Digitalization and Cultural Heritage in Italy

Innovative and Cutting-Edge Practices

edited by
Antonio Scuderi and Fernando Salvetti

Works by G. Amoruso, M. Bisson, J. Bradburne, G. Busulini, F. Salvetti, A. Sartori, A. Scuderi, A. Solito de Solis

Sociologia del lavoro

FrancoAngeli

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Foreword: Digital Heritage

by *Giulio Busulini*

I am very pleased to write a short introduction about this book. During my 8 years at the Embassy of Italy in Washington DC as a Science and Technology Attaché, I had to take care of several dossiers: one of those was about 'technologies for cultural heritage'. The topic was a master pillar of Italy-U.S. science and technology collaboration for at least the past ten years. In 2016, in occasion of the 12th IT-US Science and technology joint commission meeting, the bilateral working group 'Technologies Applied to Cultural and Natural Heritage' was launched. Among a number of initiatives it was created as a subgroup focalized on Cultural and creative industries, and cultural heritage management and use of new technologies (2D - 3D Digitization/3D Printing/Virtual Reality/Augmented and Mixed Reality). This book is the first exercise of mapping major emerging technology, identifying some user-cases coming from the field and the applied research. You will appreciate an overview of 30 Italian organizations (some of them spinoffs of university and research labs) that are using and implementing new solutions with their clients (mainly from the public sector, because in Italy the main museums are managed by the public administration). All 30 cases are representative of a dynamic ecosystem that Italy can offer, because it's the country with the largest number of UNESCO sites in the world (currently: 53).

Cultural heritage, the achievements of our predecessors, is a source of energy and inspiration for innovation by digital technology. In Italy, cultural heritage is a limitless source of innovation where traditions meet cutting-edge technology, mainly from the ongoing 4.0 digital revolution.

Over the last decade, Italy has seen thriving Research and Development activity focused on the application of information technologies and digital solutions in the field of communication and fruition of cultural heritage,

thanks to the intersection of the outstanding endowment of cultural research and advanced technological competencies.

The present report aims to identify a set of Italian developers and providers of solutions in this sector that are ready for internationalization, or already internationalized.

Today the perception of the Museum is changing: the contemporary audience expects both stability and flexibility from museums, which should attractive without losing credibility. Technology and exhibition design can help in the creation of new spaces and innovative solutions within museums, to have the audience enjoying and living a memorable experience.

“Digital heritage” is becoming a key-word: the integration of cultural heritage with digitization technology (“cultural heritage + digitization”), and of digital knowledge with research. It includes not only the three conventional aspects of cultural heritage digitization - digital collection and documentation, digital research and information management, digital presentation and interpretation - but also the creation and innovative use/application of the digital content (cultural heritage intellectual property, experiential education, cultural tourism, film and media). The so called 4.0 Digital Revolution has fundamentally changed the way people communicate and disseminate knowledge and revolutionized the traditional industries. New digital information technologies, which exceed the limitations placed on heritage protection by traditional methods, provide powerful tools for heritage recognition, protection, presentation, and communication that may solve many of the present problems of monument preservation.

Digitalization has a primary role to play in the conservation and promotion of cultural heritage, mainly by enhancing real-life experiences - rather than replacing them. Digital is not only a way to dematerialize our cultural heritage, but - mainly if associated to visual storytelling - also a powerful way to enhance the human capacity to generate engaging content and memorable experiences.

There are a number of best practices reported in the following pages, so I need not say more and I can close my introductory remarks quickly to focus on another point: digital technology is not just a new tool to visualize, explore or consume cultural heritage - it can assist with conservation efforts.

Enjoy the report: it’s short, easy to read, strict to the point!

Digitalization and Cultural Heritage Preservation in Italy: Innovative and Cutting-Edge Practices

by *Antonio Scuderi* and *Fernando Salvetti*

Digital heritage is becoming a key-word for cultural preservation. Over the last decade, Italy has seen thriving Research and Development activity focused on the application of information technologies and digital solutions in the field of communication and fruition of cultural heritage, thanks to the intersection of the outstanding endowment of cultural research and advanced technological competencies.

