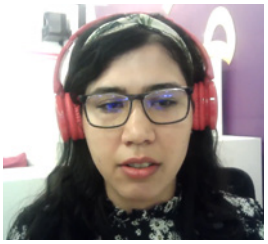
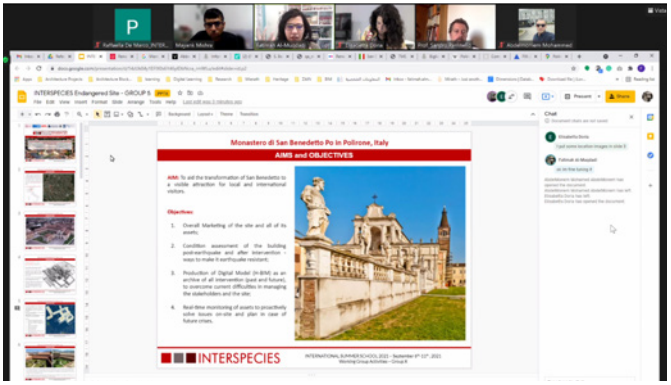
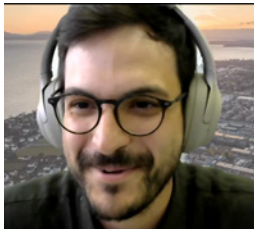
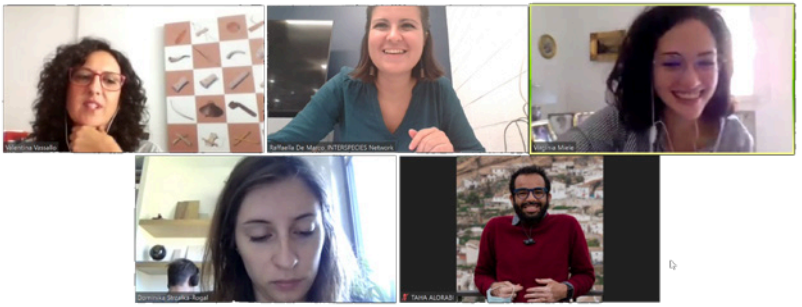
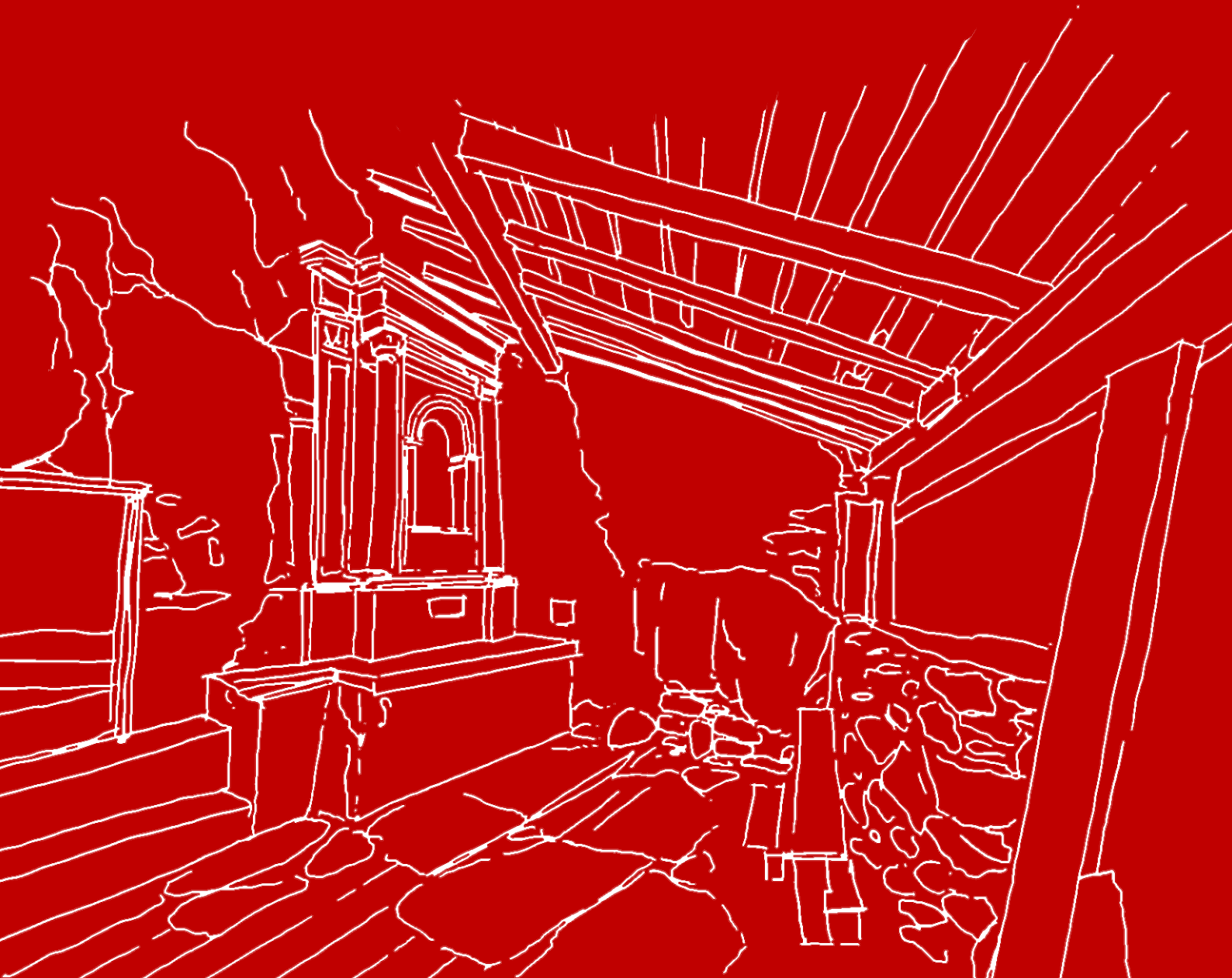



