THE MATTER OF FUTURE HERITAGE

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URBAN HERITAGE ACCESSIBILITY AND CONSERVATION THROUGH 3D MODELS AND DIGITAL TOOLS

Technological tools; Fruition; Accessibility; Performances; Environmental Sustainability; Comfort

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One of the main challenges to be tackled today within the multidisciplinary field of Cultural Heritage is to increase the fruition, preservation and enjoyment of heritage assets. New technologies and digital cultural heritage should play an important innovative role, as well as ICT tools and digital devices represent a great opportunity to understand, access, enhance and preserve cultural heritage. This contribution understands the overall research approach toward the enhancement of the accessibility of digital cultural heritage as the ability to access cultural contents and resources by as many people as possible, using ICT functionalities and applications (web sites, data-bases, digital libraries, virtual applications, etc.) while overcoming cultural, environmental and management barriers, fostering an easier and widespread fruition. Despite the constant evolution and increasing use of digital media, there is still a lack of platforms able to collect and aggregate space-related data with information on the use and accessibility of heritage monuments, buildings and entire sites at the urban scale. Moreover, heritage conservation, accessibility and fruition are still strongly associated with buildings as, for instance, museums and

monuments, yet struggling to overcome the ordinary dichotomy "object - cultural heritage asset" understanding entire urban historical areas as valuable per se, and enlarging both vision and possibilities to the urban dimension as a whole. Innovative strategies in heritage documentation could be reached through the implementation of effective data collection processes, and the development of semantically enriched 3D models; experimentation of new uses, connections and reuses of digital data applied to cultural heritage should also address a wide range of users (tourists, policy-makers, scholars, ICT-inexperienced users). In this perspective, outcomes from the project funded by the European Union "INCEPTION - Inclusive Cultural Heritage in Europe through 3D semantic modelling" (2015-2019), and coordinated by the Department of Architecture of the University of Ferrara, are presented.

Introduction

Today, one of the main challenges to be tackled within the multidisciplinary field of Cultural Heritage is to increase the fruition, preservation and enjoyment of heritage assets. In this perspective, new technologies and digital cultural heritage should play an important innovative role, as well as Information and Communications Technology (ICT) tools and digital devices represent a great opportunity to interpret, access, enhance and preserve cultural heritage. This contribution understands the overall research approach towards the enhancement of the accessibility of digital cultural heritage as the ability to access cultural contents and resources by as many people as possible, using ICT functionalities and applications (web sites, data-bases, digital libraries, virtual applications, etc.) while overcoming cultural, environmental and management barriers, fostering an easier and widespread fruition.[1]

The recent Declaration "Cooperation on advancing digitization of cultural heritage" signed by European Union Member

1   Federica Maietti, Roberto Di Giulio, Marco Medici, Federico Ferrari, Anna Elisabetta Ziri, Beatrice Turillazzi, and Peter Bonsma, "Documentation, processing and representation of Architectural Heritage through 3D semantic modelling", in Impact of Industry 4.0 in Architecture and Cultural Heritage (IGI Global – in press).

States during the Digital Day 2019, confirmed the European commitment in fostering digital technologies to record, document and preserve Europe's cultural heritage and its accessibility to all citizens. The above-mentioned Declaration states that "The Union needs to collaborate to advance 3D digitization of our cultural heritage. European research institutes and start-ups have developed world-leading expertise and are pioneering technologies in these fields, and can contribute to advancing the digital transformation of the cultural heritage institutions. The Union also needs to ensure that its digitized cultural content and related applications are available, where appropriate, on European platforms, in line with our values".

Moreover, as stated at the opening high-level Horizon 2020 conference *Innovation and Cultural Heritage* held in Brussels in 2018, cultural heritage represents a limitless source of innovation in which traditions could meet with new, cutting-edge technologies. One of the key questions raised by the Directorate-General for Research and Innovation Europe in a Changing World (Inclusive, innovative and reflective societies) was how to best use the opportunities provided by digitalisation within the cultural heritage valorisation process. Digitalisation can be an effective instrument for the democratisation of cultural heritage as it opens new forms of access, and new and innovative technologies are a great opportunity to understand, access, enhance and preserve cultural heritage. "Combining innovation with heritage points to the fact that cultural heritage has an inspiring and creative role in present European societies and communities. Research and innovation are needed to better protect cultural heritage from natural or man-made destruction. […] Innovation in the context of cultural heritage has manifold meanings […] technological, social, policy, entrepreneurial, economic or methodological".[2]

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2   Tanja Vahtikari for the European Commission. "Innovation & Cultural Heritage. Conference Report" - 20th March 2018, Royal Museum of Arts and History, Brussels. (Luxembourg: European Union Publication Offices, 2018), 4.

