

DIGITAL VISUALIZATION FOR CULTURAL DISSEMINATION

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# SCIRES

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*Cover Illustration: A. Palmieri*

*Midjourney experimentation: representing Nature on a macro scale*

## EDITORIAL SCIRES-IT. A VIRTUAL JOURNEY THROUGH CULTURAL AND ENVIRONMENTAL HERITAGE, TECHNOLOGIES, AND CREATIVE IMAGES

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### Abstract

This issue of SCIRES-IT contains various and interesting contributions that take us on a virtual journey, in time and space, among cultural and environmental heritage, through research, technologies, creative images and innovative technological developments. The virtual journey ends with a surreal flight on the wings of a dragonfly in a protected Nature Reserve rich in biodiversity, to know and preserve.

### Keywords

SCIRES-IT, Editorial, SCientific RESearch and Information Technology, Cultural and Environmental Heritage, Multimedia Technologies, Biodiversity, Nature in Dante, Eco-sustainable Publications, Diamond Open Access Journal

This issue of SCIRES-IT - SCientific RESearch and Information Technology (No. 1, vol. 13, 2023) contains various and interesting contributions that take us on a virtual journey, in time and space, among cultural and environmental heritage, through research, technologies, creative images and innovative technological developments.

The opening article, titled "Ribbed vaults with Renaissance characteristics: singular design and construction in some of Diego Siloé's vaults", by Eduardo Acosta, examines a particular construction technique used by the Renaissance master. The paper presents the results of 3D data acquisition and processing methodologies for the survey of ribbed vaults highlighting their historical-typological characteristics, representative of Spanish architecture in the mid-16th century, as well as the technique and thinking of Diego Siloé.

With a different slant from the previous one, the article "Architectural Intangible Heritage and Graphic Reconstruction. Terminological and Philological Notes" by Fabio Colonnese instead analyzes the concept of intangible architectural heritage by attempting to identify the historical and cultural roots of the practice of architectural reconstruction, with a focus on the work of Quatremère de Quincy, a French archaeologist and architectural theorist.

The article "Industrial metrological technologies for Cultural Heritage", by Cecilia Maria Roberta Luschi and Alessandra Vezzi,

address the issues related to the survey of small-scale artifacts made of reflective materials, starting with the specific case of a bronze horse preserved at the Isidoro Falchi Civic Archaeological Museum (MuVet) in Vetulonia.

The essay "Sculptural fragments from the church of San Gennaro extra moenia in Naples: digital twins for heritage knowledge, analysis and fruition", by Greta Attademo, also address the use of new technologies and advanced digital representation techniques for the preservation and enhancement of medieval sculptural heritage, in the specific case related to the apparatus of sculptural fragments currently preserved in the Palatine Chapel of the Castel Nuovo Museum in Naples.

Instead, Alfonso Ippolito, Martina Attenni and Rawan Darwa in their essay "HBIM as a tool for heritage presentation of Santa Maria in Trastevere" illustrate the use of a digital procedure for the documentation of historical architecture by focusing on a specific case study and confirming in this sense the ascertained potential of the BIM paradigm.

The essay "Cultural heritage recovery in rural Spain through digital means of surveying and graphic reconstruction. Case study of El Paular wool complex", by Nicolás Gutiérrez-Pérez, shows a research experience on the recovery of industrial archaeological heritage located in a rural area of Spain. Specifically, it analyzes the large wool

processing center built in 1624 by the Royal Monastery of El Paular in the small village of Trescasas (Segovia), which is today in a situation of deep degradation after being abandoned and looted following the French invasion (1808-1814).

With a shift that takes us from the architectural to the urban scale, the article "Virtual access to heritage through scientific drawing, semantic models and vr-experience of the Stronghold of Arquata del Tronto after the earthquake", by Fabrizio Banfi, Chiara Stanga and Angelo Giuseppe Landi, proposes a research method that uses a tool already tested in the field of Digital Cultural Heritage, the interactive representation. This tool is aimed, in the specific case of a study to which it is applied, at sharing complex scenarios, improving the reliability of the model and facilitating new forms of heritage dissemination.

Also Margherita Lasorella and Elena Cantatore, in their contribution "3DCityModels to support technical knowledge and management of historic built environments. A semantic CityGML-based model for the ancient core of Carovigno (BR), Italy" address a topic at the urban scale, proposing and discussing the application of CityGML standards for the collection, cataloging and management of semantic, geometric and geolocalized data applied to an entire historic center.

With a further shift of scale, the paper "Machine learning and landscape quality. Representing visual information using deep learning-based image segmentation from street view photos", by Fabio Bianconi, Marco Filippucci, Marco Seccaroni, Andrea Rolando and Domenico D'Uva, aims instead to define a methodological process and a digital criterion for automatically assessing the quality of a landscape from the analysis of Google Street View images processed by an artificial intelligence system.

Closing the essays involving applications, Davide Mezzino's article "Digital visualization for cultural dissemination" instead proposes a reflection on possible approaches to presenting archaeological sites and museum collections. Creative uses of virtual reality (VR) and multimedia technologies and related opportunities for communication and interpretation are here presented through two case studies in archaeology, the UNESCO heritage site of Bagan and the Egyptian Museum in Turin.

Gonzalo Alfonso Beltrán Alvarado's contribution, "Augmented Reality (AR) in

Education, Medicine and Industry: a systematic review of the literature," proposes a review of the main applications of Augmented Reality in different fields ranging from Education to Medicine, from Industry to Cultural Heritage.

The article "Similarity based Optimization to Fractal Image Encoding based on multithreading parallelization", by Ranjita Asati, Mukesh Raghuwanshi and Kavita Singh, proposes an integrated approach combining both multithreaded parallelism and similarity based encoding space reduction to diminish the time of compression in Fractal image coding. The compression time of the proposed integrated method is tested for images of different resolution and the proposed solution is able to reduce the compression time by almost 4.4 times compared to existing fractal image compression techniques.

The virtual journey addressed within this new issue of SCIRES-IT finally concludes with a surreal flight, on the wings of Alice Palmieri's dragonfly, in the Nature Reserve "Cratere degli Astroni," a protected area located within one of the craters of the Phlegraean Fields, located in the municipalities of Pozzuoli and Naples, in the metropolitan city of Naples (Italy).

Indeed, the article "Midjourney experimentation: representing Nature on a macro scale" by Alice Palmieri offers insights into the use of artificial images generated through machine learning, investigating the advantages and criticalities of these tools. The proposed experimentation is aimed at testing a new form of communication to stimulate reflections on the Human-Nature relationship and increase ecological awareness, exploiting the ability to raise awareness through surreal representation.

The article addresses a very topical issue, and the objectives of the project are appreciable.

Nature, in fact, in all its forms and manifestations, the environment seen as biodiversity and ecosystems to preserve, not only to exploit, are among the main objectives of our SCIRES-IT Journal, since it was founded. (SCIRES-IT Manifesto, 2011).

The tools used for communication are very important, and AI (Artificial Intelligence) can be of great help, but it is not automatic that they will lead to the stated aim. The limits of these tools reside in the way they will be used.

