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Kultur und Informatik: Extended Reality

Multimedia

vwh

Israel/Kassung/Sieck (Hrsg.)
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Content

Preface

Culture and Computer Science 2020 – Extended Reality

Fifteen years ago, the media theorist Lev Manovic provided a preview of our present-day media situation by coining the idea of "augmented space". For Manovic, this has been a space in which we act between various "layers" of dynamic information that are localised and personalised for each user (Manovich 2006: 226). Among the layers, we can imagine today, for example, various social networks or other programs that work with GPS-based and personalised information that users can access via mobile devices.

Furthermore, and Manovic could not have foreseen this, these layers are getting more and more hybrid by themselves. In Manovic's "augmented space", these information layers only complement space. There is still a clear distinction between real space and additive data. Yet with the step from Manovic's vision of an "augmented space" to today's "augmented reality", virtual content is getting more and more seamlessly integrated into the perception of the real world. Even if the technology is not yet ready for low-threshold and 'invisible' integration into daily life, it probably will be in the near future. At present, there are already cutting-edge technologies like smartphones or Microsoft's Hololense well on their way to making this technology suitable for mass production. Human perception is thus expanded, and new spaces of communication and interaction are created.

Going one step further leads to the concept of extended reality. As an umbrella term, extended reality refers to all kind of human-machine interactions being generated by computer and media technologies. However, extended reality not only addresses the whole range of technologies from augmented and mixed to virtual reality. Extended reality means all current as well as future technologies. It is a media-technological concept,

From Physical to Virtual Memory

Digital Survey for the Creation of an Informative "Double" of Florence Heritage

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Abstract

The aim of the research is to investigate the relationship between digital survey and remote sensing methodologies and the development of 3D models and tools for the dissemination of Cultural Heritage. The use of information and digital data as contents of web platforms and AR and VR applications, permit to develop useful instruments for the transfer of knowledge as well as its critical/analytical use for scientific purposes. Furthermore, the conclusions want to highlight the use of these technologies aim at educational scope, in order to evaluate the communicative experience that they can offer of tangible or intangible cultural spaces and contents, which are difficult to access or that no longer exist.

1 Intro[1]

In recent years, analytical protocols and methodologies for the collection of relevant data about Cultural Heritage, together with the related modeling and visualization processes, have attended a fast development. This evolution increases the interdisciplinary applications, thanks also to a significant increase in specific research in the related sectors, such as remote sensing, geomatics, parametric or procedural modeling, gaming or those connected to Information and Communication Technologies (ICT). New digital technologies, Augmented, Extended, Mixed and Virtual reality [Beke18], allow the development of oriented and specific narrative systems regarding the use and representation of Cultural Heritage (CH). The remote access to information and data promote the safeguarding of CH by spreading knowledge, in order to develop a sustainable, inclusive and flexible memory conservation strategy [Mald05]. Nowadays, this technology can help to pass on information in a more inclusive way and to a wider public, overcoming the barriers of communication and culture. The transfer of reality into a surrogate environment, enriched by the information made available by the new technologies of extend reality and digital investigation, allows to achieve a holistic understanding of space through a system of direct, indirect or mediated use [Riva07].

The paper aims at presenting the results of different case studies in Florence UNESCO city centre, which show different scale of intervention, from the urban scale to the cultural object. The experiences want to analyze the importance and limitations of the use of digital survey and remote sensing for the creation of contents for the development of virtual experiences. The most popular technologies for the acquisition of three-dimensional data today are based on images (for example Structure from Motion SfM or Photogrammetry) or spatial data structured as point clouds acquired by active sensors (for example 3D scanner). The application of the different approaches it depends on the purposes of the survey [DoCh17]. These methodologies allow creating a virtual "double" of the object under investigation at a high level of reliability. The problem that arises is to assess the level of reliability between reality and its virtual "double", often too

1 The paragraphs 1 and 4 were written by Stefano Bertocci; the paragraphs 2, 3.1 and 3.2 were written by Federico Ferrari; the paragraphs 3.3 was written by Federico Cioli; the paragraphs 3.4 was written by Eugenia Bordini.

rich in unnecessary details for the purposes of virtualization for educational and enhancement. The difficulty of documenting complex systems is the management of large amounts of data necessary for their description. These data, acquired and processed following different methodological approaches, constitute databases rich in useful information, which however run the risk of not establishing a reciprocal dialogue with the real object.