Field of Analysis

The mapping is comprised of 5 main fields of implementation that have been identified as the most promising on the basis of a review of sector publications and press. These are:

- 2D digitization, digital archiving and collection management: The digitization of tangible cultural heritage implies the translation of artifacts (paintings, sculptures, books, documents, etc.) into a digital representation through optical scanning instruments and digital imaging software. The resulting reproductions can thus be stored, archived, displayed, organized and preserved through specific software platforms - generally labeled as Digital Cataloguing or a Collections Management System - that represents valuable support for the daily work of museum registrars, curators and archivists.
- 3D scanning and print: 3D scanning involves analyzing a real-world object or environment in order to collect data on its shape and appearance. That information is then used to construct digital 3D models. These can then be used for various applications, such as diagnostics and the development of VR/AR experiences and 3D printing - or additive manufacturing - that enables the creation of lifelike physical reproductions of the original object, opening up new opportunities for preservation and visitor engagement.

- According to recent research, the global 3D printing market is forecast to reach $16.8 billion by 2022 (Global Analysts Inc.).
- Virtual Reality, immersive projections and holography: VR consists of the computer-generated simulation of a 3D environment that can be interacted with in a seemingly real or physical way using special electronic equipment, such as head-mounted displays connected to headphones, controllers and other peripherals. As a result, the user gets immersed in and navigates within a lifelike environment that temporarily replaces the "real" one in his perception. The same sense of "presence" in a simulated environment can be achieved through different hardware technologies, such as 360-degree, 3D caves or domes, 3D immersive projections and holographics mapped onto the real space. In the cultural heritage sector, VR and immersive projection technologies are generally applied to let visitors navigate in a simulated context (such as a distant or non-accessible site or room) and live fictional experiences.
  - Overall, VR is projected to be a $25 billion industry by 2021 at a global level (Touchstone Research).
- Augmented and Mixed Reality: AR and MR broadly refer to visualization, either through wearable (smart-glasses, AR helmets) or mobile (smartphone, tablet) devices, or the use of digital contents (such as sound, text, images, video, graphics, 3D models and animations) that overlay and interact with physical reality.
  - As a result, the technology functions by enhancing one's current perception and interpretation of reality without losing contact with the physical context. This is different from VR which replaces the real world with a simulated one. In cultural heritage contexts, augmentation happens in real time and in semantic relation with environmental, artistic and architectural elements. MR differs from AR in that it integrates some elements coming from VR. For present purposes, however, it is considered as part of the same technological cluster.
  - Overall, the AR market size is expected to reach $100.24 billion by 2024 thanks to a substantial growth owing to advances in hardware technologies and sophisticated mobile software. The hardware and software sectors are projected to grow respectively by a 90% and 55% yearly rate (Grand View Research).
- IoT, proximity marketing and smart access: The Internet of things (IoT) is the inter-networking of physical devices and other items - embedded with electronics, software, sensors, actuators, and network connectivity - that enable these objects to collect and exchange data.

The application of IoT to cultural heritage contexts is still an emerging field of development, whose most promising avenue concerns the interaction between users' mobile devices and the museum through technologies such as iBeacons and sensors, in order to facilitate and enhance the fruition experience. Features such as ticketless access, geo-localized information retrieval and onsite navigation are potentially able to transform museums and art galleries into "smart" cultural environments.

- McKinsey estimates the total IoT market size in 2015 was up to $900M, growing to $3.7B in 2020 and attaining a 32.6% CAGR.

Data Collection

The sample of developers and providers has been identified drawing on different data sources:

- personal knowledge of the researchers;
- participation in sector conferences and events;
- review of national sector press.

Information regarding the selected firms has been collected from company websites, communication materials and national firm directories and databases.

Criteria for Identification

The level of novelty and quality of the identified solutions and the internationalization-readiness of the developers has been evaluated qualitatively through the following criteria:

- First-mover advantage and technology leadership (e.g. being early developers and/or adopters of emerging technologies and solutions with relevant implementation case studies);
- IP (international patents for specific solutions or trademarks);
- size of the portfolio, in terms of product, project and/or customers:
  - at least 2 products having fully reached the market stage with at least 20 customers;
  - at least 5 projects of a significant size or value or, alternatively, at least 1 case study of national or international relevance;
- Strategic partnerships with relevant institutions (universities, research centers, national and international sector organizations, professional associations, etc.).