As Ferdinando Boero (eminent Professor of Zoology and Marine Biology, internationally renowned scientist and ecologist, and member of

the Editorial Board of SCIRES-IT) states, in spite of the obvious relevance of the ocean, it is still necessary to promote awareness about its importance. "The biodiversity that is usually shown, and protected, does not contribute much to the functioning of ecosystems, and the processes that sustain it remain in the shade. ... The usual communication strategy is to elicit, with beautiful images of iconic species and habitats, a reaction of wonder from the public which does not lead to a reaction of understanding, to the full perception of the role of ocean sciences for our well-being. ... Sustainability is currently perceived as a necessary goal for all governments, but the way it is depicted substantiates the perception that social and economic sciences overwhelm ecological ones." (Boero, 2021).

We take this opportunity to remind you that SCIRES-IT - SCientific REsearch and Information Technology publishes original works, focused on Digitalization and Multimedia Technologies and Information & Communication Technology (ICT) in support of Cultural and Environmental Heritage (CH) documentation, preservation and fruition. It is a "Class A" Diamond Open Access Journal and eco-sustainable which combines the main principles of the Berlin Declaration on Open Access and the aims of the International Convention on Biological Diversity (Proietti & Valzano, 2011, 2014; Boero & Lucarella, 2018; Valzano & Cigola, 2020; Gallo & Accogli, 2022).

In line with the editorial project "Eco-sustainable OA publications", for each issue of SCIRES-IT, an action of environmental restoration has been carried out in protected areas by planting local ecotypes of native species, in cooperation with CEIT (Euro-Mediterranean Centre for Innovation Technology for the Cultural and Environmental Heritage and Biomedicine)<sup>1</sup> and the Botanical Garden of the University of Salento<sup>2</sup>.

Over the years, in cooperation with CEIT, the Laboratory of Zoology and Marine Biology<sup>3</sup>, and the Department of Mathematics and Physics of the University of Salento, other initiatives and workshops have been organized aimed at the knowledge, enhancement, management and preservation of natural and environmental

resources, as well as the development of study programmes aimed at carrying out interventions of restoration of the natural environment, thus enabling policies of improvement and cultural, economic and eco-sustainable development of the areas involved. (Boero & Lucarella, 2018).

In full accordance with its policy, SCIRES-IT published a Supplement containing the results of CoCoNet, the projects of the EU Oceans of Tomorrow programme, which tackled two interconnected problems, namely, the protection of the marine environment and the production of clean energy. (Boero, Valzano & Bartolomei, 2016). The CoCoNet Consortium involved hundreds of scientists from 22 states, based in Africa, Asia, and Europe, contributing to build a coherent scientific community. (Boero, Foglini, Frascchetti, Goriup, Macpherson, Planes, Soukissian, & CoCoNet Consortium, 2016).

SCIRES-IT published articles on new technologies for monitoring and managing historic gardens and green spaces in general, and on support systems for high-quality urban green space management (Romani, Rapi, Cacini, Massa, Mati, Rocchi, Sabatini, & Battista, 2020).

In 2021 and 2022, SCIRES-IT also hosted some contributions on the multimedia projects carried out for seventh centenary of Dante Alighieri's death (Valzano & Gallo, 2021; Maggiore, 2022). In such a context, Dante played a role as a poet, but also a man of the Middle Ages interested to the functioning of machines and technological processes contemporary to him (Caroti, Piemonte, Capriuoli, Cisaria, 2021) and, especially, a naturalist and ecologist ante litteram (Valzano & Sartor, 2021; Valzano, Sartor, Romani, & Accogli, 2022).

In particular, in the open access multimedia project "Dante as an ecologist and poet in the world. 'Divine illustrations' by Gustave Doré", emerges Dante's interest and respect for the environment, for the Nature in all its forms and manifestations, that he observes with great wonder and curiosity, with the eyes of a researcher, a naturalist. His attention is focused also on the sustainability of human intervention and on the consequences it has on a number of

<sup>1</sup> CEIT. Centro Euromediterraneo di Innovazione Tecnologica per i Beni Culturali e Ambientali e la Biomedicina (Euro-Mediterranean Centre for Innovation Technology for the Cultural and Environmental Heritage and Biomedicine), directed by Virginia Valzano (see: <http://www.ceit-otranto.it/>).

<sup>2</sup> Orto Botanico (Botanical Garden) of the University of Salento. Technical manager: Rita Accogli.

<sup>3</sup> Laboratory for Zoology and Marine Biology of the University of Salento, directed by Ferdinando Boero.

natural habitats, on biodiversity and, therefore, on ecosystems. This project has been nominated for the World Summit Award 2021, in the category Culture & Tourism, as the most innovative digital solution from Italy.

SCIRES-IT has maintained its fundamental objectives and its policy, thus achieving excellent results in both national and international scientific fields, thanks to the work and commitment of the Editorial Team, Reviewers, and Authors, to whom goes our sincere gratitude.

Starting with this first issue of Vol. 13, 2023, SCIRES-IT has expanded its International Editorial Team with a Journal Manager, whose role has been assumed by Ilaria Trizio, and with some Directors

from different academic Institutions, Professors and experts from several disciplinary fields, relevant to the journal's themes.

Among them is the eminent Professor Salvatore Settis, archaeologist and art historian, as well as one of the most authoritative voices on the Italian intellectual scene, always in the forefront of promoting culture and research, and campaigning for the protection of cultural and historical-artistic heritage, landscape and environment.

To all of them goes our sincere gratitude, with the hope that these new collaborations will lead SCIRES-IT towards greater and more significant accomplishments.

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## DIGITAL VISUALIZATION FOR CULTURAL DISSEMINATION

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### Abstract

Considering the consolidated use of visualization techniques for cultural heritage dissemination, the article illustrates different approaches to present archeological sites and museums' collections. Through two case studies within the archeological field - the UNESCO cultural heritage site of Bagan and the Museo Egizio di Torino - creative uses of virtual reality (VR) and multimedia technologies and the related communication and interpretation opportunities are presented. By explaining the adopted workflows (from data/information acquisition to information processing and elaborated dissemination strategies), the contribution focuses on the role of graphic language and digital representation in defining narrative strategies addressed to heterogeneous audiences. Additionally, the expressive potential of digital visualization techniques for both online and onsite cultural communication is highlighted.

### Keywords

Built heritage, museums, digital visualization, virtual reality (VR), visual storytelling, multimedia technologies.

### 1. Introduction

Cultural dissemination refers to the process of sharing and promoting knowledge about cultural heritage to various audiences. However, traditional methods of cultural dissemination such as exhibitions, lectures, and publications may not be sufficient to engage and inform diverse audiences, especially younger generations who are increasingly digitally savvy and have different expectations and preferences.

Heritage sites and museums are increasingly adopting multimodal approaches to disseminating and communicating cultural heritage (Silva & Teixeira, 2022), using digital technologies to develop new narratives for cultural content and concepts.

Within this framework, digital visualization plays a crucial role in defining immediate and engaging ways of communication that could be either 2D (such as images and infographics), 3D (i.e. 3D models and virtual environments), statics, and/or dynamics.

Recent advances in digital visualization techniques, the rapid growth and affordability

across various users devices are providing new opportunities for cultural heritage.

Virtual reality (VR) and multimedia technologies open up several opportunities in terms of media hybridization and users interactions allowing to transmit the outcomes of the scientific research on cultural heritage sites and museums' collections in immersive and engaging ways towards different audiences.