Monastero di San Benedetto Po in Polirone, Italy
AIMS and OBJECTIVES
INTERSPECIES





Afterword



Civil Society and Digitalization: Pioneering in the Defence of the Endangered Heritage

Jasna Popović
Universidad Carlos III de Madrid (Spain), Programmes Officer in Hispania Nostra, ESACH Coordination Committee Secretary

Endangered heritage has been one of the recurring topics of interest for many heritage scholars and practitioners. And very rightly so. Those usually less known heritage sites have been on the verge of complete destruction and disappearance and, with them, the knowledge, the value, and part of the identity they carry with them.

Introduction

Before starting this article, I would like to point out some of the limitations regarding its scope and the cases and examples I will be giving. In this text, I will primarily talk about the endangered cultural tangible immovable heritage. That encompass sites like churches, palaces, military or civil infrastructure, or industrial heritage. However, due to the limitation of the text as well as the particularity of the topic this book aims to study, natural and movable heritage will be excluded, as well as some of the good practices of intangible heritage that might be threatened to disappear. There will be, I hope, some other occasion to study in depth these subjects.

I would also like to note that my examples will primarily, if not in their totality, be taken from my work in Hispania Nostra[13], an association for the protection and promotion of cultural and natural heritage on the national level in Spain. Thus, I will be focusing on the practitioner´s approach, analyzing the topic from the point of view of civil society. Even though the emphasis would be on the Spanish territory, the intention will be to highlight some of the universal problems the heritage community faces when it comes to the preservation of endangered heritage, as well as present some possible solutions.

Finally, I wish to make a quick linguistical remark. In our daily work, aside from the term "endangered" we also use the term "vulnerable", so I will be using those two words alternatively, and throughout the text, I will try to explain why we do it.

Civil society and Endangered Heritage

Numerous causes lead to cultural heritage being endangered. The most obvious of the divisions is the one destroyed during armed conflicts, and the one neglected or abandoned in peacetime, which led to its current state. It is quite clear, therefore, that the approach can and should be different in those situations. With no intention of entering a very complex, legal, political, and humanitarian topic of heritage and its safeguarding during the armed conflict, my only wish here is to draw attention to the fact that cultural heritage is a fragile legacy left to us with the idea of protecting it and that there are many obstacles to that goal, both in war and peacetime.

Some of the reasons that lead to cultural heritage being endangered are well known, such as the limited resources of the administration (both in personnel and

Fig. 1 The Red List - Santa Catalina Castle, ceded to Hispania Nostra.

funding) to secure proper care for all the heritage sights. Consequently, prioritizing is in order, and many heritage sights are left unattended. Many others have far more complex sets of issues, like contested heritage, the heritage of religious and ethnic minorities, or heritage whose values and ideas no longer coincide with the ones of current society.

