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Chapter

Novel Ways of Discovering, Capturing and Experiencing Cultural Heritage: A Review of Current State-of-the-Art, Challenges and Future Directions

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Abstract

The present chapter investigates the **emerging paradigm of cultural heritage experience**, as shaped by the continuous advances in information technologies. Recent years have seen the growing **digitisation** of cultural heritage, leveraged by innovative information technologies (imaging technologies, multimedia, virtual reality etc.). **Advanced digitisation, and digital preservation and accessibility** have been instrumental in transforming conservation and scientific research methods in the field of cultural heritage, as well as people's experience of cultural heritage assets, relics, and monuments. Digitisation and **immersion technologies** are already in use in the context of cultural tourism in museums and on location. At the same time, a manifold of new applications and services can be generated from the adoption and adaptation of relevant technologies already applied in other sectors (e.g. 2D/3D digital scanning technologies applied in the construction industry). The present chapter will provide a thorough review of relevant digital technologies and existing work in the field, highlighting important research efforts and achievements; and will discuss the current challenges and promising avenues for future work. Following a literature review methodology, our research will provide a critical appraisal of carefully selected work from recent scientific literature and contribute to the systematisation of the current knowledge in the field towards the identification of key challenges and the extraction of new insights in terms of potential for practical applications and future research directions in the area.

Keywords: cultural heritage, heritage experience, virtual heritage, digitisation, immersive technologies

1. Introduction

UNESCO [1] defined **cultural heritage** as “the entire corpus of material signs either artistic or symbolic, handed on by the past to each culture and therefore to the whole of mankind”. It thus represents “the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations” [1].

Ramos & Mafé-García [2] explain that cultural heritage includes “physical artifacts and intangible attributes of a place or society that are inherited from past generations”. Cultural Heritage is thus an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values. This includes **both tangible and intangible elements**, namely (a) tangible heritage assets, such as buildings, monuments, archaeological sites and locations of cultural significance, books, material objects including works of art (paintings, sculptures, drawings, prints, etc.), objects of the decorative arts (furniture, glassware, textiles, ceramics, etc.) and other artefacts, landscapes and natural heritage; and (b) intangible heritage assets, such as oral traditions, arts, rituals, folklore, language, and knowledge [2–4]. **Intangible cultural heritage** is described as a set of “practices, representations, expressions, as well as the knowledge and skills including instruments, objects, artefacts, cultural spaces” that are recognised as part of national heritage [5]. Cultural heritage is an evolving concept that experiences continuous reinterpretation and extension. Rather than representing concrete objects or artefacts, cultural heritage is increasingly regarded as a process, featuring a complex set of meaning, values, associations and related concepts [6].

The recently introduced term “**Digital cultural heritage**” describes cultural resources that were created in digital form (for example digital art or animation) or were digitised as a way to preserve them (including text, images, video and records) [7].

UNESCO [1] further notes that cultural heritage is not only a source for business and economy, but a fundamental condition for the maintenance and development of society and its economy. In terms of value, cultural heritage assets comprise both economic and cultural value. Cultural value is a complex concept that spans several dimensions: aesthetic, spiritual/religious, social, historical, symbolic and authenticity value [8]. Accordingly, “the **experience** of cultural heritage is varied according to the person’s realm of experience, the setting of the experience, and the intent of the experience from the point of view of the participator and the provider” [9]. A visitor’s overall engagement and satisfaction, and quality of experience are inter-linked with the attributes of the heritage site [10, 11].

The most readily accessible experience of cultural heritage is in the realm of **tourism** [9]. For the tourism industry, **culture and heritage** represent an important asset for generating economic value. New types of tourism offerings have emerged, drawing on culture and heritage, and focusing on aspects such as **a site’s built/historical heritage, popular culture, living culture, shared culture, cultural events, culinary culture etc.** The European Travel Commission (ETC) describes international cultural tourism as “a movement of persons to specific cultural attractions, such as, heritage sites, artistic and cultural manifestations, arts and drama to cities outside their normal country of residence”. With tourists seeking more diversified, engaging and intellectual experiences [12], the tourism sector is shifting towards more experience-based products [13]. Culture **emerges as a key motivation for travelling among tourists**. Heritage tourism is growing in popularity, transforming cultural heritage into one of the principal attractions of a tourism destination and increasing the importance of cultural heritage preservation and valorisation.

McKercher et al. [14] stress the complexity of cultural tourism, as reflected in the variety of perspectives adopted for its definition: tourism-derived, motivational, experiential and operational. ICOMOS [15] describes cultural tourism as a form of tourism whose object includes the discovery of monuments and sites. Richards [16] defines **heritage tourism** as ‘the movement of persons to cultural attractions away from their normal place of residence, with the intention to gather new information and experiences to satisfy their cultural needs’.

There are different types of “**cultural tourists**”, in terms of the segmentation of these in heritage destinations [14, 17]. Cultural tourism is shaped as a combination of four elements: tourism, use of cultural heritage assets, consumption of experiences and products and the tourist [18].

Cultural tourists in growing numbers pursue an in-depth appreciation and understanding of different aspects of the culture and heritage of the places they visit. Cultural heritage tourists are in search of authentic experiences associated with a variety of cultural traits that are linked to distinct geographic locations. Dallen [19] highlights this diversity, stating that cultural heritage tourism “encompasses **built patrimony, living lifestyles, ancient artifacts and modern art and culture**”. The importance of culture and the importance of the cultural experience may also vary among visitors [20], the scale and depth of the information that the tourists have regarding this place likewise.

Recent years have seen the growing digitisation of cultural heritage, leveraged by innovative information technologies (imaging technologies, multimedia, virtual reality etc.). Advanced digitisation, and digital preservation and accessibility have been instrumental in transforming conservation and scientific research methods in the field of cultural heritage, as well as people’s experience of cultural heritage assets, relics, and monuments. Digitisation and immersion technologies are already in use in the context of cultural tourism in museums and on location. At the same time, a manifold of new applications and services can be generated from the adoption and adaptation of relevant technologies already applied in other sectors (e.g. 2D/3D digital scanning technologies applied in the construction industry).

On the consumer side, technology is driving change in lifestyles. New forms of tourism are emerging in the place of conventional tourism. Alsos et al. [13] note a transition of the tourism sector towards more experience-based products. Experiences are inherently personal. When a person buys an experience, they pay for a memorable event staged by the experience provider to engage them in an inherently personal way, on an emotional, physical, intellectual, or even spiritual level [21]. Stamboulis, and Skayannis [22] further explain that in this experience-based exchange the tourist enters into a multifaceted interaction with the actors and the setting of a narrative staged by the local community.

The United Nations World Tourism Organisation [23] concluded that “Culture and tourism have a symbiotic relationship”. This symbiotic relationship is increasingly facilitated by information and communication technologies. Overall, the economic valorisation of cultural heritage through tourism implies incorporating cultural heritage into the tourism supply [24], which means viewing cultural heritage as a component in the production of heritage-related tourism products and services. Given the high market interest of cultural tourism, local destinations strive to leverage what makes their societies unique, promote the region’s cultural identity, in order to boost economic growth. According to Opačić [24], tourism valorisation of cultural heritage includes several steps, starting with the identification of cultural heritage suitable for conversion into tourism attractions.