Virtual Reality enables to envisage natural and/or complex interactions with 3D digital environments<sup>1</sup> (Gaugne, Barreau, Lécuyer, Nicolas, Normand & Gouranton, 2022) while multimedia solutions facilitate the dissemination of complex concepts, ideas and support intuitive as well as immediate visualization for data and information interpretation.

The benefits of VR and multimedia for cultural dissemination range from cultural and physical accessibility, to interpretation, engagement, and communication.

Nevertheless, some challenges need to be considered.

The design and planning of transmedia narratives and communications styles as well as

<sup>1</sup> VR provides several potentials for cultural dissemination by enabling people to experience and interact with cultural heritage in new and engaging ways. VR technologies can enhance the accessibility, interactivity, support users'

interpretation and creativity of cultural dissemination and offer opportunities for personalized and adaptive learning experiences.



interaction paradigms and technologies present several complexities in the planning phase.

These include technical complexity (i.e. VR and multimedia technologies require specialized hardware and software as well as skilled personnel to develop, operate, and assess VR and multimedia projects) and quality of the digital content (including, but not limited to, 3D models, textures, animations, sound effects, etc.) which may be time-consuming and costly.

Finally, yet importantly, the design of digital experiences also requires careful curation and validation of the contents.

Therefore, the design and development of virtual environments and multimedia solutions require the collaboration of experts and professionals with different competencies and skills to fully leverage the potential of immersive and multimedia experiences. These include, for instance, curators, architects, visual artists, software developers, system integrators, and digital experts that must work together to develop efficient and effective interconnections among visitors, museums' collections, or cultural heritage sites and digital solutions.

In line with these considerations, through two case studies<sup>2</sup>, within the field of archeology - heterogeneous for type, topic, geographical location, historical background, dimensions, access typology, content, project goals, workflows, techniques, and tools adopted - the role of representation disciplines in the design of engaging and immersive visualization is presented.

The dissemination strategy, developed for two case studies, differs for devices, location dependency, type of experience (online and onsite), type of users, interaction and collaboration, tasks, set of quantitative and qualitative data, and interpretation types.

Both projects illustrate different narrative approaches involving, on one hand, the development of a Virtual environment for the knowledge of a cultural heritage site, on the other hand, storytelling strategies based on multimedia integrated with real objects, for the dissemination

of archaeological remains within a museum environment.

The article illustrates a theoretical approach derived from a critical analysis of the state of the art and describes possible operative workflows based on the author's experience in this domain.

As is common with projects in the digital humanities, both experiences involved multiple stakeholders including researchers and specialists (archaeologists, curators, historians, architects, visual artists, and computer scientists), home and partner institutions, media and technologies companies, and members of the community.

Concerning the article structure, Paragraph 2 introduces the role of digital visualization for cultural dissemination, by presenting an overview of the available technological solutions for digital visualization.

Paragraph 3 illustrates the role of graphic language and transmedia narratives in the definition and generation of the VR experience for the ancient Loka-hteik-pan temple in the site of Bagan, Myanmar.

Paragraph 4 describes a creative application of multimedia solutions, focusing on the concept elaboration and design phases for the permanent installation "In search of life" realized at the Museo Egizio di Torino.

Finally, paragraph 5 reports the conclusive remarks on the challenges faced, on the replicability and advantages of the adopted methods, workflows, and solutions.

## 2. *Technological solutions for digital visualization*

Digital technology has transformed the way cultural institutions<sup>3</sup> engage with audiences, explain, narrate, and trigger tangible and intangible aspects and values of objects and sites.

Cultural institutions have leveraged digital visualization techniques to enhance storytelling modalities and connect with visitors either online or onsite.

Digital visualization solutions can expand narrative potentials by representing and communicating contextual and historical

<sup>2</sup> The author actively participated in both projects. His involvement focused on the concept and design phases and definition of the digital storytelling strategy.

<sup>3</sup> In this case 'cultural institutions' is intended in its broader meaning including all the organizations (public, private, public-private) working for the interpretation, preservation and dissemination of cultural, scientific, and environmental

knowledge. These organizations promote activities aimed at informing and educating individuals on associated aspects of culture, history and science. Examples include but are not limited to: museums, libraries, art galleries, archives, historical societies, community and cultural centers and local Soprintendenze (in the Italian case).

information as well as goals, workflows, and outcomes of the research activities carried out, thus stimulating reflections and critical thinking. Digital representations (2D or 3D) enable to visualize and create objects, places, data sets, interactive graphs, simulations, images, videos, virtual environments, and other forms of digital media to communicate complex information, concepts, and ideas in a more intuitive and accessible way. In terms of interpretation and dissemination of cultural heritage objects and sites digital visualization techniques allow to:

- communicate complex historical and cultural concepts facilitating understanding and engagement;
- improve cultural accessibility to a wider audience (i.e. people who may not be able to physically visit heritage sites or museums);
- increase the knowledge by supporting the analysis and study of cultural heritage artifacts and sites help to uncover new information and insights;
- stimulate transdisciplinary approaches (for instance bringing together experts from different fields, such as historians, archaeologists, designers, and technologists).

Therefore, to exploit digital visualization possibilities, an updated knowledge of the different technological solutions available is needed. The most recently used for cultural dissemination are the following: large and immersive projections, digital frames, holographic showcase and projections, led walls, video walls, Oled (including Oled signage), touch tables and screens, monitors, sliders, and virtual reality displays.

Large and immersive projections are suitable to show dynamic animation and in some cases provide also a certain level of interaction such as the immersive projection of the Alimentarium museum in Vevey<sup>4</sup> (Fig. 1).



**Fig. 1:** Immersive and interactive projection in one of the sections of the Alimentarium museum. Image source: Videmus, 2023.

Monitors and touch tables allow browsing and displaying contents, selecting or querying digital objects such as images and 2D and 3D reconstructions.

Digital frames can visualize static and dynamic information on the objects nearby.

Holographic showcases or screens can instead narrate concepts and stories with a high 'dramaturgy' (Pietroni, 2019) allowing our collective vision and contact with the animation. This solution can also allow integration with real objects.

Regarding Virtual Reality technologies, these need immersive devices that can be grouped into standalone devices, tethered VR headsets, smartphone VR headsets, and handheld VR viewers.

The increasingly broad range of VR displays gives users the impression of being fully immersed, from the visual point of view, in the generated virtual context. These devices allow to experience VR projects such as the 'VR ZONE'<sup>5</sup> (Museo Nazionale Scienza e Tecnologia Leonardo da Vinci, 2023), 'Modigliani VR: The Ocher Atelier'<sup>6</sup>

<sup>4</sup> The Alimentarium museum was Founded by Nestlé (a Swiss multinational corporation, operating in the food and drink processing). The Museum features a delightful selection of exhibitions and interactive presentations. Among these installations there are some immersive projections that allow users to interact with the digital projected contents to gain additional information on them, thus improving their knowledge in an interactive and dynamic way.

<sup>5</sup> The VR ZONE is a weekly event, organized by the Leonardo da Vinci National Museum of Science and Technology in Milan, aimed at offering visitors immersive VR experiences related

to the museum's topics. The project has been realized in collaboration with Sony Interactive Entertainment Italia and Rai Cinema.

