CHAPTER 13

UDC: 004:930.85
doi: https://doi.org/10.18485/akademac_nsk.2023.4.ch13

APPLICATION OF NEW TECHNOLOGIES IN THE PROMOTION AND PRESERVATION OF CULTURAL HERITAGE

Nemanja Deretić[1]*
ORCID ID: 0000-0001-6564-7137

Saša Kukolj[2]
ORCID ID: 0009-0001-2145-6133

Summary: This paper explores the potential of applying new technologies, including the Internet of Things (IoT), in the protection and promotion of cultural heritage. The introductory chapter sets the context and emphasises the importance of preserving cultural heritage in a modern, dynamic environment. The second chapter provides an overview of contemporary technologies used in heritage protection, with a special focus on IoT, digital documentation, 3D scanning, virtual and augmented reality and Big Data analytics. The third chapter considers the challenges and opportunities these technologies present, including technical, financial, ethical, and legal aspects. The concluding chapter summarises the key findings of the work, highlights the implications of the research for the future protection of cultural heritage, and suggests directions for further research. This paper aims to demonstrate that the application of new technologies can enable continuous and precise monitoring of the conditions in which artworks and historical artefacts are kept, optimise resources within cultural institutions, and enhance the global visibility and accessibility of cultural heritage.

Key words*:* cultural heritage, internet of things, digital documentation, management of cultural resources.
JEL classification: *Z10, L86*

1 Nemanja Deretić, Professor of Applied Studies, Belgrade Business and Arts Academy of Applied Studies, e-mail: nemanja.deretic@bpa.edu.rs

2 Saša Kukolj, Assistant, Faculty of Management, University "Union Nikola Tesla", e-mail: sasa.kukolj@famns.edu.rs

1. Introduction

Cultural Heritage is a globally invaluable asset, drawing millions of visitors annually to landmarks, museums, events, and exhibitions. Key elements of this resource that require amplification include its promotion, protection, preservation, and public enjoyment. To establish an intelligent Cultural Heritage that is both appealing and sustainable, it is essential to conceive and implement ubiquitous and pervasive solutions within cultural settings, such as museums, archaeological sites, historic centres, art exhibitions, and the like (Piccialli & Chianese, 2018).

According to UNESCO's description, Cultural Heritage includes items, landmarks, collections of structures, and places, as well as museums, which possess a range of important values such as symbolic, historical, artistic, visual, cultural, scientific, and societal relevance (Chen et al., 2022).

There's a growing recognition among leading heritage institutions about the intricate threats facing heritage at various levels. Globally, UNESCO's World Heritage Committee has highlighted the necessity to systematically identify these multifaceted dangers to heritage by establishing a comprehensive list of primary and secondary risk factors, both natural and human-induced (as seen in Table 1).