Civil society can and should be a part of the solution regarding both of these sets of problems. Far from intending to take over the work and competence of the public administration, the role of civil society associations and foundations is to be a proactive ally and to help identify and tackle the problems that are a top priority identified by society.

There are several, more or less, developed techniques to do so which have proved to work. Today, more than ever, we have the options and possibilities to use modern technology, digital tools, AR, and VR, all in the service of promoting and preserving cultural heritage. But, before I come to that, I would like to mention some mechanisms we developed to raise awareness about the topic of endangered heritage.

The Red List and similar initiatives

Associations that deal with cultural heritage repeatedly act as an alarm, sending warning signals to the authorities and pointing out the biggest priority in conservation. They also reflect the interest of the general public in cultural heritage that should, and hopefully, would be reflected in the budgeting and attention this topic gets from the public administration.

Hispania Nostra has, with that in mind, developed a tool that helps society, and its active individuals raise a voice when it comes to protecting vulnerable cultural heritage. *The Red List of Hispania Nostra*[14] (in the following text: *The Red List*) was created in 2007 with the idea of offering civil society the possibility to actively participate in the safeguarding of endangered heritage and the whole procedure is based on the public interest to protect a specific sight. Since the main topic of this text is not *The Red List* itself, I will not go into too many details, but I believe it´s important to briefly explain the whole process. An interested individual, as a natural person, fills up the form available on the dedicated website, explaining the history, significance, and value of the sight, as well as providing some photos. That information is complemented by the in-house research done by the team of Hispania Nostra (fact-checking, but also finding additional information, trying to contact the owner, and letting them know about the petition for their property to be enlisted in *The Red List*).

Fig. 2 The Red List - Bon Xesús de Trandeiras Convent, ceded to Hispania Nostra.

All that dossier is, afterwards, studied by a scientific committee, an interdisciplinarity group of experts who volunteer their time and meet every month to discuss the possible new inclusions to the list. Finally, if they conclude the property should be enlisted, the final attempt to contact the owner is made. After that, the dossier is published, and the communication team tries to contact the local press for the news to get more attention.

The process is proven effective, but also very indicative of the public interest in abandoned and ruined cultural heritage. To date, more than 1200 heritage sights have been included and subsequently, *The Green List* and *The Black List* were introduced (for the "saved" and for the heritage forever lost).

During these 15 years, *The Red List* has been showing that society is interested in preserving endangered

Fig. 3 The Red List - Davalillo Castle, author Biblioteca Gonzalo de Berceo, ceded to Hispania Nostra.

Fig. 4 The Green List, Castillo de Belmonte de Campos, ceded to Hispania Nostra.

Fig. 5 The Black List, Casa de Pico de Velasco o de los Godos, ceded to Hispania Nostra.

heritage. All over the Spanish territory, people interested in the protection of the cultural heritage they see in their surroundings believe this tool is an efficient way of alarming society. For that to happen, they have to feel connected, they have to understand the value and the current state of vulnerability that the sight is facing. Hence such a strong emotional implication the word "vulnerable" carries. It reminds us of our duty to protect the vulnerable. All of this is possible because of new ways of communication, developed in the last couple of decades. The association via website and social media accounts has a wider reach and can more effectively work throughout Spain, always pioneering the campaign for the safeguarding of vulnerable heritage.

Another initiative, similar to this one, is *The 7 most endangered* run by Europa Nostra[15]. Over the last 10 years, this pan-European movement for the protection of cultural and natural heritage has been alerting the European public about the endangered heritage with a similar procedure as in Hispania Nostra (with differences in the limitation of the number of the sights to enlist every year or who can present the petition for the inclusion).

Digitalization of the Cultural Heritage sector - Hispania Nostra app as a case study

With the new technologies came endless opportunities and possibilities to further document, promote and protect heritage worldwide. As we can see throughout this book, interdisciplinarity in the approach will only benefit cultural heritage studies, as it opens up this field to the implementation of the new tools while not inflicting on the actual heritage site or coming in conflict with the values (tangible and intangible) of the place.

Many of the well-known, protected, and preserved sites that are also tourist attractions have started using this technology to better manage and coordinate their services, offering the visitors additional information (via apps or QR codes), more quality time spent on the site, meanwhile trying to diminish the negative impact large number of tourists create.