<sup>6</sup> It is a temporary exhibition on the Italian painter Amedeo Modigliani realized by the Tate Modern between the end of 2017 and the beginning of 2018. Part of the exhibition is a wearable virtual reality experience (with the VR VIVE viewer) allowing visitors to visualize the painter's studio in Montparnasse, as it was in 1919. The final aim is to let visitors know the painter in an intimate setting like his studio-home. The modelling of the digital environment is the work of the

(Tate gallery, 2023), the 'Perpetuity' project (Arc/k Project, 2023), 'Unraveling the Gordian Knot: Integrating Advanced Portable Technologies into the Analysis of Rock Art Superimposition' (Kotoula, Robinson, & Bedford, 2018) project<sup>8</sup> and the 'VIRTUALDiver'<sup>9</sup> project (Pehlivanides, Monastiridis, Tourtas, Karyati, Ioannidis, Bejelou, Antoniou, & Nomikou, 2020) (Fig. 2).

Additional technological solutions for digital visualization can include "visor-free" technologies.

For instance, the 'Virtual Reality Bus' project developed an ad-hoc installation for a collective and simultaneous VR experience. This project offers the public the possibility to visualize the reconstruction of the architecture and urban image of ancient Rome as appeared 2,000 years ago<sup>10</sup> (Sovrintenza Capitolina ai Beni Culturali, 2023). Using the "visor-free" VR technology to guarantee an immersive experience, the 3D reconstructions of the architectures, created by visual effects specialists and supervised by expert archaeologists, appear on the OLED screens superimposed on the windows of the bus while a system of motorized blinds allows visitors to admire the beauties of today and to compare them with those of the past (VR BUS ROMA, 2023). Thanks to the MOVX patent (with 3 GPS, a three-axis accelerometer, a magnetometer, a velocimeter, and a surface laser) it is also possible to synchronize the speed and position of the bus in real physical space with those in virtual space (Artemagazine, 2023).



**Fig. 2:** 'VIRTUALDiver' project. Multimedia selection and navigation in VR environments. Source: Pehlivanides, Monastiridis, Tourtas, Karyati, Ioannidis, Bejelou, Antoniou, & Nomikou, 2020.

This synthetic overview of the available COTS technologies and the gaze on the possible applications, highlights that digital resources alone are not enough to adequately present cultural heritage objects/sites.

Preloaded gaming studio and the project is the result of collaboration with the Museu de Arte Contemporanea de Universidade de São Paulo in Brazil and the Metropolitan Museum of Art.

<sup>7</sup> The project is part of the Arc/k Project, an association of cultural bodies, organizations, and professionals whose mission is digital preservation and the protection of the world's cultural heritage from war, climate change, and vandalism. The 'Perpetuity' project, launched in 2016, used a photogrammetric technique to generate a 3D reconstruction of the archaeological site of Palmyra, in Syria, employing photos previously shot on-site by visitors and specialists. This creative approach allows the virtual exploration of the digitally reconstructed historical structures destroyed by the so-called Islamic State (ISIS), between 2015 and 2016.

<sup>8</sup> The project developed by the University of Central Lancashire, in 2017, concerns the reconstruction of the archaeological sites Pleito and Cache Cave, two prehistoric rock sites located in the Wind Wolves Preserve in California. The digital reconstruction has made it possible to preserve and give access to the archaeological finds and sites without disfiguring them considering that both caves, due to their morphology and the material, sandstone rock, are fragile and difficult to access. Photogrammetry was adopted to generate the 3D model of the archaeological site, while the DStretch

technique was used to visualize the "superimposition" that characterizes the walls of the cave, i.e. the overlapping of the layers of color paintings. The project is the result of a collaboration between the Arts & Humanities Research Council, California State University, and the University of Strathclyde.

<sup>9</sup> It is a research project involving virtual and augmented reality to visualize the submerged heritage of Greek civilization in the Mediterranean Sea. The goals of the project aimed at developing a content presentation platform and a custom-made add-on environment, offering the ability to visualize and interact with the reconstructions of 3D environments depicting explorable inhabited centers of the island of Santorini (on the land) and underwater sites. The project is led by the Faculty of Geology and Geoenvironment, part of the School of Sciences of the National and Kapodistrian University of Athens.

<sup>10</sup> The project has been realized by Invisible Cities, a start-up specialized in EXTENDED REALITY (XR), with the support of Linkem. The project is promoted by Roma Culture, Sovrintendenza Capitolina ai Beni Culturali and Invisible Cities, in collaboration with the Parco Archeologico del Colosseo and the organizational support of Zètema Progetto Cultura.





**Fig. 3:** Image illustrating the 'Virtual Reality Bus' project allowing a collective "visor free" VR experience. Image source: Author.

Additional information in the form of text, infographics, audio descriptions, images, video animations, digitized objects, and virtual 3D reconstructions is needed. All of this information can be implemented by integrating digital visualization techniques and multimedia solutions.

In line with these considerations, the following paragraphs illustrate two different projects for online and onsite cultural dissemination.

### 3. *The role of graphic language and transmedia narrative in VR: the virtual storytelling of Bagan temples*

The consolidated use of EXtended Reality (XR) solutions allows realizing more sophisticated and immersive narrative forms through the integration of techniques and tools able to capture, develop and manage a virtual environment.

Within the field of XR solutions, virtual reality technologies enhanced the production possibilities for the creation and non-linear manipulation in real-time, of almost any story form, leading to the concept of the so-called 'Virtual Storytelling' (Subsol, 2005).

In the wider context of a digital documentation project of the UNESCO site of Bagan, Myanmar (Mezzino, 2022), the opportunities of virtual reality for cultural dissemination and accessibility, have been tested.

Immersive environments can be generated through virtual reality applications for education, promotion, and dissemination purposes. From the records gathered on the ground in the data acquisition phase<sup>11</sup> (Agnello, Avella & Agnello, 2019), it has been possible to recreate virtual environments and share information through engaging modalities.

The development of the Virtual reality project for the Bagan temples began with a test on the Loka-hteik-pan temple.

The goal consisted of the development of a visual communication strategy, with the final aim of disseminating to different audiences (including non-specialists) the outcomes of the knowledge project developed on the Buddhist temples located in the site of Bagan.

The developed VR project combines two main senses<sup>12</sup>, hearing and sight. These can guide the exploration of the virtually reconstructed temple recreating an environment that stimulates motional and physical closeness to the place. This kind of experience stimulates, at the same time, the user's consciousness of the recreated environment, its features, and its values. Additionally, the generated virtual environment allows one to experience these places remotely, making anywhere and anyone feel local (Milk, 2016). The designed experience is independent of the physical place and the contents can be accessible anytime and anywhere. The generated VR experience was implemented after the military coup of February 2021, which brought Myanmar into a political, economic, and humanitarian crisis, strongly limiting any visit to the country, due to civil unrest and armed conflict.