The Florence case study highlights the problems linked to the growing tourism industry in the historic centers and the possibilities introduced by E-Tourism for the promotion of a more sustainable and cultural tourism. The digitalization of cultural heritage and the development of platforms for the organization and dissemination of information related to historical, architectural and demo-ethno-anthropological aspects allow to involve a widest audience and to provide the users with new methods of fruition with a strong communicative impact [BeCB18].

2 Methodology for 3D acquisition and modeling

2.1 Main scope

All the Demonstration Cases are developed in order to meet and test the overall procedure set by the research: from the documentation up to use and re-use of 3D models for the valorisation conservation of Cultural Heritage (CH) by innovative tools. CH workflows can be performed for tasks such as preservation, site management, connect tangible and intangible information, etc.

Starting from these workflows, it is possible to define the required user tools and technical solutions. The main workflow set is related to the understanding of the evolution of the building for historical research, as a support for restoration or dissemination.

The workflow allows the definition and implementation of what a user can do to retrieve, provide, link, analyze, validate, interpret and use data.

2.2 Data acquisition process

The data acquisition of the demonstration cases has been performed by applying a specific Data Acquisition Protocol [DMPM17]. Using a 3D

morphometric survey, it was possible to identify the complexity of the volumetric composition of the object using different technologies such as:

- the 3D laser scanner in order to obtain a 3D database;
- the topographic survey for geo-referencing of the database;
- aerial imagery for the 3D survey and the texture mapping of the roofs;
- structure from Motion SfM or Photogrammetry survey for detail and texture;
- HDR-RGB photographic survey aimed at the implementation of a comprehensive knowledge of surfaces state of conservation and for texturing;
- 360° HDR-RGB photographic for documentation and virtual tours; historical and archival research, for reconstruction phases, for example.

The overall documentation aimed at the creations of a 3D models that could allow multimedia visualizations and VR/AR applications to enhance and to create innovative ways to explore the artistic and architectonic heritage and new forms of accessibility.

Since the project started, the main aim was the achievement of a three-dimensional metric database aimed at understanding spaces as a function of accessibility and for future conservation and restoration work.

2.3 3D or BIM modelling for User-Oriented Application

Three-dimensional data captured in the form of point cloud and the massive variety of significances that are represented by a building, needed to be aggregated into a 3D or BIM environment [Hich13]. The three-dimensional modeling used for communication and enhancement purposes therefore comes from a high density and precision database discretized/reorganized/restructured on different LODs (Level of Detail/ Development) [often working independently on LOG (Level of Geometry) or LOI (Level of Information)] according to the different applications developed. We identified in the so-called "final scope", in this case VR and AR apps addressed to cultural tourism, the element that leads the data modeling aggregation and the interconnections between geometries and information. In order to give an example, a VR application needs for a more accurate geometrical detail rather than an AR application, where

probably we'll not see only the historical enrichment popping up from the reality.
When we have a point cloud of a building as in our cases, we usually have a bunch of data still uninterpreted and unsegmented. Thus, the 3D models was created out of the point cloud, trying to strike the right balance between minimizing deviation of the object (from the point cloud), segmenting the point cloud into single objects, defining the right level of geometric detail needed for each final application [Mett16]. The level of geometrical detail, that describes objects with a certain degree of geometrical accuracy, is dependent on the final scope due to the final appearance that a 3D models need to have (i.e.: VR application) or rather the coherency of the quantity take-off (i.e.: maintenance). While the level of object granularity is still dependent on the final scope but with a more strictly link with the knowledge that we want to attach at it.
In this specific case, we preferred to ignore parametric capabilities of BIM but foster on the informative part.