The digital revolution and its challenges

Today it is possible to digitally integrate different information in order to access cultural assets in many different ways and for many different purposes. Beyond the application of ICT for management, research, diagnosis, conservation and restoration, training and enhancement, new technologies allow the communication and dissemination of cultural heritage that become increasingly accessible producing new knowledge and experience. Through digital technologies, broad categories of users have access to Europe's tangible and intangible cultural assets, and it is mainly the availability of databases collecting different information that enables the widest possible accessibility and interoperability at a multidisciplinary level. New applications also permit to access heritage sites and objects either from the site itself, or remotely from museums, classrooms, laboratories, and even from one's home or office. Users can dispose of a constantly growing set of interactive possibilities to access a variety of information on different places and artefacts; to exchange the derived knowledge among each other; and to enrich and feed this knowledge with their findings and complementary insights by means of interactive platforms and social media. In this perspective, we can affirm that the development of data capturing technologies and graphic features has maximized the improvement of digital contents for different applications.

As part of 3D integrated survey applied to cultural heritage, digital documentation is gradually emerging as an effective support,[3] giving many different information in addition to shape, morphology, and dimensional data. Innovative strategies in heritage documentation can be reached through the

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[3]   Federica Maietti, Roberto Di Giulio, Marcello Balzani, Emanuele Piaia, Marco Medici, and Federico Ferrari, "Digital Memory and Integrated Data Capturing: Innovations for an Inclusive Cultural Heritage in Europe through 3D Semantic Modelling", in *Mixed Reality and Gamification for Cultural Heritage* (Springer International Publishing, Ioannides, Magnenat-Thalmann, Papagiannakis (Eds.), 2017), 225-244.

implementation of effective data collection processes, and the development of semantically enriched 3D models. The increasing development of 3D laser scanner technologies allows to create high definition databases grounded on even more detailed three-dimensional morphometric data. Such "digital archives" represent an extremely valuable research tool in the cultural heritage field as the so-called "geometric memory" is essential for knowledge, protection and sustainable conservation of cultural heritage, although there are still some limits to the exploitation of 3D models obtained by laser scanner survey. The growing number of unexploited and "un-interpreted" 3D models highlights the remarkable need for innovative methods that could benefit from the informative value provided by new survey and representation systems, as well as from data management tools.[4]

Technologies are constantly evolving and new digital media are increasingly used for accessing and understanding cultural heritage.

However, there is still a lack of platforms able to collect and aggregate space-related data with information on the use and accessibility of heritage monuments, buildings and entire sites or areas at the urban scale. It is a fact that, still today, heritage conservation, accessibility and fruition is still strongly associated with buildings as, for instance, museums and monuments, yet struggling to overcome the single artefact approach, and enlarging both vision and possibilities to the urban dimension as a whole. This could be the case of valuable and/or heritage listed historic city centres, archaeological sites, and all those complex and heterogeneous spatial systems supporting all kinds of relationships and connectivity at different levels. Within such framework, the concepts of heritage accessibility, fruition, sustainability should be re-interpreted in order to overcome

4   Marcello Balzani and Federica Maietti, "Architectural Space in a Protocol for an Integrated 3D Survey aimed at the Documentation, Representation and Conservation of Cultural Heritage", *Diségno* 1(2017): 113-122.

the ordinary dichotomy "object - cultural heritage asset", understanding entire urban historical areas as valuable per se. A system of buildings and spaces to be enhanced and promoted also through new technological tools and sharing platforms. Such an approach, applied to the urban scale, could represent an innovative step forward in both the Italian disciplinary debate, and the experimentation of new uses, connections and uses of digital data applied to cultural heritage, addressing a wide range of users such as tourists, policy-makers, scholars, and ICT-inexperienced ones.

Innovative Tools: the INCEPTION Project

Innovatively moving towards this direction, the Department of Architecture of the University of Ferrara, leading a consortium of fourteen partners from ten European countries, was funded by the Horizon 2020 Societal Challenge Work Program for the EU project INCEPTION (*Inclusive Cultural Heritage in Europe through 3D semantic modeling*, funded under the call *Reflective Societies: Cultural Heritage and European Identities, Advanced 3D modeling for accessing and understanding European cultural assets*). INCEPTION aims at developing new research paths in the field of heritage 3D data acquisition and modeling, while optimizing a 3D data acquisition protocol able to guide the process of digitisation of cultural heritage and innovation strategies to the three-dimensional modeling.[5] Overall, the project aims at representing and disseminating cultural heritage through ICT processes, analysing semantic information in a wider and more extensive use of digital models, up to market research and business strategies tackling the economic value of cultural heritage, a sector particularly struggling because of the current financial crisis.