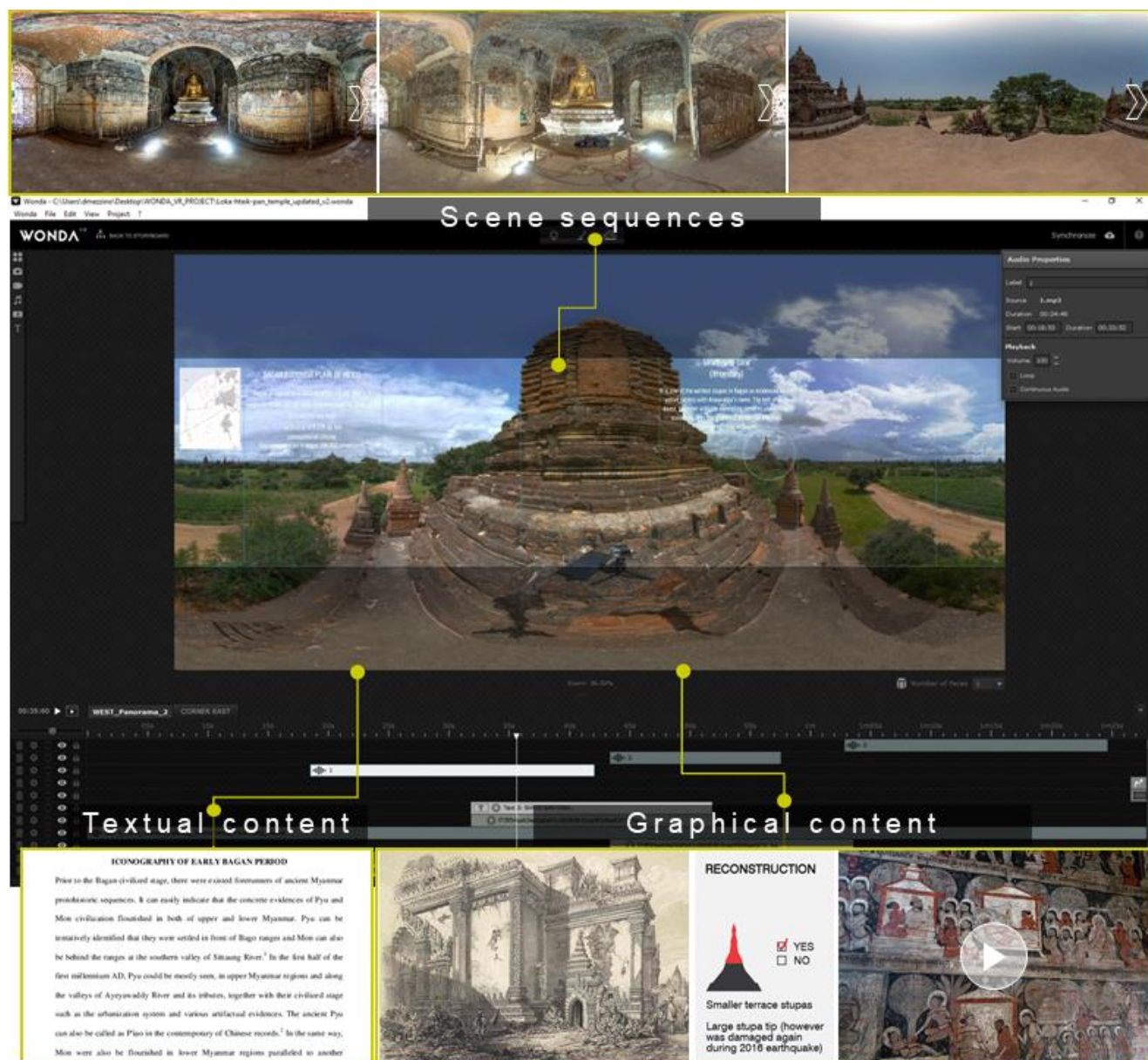
Consequently, cultural heritage sites, such as Bagan, became no more accessible.

The virtual simulated space reproduced in 3D indoor and outdoor space gives the impression of chiaroscuro, depth planes, lighting, and light

<sup>11</sup> The documentation activities included 3D laser scanning, photogrammetry, digital photography, diagnostics, structural and material analysis as well as historical and archival research.

<sup>12</sup> Tomasz Mazuryk and Michael Gervautz considered the different contribution of the five senses in relation to the

significance and quality of the stimuli transmitted to human brain. They reported that sight contributes to most of the information passed to our brain (70%), capturing most of human attention, it is followed by the hearing (20%) while the other senses - smell (5%), touch (4%) and taste (1%) - contribute only marginally to the stimulation of human brain.



**Fig. 4:** Image illustrating the work in progress of the Virtual Reality project carried out for the Loka-hteik-pan temple. Software employed: Wonda VR. Image source: Author.

distribution, thus providing volume to flat surfaces (Rossi, 2020).

The virtual reality experience allows a broad communication of the research achievements and of the information gathered on the ground providing a better understanding of the temple and the site in which it is located.

Furthermore, this kind of audio-visual platform would potentially enable informative decisions also for a broad (and non-expert) public/audience.

From an operative perspective, the VR project of the Loka-hteik-pan temple is an image-based VR. The choice to virtually reconstruct this

environment from 360° images is derived from two main reasons.

Firstly, the aim to recreate, with a high level of correspondence with the reality, a virtual and realistic copy of the Loka-hteik-pan temple.

Secondly, the economic sustainability of the project. Indeed, image-based VR is time-saving and cost-effective compared to model-based VR (Rossi, 2020).

More specifically, the adopted workflow, to generate the VR project, included four main phases:

1) Data acquisition; a set of eight High Dynamic Range (HDR) photos was taken using a fish eye





**Fig. 5:** Possible interactions within the generated virtual environment of the outdoor spaces of the Loka-hteik-pan temple. Image source: Author.

lens to capture panoramic photos. These photos are then used to generate full spherical panoramic photographs of the selected exterior and interior locations. The images were taken using a Nikon D300 DSLR camera (12.3 megapixel DX format CMOS sensor) equipped with a fisheye Nikkor lens of 10.5mm that covers a field of view of approximately 180° diagonals.

2) Data processing; the HDR images taken were processed in Adobe Photoshop 2019. The panoramas were prepared by stitching eight overlapping images for complete coverage of 360° of the captured scenes (six horizontal, a bottom, and a top view). The taken images were then

processed in the PTGui Pro v9.0 software to merge the eight photos into a panoramic one. In this process, the software Adobe Photoshop 2019 was used to adjust and edit the exposure and saturation of the images.

3) Virtual reality project generation; this phase included several steps:

- importing the panoramic photos in the software,
- creating links among the panoramic images,
- setting up transition points (from one panorama location to another one),

**Tab. 1:** Character defining elements of the developed VR project.

<b>Goal</b>	Facilitate the understanding of the Loka-hteik-pan temple. Improve cultural accessibility. Test immersive and interactive narratives forms . Highlight the role of digital representation in communicating cultural heritage tangible and intangible aspects and in disseminating the scientific research carried out on the temple and its surrounding context.
<b>Type of experience</b>	Exclusively digital.
<b>Type of technique</b>	Image-based VR.
<b>Type of application</b>	Immersive VR – Head Mounted Display (HMD). The 3D Virtual environment can be experienced through Head Mounted Display (HMD) on which stereoscopic virtual contents are displayed.
<b>Main characteristics</b>	Immersive 360° vision. User isolated, excluding the perception of the surrounding real environment. High sense of involvement and immersion in the virtual environment.
<b>Type of contents</b>	Texts. Infographics. Images. Audio contents. Video animation.
<b>Communicative style</b>	Descriptive and emotional.
<b>Interaction level</b>	Medium.
<b>Condition of fruition</b>	The VR experience can be accessed anywhere and anytime. User access digital contents actively.
<b>Outcomes</b>	A virtual project to remotely experience the Loka-hteik-pan temple and visualize the research outcomes, thus grasping a more in depth understanding of the temple and the site.
<b>Replicability</b>	High replicability of the adopted workflows.