Communicating cultural heritage to visitors in understandable and engaging ways is challenging, yet it represents an increasingly important aspect of tourism destination marketing. Presently, the relationship between tourism and culture is transformed by the affordances of new technologies. Advanced learning technologies can accommodate the provision of value-added cultural experiences to tourists, improve representation, engage visitors with content in innovative ways, support cultural revitalisation and increase the overall attractiveness of heritage sites. Cultural locations and spaces can be enriched by scanning and overlaying virtual annotations on top of these places. Digital applications can provide cultural tourists

with fast knowledge acquisition: immediate cultural location-based information of specific points of interest.

Advanced digital technologies for cultural heritage management, study and analysis, conservation, restoration, and preservation, access and communication, are transforming conservation and scientific research methods in cultural heritage, as well as people's experience of cultural heritage relics, monuments and events. At the same time, digital technologies are enhancing the experiential and interpretive dynamics of the cultural heritage representations and creating innovative environments for consumers to discover, capture and experience cultural heritage and events, thus promoting the creation of new value chains for tourism through the digitisation of cultural heritage. Integral to this is the combined use of innovative digitisation technologies and affordable consumer electronic equipment, which is making innovative cultural heritage experiences accessible to all.

Following a literature review methodology, in the subsequent sections, our research will provide a critical appraisal of carefully selected work from recent scientific literature and contribute to the systematisation of the current knowledge in the field towards the identification of key challenges and the extraction of new insights in terms of potential for practical applications and future research directions in the area.

2. Methodology

The methodology applied for this research was exploratory in nature, based on an extensive review of the available literature. In recent years, there has been an increasing number of studies linking cultural heritage with digital technologies. To offer a broad overview of this emerging research domain, a review of academic literature was undertaken to examine relevant publications in the Web of Science database. The purpose of this study was to review the existing literature to describe the state-of-the-art in key areas of interest and to identify key challenges, in order to extract new insights in terms of potential for practical applications and future research directions in the area.

Scope of literature review:

- Literature sources: all corpora included in the Web of Science database
- Timeframe: 2017–2021 (covering all eligible literature in last 5 years)
- Geographical coverage: all-inclusive
- Literature selection: the literature search (covering a time window of the last 5 years) used two groups of keywords. The first group included the terms “heritage experience”. The second group referred to ADR detection and included the terms: “Technology”, “Digital”, “Virtual” etc. Thus, the literature search query for article selection had the logical form of: {heritage experience} AND {digital technology, or equiv.}.

An electronic search of Web of Science (3 June 2021) was performed using the following search string: [(*heritage experience*)] AND [(*Technology*) OR (*Digital*) OR (*Virtual*) OR (*Immersive*) OR (*Augmented*) OR (*Scan*) OR (*3D*) OR (*WEB*) OR (*PORTAL*) OR (*Application*) OR (*Mobile*)].

The initial search resulted in a total of 824 articles. All search results were subsequently scanned, based on the title and abstract, to determine whether the

respective article should be included or not in the study. Following screening, 246 documents were excluded as they were not directly linked to the specific topic of the present study. This resulted in a final collection of a total of 578 articles. Additional records were identified through their list of references and other sources. Extracted information included [25] article title, author and publication year; [26] area of focus; [13] technology; [21] quality-related information; and [9] results and significant findings from the application.

We also reviewed research action under the EU Horizon 2020 programme (2014–2020) [27]. The Horizon 2020 programme featured initiatives aimed at the preservation and valorisation of cultural heritage, specifically targeting areas such as the curation of digital assets and advanced digitisation, cost-effective technologies for advanced 3D modelling, Virtual Museums etc. [7].

With regards to museums, the study revealed a strong correlation with digitisation, followed by a strong interest in immersive technologies (virtual/augmented reality) and the development of specific applications for museum visitors to experience the exhibits. Mobile access is also among the focus points, while 3D representation is gaining ground. Less discussion is made about web portals in the present time frame, as this was strongly pursued in earlier times.

The most significant insights drawn are outlined in the following sections. Section 3 provides an overview of the study results, Section 4 discusses the application of advanced digitisation technologies for powering cultural heritage experiences, while Section 5 summarises the current challenges and examines the way forward.

3. Results

With regards to the application of digital technologies in cultural heritage, the study revealed a broad scope: (a) to promote the preservation of cultural heritage and assist scientific research, and (b) to enhance the communication of digital heritage. The following Figure (Figure 1) provides an example of key applications of advanced digitisation technologies and applications in the context of cultural heritage. Three main areas have been identified: preservation, research on, and communication of cultural heritage. The first two relate to making sense of and

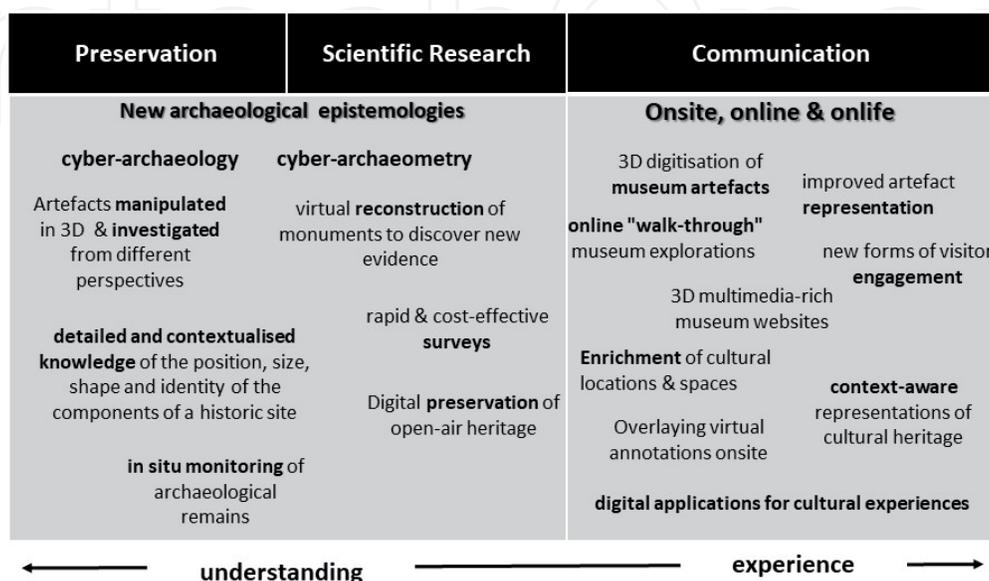


Figure 1.
 Key applications of advanced digitisation in cultural heritage.

interpreting cultural heritage. The latter is about how cultural heritage is divulged and experienced.

Accommodating cultural heritage experiences mainly falls under communication of cultural heritage and cultural tourism, but also draws from advances in cultural heritage preservation. The study revealed that digital technologies are reshaping the cultural heritage value chains, by affecting both the **back office**, where the cultural resources originate and the **front-end**, where the **consumption of cultural heritage experiences** takes place. Consumption itself can flow through different communication channels. Discussing museum experiences, Simone et al. [28, 29] identified four main areas, in which digital transformation is taking place: [25] in the **back-office**, referring to the preservation of cultural heritage; [26] **onsite**, relating to the quality of the museum experience; [13] **online**, referring to how the museum experience can be extended beyond museum doors; and [21] **onlife**, referring to the creation of wider, hybrid museum experiences.

In the following section we discuss critical developments in the back office and front end.