Table 1. UNESCO's list of elements impacting the sites

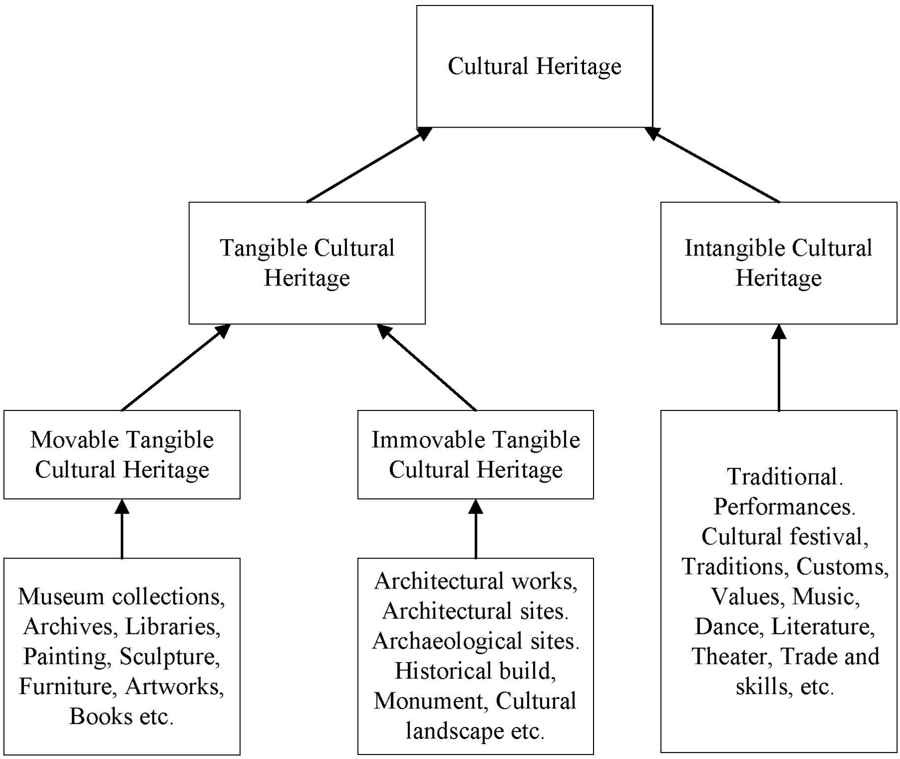
Primary Risk Factors	Secondary Risk Factors
Buildings and Development	Housing, Commercial development, Industrial areas, Major visitor accommodation and associated infrastructure, Interpretative and visitation facilities
Transportation Infrastructure	Ground transport infrastructure, Air transport infrastructure, Marine transport infrastructure, Effects arising from use of transportation infrastructure, Underground transport infrastructure
Utilities or Service Infrastructure	Water infrastructure, Renewable energy facilities, Non-renewable energy facilities, Localized utilities, Major linear utilities
Pollution	Pollution of marine waters, Ground water pollution, Surface water pollution, Air pollution, Solid waste, Input of excess energy
Biological resource use/modification	Fishing/collecting aquatic resources, Aquaculture, Land conversion, Livestock farming/grazing of domesticated animals Crop production Commercial wild plant collection Subsistence wild plant collection Commercial hunting. Subsistence hunting Forestry /wood production

Physical resource extraction	Physical resource extraction, Mining, Quarrying, Oil and gas, Water extraction
Local conditions affecting physical fabric	Wind, Relative humidity. Temperature, Radiation/light Dust, Water (Rain/Water table). Pests, Micro-organisms
Social/cultural uses of heritage	Ritual/spiritual/religious and associative uses Society's valuing of heritage Indigenous hunting, gathering and collecting Changes in traditional ways of life and knowledge system Identity, social cohesion, changes in local population and community Impacts of tourism/visitor/recreation
Other human activities	Illegal activities, Deliberate destruction of heritage Military training, War, Terrorism, Civil unrest
Climate change and severe weather events	Storms, Flooding, Drought Desertification, Changes to oceanic waters Temperature change, Other climate change impacts
Sudden ecological or geological events	Volcanic eruption, Earthquake Tsunami/tidal wave. Avalanche / landslide Erosion and siltation/deposition. Fire (wildfires)
Invasive/alien species or hyper-abundant species	Translocated species. Invasive/alien terrestrial species Invasive / alien freshwater species Invasive/alien marine species. Hyper-abundant species Modified genetic material
Management and institutional factors	Management System/Management Plan Legal framework Low impact research/monitoring activities Governance High impact research/monitoring activities Management activities Financial resources Human resources
Other factor(s)	

Source: Lerario, A., & Varasano, A. (2020). An IoT Smart Infrastructure for S. Domenico Church in Matera's "Sassi": A Multiscale Perspective to Built Heritage Conservation. Sustainability, 12(16), 6553.

The Internet of Things (IoT) systems that are being designed and developed are aimed to be widespread and seamlessly integrated into various environments. The ultimate purpose of these systems is to reshape Cultural Heritage in a way that prioritizes sustainability, enrichment, and adding value for the benefit of future generations. In addition, the Internet of Cultural Things (IoCT) framework is designed to enhance the efficiency of coordinating various processes. This framework also aims to make it easier to initiate new activities that have the potential to generate economic benefits. The overarching objective of this initiative is to put forward a comprehensive strategy. This strategy involves the integration of a diverse range of technologies, such as Social Network Analysis, Business Intelligence, Internet of Things, Big Data, GeoSpatial Information Processing, as well as structured and unstructured content analysis using Semantic techniques, and the incorporation of multimedia resources (Chianese et al., 2017). A depiction of the diverse aspects of cultural heritage can be seen in Figure 1.