Digital Technology for Knowledge, Design and Experiential Education for Culture

by *Giuseppe Amoruso*

The *learning society* represents a new human condition linked to contemporary social phenomena, a society where men and women live, work, organize themselves and utilize know-how and knowledge as a new form of capital. This vision lays the structural foundation for economics and social development: starting from Donald Schon's paradigm, "learning, reflection and change" is translated into the promotion of creativity at all levels, addressing a critical and civic awareness and inducing a process of social change.

Design, considered as a whole set of disciplines in the universe of industrial design, deals with designing the value of processes, goods, environments and services, of increasing it and imparting this to society and citizens. Experiential design proposes a system of mediation between the territorial context and the cultural heritage system or the widespread heritage (memory, history, landscape) and the reference community intended as the final user. This makes it possible to have multiple forms of representation of goods and legitimizes their differentiated values, access, use and appropriation, whether directly or by using technology. Bearing this vision in mind, design does not solely restrict itself to designing the experience of use of goods (economy of experience), but introduces an innovative vision of systems and a shared vision of cultural heritage in all its forms; it also makes it possible to start upon a participatory and inclusive learning path and social well-being, which makes its diffusion in the community sustainable and cost-effective (from the institution to the cultural operator, to the different categories of users).

The service economy in recent years has shown considerable potential by creating an innovative system with a social nature, based on a particular type of economic performance. Goods and services are no longer sufficient as economic products; a new need has been created: through a design process, an integrated fruition project can be created, that is to say, the

project of experience, leaving an experiential impression in people, in other words, giving a sensorial and psychological form to experience.

Knowledge technologies are recognized as opportunities in terms of conservation, study and communication of heritage, but also of creating culture and awareness that is expressed in the contemporary forms of sharing and dissemination. Learning, in the different seasons of life, should therefore be considered as the source of an increasingly innovative economy that becomes sustainable and has an impact if it reaches a substantial and diversified number of users and social subjects.

Design for cultural heritage includes theories, methodologies and enhancement techniques that have the cultural heritage system understood in its cognitive, social and symbolic dimensions as their application sphere. The disciplines of representation interact with the multiple disciplinary specializations of design, proposing the definition of interpretative models for the analysis and representation of the historical, cultural, aesthetic and environmental values of a cultural asset as well as its material and immaterial meaning. The value enhancement strategy produces advanced visualizations as well as computer and multimedia modelling. Moreover, the experiential value, with its emotional imprint and fruition, is emphasized through immersive and interactive technologies. The applications make it possible to have a structured and flexible knowledge process including the simulation of forms of innovation and an increase in the social value of the transmission and sharing of cultural contents.

In fact, in order to fulfil their educational mission, the spaces of culture need to go beyond the tangible and common sensorial dimensions in order to communicate and share a heritage, understood also as a process of appropriation and as such also linked to the intangible dimension. It is in this direction that the *Convention for the Protection of Intangible Cultural Heritage* (Paris, 2003) goes. It defines the intangible cultural heritage as "the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage".

Within the framework of UNESCO, there is the "*Recommendation Concerning the Protection and Promotion of Museums and Collections, Their Diversity and Their Role in Society* (Paris, 2015) which underscores the importance of technologies in assisting museums in their task of educating and encouraging continuous learning.

Technologies are therefore changing the relationship between users and the utilization environment and cultural content in museums, libraries and places of learning. The environments must be imagined and transformed by

also considering their virtual extension and allowing a range of customizations linked to the selection of contents. Participation and sharing mediated by the user can also create new cultural content by blazing a path to new forms of active and participatory learning. Among the cultural actions that are related to new media and their language, the creation and sharing of information and knowledge are included, as well as the accessibility to heritage through digital artefacts that represent ideas, identities and values of belonging. To these, Manovich also adds the interactive cultural experience, the opportunity to enjoy the experiences and cultural products by visitors, as well as ways to recreate the displayed objects, textual, vocal and/or visual communication and participation in a type of information that "ecologically" regenerates knowledge and its diffusion.

Knowledge technologies offer multiple opportunities and challenges to cultural and scientific practitioners; the challenge of involvement and experience is not only one of technology and design, but also, and perhaps more importantly, a mental and imaginative one.

Advanced measurement system for tactile replication of statues, bas-reliefs and museum artefacts

The applied research project foresees the creation of a physical replication of bas-reliefs and stone artefacts conserved in museums. This application may also form a collection of tactile replications in order to encourage wider access to collections by children and visually impaired visitors, but also for the benefit of laboratories and continuous learning. The workflow starts from the instrumental characterization in relation to samples and material features; a set is created on site, testing methodologies, different tools and the final data integration from photogrammetry and scanners.