4. Discussion

4.1 Back-office capabilities

The research results identified several novel digital transformation approaches to improve the preservation of cultural heritage in the back-office. Focal point is the digital preservation of cultural heritage.

4.1.1 Digitisation and archiving

Digitisation and archiving constitute the foundations for the development of virtual heritage applications and services. Recent advancements in information and communication technologies have made it possible for heritage artefacts to be preserved and made available in digital form. Already in 2011, the European Commission's Recommendation on the Digitisation and Online Accessibility of Cultural Material (2011/711/EU) emphasised [30] the importance of bringing Europe's cultural heritage online, for improving access to and promoting the re-use of digitised cultural heritage material, e.g. by the creative sector. Recent years have seen a growing trend towards the **digitisation** of museum collections, library and archival cultural resources (such as manuscripts, books, and journals), sound and audiovisual heritage, immovable cultural heritage (such as monuments, historical buildings and archaeological sites), as well as **intangible** cultural assets, such as the living arts, and traditional folklore culture (traditional dances and folk customs) [31].

Cloud computing technologies facilitate the aggregation, storage and reuse of digital content. A wide array of national and international, thematic or domain-specific cultural heritage **aggregators** have emerged, allowing for joined up access to cultural resources. This includes digital platforms, applications and repositories that bring together cultural collections from cultural institutions through virtualisation. Europe's digital platform for cultural heritage, **Europeana** provides access to over 50 million items, (including image, text, sound, video and 3D material) from the collections of over 3000 libraries, archives, museums, galleries and audiovisual collections from all over Europe. Similarly, the **Google Cultural Institute** provides access to cultural artefacts from 1400 cultural institutions in 70 countries and to more than 3000 online exhibitions curated by experts. Its services include

1800 Street View captures of famous museums and landmarks that allow users to immerse themselves and get a 360° view of these places from anywhere, using their PCs, laptops or mobile devices.

Nonetheless, challenges to aggregation continue to persist, referring to issues that range from the lack of granular and rich descriptive metadata [32], to technical interoperability and copyright [33, 34].

Organised memory institutions (e.g. museums, libraries, archives) hold disparate collections of heritage resources, in terms of format, organisation and storage. Digitisation efforts are often fragmented and ineffective, with smaller organisations lacking the knowledge and resources needed, and further being unable to attract significant visibility to impact tourism and the local economy. To ensure the quality of digitised materials, digitisation standards and specifications, as well as guidelines concerning interoperability and metadata descriptions. Several domain-specific standards have been adopted, such as LIDO for museums, EAD for archives and METS for digital libraries. Led by Europeana, standardisation and common approaches for content and metadata management represent an on-going priority for Europe. The Europeana Data Model (EDM) is a cross-domain metadata standard that enables content interoperability, exchange and aggregation.

The need to improve the quality of cultural heritage metadata and collection management systems (CMSs) is stressed [35]. Metadata enrichment through crowdsourcing annotation services [32] and machine learning techniques [36–39] is recommended.

Digitisation goes beyond the transposition of analog objects into the digital space. A key concern is the **digital readiness** of cultural heritage institutions, concerning their capacity to adapt and adopt disruptive technologies in their practices. This implies a profound transformation of their internal processes and calls for a holistic approach at different levels in the institutions (organisational, operational, human resources, etc).

Cultural heritage is not limited to culture repositories and digital collections. Intangible cultural assets include the living arts, traditional folklore culture and crafts [40]. Furthermore, the largely untapped potential of cultural heritage embedded in individual memory needs to be harnessed through citizen's collection and interpretation of digital heritage [41–43]. Nowadays, we are witnessing a transition towards social engagement in culture that is driven by the rise of digital content production and digital connectivity. Crowdsourcing and digital storytelling can help capture the **living cultural heritage** of different communities or groups, in terms of practices, representations, expressions, knowledge, skills [43, 44]. The collection and archiving of a community's or region's cultural memory further involve raising public awareness about the importance of their cultural heritage and gearing up citizens' knowledge about and access to this heritage. **Social platforms** can provide the means for citizens to share their local knowledge and everyday experience with others, together with the contribution of cultural institutions [41, 42].

4.1.2 Advanced digitisation technologies

In recent years, numerous initiatives have been launched, involving the modelling and rendering of digital cultural heritage in 3D for research and preservation and/or communication purposes. Cultural heritage artefacts that traditionally were presented in two-dimensional form are increasingly captured, modelled and visualised in three dimensions and/or in 3D virtual environments [45]. The 3-D model can be realised from physical objects (according to a “reverse modelling” process) or directly assembling 3-D digital forms. It could provide a photorealistic image or

a symbolic representation of the original artefact, depending on the object and the scope of the representation. Advanced digitisation technologies have been instrumental in transforming conservation and scientific research methods in cultural heritage, as well as people's experience of cultural heritage relics, monuments and events [28, 29, 46–49].

New technologies and techniques, such as photogrammetry [50] and laser scanning [51], allow for more accurate digital capture of 3-dimensional objects and surfaces. Early efforts included modelling and rendering of artefacts and architecture from photographs (e.g. [52]). Current applications employ advanced non-contact close or long range scanning, modelling, analysis and computer-based visualisation tools to produce: three-dimensional (3D) recordings of archaeological sites and buildings (e.g. [53]) and of small objects (e.g. [54]) and three-dimensional visualisations of cultural heritage sites, using airborne scanning and imaging [55] or from geospatial information [56].

Digitisation technologies are already in use in the field of heritage (e.g. in museums or monuments). Limited research and solutions can be found regarding the interaction between cultural heritage, scan/photo and immersive technologies, potential customers and visitors' experiences in the cultural tourism locations, events and attractions. The use of advanced 2D/3D digital scanning of small and large-scale objects and surroundings and the valorisation of the digital spatial models produced has the potential to create unique, immersive cultural experiences, using affordable consumer electronics.

4.2 Front-end delivery

4.2.1 *Communication of cultural heritage and cultural tourism*

The introduction of technologies for cultural heritage communication has revolutionised the concept of “museum experience” and “historic site experience”, leading to the emergence of novel services powered by the **digitisation of cultural heritage artefacts**. In recent decades many GLAM organisations (i.e. Galleries, Libraries, Archives, and Museums) and historic sites have launched initiatives to improve representation, engage visitors with content in new, innovative ways and support cultural revitalisation. Technology is increasingly used to support novel forms of narration and improve the **historic interpretation** of cultural heritage, i.e. the ways visitors make meanings and connections to the past, in order to experience culture [57, 58]. Digital technologies have the power to transform history and cultural heritage into a living resource, also in the form of embodied Interactions [59]. Complex interconnected cyber-physical systems for experiencing cultural heritage can thus emerge [60].

4.2.2 *Hybrid onsite experiences*

Digital technologies have the potential to redefine the way visitors experience and connect with museums and cultural sites, as well as expand the on-site visit with prior and post experiences [61]. Most heritage sites are multidimensional and dense with meaning. Different cultural heritage contexts can coexist and serve as a backdrop for many overlapping services and experiences, suitable for diverse audiences. As the motivations, interests and degree of engagement of audiences vary, creating relevant cultural heritage experiences that engage and resonate with each visitor represents a challenge for the sector. The early “electronic” tour guide model was based on predefined itineraries, complemented by the synchronised delivery of textual and/or multimedia content that was curated by museum experts.