3 Florence Case Study

3.1 Intro

The Florence case study highlights the problems linked to the growing tourism industry in the historic centers and the possibilities introduced by E-Tourism for the promotion of a more sustainable and cultural tourism. The digitalization of cultural heritage and the development of platforms for the organization and dissemination of information related to historical, architectural and demo-ethno-anthropological aspects allow to involve a widest audience and to provide the users with new methods of fruition with a strong communicative impact [MoRi06].
The illustrated case studies range from the scale of the city as container of several other containers, represented by the built heritage, to the more detailed scale of the artifacts, deeply connected with the intangible aspect of traditions, and the educational aspect of museum collections.

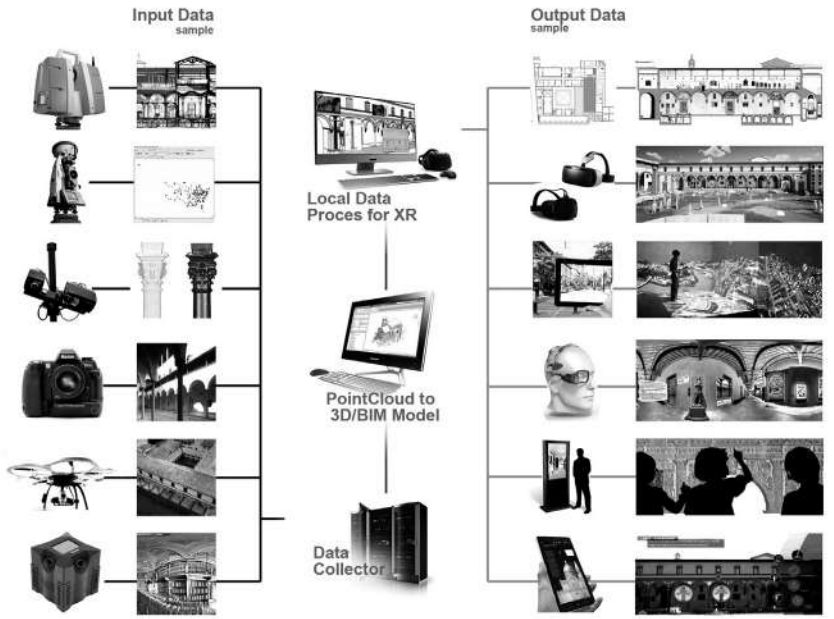

Fig.1: Ospedale degli Innocenti.
Methodological scheme. From survey to Extended Reality for conservation to restoration

3.2 The Ospedale degli Innocenti

The Ospedale degli Innocenti (Hospital of the Innocents) was built in several phases and the first phase (1419–1427) was under Brunelleschi's design and direct supervision. It is one of the main relevant example of early Italian Renaissance architecture [Mula16]. The hospital, originally a children's orphanage, which features a nine-bay loggia facing the Piazza SS. Annuziata. The building reveals a clean and clear sense of proportion. The height of the columns is the same as the width of the intercolumniation and the width of the arcade, making each bay a cube. The building's simple proportions reflect a new age, one of secular education, and a sense of great order and clarity.

Today the building also houses a museum of Renaissance art with works by Luca della Robbia, Sandro Botticelli, Piero di Cosimo and Domenico Ghirlandaio, reopened in 2016, after restoration works, with expanded and renovated exhibition spaces, new services and activities available to visitors and citizens.

The 3D integrated survey was the basis for using for restoration and the new museum project.
The virtualization of Piazza SS. Annunziata, through historical reconstructions and the description of the current physical features, analyzes the perceptive aspect connected with the environment for the creation of more immersive models. The experimentation begins directly during the restoration and construction of the new museum inside the "Spedale degli Innocenti" complex. The multiscale three-dimensional surveys, the analyses, the historical and material insights, merged within a BIM-Based model (Building Information Modeling) linked to the needs of the restoration project, have become the stimulus to create a story about the factory, its evolution and its content. The aim of the project range from the BIM-Based model for project and construction site management to Augmented or Virtual reality models for Onsite and Offsite use, to hybridization with 360° images or raster video.
The implementation of the overall documentation and data aggregation for the 3D modelling semantic approach, allowed data association among survey data, modelled geometries (parametric modelling), raster data and information enrichment focused on the main purposes (building evolution, historical analysis, new form of accessibility to the Museum). The "Time Machine" functionality is directly provided by the BIM/IFC model. The information included comprehend the date of construction of the single object (components or building parts) so it is possible to ask how the building was in a certain period. The model working on the "INCEPTION Time Machine[2]" exploits the advantages offered by the integration of the OWL-Time Ontology, providing the possibility of navigating nonlinearly over time and therefore in the history of a building.
The applications developed are intended to provide a deeper understanding of the building, its history and virtual accessibility of the building and its contents or of those that no longer exist.