- adding context information related to the panoramic photos,
- inserting audio tracks to support the user to understand and follow the storytelling of the site,
- attaching images to illustrate details and additional information.

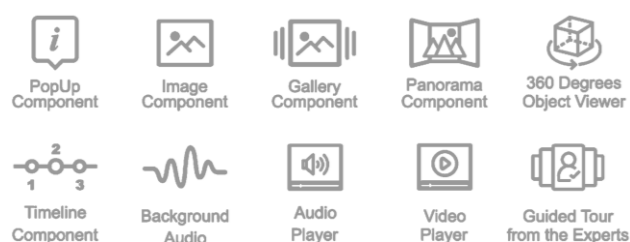
Through the inserted information, users can visualize and analyze contents opening up to new interpretations and visualization in real time. Compared to 2D graphic content or static 3D renderings, VR visualization allows dynamic and 3D immersive visualization forms. The integration of different multimedia elements to interact with

users allowed the dissemination of values embedded in the site, including the intangible ones.

Regarding the User Interface (UI), customized buttons have been designed (Angeloni, 2022). Buttons with explanatory and intuitive infographics provided visual instructions for the virtual exploration. For instance, the 'Brick and hammer' button activates textual and audio descriptions of the temple's reconstructions, while the 'Feet prints' button allows users to navigate into different scenes (Fig. 5). Other buttons complete the UI such as 'White points' to disclose information and data about architectural elements and materials, 'Play' to visualize video animations,



'Speaker' to listen to audio descriptions, 'Help' to get information on the virtual experience, 'Credits' providing textual information on the sources used.



**Fig. 6:** Available interactions and contents in the designed VR experience. Image source: author.

4) Project dissemination; this last phase consists in publishing the project, accessible from URL and QR code, on different social media and communication platforms. The same workflow was developed employing two software applications Panotour and Wonda. This allowed to test the versatility and to produce virtual reality projects to be visualized from mobile devices that can be inserted in head-mounted devices (HMD) or directly from HMD. Nevertheless, Wonda software application showed better functions in terms of content integration and management in the virtual environment.

Notwithstanding the potential of the developed project in terms of knowledge dissemination and cultural heritage interpretation, some aspects such as the level of collective involvement and the psycho-physical tolerability of such technologies (i.e. motion sickness) still present some of the limits of VR applications.

From a general point of view, in the project development, the role of drawing has been fundamental in the definition, organization, and elaboration of virtual images<sup>13</sup>. Indeed, according to Daniele Rossi "*Drawing for virtual reality means to elaborate explorable images*" (Rossi, 2020, p.25).

More specifically, the role of representation disciplines has been fundamental throughout the project elaboration and in particular in: 1) the definition and development of static and dynamic images; 2) the definition and elaboration of the infographic to access the multimedia contents, to move and interact in the virtual environment; 3) the elaboration of the video animation to be experienced in the virtual environment.

#### 4. Visual communication and multimedia in museums: the installation "In search of life. What do human remains tell?"

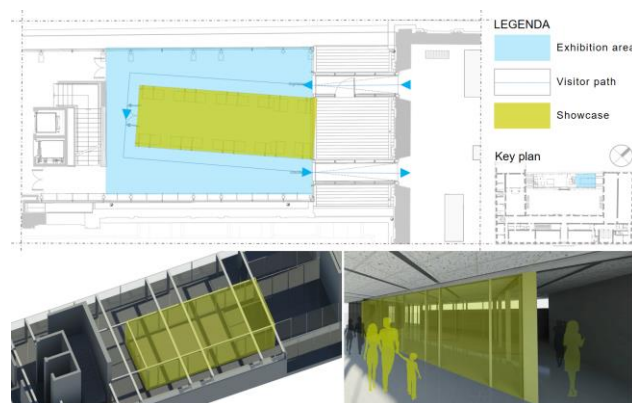
The presented case study illustrates the digital visual communication opportunities for museums' environments. The installation of digital content within museums presents several constraints and challenges.

Firstly, the design of the digital experience needs to be integrated with the indoor physical space.

Secondly, preservation constraints for both content – museum objects and collections – and container – museums' buildings (mainly for museum environments within historic fabrics) – have to be considered in planning and designing a hybrid museum experience involving multimedia content.

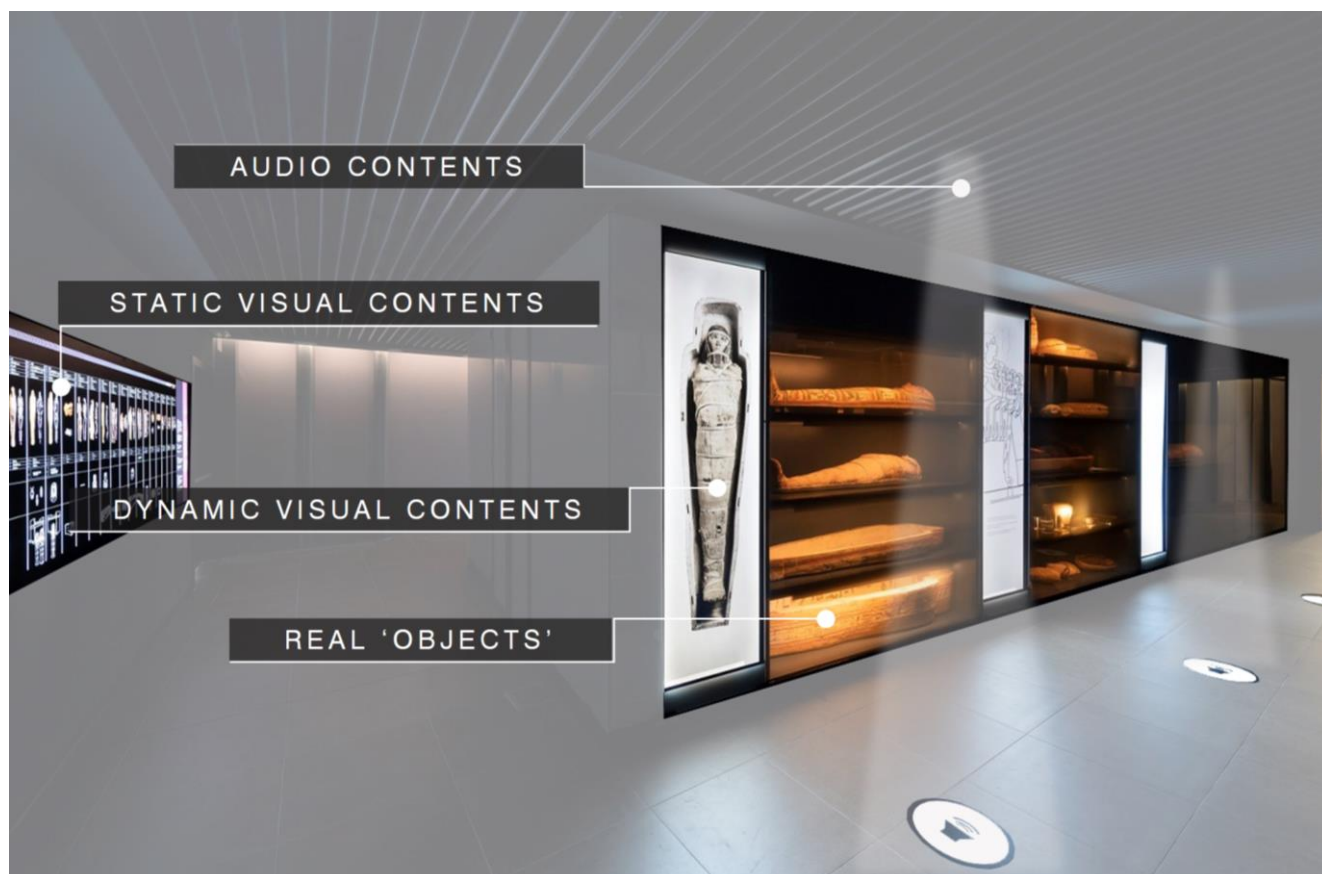
Despite these considerations that can appear prosaic, in most museums, multimedia contents are often designed as accessories, confined to a secluded space, or isolated in a 'frame' as a monitor, a projection surface, a tablet, or an immersive viewer (Pietroni, 2019).