The evolution of Ubiquitous Computing technologies enabled the introduction of context-aware and location-aware features that offer the user increased degrees of freedom (e.g. through the combined use of mobile phones and RFID technologies). Traditional linear narratives (e.g. in the form of typical guided tours) are thus replaced by **visitor-directed narratives**, in which the visitor is in control of the content they consume [62]. The former involved mainly applications that mimic the purposes and experience of a **traditional guided tour** (e.g. mobile tour guides and museum websites), while the latter is facilitated by technologies that help create interactive and immersive experiences [63, 64]. The challenge is to not merely communicate scientific information, but to develop audience-centric experiences that achieve a **narrative and emotional engagement** of the audience [65, 66]. Better cultural accessibility and inclusion has the potential to enhance citizens' **well-being** [67].

Digital storytelling represents an effective way to deliver content in cultural heritage [68], achieve emotional resonance and create human connection. Immersive experiences can put the visitor in control of the content and make them feel as if they are a part of the exhibit or program [63, 64]. The combination of advanced immersive technologies with storytelling techniques, can help create **emotive digital experiences** that bring cultural heritage sites and events alive [69].

For example, the GIFT project developed a portfolio of free, open-source tools and methods that museums can use to enrich the physical experiences of their visitors, such as a Mobile Game to encourage collaborative storytelling within the museum [70]. The EMOTIVE project developed immersive storylines using a range of technologies including virtual and augmented reality and mobile phone apps, to create more 'emotive' cultural site visits [69].

Audio augmented environments, featuring concepts like sonic narratives, soundscapes and binaural spatialisation have also been explored in the cultural heritage context [71].

Digital technologies can help enrich a physical visit to a cultural site or a museum, with rich complementary content tailored to the needs of the visitor. Heritage sites can be enriched by scanning and overlaying virtual annotations on top of these places. Devices can be directed at the point of interest, and 2D/3D e.g. texts, sounds, icons, videos are added to the users' view. These applications provide visitors with immediate cultural location-based information regarding specific points of interest [72], they allow them to explore personal cultural locations and points of interest [73] and give them opportunities to discover new or unknown knowledge [74]. Every cultural site has a specific "wow-factor" that has to be captured and transported via digital technology and digital communication channels. From the provider view, new business models and opportunities can be identified and initiated using novel digitisation technologies [75], which can help increase the competitiveness of the cultural site [76] with significant spillover effects on the local economy. Recent research efforts go beyond visual, sound, or narrative enhancements, to provide visitors with multisensory stimulations [77].

For people with **disabilities**, digital innovations, such as sign language video avatars, tactile artwork reliefs, barrier-free apps for museum visits, etc., can help them overcome access barriers to cultural spaces [78].

4.2.3 Online experiences—virtual museums

The online presence of museums is changing, with traditional museum websites evolving into **online "walk-through" museums**, featuring dynamic exhibitions and versatile multimedia explorations of cultural heritage [79]. Advances in digitisation technologies provide the means for new forms of engagement with

museum-held heritage via 3D multimedia-rich museum websites, online “walk-through” museum explorations [80], virtual museum exhibitions [81], virtual environment system installed within a real museum [82], online community platforms [83, 84], etc. This has also led to novel context-aware representations of cultural heritage, produced from merging 3D models of artefacts, like in the case of the MUVI - Virtual Museum of Daily Life [85].

Ambient intelligence technologies (AmI) provide the means for personalizing content and user interfaces (UIs) to each individual user [86].

Virtual museums have also emerged. The term **virtual museum** describes “a collection of digitally recorded images, sound files, text documents, and other data of historical, scientific, or cultural interest that are accessed through electronic media” [87]. Unlike a traditional museum, a virtual museum does not house actual objects. Instead, it channels digitised representations of artefacts from one or several cultural institutions (e.g. Google Cultural Institute). A virtual museum can also be set up, in order to provide access to cultural sites that are otherwise invisible to the general public and to cultural artefacts that no longer exist or are impossible to view physically [88–94].

For example, the “Underwater Malta”, virtual museum for submerged cultural heritage, provides access to numerous inaccessible underwater archaeological sites [95]. This is facilitated by recent advances in underwater imaging and processing software and the development of 3D photogrammetry of submerged sites. The GRAVITATE project developed software tools to allow archaeologists and curators to reconstruct shattered or broken cultural objects and to identify and re-unify parts of a cultural object that has been separated across collections [96]. Similarly, the Time Machine project [25] combines digitised archives from museums and libraries, with Artificial Intelligence and Big Data mining, to offer richer interpretations of our past. The project developed a 4D (3D plus time) engine which ‘recreates’ past cities, as digital twins of our cities (‘Mirror Worlds’) that is accessible from mobile phones or through specific Augmented Reality interfaces. 3D models can “**time-travel**” users to historical places, cities or buildings in a specific historic period to deliver a feeling of how daily life was [97, 98]. While in the past, 3D visualisation content was merely used to digitally visualise historic artefacts (e.g. replace damaged or missing physical artefacts), presently realistic **virtual heritage environments** can be developed to contain 3D models of heritage object, thus visualising three-dimensional contexts as well, in order to offer a much richer user experience. For example, the INCEPTION project revolved around the development of heritage “spaces” (complex architectures and sites) and semantic enrichment for creating 3d Models to cater for multiple purposes, in line with the specific needs and level of knowledge of the end-users [99].

In the last two years the Covid-19 pandemic, which disrupted the daily routine of museums and brought the global tourism industry to a standstill prompted the adoption of innovative approaches building on digital instruments, such as **virtual tours** [100, 101] that build on geo-referenced sequences of panoramic images and three-dimensional models of the actual site [102]. According to Nemtinov et al. [103] “Virtual trips to memorable places allow experiencing history in an interactive form; they attract the audience and promote interest in museums and, accordingly, strengthen their cultural and educational functions”.

4.2.4 Onlife cultural experiences

Advances in digital technologies are helping connect a person’s cultural heritage experiences to their “daily” life, i.e. they provide the means to enhance other experiences outside the museum site, based on experiences at the museum site [61].

Overall, immersive experiences for cultural heritage can take shape in a variety of forms, including the use of augmented reality, virtual reality, serious games and gamification, embodied interaction etc. Central is the role of Virtual Reality and Augmented Reality which allow for new ways of experiencing cultural heritage. Augmented reality can overlay additional information onto existing artefacts, while virtual reality facilitates fully immersive virtual explorations [104]. Virtual Reality head-mounted displays (HMD) provide a first-person stereoscopic view of the environment and the ability to physically change the looking direction with head rotations. Mixed reality and semi-immersive VR applications combine the real and virtual environments [26]. Audio augmented environments, featuring concepts like sonic narratives, soundscapes and binaural spatialisation are also being explored in the cultural heritage context [71].

4.2.5 Mobile applications

Central to this shift is the rise of mobile communications and the rapid uptake of smartphone technology. Users today are increasingly connected to the world of digital information while “on the go” via mobile devices. GSMA [105] estimates that the number of unique mobile subscribers will reach 5.8 billion by 2025, equivalent to 70% of the world’s population. The European Travel Commission (ETC) stressing that ownership of mobile devices and mobile online access is high and increasing, reached the conclusion that in the future those travelling within and to Europe will be smartphone-equipped and will have both the technological capability and the online access to engage with online content that will make their travel and experiences richer and smoother. Smartphones, tablets and other mobile and handheld technologies are increasingly playing a central role in touristic experience mediation [106] and as a travel tool during all stages of tourism consumption [84]. Wang et al. [106] noted that “the instant information support of smartphones enables tourists to more effectively solve problems, share experiences, and “store” memories”. Dickinson et al. [84] concluded that smartphones are enhancing temporal and spatial awareness, i.e. are evolving society’s contemporary understandings of time and relationships with place and things in significant ways for travel by (a) enhancing the temporal alignment between people, the things they need, destinations and attractions, and activity options and (b) providing tourists with enhanced spatial tools and awareness (place-related information and content), ultimately leading to knowledge-rich visitors.