- AR app for museum guided tour with particular reference to the picture gallery, testing mixed reality linked to main exhibited works;
- VR app for building tour from abroad, with the construction phases (time machine);

2 Research performed by the Department of Architecture of Ferrara within the project "INCEPTION – Inclusive Cultural Heritage in Europe through 3D semantic modelling", funded by the European Commission under the Horizon 2020 Programme, Research and Innovation Action under Grant Agreement No. 665220.

- AR app for building maintenance with particular reference to the hypogeum.

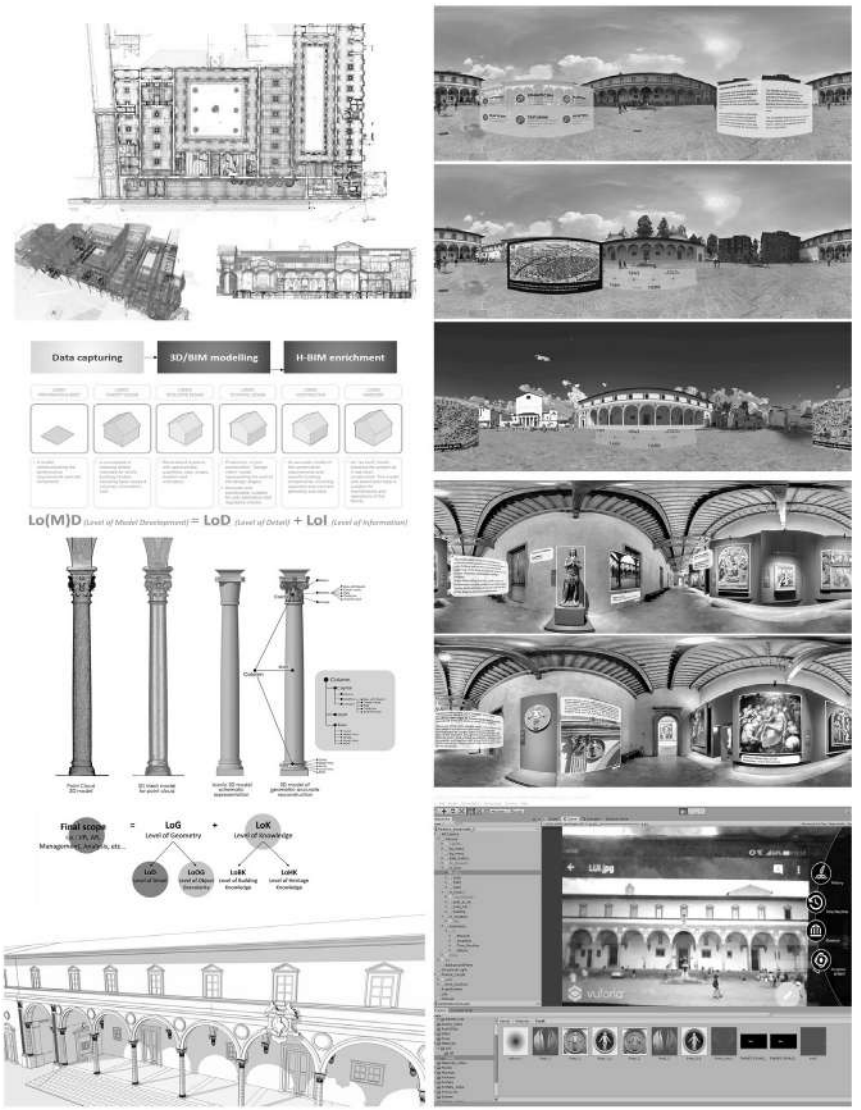

Fig.2: Ospedale degli Innocenti.
In the left column, the process from 3D survey for conservation and restoration to 3D/Bim modeling in relation to the different granularity levels. On the right different outputs, from the VR off-site for time machine, the VR Raster based for the Museum and the AR application for enhancement of the artworks on the facade.