Therefore, the challenge is to define an integrated approach – among museum environments, storytelling strategy, and digital visualization techniques – to improve contextualization, sensorial immersion, and visual display narratives able to provide a deeper understanding and awareness of museum objects and collections.



**Fig. 7:** Floor plans and 3D views of the project for the permanent exhibition space "In search of life. What do human remains tell?". Software employed: AutodeskAutoCad2020, AutodeskRevit2020 and Adobe Photoshop. Image source: Author.

<sup>13</sup> For instance, the science of drawing provided the guidelines to be followed regarding the frame, the shape of the frame (format), and the point of view of the virtual images.



**Fig. 8:** Multimedia contents of the permanent installation "In search of life. What do human remains tell?". Image source: Author.

Aware of these reflections, in 2021, the Museo Egizio di Torino opened a new permanent exhibition space named "In search of life. What do human remains tell?". This extension of the Museum's visit path was aimed at two main objectives: 1) relocate the human remains preserved in the Museum's deposits; 2) set up a new display aimed at stimulating reflections and disseminating knowledge on life and death in ancient Egypt, through the study of human remains.

Therefore, this new section of the Museum, explores and deepens the theme of life in ancient Egypt, the relationship of the Nilotic culture with mummification, and the concept of the afterlife, starting from the study of human remains and of the kits that, in some cases, accompany them.

These goals were addressed by adopting a storytelling strategy involving six individuals, specially chosen of different ages, showing the various stages of existence (from the not even blossomed one of a fetus, up to the advanced maturity of a fifty-year-old woman) (Archeologia voci dal passato, 2023).

For each of the six selected stages of life, a video animation has been planned and elaborated. The six animation topics focused on six associated themes: Pregnancy and birth, Raising a child, Being 13 years old, The singer of Amon, The guardian of the Pharaoh's children, and The third age.

The contents of the different video animations, with an average length of three minutes, include graphical (i.e. pictures, graphs, illustrations, photographs, video clips, or any other type of image such as 3D models), textual, and audio information.

Further, to expand the visitor experience even beyond the room, an online experience in addition to the onsite one has been also developed allowing to review the video's contents projected in the spaces of "In search of Life. What do human remains tell?" also remotely before or after the visit (the video animations are publicly available on the YouTube channel of the Museo Egizio). From the architectural point of view, the case has been designed to contain 91 mummies that are part of the Museum's collection (Fig. 7).



**Fig. 9:** Renderings developed for installation design showing the type of content used for visual storytelling. Image processing: Author.

The project required the construction of a central showcase consisting of a metal supporting structure, formed by profiles with a section of 10 x 5 cm, supporting glass panels (l. 160 x h. 230 cm) alternating with opaque panels (l. 70 x h. 2.30 cm), useful for inserting vertical monitors to display digital multimedia contents<sup>14</sup> (Fig. 8).

Visitors can pass around this showcase along three sides where human remains, archeological objects along with multimedia content are displayed.

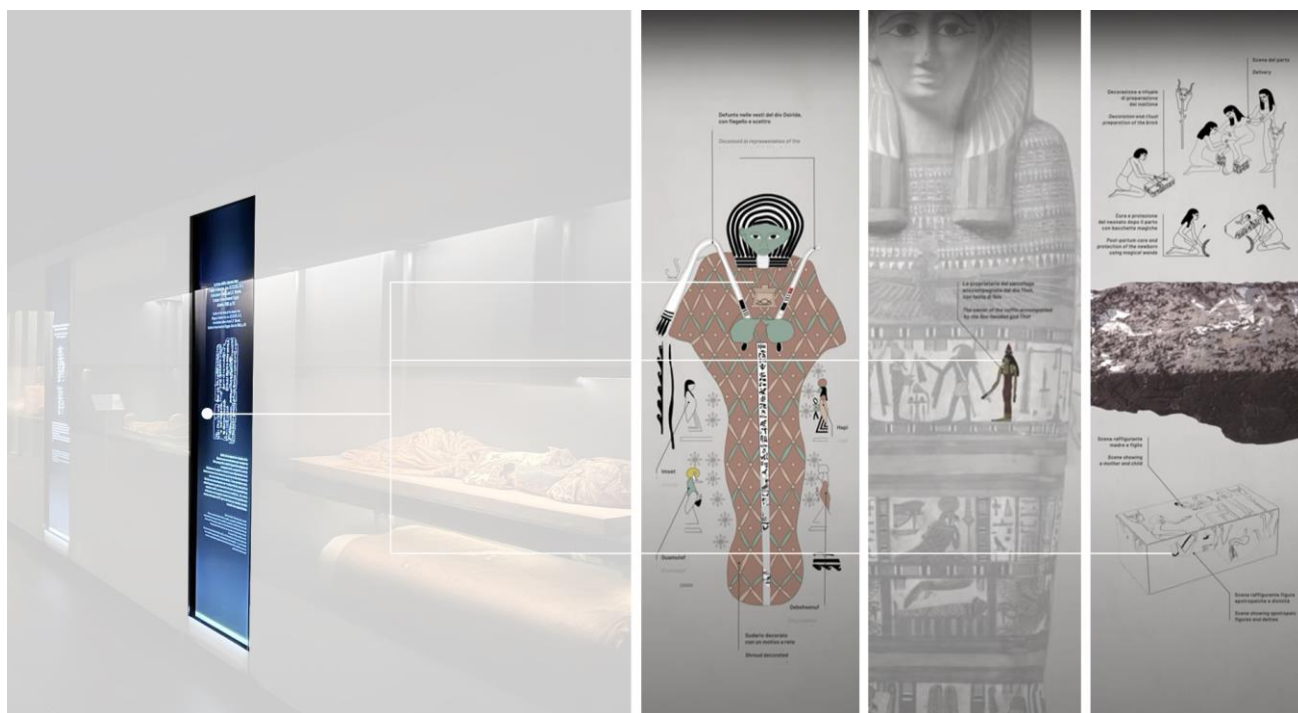
In terms of museum installation, this special display case performs the double function of showcase and deposit. It was designed to guarantee the highest conservation standards for extremely fragile human and organic remains, as

well as to support new and engaging modalities of cultural dissemination.