Through the use of advanced digital technologies, a digital cast is initially created, reproducing every part of the sculpture or artefact in extremely fine detail. The three-dimensional geometric acquisition can be carried out by means of scanning devices, either with scanning arms and/or structured light scanners, i.e. the external surface can be detected with a high-quality photographic acquisition and subsequent photogrammetric mapping. The two techniques can be integrated in relation to the characteristics of the scanner (for example, if it mounts an RGB sensor), to the foreseen final accuracy and to the scale ratio between the artefact and the final copy to be reproduced. Initially, a measurement taking project is developed that includes installation and setup with the lighting of the subject and the use of photogrammetric targets and then proceeds to the measurement taking with the

photogrammetric system (SFM-Structure From Motion), laser (scanning arm or with optical scanner) and, if necessary, also the assessment of the texture and colour calibration of the surfaces in the digital format.

The digital scan provides a set of hundreds of millions of three-dimensional points, constituting a discrete cloud of points from which it will be possible to generate the high-fidelity model with reverse-modelling procedures, as well as making an optimal distribution of 3D points in relation to the geometry of the sculpture. Proven and simplified models for lithographic stereo printing using additive technologies with polymeric materials or with mineral powder will be extracted from the optimized digital copy. Alternatively, it is possible to create a replica through a low-cost 3D print technology; today a variety of solutions and materials are available. Subsequently, considering the final and permanent exhibition to the public, the realization of a gypsum/marble powder replica through the traditional artistic technique is recommended.

In the case of large-sized statues, the model will be designed to be physically reproduced with a robotic milling system that usually uses soft materials such as compact polyurethane; it is the most advanced technology available, used by the mechanical industry and for rapid prototyping whose use is being tested in the field of cultural heritage, design and art.

Integrated techniques for analysis, experiential simulation and reconstruction of architectural and archaeological heritage

Geometry and digital representation of the Teatro Olimpico by Andrea Palladio

The Teatro Olimpico of Vicenza, designed by Andrea Palladio and built by his son Silla after 1580 is a work of great importance: as a matter of fact, it shows the maturation by Palladio in the study and design of scenic devices, thanks to an accurate analysis of the prescriptions by Vitruvius, which in Book V of *De Architectura* provides, albeit without any illustrations, some geometric rules for the sizing of spaces. Andrea Palladio invented a model of a classical theatre that is covered and permanent, which gave built form to the Vitruvian space around the solid perspective of illusory scenes; he also consolidated the tradition of perspective knowledge, coming from ancient sources, by projecting its influence on a modern architectural space and allowing the material realization of a solid (and illusory) stage set.

The Teatro Olimpico was designed with a *cavea* defined by historians as "semi-elliptical," and which ends in the upper part with a Corinthian

colonnade and a further terraced crown. Opposite the *cavea* is the stage, and in the *scaenae frons back screen,* the viewers see *trompe-l'œil* onstage scenery, designed by Vincenzo Scamozzi between 1584 and 1585 for the representation of Sophocles' *Oedipus Rex,* giving the appearance of long streets receding to a distant horizon.

The stage set is characterized, therefore, by its unique geometric form in relation to the design theory of theatre spaces and offers numerous ideas for an accurate analysis that nowadays may be carried out with advanced measuring technologies. The search for the correct interpretation of the typological parameters of the Roman theatre, provided by Vitruvius, would engage the most illustrious humanists, artists and architects throughout the Italian Renaissance.

The research also seeks to extend its fruition through the display of dedicated contents (such as video animations) or access to augmented reality interactive platforms (thus making it possible to visit the secret corners of the theatre) or being able to produce physical tactile replicas intended for a wider category of users.

Modeling and advanced generative techniques for the experiential simulation of the Roman amphitheatre in Milan

Theatres and amphitheaters represent the most fascinating and complex buildings for geometry and architectural construction, a universal heritage that ancient Rome has bequeathed to us: not only the extraordinary Colosseum, but also the hundreds of structures scattered throughout the empire, as in Verona, Pola and in *Mediolanum* itself, which was the protagonist of the history of Rome for many centuries.