5. Conclusions and way forward

The present chapter discussed the emerging paradigm of cultural heritage experience, as shaped by the continuous advances in information technologies. Cultural heritage experiences can benefit greatly from the current trend towards digitalisation, systematisation and accessibility of digital cultural resources. Advancements in technology are creating new opportunities to digitise cultural heritage for preservation, conservation, restoration, research, as well as for broader online access and re-use by citizens and various sectors, such as tourism. The amount of digitised cultural material is growing very rapidly, also thanks to numerous initiatives for the digitisation of cultural heritage content belonging to museums, libraries, archives etc. The experience of cultural heritage is constantly evolving and is expected to continue to develop in complexity and sophistication, as new opportunities for the technological representation and communication of culture emerge and the types of transaction and encounter with tangible and intangible cultural heritage increase.

The experience of cultural heritage will continue to develop in complexity [9]. The shift towards more sophisticated technology-enhanced cultural heritage experiences is facilitated by the growing digitisation of cultural heritage, continuous innovations in 2D/3D digital scanning, in image enhancement and 3D reproduction, and in immersion technologies, the emergence of advanced equipment (such as head-mounted displays (HMD), the affordances of ubiquitous computing and mobile applications and novel easy-to-use authoring tools. Advanced digitisation, and digital preservation and accessibility have been instrumental in transforming people's experience of cultural heritage assets, relics, and monuments, as well as of intangible heritage. The ViMM project concluded that harnessing additional technologies will have increasing relevance for museums and cultural heritage institutions, including: artificial intelligence; computer vision; deep learning/machine learning; and adaptive cognitive methods [107].

Given the strong economic spill over effect of cultural heritage, interest in advancing the communication of cultural heritage goes beyond the traditional players of the sector: GLAM organisations (i.e. Galleries, Libraries, Archives, and Museums), cultural and historic sites etc.

Regions and local communities increasingly pursue the valorisation of their local heritage, leveraging what makes their societies unique, to promote their cultural identity and boost economic growth. Communicating cultural heritage to visitors in understandable and engaging ways is challenging, yet it represents an increasingly important aspect of tourism destination marketing. Presently, the relationship between tourism and culture is transformed by the affordances of new technologies. Advanced digital technologies can accommodate the provision of value-added learning experiences to visitors to increase the attractiveness of heritage sites.

Developing cultural heritage experiences is a **complex socio-technical, multi-disciplinary exercise** that spans several distinct areas: **Back-office** capabilities, in terms of accessible, quality digital cultural content, need to be in place, to subsequently be able to **design, develop and provide** cultural heritage experiences, and to **align** these with the requirements and expectations of the intended users.

Required technical capabilities thus range from back-office infrastructures for digitisation, standardisation, storage and retrieval, computing, connectivity, instrumentation and online accessibility of cultural materia, to authoring, service development and collaboration tools, to digital solutions for the technology-enabled experiencing of cultural events, arts and heritage and the creation of new applications on new devices, for different audiences and for different purposes.

Offerings should be expert-driven and **user-oriented** at the same time. Meeting the need for customised cultural heritage communication offerings implies continuously developing cultural heritage experience services and new processes of value creation. This implies a need for rapid development, and continuous adaptation and enrichment of the offerings. On the backend side, this translates into tailored content creation and easy content reuse, re-purposing and improvement, which in turn call for access to sources of relevant digital content (Cultural Heritage repositories) and domain expertise, besides technical skills and authoring environment capabilities. As value shifts to visitor experiences, cultural heritage experience development essentially should be regarded as a **co-creation** exercise, in which cultural heritage experience services are shaped and continuously adapted through the interactions between consumers and service providers [108].

Of particular importance is to increase awareness and acceptance of the "Digital Turn" within the cultural heritage community. Increasingly cultural institutions will have to incorporate technology solutions within their day-to-day responsibilities. Skills requirements and organisational aspects also need to be considered.

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References

- [1] UNESCO (1989). Draft Medium Term Plan 1990-1995. 25 C/4, 1989:57
- [2] Ramos, C. M., & Mafé-García, A. (2019). Analysis of the Contribution of ICT to Cultural and Religious Tourism: In Communicating Religious Heritage to Visitors and Tourists. In Handbook of Research on Socio-Economic Impacts of Religious Tourism and Pilgrimage (pp. 167-194). IGI Global.
- [3] Brooks, G. (2002). The ICOMOS International Cultural Tourism Charter: Linking cultural heritage conservation to the celebration of cultural diversity.
- [4] Cigola, M. (2016). Digital tools for Urban and Architectural heritage. In Geospatial Research: Concepts, Methodologies, Tools, and Applications (pp. 743-764). IGI Global.
- [5] UNESCO (2018). Basic texts of the 2003 convention for the safeguarding of the intangible cultural heritage.
- [6] Viejo-Rose, D. (2015). Cultural heritage and memory: untangling the ties that bind. *Culture & History Digital Journal*, 4(2), e018-e018.
- [7] Zygierewicz, A. (2019). Cultural heritage in EU discourse and in the Horizon 2020 programme. European Parliament Research Service.
- [8] Throsby, D. (2001). *Economics and Culture*, Cambridge: Cambridge University Press
- [9] Baxter, I. (2014). Experiencing Cultural Heritage. In *Encyclopedia of Global Archaeology* (pp. 2714-2716). Springer.
- [10] de Rojas, C., and C. Camarero. 2008. "Visitors' Experience, Mood and Satisfaction in a Heritage Context: Evidence from an Interpretation Center." *Tourism Management* 29 (3): 525-537. doi:10.1016/j.tourman.2007.06.004.
- [11] Kempiak, J., Hollywood, L., Bolan, P., & McMahon-Beattie, U. (2017). The heritage tourist: An understanding of the visitor experience at heritage attractions. *International Journal of Heritage Studies*, 23(4), 375-392.
- [12] Timothy, D. J. 2011. *Cultural Heritage and Tourism: An Introduction*. Bristol: Channel View Publications
- [13] Alsos, G. A., Eide, D., & Madsen, E. L. (Eds.). (2014). *Handbook of research on innovation in tourism industries*. Edward Elgar Publishing.
- [14] McKercher, B., Ho, P. S., Cros, H. D., & So-Ming, B. C. (2002). Activities-based segmentation of the cultural tourism market. *Journal of Travel & Tourism Marketing*, 12(1), 23-46.
- [15] The International Council on Monuments and Sites (ICOMOS) (1976). *ICOMOS Tourism Handbook for World Heritage site managers*
- [16] Richards, G. (Ed.). (2001). *Cultural attractions and European tourism*. Cabi.
- [17] Menor-Campos, A., Pérez-Gálvez, J. C., Hidalgo-Fernandez, A., & López-Guzmán, T. (2020). Foreign Tourists in World Heritage Sites: A Motivation-Based Segmentation. *Sustainability*, 12(8), 3263.
- [18] McKercher, B., & Du Cros, H. (2002). *Cultural tourism: The partnership between tourism and cultural heritage management*. Routledge.
- [19] Dallen, J. T. (2020). *Cultural heritage and tourism: An introduction*. Channel View Publications.
- [20] Chen, G. & Huang, S. (2018). *Understanding Chinese cultural*

tourists: Typology and profile. *J. Travel & Tour. Mark.* 35, 162-177

[21] B Joseph Pine, I. I., & Gilmore, J. H. (1998). Welcome to the experience economy. *Harvard business review*, 76(4), 97-106.