3.3 Historical Shops

The documentation of the Intangible Heritage of the Historical Shops highlights the issue of the musealization of historical city centres under UNESCO protection. The documentation involves several methodologies of approach, starting from the data sheet census and photographic campaigns, to the digital survey conducted with laser-scanners and 360° panoramic images and videos, producing a great amount of heterogeneous data. In order to manage and develop a system for the use and dissemination of this data has been designed a virtual open-air museum system in the city accessible by mobile devices.

The longstanding presence of traditional local shops has been identifying cities and their urban "image" for a long time. The research focuses on the case study of artisanal and historical commercial activities in the center of Florence under UNESCO protection, investigating the issue of documenting Tangible and Intangible Cultural Heritage. Under the great pressures of the mass tourism era, the main streets are slowly turning into stereotyped scenes. The commercial activities and traditional crafts that were related to the social and cultural background of the city are disappearing, while the massive arrival of multinationals is transforming the historic center into a Renaissance-themed mall [Amen06]. The city preserves its tangible assets but it is losing the anthropic heritage that constitutes, with residents and artisans, a fundamental controller and catalyst of urban reality. The social dynamics and the relationships established between the seller and the client, between the artisan and the citizen are the same that define the neighborhood identity, which represents a microcosm of the city [ZuKC15]. To develop a plan of intervention and enhancement of historical commercial activities, the Department of Architecture DIDA of the University of Florence, in collaboration with the Municipality and the UNESCO office, carried out a research project to document the current situation. The first phase concerned the listing of all activities through a structured census system taking into account the architectural and historical-artistic features and the relationship of the businesses with the surrounding urban context; at the end of this evaluation, a new urban regulation was approved. The field research has directly involved shopkeepers and artisans, who pass down traditions and skills to date. The census has been matched by a photographic campaign aimed at representing the identity of these activities and by the realization of 3D

digital surveys. The great amount of data acquired during documentation and digital survey campaigns constitute a rich updatable and upgradable database, which run the risk to remain unused. The issue of digital data and its preservation is also connected with the constant changing of file extensions, which quickly become obsolete. The necessity to integrate the physical archive with new digital data is a fundamental aim for cultural institutions. To implement a promotional campaign for historical activities that involves the application of these digital tools, data accessibility is an issue of primary importance. It is necessary to collect and digitalize a large amount of heterogeneous data, acquired during the documentation activities, in a single digital database. Commencing from a "static" database, the creation of a web platform as storage of interconnected data (multimedia, text, etc.) is useful to provide complete and understandable documentation to the user. The present research proposes to structure an interactive virtual experience for the promotion of cultural tourism of the historical activities and artisanship, which includes the development of an online platform and the integration of the new Virtual Tourism technologies. The strategy consists of providing an interactive and user-friendly interface, combining traditional and innovative techniques, which connects the datasheet census system with the archive data to develop an open-air museum of the city.

One of the aims of the research is to experiment the use of point-clouds deriving from 3D laser-scanner and SfM-IM surveys for the development and creation of virtual environments, reducing the time for modeling and texturing procedures. The high defined and reliable point cloud produced during the digital laser-scanner 3D survey campaigns on the historical shops, appropriately optimized, and has been used as a support to experiment the use of the three-dimensional model in a virtual environment, using the plug-in Lidar Point Cloud of the software Unreal Engine (Epic Games).

The documentation of the heritage rather than through static databases should be operated through dynamic information systems that allow authorized third parties to implement them by adding information, thus obtaining a degree of democracy and scientificity never achieved in the documentation of oral and intangible cultural practices [Bort08].