Figure 1. Types of cultural heritage



Source: Reshma, M. R., Kannan, B., Raj, V. J., & Shailesh, S. (2023). Cultural heritage preservation through dance digitization: A review. Digital Applications in Archaeology and Cultural Heritage, e00257.

The problem explored in this paper is how new technologies can be applied in a sustainable and ethical manner to enhance the protection, management, and promotion of cultural heritage, while simultaneously making efficient use of resources and adhering to relevant laws and regulations.

The aim of this paper is to demonstrate that the application of new technologies, including IoT, in the protection and promotion of cultural heritage primarily serves to enable continuous and precise monitoring of the conditions in which artworks and historical artefacts are housed. This allows for the timely identification of potential hazards and the implementation of preventive measures to ensure their protection.

Additionally, these technologies facilitate more efficient resource management and the optimisation of operations within cultural institutions, which can lead to cost reductions and a more sustainable operational model. Moreover, the adoption of new technologies can enhance the promotion of cultural heritage, offering visitors a richer and more interactive experience through digital platforms and virtual tours, thereby increasing the accessibility and global visibility of cultural heritage.

The rest of this article is organized as follows. Section 2 offers a detailed insight into current technologies, including the Internet of Things (IoT), digital documentation and 3D scanning, virtual and augmented reality, Big Data and data analytics, and illustrates examples of successful applications of these technologies in the protection of cultural heritage. Section 3 focuses on the technical, infrastructural, financial, organisational, ethical, and legal aspects of the implementation of new technologies in the protection of cultural heritage, exploring how these challenges can be overcome and what opportunities are opened up. Section 4 summarises the key findings of the work, highlights the implications of the research for the future protection of cultural heritage, and suggests recommendations for further research in this area.

2. Review of Modern Technologies for Cultural Heritage Protection

2.1. Internet of Things (IoT) in the context of cultural heritage

IoT technologies have the potential to play a significant role in the preventive conservation of Cultural Heritage by enabling the systematic and efficient management of data collected from electronic sensors. The IoT represents a system of interconnected computing devices, mechanical and digital machines, objects, or people, each equipped with unique identifiers, capable of exchanging information over a network without the need for human-to-human or human-to-machine interaction (Deretić, Samardžić, & Milošević, 2023).

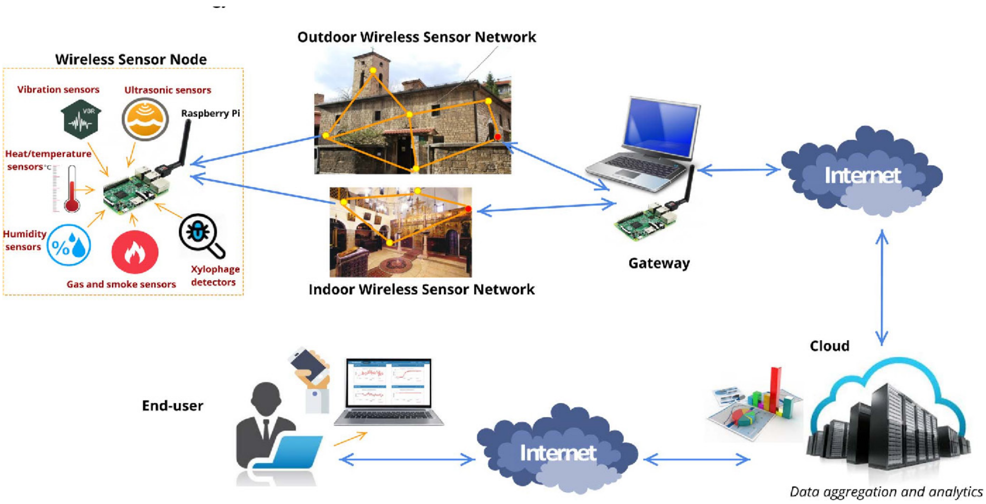
Advantages of using IoT technologies are (Perles et al., 2018):