Recently, this technology has been employed in the sector of endangered heritage. The development of different, user-friendly, and accessible tools opened numerous prospects for vulnerable heritage to be

Fig. 6 The Red List - Santa Marina La Seca Convent, author Artesiver Fotografia, ceded to Hispania Nostra.

better documented as well as presented to the broader audience, all to protect and safeguard. We could be using virtual reality to reconstruct something that has been ruined. Or we can make it disappear completely showing the people the ultimate faith of those heritage sights, should they not be cared about.

In the sea of endless possibilities, Hispania Nostra opted for creating an APP whose central function would be promoting vulnerable and forgotten Spanish heritage. The map collects unexplored cultural and natural heritage, in the widest of the senses, including unknown lookouts and hidden gardens, small local carnivals and festivals, craftsmen´s shops, and markets with local and regional products.

But the goal is not just to create a database with all these details, nicely presented on a map. The primary purpose of this project is to take people to see that forgotten heritage, to be interested in the vulnerable and less-known, and become active defenders of this immense heritage.

Having that in mind, Hispania Nostra has developed a sophisticated algorithm that creates tours a la carte, providing users with options for what to see in their

Fig. 7 Opening door to the Descubre (Discover) section, first and the most innovative part of the APP.

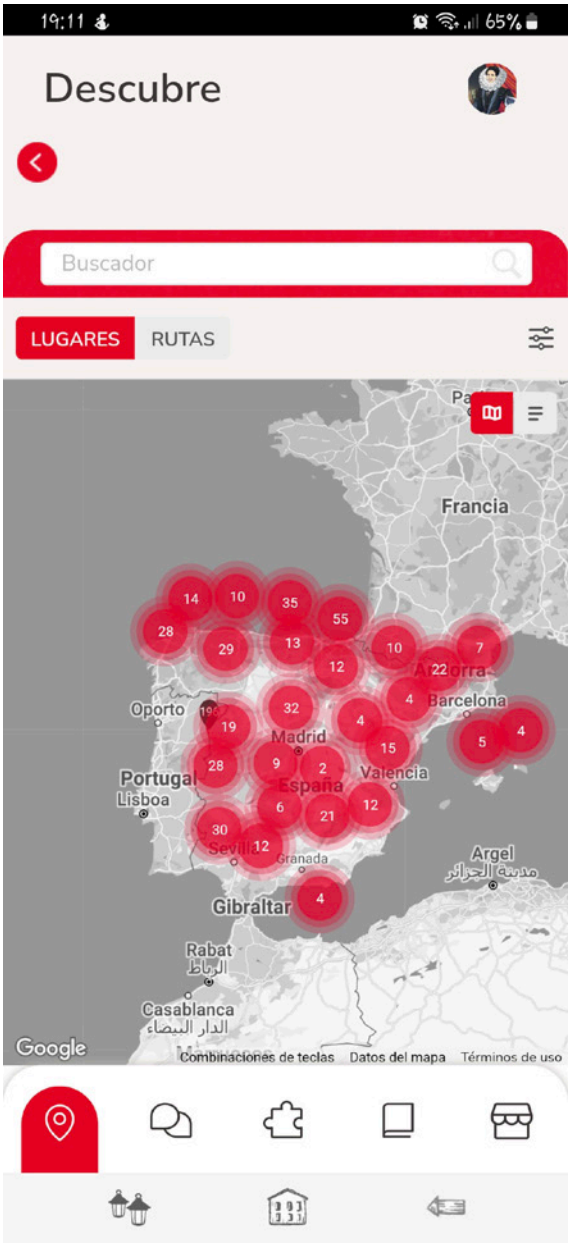


Fig. 8 Map of the "hidden" (cultural and natural heritage, both tangible and intangible, such as festivals, carnivals or fairs) identified by Hispania Nostra as perfect places for the "accidental tourist"; within the section: Descubre (Discover).