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5   Inception website https://www.inception-project.eu/en (accessed April 14 2019)

The main objective of the INCEPTION project is focused on innovation in 3D modeling of cultural heritage through an inclusive approach for 3D reconstruction of heritage sites and on the possibility of creating an inclusive understanding of European cultural identity and diversity, stimulating and facilitating collaboration between disciplines, technologies and sectors. The project, which ended on May 31 2019, has been developed through five main steps. The first requirement was related to the construction of a common framework and knowledge management: such stage allowed to deepen the cultural dimension of the project, facing first of all the significances of Cultural Heritage to be represented and interpreted through digital models. The advancement into the integrated 3D data capturing methodology led to the development of an integrated and optimized Data Acquisition Protocol. The semantic modeling for Cultural Heritage buildings led to the development of a procedure of parametric modeling of Cultural Heritage, approaching the H-BIM. Additional steps concerned the development of the INCEPTION platform and the deployment and valorisation through different on-site and off-site applications for a wide range of users. This first step, related to the development of a common framework, was based on stakeholder feedbacks: the whole project was developed thanks to a strong synergy among the Consortium Partners and the Stakeholder Panel, an assembly of different European institutions involved with the aim of directing research toward those strategies needed by "end users" and institutions to increase knowledge, enhancement and dissemination through digital models.[6] In this way, the project was targeted towards scholars, technicians, citizens and governments' needs,

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6   Federica Maietti, Emanuele Piaia, Giuseppe Mincolelli, Roberto Di Giulio, Silvia Imbesi, Michele Marchi and Silvia Brunoro, "Accessing and understanding Cultural Heritage through users experience within the INCEPTION project", in *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. Euro-Mediterranean Conference* (Springer, Cham, 2018), 356-365.

through the identification of key requirements that contribute to meet Europe's societal objectives related to Cultural Heritage.[7]

The integrated 3D data capturing has been faced both as a methodological procedure and an optimized workflow by developing the INCEPTION data acquisition protocol.[8] Another action focuses on the identification of the Cultural Heritage buildings semantic ontology and data structure for information catalogue. Integration of semantic attributes with hierarchically and mutually aggregated 3D digital geometric models is set up for managing heritage information.[9] The fourth action is the development of the INCEPTION Semantic Web Platform. The interoperable Semantic Web H-BIM Platform allows achieving the widest accessibility and interoperability, the use of three-dimensional models by researchers from different disciplines and non-expert users,[10] minimizing the difficulties of interaction with these kind of data, now accessible only by experts through the use of different software. The "browsing and query interface" is defined allowing contributions by researchers and experts that do not deal with 3D data, and enabling a wide and easy access to the data by citizens, non-expert users and public at large. The need to develop an integrated survey procedure according to a holistic approach to cultural heritage, arises from the INCEPTION

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7   Roberto Di Giulio, Federica Maietti, Emanuele Piaia, "3D documentation and semantic aware representation of Cultural Heritage: the INCEPTION project", in *EUROGRAPHICS Workshop on Graphics and Cultural Heritage* (2016), 195-198.

8   Federica Maietti, Federico Ferrari, Marco Medici, and Marcello Balzani, "Integrated Laser Scanner Survey and Modelling for Accessing and Understanding European Cultural Assets", in *Proceedings of the International Conference "SBE Malta 2016. Europe and the Mediterranean: Towards a Sustainable Built Environment"*, ed. Ruben Paul Borg, Paul Gauci and Cyril Spiteri Staines (Malta: Gutenberg Press, 2016), 317-324.

9   Marinos Ioannides, Nadia Magnenat-Thalmann, Eleanor Fink, Ronchi Zarnic, Alex Yaning Yen, Ewald Quak, (eds.), "Digital Heritage. Progress in Cultural Heritage. Documentation, Preservation, and Protection", *Proceedings of the 5th International Conference, EuroMed,* (Berlin Heidelberg, Springer, 2014).

10   Emmanuel Maravelakis, Antonios Konstantaras, Athina Kritsotaki, Dimitris Angelakis, and Michalis Xinogalos, "Analysing user needs for a unified 3D metadata recording and exploitation of cultural heritage monuments system", in *International Symposium on Visual Computing* (Berlin Heidelberg, Springer, 2013), 138-147.

application' context. The project indeed deals with heritage "spaces" (complex architectures *and* sites), working at building-scale in order to be able to manage the issue of layering different information related to different features, according the aim of the documentation and survey procedure.

The INCEPTION protocol

The 3D survey of heritage architectural space needs a common protocol for data capturing and related enhancement of func-tionalities, capabilities and cost-effectiveness of technologies and documentation instruments.[11] INCEPTION considers the uniqueness of each site, including different indicators within the digital documentation procedure, such as time and costs, data accuracy and reliability, additional data and semantic prop-erties to be recorded for heritage applications, adaptability to different sites with different historical phases. The identification of the multi-function and multi-scale role of the model allows the exploitation of uneasy and complex resources (obtained by the collection of geometric shape, and not just of the archi-tectural and urban context) at different levels, over time and by different actors.