[22] Stamboulis, Y., & Skayannis, P. (2003). Innovation strategies and technology for experience-based tourism. *Tourism management*, 24(1), 35-43

[23] World Tourism Organization (2018). *Tourism and Culture Synergies*, UNWTO, Madrid

[24] Opačić, V. T. (2019). *Tourism Valorisation of Cultural Heritage*. In *Cultural Urban Heritage* (pp. 181-196). Springer, Cham.

[25] Abbott, A. (2017). The 'time machine' reconstructing ancient Venice's social networks. *Nature News*, 546(7658), 341.

[26] Adão, T., Pádua, L., Narciso, D., Sousa, J. J., Agrellos, L., Peres, E., & Magalhães, L. (2019). MixAR: A Multi-Tracking Mixed Reality System to Visualize Virtual Ancient Buildings Aligned Upon Ruins. *Journal of Information Technology Research (JITR)*, 12(4), 1-33.

[27] European Commission (2019). *Horizon 2020 Cultural Heritage. List of projects 2014-2018*. Directorate-General for Research and Innovation Open and inclusive Societies. Online <https://www.reach-culture.eu/wp-content/uploads/2019/03/Horizon-2020-cultural-heritage-synopsis-2018.pdf>

[28] Simone, C., Cerquetti, M., & La Sala, A. (2021a). Museums in the Infosphere: reshaping value creation. *Museum Management and Curatorship*, 1-20.

[29] Simone, C., Cerquetti, M., & La Sala, A. (2021b). Museums in the Infosphere:

reshaping value creation. *Museum Management and Curatorship*, 1-20.

[30] European Commission (2011) C(2011)7579 final. Recommendation on the digitisation and online accessibility of cultural material and digital preservation.

[31] European Commission (2018) *Cultural Heritage: Digitisation, online accessibility and digital preservation. Consolidated Progress Report on the implementation of Commission Recommendation (2011/711/EU) 2015-2017*. Directorate-General for Communications Networks, Content and Technology. Online: <https://www.digitalmeetsculture.net/wp-content/uploads/2019/06/ReportonCulturalHeritageDigitisationOnlineAccessibilityandDigitalPreservation.pdf>

[32] Kaldeli, E., Menis-Mastromichalakis, O., Bekiaris, S., Ralli, M., Tzouvaras, V., & Stamou, G. (2021). CrowdHeritage: Crowdsourcing for Improving the Quality of Cultural Heritage Metadata. *Information*, 12(2), 64.

[33] Busacca, A., & Monaca, M. (2019). Cultural Heritage UGC e tutela dei dati. *ArcHistoR*, 6(12), 76-83.

[34] Ramos Simon, L. F., & Blazquez Ochando, M. (2018). Solutions for online access to copyright works belonging to the collections of documentary and cultural heritages institutions. *REVISTA GENERAL DE INFORMACION Y DOCUMENTACION*, 28(2), 525-554.

[35] Renshaw, C., & Liew, C. L. (2021). Descriptive standards and collection management software for documentary heritage management: attitudes and experiences of information professionals. *Global Knowledge, Memory and Communication*.

[36] Belhi, A., Bouras, A., Al-Ali, A. K., & Foufou, S. (2020). A machine

learning framework for enhancing digital experiences in cultural heritage. *Journal of Enterprise Information Management*.

[37] Briola, D., Deufemia, V., Mascardi, V., & Paolino, L. (2017). Agent-oriented and ontology-driven digital libraries: the IndianaMAS experience. *Software: Practice and Experience*, 47(11), 1773-1799.

[38] Foley, J., Kwan, P., & Welch, M. (2017). A web-based infrastructure for the assisted annotation of heritage collections. *Journal on Computing and Cultural Heritage (JOCCH)*, 10(3), 1-25.

[39] Moreux, J. P. (2019). Recherche d'images dans les bibliothèques numériques patrimoniales et expérimentation de techniques d'apprentissage profond. *Documentation et bibliothèques*, 65(2), 5-27.

[40] Partarakis, N., Zabulis, X., Chatziantoniou, A., Patsiouras, N., & Adami, I. (2020). An approach to the creation and presentation of reference gesture datasets, for the preservation of traditional crafts. *Applied Sciences*, 10(20), 7325.

[41] Lim, V., Frangakis, N., Tanco, L. M., & Picinali, L. (2018a). PLUGGY: A pluggable social platform for cultural heritage awareness and participation. In *Advances in Digital Cultural Heritage* (pp. 117-129). Springer, Cham.

[42] Lim, V., Frangakis, N., Tanco, L. M., & Picinali, L. (2018b). PLUGGY: A pluggable social platform for cultural heritage awareness and participation. In *Advances in Digital Cultural Heritage* (pp. 117-129). Springer, Cham.

[43] Psomadaki, O. I., Dimoulas, C. A., Kalliris, G. M., & Paschalidis, G. (2019). Digital storytelling and audience engagement in cultural heritage management: A collaborative model based on the Digital City of

Thessaloniki. *Journal of Cultural Heritage*, 36, 12-22.

[44] Oomen, J., & Aroyo, L. (2011). Crowdsourcing in the cultural heritage domain: opportunities and challenges. In *Proceedings of the 5th International Conference on Communities and Technologies* (pp. 138-149).

[45] Georgopoulos, A., Kontogianni, G., Koutsaftis, C., & Skamantzari, M. (2017). Serious games at the service of cultural heritage and tourism. In *Tourism, Culture and Heritage in a Smart Economy* (pp. 3-17). Springer, Cham.

[46] Bianchini, C., Ippolito, A., & Bartolomei, C. (2015). The surveying and representation process applied to architecture: non-contact methods for the documentation of cultural heritage. In *Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modeling, and Representation* (pp. 44-93). IGI Global.

[47] Brusaporci, S. (Ed.). (2017). *Digital Innovations in Architectural Heritage Conservation: Emerging Research and Opportunities: Emerging Research and Opportunities*. IGI Global.

[48] Liritzis, I., Al-Otaibi, F. M., Volonakis, P., & Drivaliari, A. (2015). Digital technologies and trends in cultural heritage. *MEDITERRANEAN ARCHAEOLOGY & ARCHAOMETRY*, 15(3), 313-332.

[49] Makropoulos, C., Pappa, D., Hellmuth, R., Karapidis, A., Wilhelm, S., Pitsilis, V., & Wehner, F. (2018). DiscoVRCoolTour: Discovering, Capturing and Experiencing Cultural Heritage and Events Using Innovative 3D Digitisation Technologies and Affordable Consumer Electronics. In *International Conference on Transdisciplinary Multispectral Modeling and Cooperation for the Preservation of Cultural Heritage* (pp. 232-249). Springer, Cham.