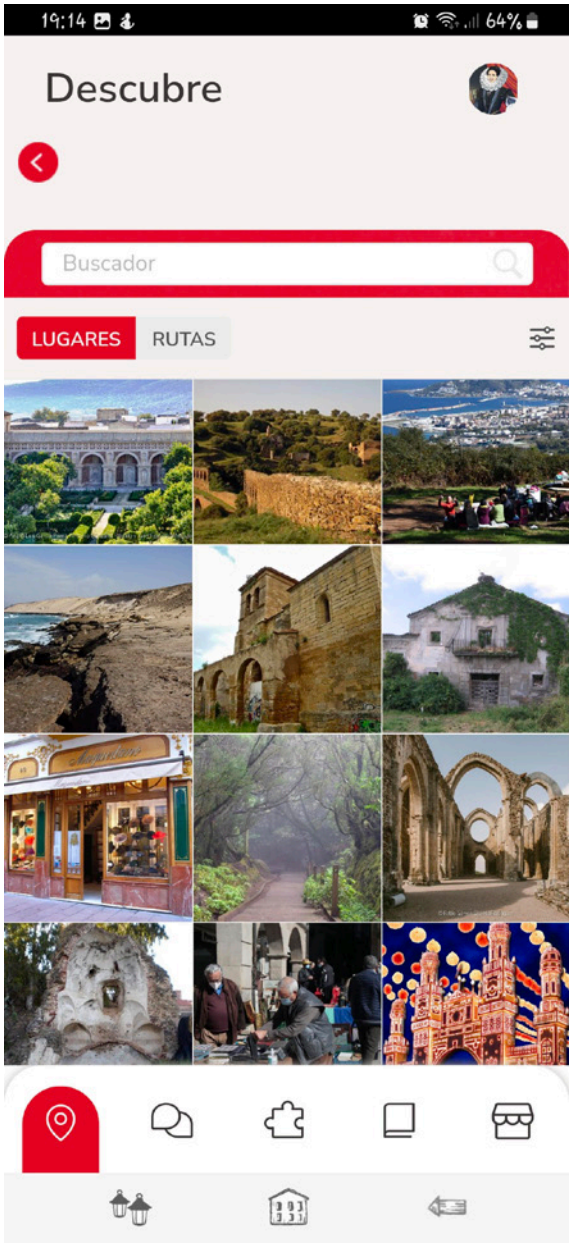


Fig. 9 Photo-grid of the identified places in the order of the best rated place. Within the places with the same rates, the algorithm changes the order randomly, using the visually appealing photos that will try to attract the future visitors if they scroll the list.

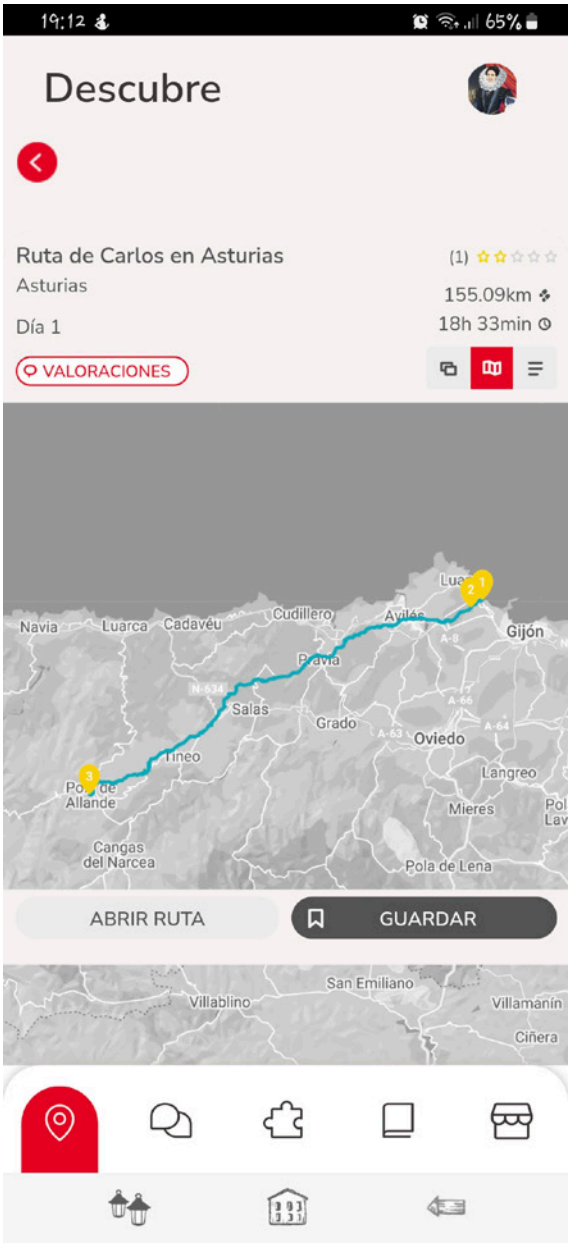


Fig. 10 An example of the personalized route (selecting province and date). From the photo-grid, clicking on the photo, the APP opens detailed information and the location of the sight.