The INCEPTION protocol is conceived as a procedure or a set of steps to be followed during the digital documentation. The first aim was to bridge the gap within the data acquisition state of the art: a wide range of devices and technologies for 3D data cap-turing is available, as well as more and more accurate and fast devices, but bigger data means time-consuming processes and, very often, there is a lack of technological integration between different kinds of devices. Therefore, INCEPTION proposes a common protocol for 3D data capturing and device enhancement

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11   Robert Zlot, Michael Bosse, Kelly Greenop, Zbigniew Jarzab, Emily Juckes, and Jonathan Roberts, "Efficiently capturing large, complex cultural heritage sites with a handheld mobile 3D laser mapping system", *Journal of Cultural Heritage* 15 (2014): 670–678.

for a more efficient processing, helping preparing the overall survey project by asking the fundamental question "why to document the heritage site by means of laser scanning devices, and what use will one make of such data?". It includes four different evaluation categories which, however, are intended to be flexible and upgradable according to technological progress and different applications. The first one is for very simple buildings or for the creation of low-detailed BIM model for digital reconstruction aimed at VR, AR and visualization purposes. The second one is suitable for documentation purposes, where the metric and morphological values are equivalent in terms of impact on the survey that needs to be preliminary scheduled and designed, and different instruments integration is foreseen. The third category includes preservation purposes; these surveys support restoration projects in need of extremely accurate metric data. The documentation phase is developed organizing the information into Metadata and Paradata. The fourth category is to be used for very complex buildings where the capturing process need to be documented and traced in order to get the maximum control on data or when monitoring process developed in a non-continuous time span take place. This category includes surveys where different teams of technicians work together, simultaneously or in sequence, with different capturing instruments and different accuracies.

All these categories were set up in order to manage digital modes compliant with the INCEPTION Platform. The Platform is a space for interchanging information and fostering the dialogue among professionals, students, scholars, curators, non-expert users, and so forth. The combination of innovative methodologies and protocols, processes, methods and devices allows enhancing the understanding of European Cultural Heritage by means of 3D models bringing new knowledge, collaboration

across disciplines, time and cost saving in the development and use of 3D digital models.[12]

Future urban research development and implementations

INCEPTION supports Heritage information, ranging from data acquisition, analysis, data management, 3D documentation, new forms of interaction, according to the interdisciplinary approach and to a specific methodology (holistic documentation, optimized data acquisition, data analysis, classification, and interpretation). The above-described technologies and new methodologies and tools in the field of cultural heritage greatly broaden and enrich the spectrum of possible experimentations and implementations, especially at the urban scale. In fact, urban heritage accessibility and conservation through 3D models and digital tools is a research avenue that starts from the main INCEPTION outcomes, moving towards a wider use of the applied methodology and developed IT framework.

Clearly, addressing the urban scale also introduces a series of new challenges and variables. If considering, for instance, an entire village, neighbourhood or historic city centre as a heritage asset per se – a site to be enhanced for either touristic/research/ad hoc-conservation purposes – the strong heterogeneity of both its components and uses arises a variety of additional issues. The richness and vitality of a lived urban area made by both buildings/monuments with specific characteristics and functionalities, *and* a series of non-built different spaces among them, make the urban realm a highly layered system that needs to be addressed and investigated through several disciplinary

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12 Marinos Ioannides, Eleanor Fink, Antonia Moropoulou, Monika Hagedorn-Saupe, Antonella Fresa, Gunnar Liestøl, Vlatka Rajcic, and Pierre Grussenmeyer (Eds.), "Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection" 6th International Conference, EuroMed (Berlin Heidelberg: Springer, 2016).

points of view, as well as different operational instruments.

Benefits from the application of the protocol and, more generally, of the above-described methodologies to the urban scale could be manifold, targeting many different "end users" at once. For instance, technicians could use the 3D continuous documentation and modeling of a determined city area for monitoring urbanisation abuses, or any other structured, irregular or harmful use of the public domain. Moreover, all acquired information would be of great value in case of the occurrence of any natural or man-made disaster, such as earthquakes, fires, flooding, etc. severely damaging the site, allowing an in-depth knowledge of all urban aspects on which to ground eventual reconstruction/re-qualification debates. Scholars in the broad field of urban studies would also take advantage from these implementations, having access to a rich interactive, yet implementable, database connecting additional information to the urban digital models. Finally, all semantically aggregated data would overall generate a huge amount of information to be spent for educational, awareness raising, and dissemination purposes, targeting either school children and adolescents, citizens and local inhabitants, and tourists.

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