- [50] Vecchione, A., Lureau, A., & Callieri, M. (2019). 3D archaeological data management via web: The experience with 3DHOP software. *Archeologia e calcolatori*, 30, 483-486.
- [51] Niquet, N. D., Sánchez López, M., & Mas-Barberà, X. (2018). La revalorización de la creación efímera a través de la conservación virtual. Aplicación del registro 3D y propuesta de repositorio interactivo de la Exposición del ninot. *Revista Sonda: investigación y docencia en artes y letras*, 7, 89-101.
- [52] Debevec, P. E., Taylor, C. J., & Malik, J. (1996). Modeling and rendering architecture from photographs: A hybrid geometry-and image-based approach. In *Proceedings of the 23rd annual conference on Computer graphics and interactive techniques* (pp. 11-20). ACM.
- [53] De Reu, J., Plets, G., Verhoeven, G., De Smedt, P., Bats, M., Cherretté, B., ... & Van Meirvenne, M. (2013). Towards a three-dimensional cost-effective registration of the archaeological heritage. *Journal of archaeological science*, 40(2), 1108-1121.
- [54] Boehler, W., Heinz, G., & Marbs, A. (2002). The potential of non-contact close range laser scanners for cultural heritage recording. *International archives of photogrammetry remote sensing and spatial information sciences*, 34(5/C7), 430-436.
- [55] Lasaponara, R., & Masini, N. (2009). Full-waveform Airborne Laser Scanning for the detection of medieval archaeological microtopographic relief. *Journal of Cultural Heritage*, 10, e78-e82.
- [56] Bryan, P., Dodson, A., & Abbott, M. (2014). Using Geospatial Imaging Techniques to Reveal and Share the Secrets of Stonehenge. *International Journal of Heritage in the Digital Era*, 3(1), 69-81.
- [57] Manolitsis, C. Pappa, D. Makropoulos, C. Pitsilis, V. (2020) The CLOUDLEDGE platform for Educational Tourism, *INTED2020 Proceedings*, pp. 3639-3647.
- [58] Tilden, F. (2009). *Interpreting our heritage*. Univ of North Carolina Press.
- [59] Koutsabasis, P., & Vosinakis, S. (2018). Kinesthetic interactions in museums: conveying cultural heritage by making use of ancient tools and (re-) constructing artworks. *Virtual Reality*, 22(2), 103-118.
- [60] Nisiotis, L., Alboul, L., & Beer, M. (2020). A Prototype that Fuses Virtual Reality, Robots, and Social Networks to Create a New Cyber-Physical-Social Eco-Society System for Cultural Heritage. *Sustainability*, 12(2), 645.
- [61] Wecker, A. J. (2014). Personalized cultural heritage experience outside the museum: Connecting the museum experience to the outside world. In *International conference on user modeling, adaptation, and personalization* (pp. 496-501). Springer, Cham.
- [62] Ibrahim, N., & Ali, N. M. (2018). A conceptual framework for designing virtual heritage environment for cultural learning. *Journal on Computing and Cultural Heritage (JOCCH)*, 11(2), 1-27.
- [63] Ress, S. A., & Cafaro, F. (2021a). "I Want to Experience the Past": Lessons from a Visitor Survey on How Immersive Technologies Can Support Historic Interpretation. *Information*, 12(1), 15.
- [64] Ress, S. A., & Cafaro, F. (2021b). "I Want to Experience the Past": Lessons from a Visitor Survey on How Immersive Technologies Can Support Historic Interpretation. *Information*, 12(1), 15.
- [65] Irimiás, A., & Volo, S. (2018). A netnography of war heritage sites' online narratives: user-generated content and

destination marketing organizations communication at comparison. *International Journal of Culture, Tourism and Hospitality Research*.

[66] Leow, F. T., & Ch'ng, E. (2021). Analysing narrative engagement with immersive environments: designing audience-centric experiences for cultural heritage learning. *Museum Management and Curatorship*, 1-20.

[67] Fanea-Ivanovici, M., & Pană, M. C. (2020). From Culture to Smart Culture. How digital transformations enhance citizens' well-being through better cultural accessibility and inclusion. *IEEE Access*, 8, 37988-38000.

[68] Paolini, P., & Di Blas, N. (2014). Storytelling for cultural heritage. In *Innovative technologies in urban mapping* (pp. 33-45). Springer, Cham.

[69] Katifori, A., Roussou, M., Perry, S., Drettakis, G., Vizcay, S., & Philip, J. (2018). The EMOTIVE Project-Emotive Virtual Cultural Experiences through Personalized Storytelling. In *Cira@euromed* (pp. 11-20).

[70] Ingimundardottir, E., Stanciauskaite, G., Sachse, K. K., Wray, T., & Løvlie, A. S. (2018). Word By Word: A Mobile Game To Encourage Collaborative Storytelling Within The Museum. *MW18: Museums and the Web 2018*

[71] Comunità, M., Gerino, A., Lim, V., & Picinali, L. (2021). Design and Evaluation of a Web-and Mobile-Based Binaural Audio Platform for Cultural Heritage. *Applied Sciences*, 11(4), 1540.

[72] Yovcheva, Z., Buhalis, D., Gatzidis, C., & van Elzakker, C. P. (2014). Empirical evaluation of smartphone augmented reality browsers in an urban tourism destination context. *International Journal of Mobile Human Computer Interaction (IJMHCI)*, 6(2), 10-31

[73] Leue, M. C., Jung, T., & tom Dieck, D. (2015). Google glass augmented

reality: Generic learning outcomes for art galleries. In *Information and Communication Technologies in Tourism 2015* (pp. 463-476). Springer, Cham.

[74] Charitonos, K., Blake, C., Scanlon, E., & Jones, A. (2012). Museum learning via social and mobile technologies:(How) can online interactions enhance the visitor experience?. *British Journal of Educational Technology*, 43(5), 802-819.

[75] Nägele, R. (2017). Verfahren zur technisch-induzierten Gestaltung von Geschäftsmodellen, Dissertation Uni Stuttgart 2017

[76] Neuhofer, B., Buhalis, D., & Ladkin, A. (2015). Smart technologies for personalized experiences: a case study in the hospitality domain. *Electronic Markets*, 25(3), 243-254.

[77] Marto, A., Melo, M., Gonçalves, A., & Bessa, M. (2021). Development and Evaluation of an Outdoor Multisensory AR System for Cultural Heritage. *IEEE Access*, 9, 16419-16434.

[78] Hayhoe, S., Carrizosa, H. G., Rix, J., Sheehy, K., & Seale, J. (2018). Accessible resources for cultural heritage ecosystems (arches): Initial observations from the fieldwork. In *Educational Research Association of Singapore (ERAS) Asia-Pacific Educational Research Association (APER) International Conference 2018: Joy of Learning in a Complex World*.

[79] Hidalgo Urbaneja, M. (2020). Defining online resources typologies in art museums: online exhibitions and publications. *International Journal for Digital Art History*.

[80] Proctor, N. (2011). From headphones to microphones: Mobile social media in the museum as distributed network. na.

[81] Lepouras, G., Katifori, A., Vassilakis, C., & Charitos, D. (2004). Real exhibitions in a virtual museum. *Virtual Reality*, 7(2), 120-128.