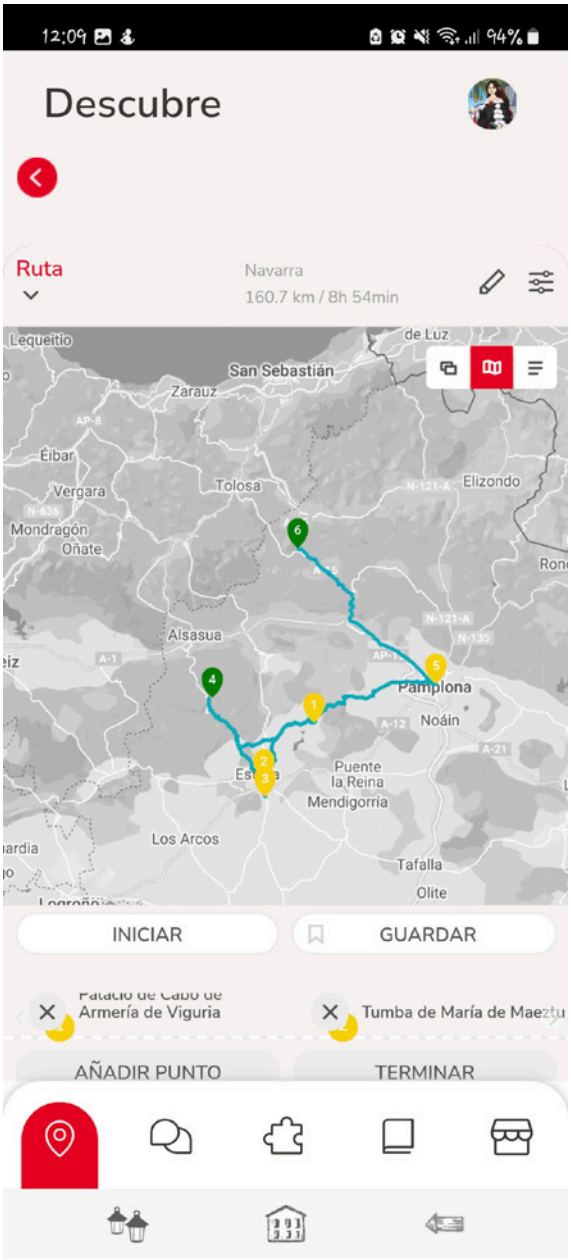


Fig. 11 An example of the personalized route (selecting province and date).

immediate surroundings. Calling it accidental tourism, the main objective is to raise awareness about the cultural and natural heritage sights that are close but unnoticed and that a traveler could visit during the spare time of their trip (for example, while waiting for the train or an afternoon meeting in the city they are in). The traveler is an unintended tourist, and the APP takes him to get to know the environment and cultural heritage around him that would otherwise be lost.

With the option of the personalized search of one's cultural interests, the time available, the budget, and the means of transport that can be counted on, the user gets a unique proposal of the tour, created just for him. In the end, it allows the user to know the places through which he travels more or less accidentally (hence the name).

Aside from the benefit for the cultural heritage, this proposal can also generate a boost for local economies of the regions scarcely populated and with few tourist visits or offer alternative tourism in the overly visited places, such as Madrid or Barcelona.

There is another use of the APP closely linked with the digitalization and implementation of new technologies in the cultural heritage sector. With the same goal of raising awareness of civil society of the cultural legacy through the rediscovery of their endangered heritage, APP offers a fun way to understand and appreciate the vulnerable heritage. With an optical illusion and the ever more extended practice to memorize a moment by taking a selfie, Hispania Nostra proposes a new benefit of this ritual. Through the APP, people can take a selfie or a regular photo, in front of the heritage sight in two ways:

- when the sight is in ruins, creating the illusion of posing in front of the sight as it once was, rebuilding it through "augmented reality"; or
- posing, when the asset is in a perfect state of conservation, and creating the illusion of doing it in front of the asset in ruins, thus giving rise to a new reality that we could name diminished reality.