- Continuous Monitoring: IoT technologies allow for the constant monitoring of environmental conditions, such as temperature, humidity, light levels, and pollutants, which can affect the preservation state of artworks and artifacts. Sensors placed near or on the artworks continuously collect data on these factors.
- Remote Supervision: These sensors are connected to the internet, which means that the data they collect can be accessed remotely. This enables conservators and museum staff to monitor the condition of artworks from anywhere in the world, without needing to be physically present.
- Preventive Action: By continuously monitoring the conditions of the artworks, potential issues can be identified before they become significant problems. For example, if the humidity level in a gallery starts to rise, this could potentially damage the artworks. With IoT technology, this change would be detected in real-time, allowing staff to take action to adjust the humidity back to safe levels before any damage occurs.
- Data Analysis and Insights: The data collected by these sensors can be analyzed to gain insights into the long-term trends affecting artworks. This analysis can inform the development of more effective conservation strategies. For instance, if data shows that light levels in a particular part of a gallery are consistently too high, this area can be redesigned to better protect the artworks.
- Enhanced Security: In addition to environmental monitoring, IoT technologies can also improve the security of artworks. Sensors can detect unauthorized movement or tampering with an artwork, triggering alerts for security staff.
- Promotion of Cultural Heritage: By ensuring that artworks are maintained in the best possible condition, IoT technologies help to preserve the value and enjoyment of cultural heritage for future generations. Well-preserved artworks can continue to be displayed and enjoyed by visitors for many years to come.
- Efficient Resource Use: IoT technologies can help cultural institutions to use their resources more efficiently. For example, by monitoring the conditions in real-time, institutions can optimize the use of heating, cooling, and lighting systems, thereby saving energy and reducing costs.

Cultural artefacts are invaluable treasures that embody the knowledge and artistry of ancient societies. When museums collaborate to showcase these items, they must undertake a series of intricate procedures, including ensuring their safe packaging and transportation. IoT plays a pivotal role in the realm of cultural heritage, offering innovative interactive experiences, analysing visitor data, facilitating interconnected museum tours, and overseeing the preservation of cultural assets. The combined use of blockchain and IoT primarily focuses on the oversight of fixed cultural heritage (Zhang et al., 2021).

IoT technologies can aid in the proactive preservation of Cultural Heritage by managing data from electronic sensors. The paper (Perles et al., 2018) introduced an IoT framework designed for that objective. In the context of cultural heritage, IoT (Internet of Things) can be used to deploy sensors and devices in historical sites, museums, and other places of cultural significance. These sensors can monitor environmental conditions, structural health, visitor traffic, and more, providing real-time data that can be used to ensure the preservation and protection of these valuable sites (Figure 2).

Figure 2. The integration of 3D scanning and 3D printing techniques results in the completed manufactured product



Source: Maksimović, M., & Ćosović, M. (2019, March). Preservation of cultural heritage sites using IoT. In 2019 18th International Symposium INFOTEH-JAHORINA (INFOTEH) (pp. 1-4). IEEE.

Religious and historical structures should be maintained for future generations. These age-old buildings, along with the invaluable collections they house, are an unmatched treasure for upcoming generations. They also offer a setting for traditions and customs to continue.

The paper (Maksimović & Ćosović, 2019) suggested a cost-effective method for monitoring the conservation conditions of a Church from the Eastern Orthodox cultural legacy. The IoT has profoundly impacted the realm of cultural heritage in various ways. One of its primary contributions is the enhanced conservation of artefacts, where sensors continuously monitor environmental conditions like temperature and humidity to maintain optimal conditions. This real-time data is crucial for the preservation of delicate items. Additionally, IoT has paved the way for interactive exhibitions. With the integration of RFID tags and sensors, visitors receive additional information on their smartphones or interactive displays as they approach an artefact, making museum visits more immersive and informative. Security in museums and heritage sites has also seen significant improvements with IoT. Connected cameras and motion sensors offer real-time surveillance, ensuring the safety of invaluable artefacts against potential threats. Beyond security, these connected devices provide institutions with data-driven insights by tracking visitor movements and interactions. Such insights can be invaluable for understanding popular exhibits, peak visiting times, and overall visitor behaviour, which can subsequently guide better exhibit design and enhance the overall visitor experience.