To allow the presentation to the public of a selection of the mummies present in the deposit and avoid, at the same time, the exposition of the artificial light of the other human remains (considering the extreme fragility of these objects) the showcase's glasses are electrically dimming type through the use of the liquid crystal system. This system enables to opacify only specific sectors of the display case to allow viewing only of the shelves containing the exhibits to be presented to visitors. The transformation from transparent to darkening can take place quickly (less than a second) and with predefined times to focus the attention of visitors on specific finds inside the showcase.

<sup>14</sup> Inside the showcase is equipped with cantilevered metal supports (60 cm long) which support metal shelves suitable for storing the human mummies placed on five levels. The

internal environment, with a rectangular plan, have a useful surface of approximately 40 square meters.



**Fig. 10:** The key role of drawing and infographics in interpreting archaeological objects depicted in animations. Image processing: Author.

More specifically, thanks to a special film in Liquid Crystal Display (LCD) applied to the glasses of the showcase, six of these mummies are revealed to the public, to represent the fundamental stages of life. The revelation of the object inside the showcase is temporized with a video projection on the showcase that anticipates the story and the features of the object that is going to be shown. To guide and distribute visitors along the museum's path, the visualization of the dynamic video animations has been temporized and synchronized with audio descriptions and with the darkening of the LCD film applied to the glasses of the showcase.

Hence, the object is first introduced by a video animation on the vertical monitor on the left, then the LCD film becomes transparent revealing the content behind it (human remains and artifacts). The described method is replicated on the eight glasses of the showcase (four on each side).

This approach increased the attractive power of the installation's contents, modelling their visibility and integrating high user experience with the curators' expectations.

The technological solutions and the communication forms have been designed for involving simultaneously multiple visitors.

Considering that the museum public is heterogeneous differing in technological alphabetization, provenance, age, cultural background, and interests, the storytelling of the installation gave particular attention to preventing cultural, psycho-sensory, and cognitive barriers.

Aware of the existing guidelines at the national (guidelines and recommendations of the Italian Ministry of Culture-MiC) and international (ICOM guidelines and recommendations) level in the "In search of life" installation digital visualization, along with audio descriptions, introduce the installation theme contextualizing and narrating the showed human remains and artifacts<sup>15</sup>. In the broader framework of the application of digital visualization techniques and tools in museums, the described example, characterized by a common transdisciplinary approach<sup>16</sup>, underlines the potential of digital representation in the different project phases.

<sup>15</sup> The essential visual representations and audio descriptions give an immediate evidence of the context and meaning of an object that becomes part of the representation.

<sup>16</sup> The project stemmed from an interdisciplinary approach integrating archaeology, museology and digital visualization

techniques, involving heterogeneous stakeholders and specialists.



**Tab. 2:** Character defining elements of the developed multimedia installation.

<b>Goal</b>	<ul style="list-style-type: none"> <li>- Support the understanding of human remains and archeological objects</li> <li>- Explain and disseminate the research carried out by the Museum</li> <li>- Test digital storytelling strategies able to reach different audience</li> <li>- Highlight the role of digital representation in communicating tangible and intangible aspects of museum's collections</li> </ul>
<b>Type of experience</b>	Hybrid, between real and digital
<b>Type of technique</b>	Digital and virtual reconstruction starting from real objects
<b>Type of application</b>	Multimedia in digital frames close to real objects
<b>Main characteristics</b>	<ul style="list-style-type: none"> <li>- Visual and audio contents, playing on screens, explaining the showed objects.</li> <li>- Integrated in the museum visit path</li> <li>- Simple and short digital contents compatible with the visitors' flow</li> <li>- Collective experience</li> <li>- Implementation of the cultural accessibility</li> </ul>
<b>Type of contents</b>	Video animations including: <ul style="list-style-type: none"> <li>- Texts</li> <li>- Infographics</li> <li>- Images</li> <li>- Audio contents</li> </ul>
<b>Communicative style</b>	Narrative and emotional
<b>Interaction level</b>	Medium-low
<b>Condition of fruition</b>	Multimedia can be accessed along the visit path, while accessing digital contents visitors are standing
<b>Outcomes</b>	An hybrid permanent installation, integrating visual technologies and real object, within the museum's visit path.
<b>Replicability</b>	High replicability of the adopted workflows and of the concept of the installation

The role of drawings and representation disciplines has oriented and supported several phases of the project: 1) the definition and elaboration of images and infographics; 2) the elaboration of 3D reconstructions of objects, geographical and architectural contexts; 3) the elaboration of the video animations to explain and implement the knowledge of the content of the showcase.

Multimedia and digital techniques introduce new interpretative levels making content and concepts presentation more dynamic.

The integration of digital forms within a museum showcase allowed to depict the recreated original context from which an object originates,

emphasize details of images and figures, show network and connections among a set of objects, visualize information related to the shown objects (in this case mostly human remains) including diagnostics outcomes, executive techniques, bibliographic archival sources as well as ancient inscriptions adopted as a reference to interpret and understand an object (Fig. 11).

The installation demonstrated the compelling opportunities of multimedia storytelling and mainly visual communication to implement cultural accessibility and inclusion by developing permanent scenarios for learning, inspiration, and creativity.



Fig. 11: Visual contents of the video animations. Image processing: author.

## 5. Conclusions

In the wider framework of the increasingly growing potential of graphical language, due to the consolidated use of digital tools, the article stimulates a reflection on the opportunities and versatility of digital visualization techniques in different contexts. The two presented experiences outline that digital visualization techniques enable the translation of cultural heritage into virtual heritage allowing the activation of new narratives with a quantitative and qualitative improvement in cultural transmission.

From the theoretical perspective, the contribution illustrates the rapid change of paradigms in visual communication highlighting how it is affecting also the cultural sector.

Section 2 evinces that visitors are increasingly getting used to striking audio-visual media and that cultural institutions are trying to keep up by testing new approaches to address the public's expectations and awareness.

Sections 3 and 4 illustrate different methodologies in the definition of visual narratives, exploiting the potential of multimedia and VR for cultural dissemination to evolve toward a more efficient interconnection among visitors, archaeological sites and collections, and digital applications.

From the practical point of view, the multimedia project for the permanent installation "In search of life. What do human remains tell?" and the designed VR experience for the Loka-

hteik-pan temple illustrate a creative combination of digital and digitalized content with different communication approaches and techniques coming from cinematographic grammar, performing arts, architecture, and games that can be integrated to shape powerful visual storytelling.

Both case studies suggest a possible operative approach. Besides narrative contextualizations, the described workflows show how additional levels of information - including historical, iconographic, and bibliographic sources - can be integrated into virtual communication to support the interpretation of objects' biography, buildings, and site transformations.

Further, the two experiences show the flexibility of visualization techniques demonstrating their application for exclusively virtual or hybrid (physical and virtual) access to information and to onsite and online cultural dissemination, sympathetic to conveying the material and immaterial value of the cultural heritage.

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