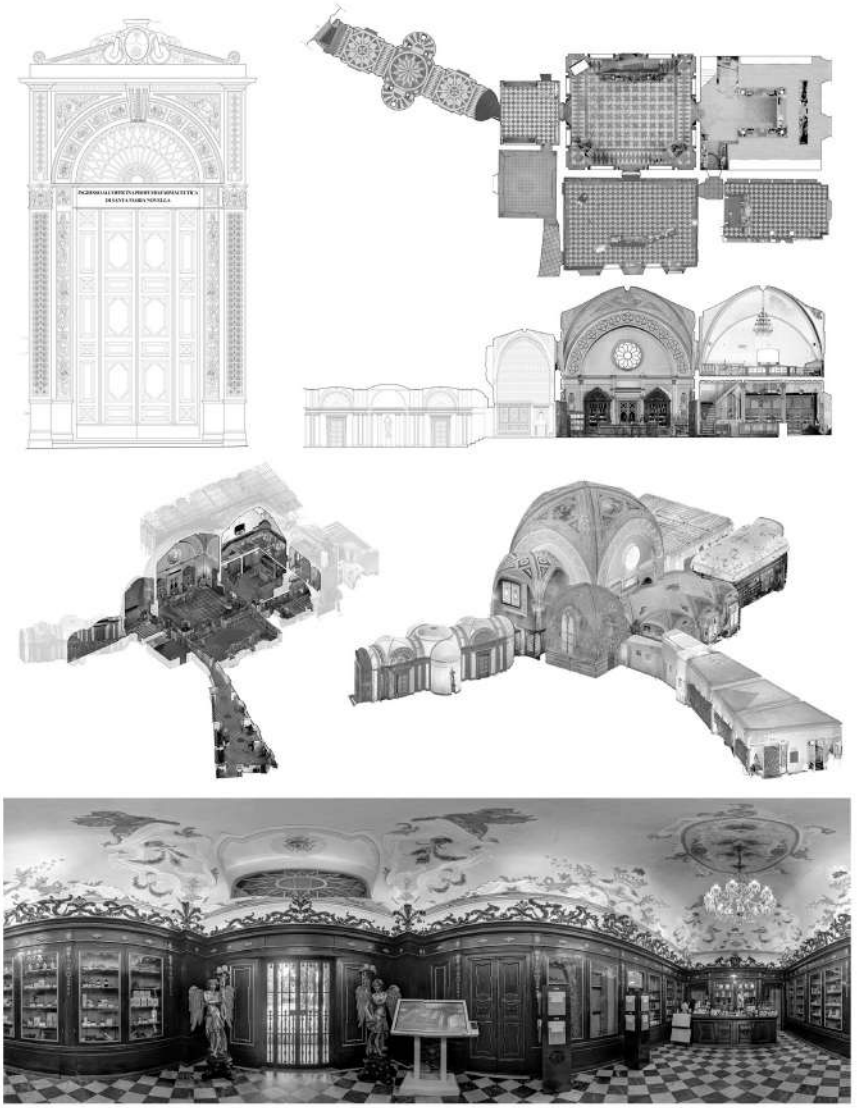

Fig.3: Officina Profumo-Farmaceutica di Santa Maria Novella
Top: examples of the detailed digital drawings produced using the descriptive point-cloud; centre: the optimized point cloud 3D model obtained by the laser-scanner campaign conducted with a Z+F 5016; down: an example of the photo-sphere acquired by the integrated camera of the laser-scanner in order to color the point-cloud.

3.4 Scientific Museums of the University

The digitalisation project on the Scientific Museums of the University of Florence deals with the survey and analysis of some collections objects to create a single system of virtual fruition of university museums artworks. The different museums' sites spread throughout the municipal area collect a large number of objects of great scientific and educational interest, creating a network of culture extended on 14 locations. The project focused on the case study of the collection of the Museum of Pathological Anatomy of Careggi, with the purpose to create 3D models usable for a wide range of applications: 3D digital database, educational apps, AR/VR systems.

The Museum hosts a collection of pathological waxes dating back to the 19th century, some of which were made by the artists of the renowned Wax Model Workshop established in 1771 in Florence. The waxes, highly realistic reproductions of anatomical parts affected by particular pathologies, were used in the past by doctors and scholars as scientific and educational tools to spread the medical knowledge throughout the community [NeST07]. Therefore, the Museum represents a real three-dimensional pathological compendium, but today it is unfortunately closed to the public and accessible only through guided tours.