This research addresses questions that are still open concerning the geometric genesis and building solutions of the Roman amphitheatre in Milan, second in size only to the *Colosseum- Amphitheatrum Flavium* in Rome, also thanks to new disciplinary advances that have been made possible by new technologies, digital modeling, and simulation as well as by 3D printing and augmented reality. In order to carry out a philological reconstruction of the amphitheatre, it was necessary to perform a high-resolution three-dimensional survey of the foundation septa with laser scanning technology.

The processing of the measurements has provided us with the metric and formal data on which all hypotheses of geometric reconstruction can be developed, making it possible to verify its original configuration; the use of graphic analysis conceptual tools as well as the comparison with similar artifacts makes it possible to estimate the dimensions of the arena and the functional hierarchies of the spaces of the amphitheatre. An additional aim

is to make documentation available for subsequent and further enhancement of the archaeological area, favoring a wide accessibility to different categories of users, both directly and through digital systems.

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Fig. 1 - Data measurements for the SFM-Structure from the Motion Photogrammetric System

Fig. 2 - Processing of the photogrammetric model, from the point-cloud to the polygonal mesh

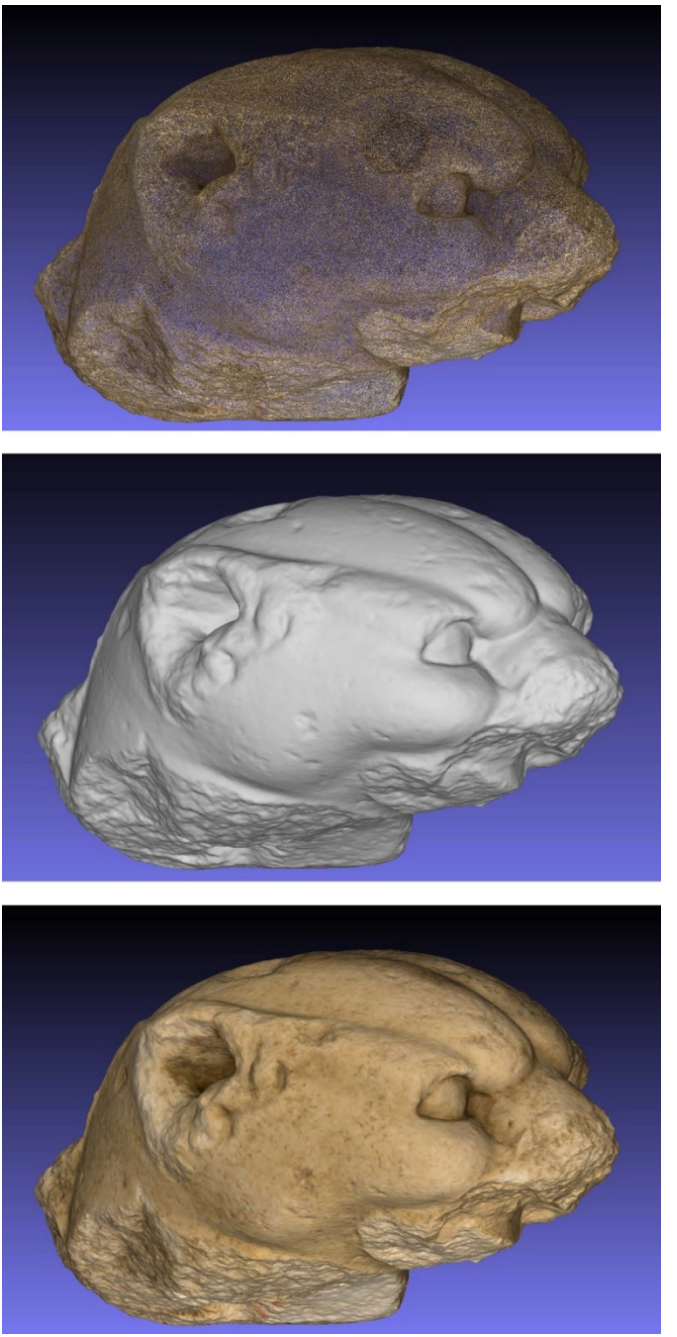

Fig. 3 - The digital replica ready for tactile printing

Fig. 4 - Panoramic High Dynamic Range image of the cavea processed from the measurement recordings carried out by a laser scanner