With these options, we pretend to alert society about the permanently existing threat cultural heritage is facing and warn of how vulnerable heritage can become if it is not given the necessary care.

Fig. 12 Tower of Hercules, Galicia, Spain, 2006 (https://whc.unesco.org/en/list/1312). Before - diminished reality.

Fig. 13 Tower of Hercules, Galicia. After - diminished reality (Author: Teresa Merello de Miguel, https://deautor.hispanianostra.org/torre-de-hercules)

The APP will be officially presented in January 2023, so people will soon have the opportunity to explore vulnerable heritage in new ways.

Conclusions

The fast-changing world has given us numerous options in the field of new technologies, smartphones, drones, 3D modeling, AR, and VR. The cultural heritage field can only benefit from the responsible use of these inventions, always having in mind the intrinsic values of cultural heritage.
This book shows us the power of uniting new technology with the heritage that comes from different centuries but needs all knowledge of the modern age to be better preserved and protected.

What I modestly intend in my text is to show the practical use already implemented in the protection of the endangered heritage and also lance a call to other stakeholders, public or private, local, regional, national, or international, to use all the tools available. United and hand in hand with the latest discoveries, we can more competently and less invasively safeguard the heritage we have around us and pass it on to future generations.

Notes

1 PhD candidate in International Public Law and Programmes Officer in Hispania Nostra; educacion@hispanianostra.org, www.hispanianostra.org
2 www.listaroja.hispanianostra.org
3 www.europanostra.org

Acknowledgements

"The sight of the ruins gives us a passing insight of the existence of a time that is not what history manuals talk about or what restorations try to bring back to life. It is a pure, undated time, absent from our violent world whose debris no longer have time to become ruins."

MARC AUGÉ
"Le temps en ruines" (Trad. "Rovine e Macerie. Il senso del tempo"), 2002.

Addressing Endangered Heritage, now more than ever, is an act of awareness and concrete confrontation within the global geopolitical events in 2023. Just a few months after the conclusion of the INTERSPECIES group's Summer School, the outbreak of the conflict between Russia and Ukraine has renewed the sense of the fragility of our built heritage to the most serious acts of destruction and danger, such as those militarily carried out by man. With the testimony of Ukrainian heritage, other and many examples of the world's heritage in a state of destruction, occupation and silent disappearance have been called to our minds, from the East to the West.
Endangered Heritage is, unfortunately, a global concept, and as such its research cannot be specifically limited. While finding singular and necessary declinations, in different geographic, cultural, and social contexts, interdisciplinary, interprofessional and intersectoral dialogue is and must remain a priority, a profound framing of the active scientific and human attitude with respect to the passive vicissitudes towards which civil society is forced.
Our thanks are addressed to all the lecturers and institutions in the 2021 edition, for their commitment and creativity in collaborating and sharing experiences for an interdisciplinary dialogue that to this day remains a challenge, to be addressed and renewed with constancy. But especially, our sincere thanks to the participants of the school, for engaging themselves as researchers, professionals, but even more as citizens and stakeholders of a variety of Cultural Heritage case studies that mutually deserve respect and sharing.
Thank you to Nancy Abdelaziz, Fatimah Al-Muqdadi, Taha Alorabi, Mohamed Amer, Burcu Buber, Alejandra Cianci Ramirez, Dominika Długosz, Elisabetta Doria, Raissa Garozzo, Abdelmoniem Mohammed Abdelmoniem Mohammed Gomaa, Francesco Grugni, Mathias Haindl, Ben Younes Houda, Yashaswini Jayadevaiah, Federico Mario La Russa, Virginia Miele, Mayank Mishra, Rahaf Orabi, Héctor Ortiz, Paulina Pawlikowska, Marina Serpe, Dominika Strzałka-Rogal, Hassan Tattan, Katarzyna Tomzynska, Valentina Vassallo, Magdalena Wałek, and Marta Wojnowska.
To you, and to all future readers and those interested in the subject: our wish to always be able to act with courage and solidarity towards Cultural Heritage, as the field to which you are devoting your studies and professional aspirations. We hope that you will always be open, both professionally and personally, to a precious dialogue that will interpose your contribution between any near future conflict and process of overcoming destruction.

S.P., R.D.M.
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