- [82] Charitos, D., Lepouras, G., Vassilakis, C., Katifori, V., Charissi, A., & Halatsi, L. (2001). Designing a virtual museum within a museum. In *Virtual reality, archeology, and cultural heritage: Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage* (Vol. 28, No. 30, pp. 284-284).
- [83] Chen, T. L., Lai, W. C., & Yu, T. K. (2020). Participating in online museum communities: An empirical study of Taiwan's undergraduate students. *Frontiers in Psychology*, 11.
- [84] Dickinson, J. E., Ghali, K., Cherrett, T., Speed, C., Davies, N., & Norgate, S. (2014). Tourism and the smartphone app: Capabilities, emerging practice and scope in the travel domain. *Current Issues in Tourism*, 17(1), 84-101.
- [85] Chiavarini, B., Liguori, M. C., Guidazzoli, A., Verri, L., Imboden, S., & De Luca, D. (2017). On-line interactive virtual environments in Blend4web. The integration of pre-existing 3d models in the MUVI-Virtual museum of daily life project. *Proc. Electronic Imaging and the Visual Arts-EVA*, 117-124.
- [86] Partarakis, N., Grammenos, D., Margetis, G., Zidianakis, E., Drossis, G., Leonidis, A., Metaxakis, G., Antona, M. and Stephanidis, C., 2017. Digital cultural heritage experience in Ambient Intelligence. In *Mixed reality and gamification for cultural heritage* (pp. 473-505). Springer, Cham.
- [87] Britannica, The Editors of Encyclopaedia (2021). "Virtual museum". Encyclopaedia Britannica, <https://www.britannica.com/topic/virtual-museum>.
- [88] Brumana, R., Oreni, D., Caspani, S., & Previtali, M. (2018). Virtual museums and built environment: narratives and immersive experience via multi-temporal geodata hub. *Virtual Archaeology Review*, 9(19), 34-49.
- [89] de Vasconcellos Motta, F. M., & Rodrigues da Silva, R. A. (2020). THE ADOPTION OF DIGITAL TECHNOLOGIES IN THE RECONSTRUCTION OF HERITAGE: experience report of the National Museum, Brazil. *INFORMACAO & SOCIEDADE-ESTUDOS*, 30(2).
- [90] Ferdani, D., Fanini, B., Piccioli, M. C., Carboni, F., & Vigliarolo, P. (2020). 3D reconstruction and validation of historical background for immersive VR applications and games: The case study of the Forum of Augustus in Rome. *Journal of Cultural Heritage*, 43, 129-143.
- [91] García, G., Saiz Mauleón, M. B., Contreras, G., Juanes, D., & Soriano, A. (2020). Immersive virtual reality to visualise the visible and infrared layer of a medieval altarpiece. *European Journal of Science and Theology*, 16(3), 165-178.
- [92] Kyrilitsias, C., Christofi, M., Michael-Grigoriou, D., Banakou, D., & Ioannou, A. (2020). A Virtual Tour of a Hardly Accessible Archaeological Site: the Effect of Immersive Virtual Reality in User Experience, Learning and Attitude Change. *Frontiers in Computer Science*, 2, 23.
- [93] Rizvić, S., Bošković, D., Okanović, V., Kihic, I. I., Prazina, I., & Mijatović, B. (2021). Time Travel to the Past of Bosnia and Herzegovina through Virtual and Augmented Reality. *Applied Sciences*, 11(8), 3711.
- [94] Sinitò, D., Fugazzotto, M., Stroschio, A., Coccato, A., Allegra, D., Barone, G., ... & Stanco, F. (2020). I-PETER (Interactive platform to experience tours and education on the rocks): A virtual system for the understanding and dissemination of mineralogical-petrographic science. *Pattern Recognition Letters*, 131, 85-90.
- [95] Gambin, T., Hyttinen, K., Sausmekat, M., & Wood, J. (2021). Making the Invisible Visible: Underwater Malta—A

Virtual Museum for Submerged Cultural Heritage. *Remote Sensing*, 13(8), 1558.

[96] Phillips, S. C., Walland, P. W., Modafferi, S., Dorst, L., Spagnuolo, M., Catalano, C. E., ... & Hermon, S. (2016). GRAVITATE: Geometric and Semantic Matching for Cultural Heritage Artefacts. *GCH*, 16.

[97] Bolognesi, C. M., & Santagati, C. (Eds.). (2019). *Impact of Industry 4.0 on Architecture and Cultural Heritage*. IGI Global.

[98] Kargas, A., & Varoutas, D. (2020). *Industry 4.0 in Cultural Industry: A Review on Digital Visualization for VR and AR Applications. Impact of Industry 4.0 on Architecture and Cultural Heritage*, 1-19.

[99] Maietti, F., Piaia, E., Mincolelli, G., Di Giulio, R., Imbesi, S., Marchi, M., ... & Brunoro, S. (2018). Accessing and understanding cultural heritage through users experience within the INCEPTION project. In *Euro-Mediterranean Conference* (pp. 356-365). Springer, Cham.

[100] Clini, P., & Quattrini, R. (2020). *Umanesimo Digitale e Bene Comune? Linee guida e riflessioni per una salvezza possibile/Digital humanities and Commons: guidelines and reflections for a possible salvation. IL CAPITALE CULTURALE. Studies on the Value of Cultural Heritage*, (11), 157-175.

[101] Greco, C., Rossi, C., & Della Torre, S. (2020). Digitalizzazione e patrimonio culturale tra crisi e opportunità: l'esperienza del Museo Egizio di Torino/ Digitalization and Cultural Heritage between Crisis and Opportunities: the Experience of the Egyptian Museum in Turin. *IL CAPITALE CULTURALE. Studies on the Value of Cultural Heritage*, (11), 197-212.

[102] Hu, Q., Yu, D., Wang, S., Fu, C., Ai, M., & Wang, W. (2017). Hybrid

three-dimensional representation based on panoramic images and three-dimensional models for a virtual museum: Data collection, model, and visualization. *Information Visualization*, 16(2), 126-138.

[103] Nemtinov, V., Gorelov, A., Nemtinova, Y. & Borisenko, A. (2020). Virtual Immersion into Timeframes of Residency of the Representatives of Chicherin Family - Famous Figures of the Russian Diplomatic Service in the Tambov Region. *Bylye Gody*. 58. 2305-2314. 10.13187/bg.2020.4.2305.

[104] González-Rodríguez, M. R., Díaz-Fernández, M. C., & Pino-Mejías, M. Á. (2020). The impact of virtual reality technology on tourists' experience: a textual data analysis. *Soft Computing*, 1-14.

[105] GSM Association (GSMA) (2020) *The Mobile Economy 2020*. Online: https://www.gsma.com/mobileeconomy/wp-content/uploads/2020/03/GSMA_MobileEconomy2020_Global.pdf

[106] Wang, D., Park, S. and Fesenmaier, D.R. (2012), "The role of smartphones in mediating the touristic experience", *Journal of Travel Research*, Vol. 51 No. 4, pp. 371-387

[107] Ioannides, M., & Davies, R. (2018). ViMM-Virtual Multimodal Museum: a manifesto and roadmap for Europe's digital cultural heritage. In *2018 International Conference on Intelligent Systems (IS)* (pp. 343-350). IEEE.

[108] Pappa, D. Makropoulos, C. Pitsilis, V. (2020) *Learning Content Design for Cultural Heritage tourism. EDULEARN2021 Proceedings*