The documentation process involved a 3D laser scanner survey, the acquisition of 360° panoramas and a Structure from Motion (SfM) survey of some collection objects selected among the waxes hosted in the Museum. The photogrammetric SfM survey produced high-poly 3d models, textured through the application of the photographic data, and then scaled to their original dimension thanks to the reliable metrical support of the laser scanner survey. Because of the high polygons count, it was necessary to optimize and post-produce them through specific processes to reduce the file size and make the data manageable and viewable through different applications. Then, each 3D model was implemented with various types of data (historical/medical information, photos, videos, etc.), thus becoming a vehicle of knowledge available to the user/visitor. The challenge of valorising scientific collections is the need to combine historical memory and scientific knowledge with innovative methodologies that allow to re-contextualise the objects, making visible and communicating their history and their original sense to the visitors. While in an art exhibition the object can be left alone, thus acquiring more importance and expres-

siveness, scientific and technological objects need elements that explain and communicate them to the public [MeRo07].

The different types of data obtained from the digital survey campaign were the basis for the creation of a 3D digital database and educational and valorisation systems: from a web platform, useful both as management and conservation tool, to implementation systems for the museum sites through Virtual and Augmented Reality apps.

Starting from the case study of the Museum of Pathological Anatomy, the final aim of the project is defining a broader strategy for the enhancement and promotion of the entire University Museum System. The purpose is to creating a common fruition platform, not only to provide services to students and researcher but also to create systems to support staff, citizens and visitors, making these structures usable and available to the community.

Fig. 4: The Museum of Pathological Anatomy of Careggi
Top: schematic phases proposed for the development of the project; centre: the 3D point cloud obtained by the laser-scanner survey and an example of 3d model created by SfM scquisition; down: graphic representation of a possible implementation of the museum's exhibition through AR/VR apps.

4 Conclusion

Thanks to Virtual Reality, it's possible to rebuild past worlds, monuments and ancient cities: because of the possibility of comparing different historical periods and their physical transformation, architecture and archaeology needs to deeply explore this technology to enhance the understanding of cultural heritage.

Experiments on the creation of an immersive virtual reality (VR) have already been tested. The raster data produced can be used both for immersive reality and for 3D point cloud model and 3D model texturing. The captured raster data will be also used to test the construction of 3D point cloud models through PhotoBased software.

Moreover, AR can be used to aid archaeological and architectural research, by augmenting features onto the modern landscape, enabling researcher to formulate conclusions about site placement and configuration or to more general users to understand what they are looking at. Computer-generated models can be superimposed into a real life to rebuild ruins, buildings, landscapes or even ancient characters as they formerly existed. This technology can be useful only on the field because it needs real-world environment or objects to be augmented. The recent Declaration "Cooperation on advancing digitization of cultural heritage" signed by Member States during the Digital Day 2019, confirmed the commitment by the European Council, the European Parliament and the European Commission in fostering digital technologies to record, document and preserve Europe's cultural heritage and their accessibility to European citizens.

Moreover, the Declaration states "The Union needs to collaborate to advance 3D digitisation 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 digitised cultural content and related applications are available, where appropriate, on European platforms, in line with our values".

The research developments, outcomes and future follow-ups on the Florence Cases will move in the direction stated by this declaration. Future researches will include data recording and digitization in order to meet the need of documentation and preservation due to the increasing threats

to cultural heritage due to natural disasters, pollution, mass tourism, deterioration over time, terrorism and vandalism, increasing at the same time the accessibility off-line heritage sites at risk [FeMe17]. High quality 3D models, interoperable formats and open access to digital cultural heritage assets are essential to an effective use of digital contents, increasing digital engagement and fostering sectors such as tourism, education, creative industries.

Big data, artificial intelligence, natural language processing, augmented-virtual-mixed reality and 5G to enable innovative use of digitized cultural resources, knowledge extraction and more engaging experience of heritage content are future research avenues that can benefit from what has already been developed.

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