IoT's influence also extends to remote engagement. Cultural heritage sites and museums can now offer virtual tours and augmented reality experiences, ensuring that even those who can't visit in person can still engage with the exhibits. This broadens access and ensures that cultural heritage reaches a global audience. For historical buildings or archaeological sites, IoT sensors play a pivotal role in maintenance by detecting structural issues or damages early on, allowing for timely interventions and repairs. Furthermore, the personalisation of museum experiences has become a reality with IoT. Based on a visitor's interactions and interests, systems can suggest specific artefacts or exhibits, tailoring the visit to individual preferences. Lastly, the educational sector benefits immensely from IoT in cultural heritage. Students can interact with connected replicas and tools, offering them interactive and in-depth learning experiences about ancient civilizations and historical periods. In essence, the marriage of IoT with cultural heritage has not only preserved history but has also revolutionised the way we interact with and appreciate our shared past.

2.2. Digital documentation and Cultural Heritage

Digitalisation techniques are extensively used in the realm of cultural heritage to safeguard assets and to bolster, enrich, and complement conventional preservation approaches for cultural heritage items (Georgopoulos, 2018). The use of digitalisation technology in the domain of cultural heritage is widely recognised. Examining research publications on the implementation of digitalisation technology in cultural heritage through bibliometric analysis can provide in-depth insights (Salleh & Bushroa, 2022). The rise of digital cultural heritage presents significant opportunities for developing innovative digital applications that engage the community in exploring cultural heritage from fresh perspectives. For example, an interactive virtual museum can offer both educational and enjoyable experiences, encouraging users to immerse themselves in cultural heritage activities (Abu Bakar et al., 2020).

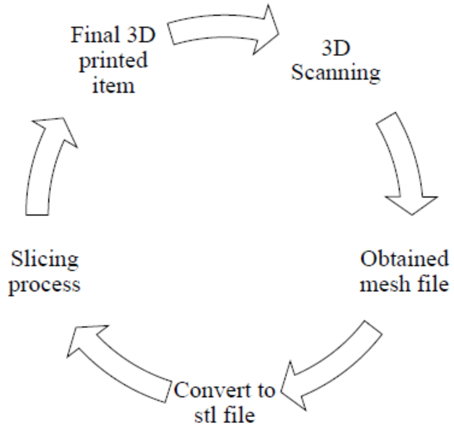
Digital documentation has profoundly transformed our engagement with cultural heritage. It provides an innovative method to record, archive, and share details about cultural entities in previously inconceivable ways. Digital methods facilitate the conservation of cultural heritage in its existing form. This is paramount for artifacts or sites that are vulnerable or deteriorating. Employing methods like 3D scanning, we can produce precise digital counterparts of historical locales, relics, and texts, ensuring their longevity for subsequent generations, even if the original deteriorates or vanishes (Wachowiak & Karas, 2009).

3D scanning involves capturing digital information about the form and look of a physical entity or setting. Its applications span diverse fields, including manufacturing, design, entertainment, healthcare, and the preservation of cultural heritage (Levoy et al., 2000; Remondino, 2011; Javaid et al., 2021). A plethora of equipment types exist for both 3D printing and 3D scanning processes. The assortment of 3D printing and scanning tools in the market has broadened the scope of their potential applications and advantages (Ramya & Vanapalli, 2016).

Various 3D printers differ in aspects like material use, precision, speed, and price, catering to an array of projects across diverse sectors. 3D scanning offers a non-intrusive and effective way to record and safeguard the intricacies and structure of cultural heritage locations and items. This technique produces highly accurate digital replicas, furnishing a rich source of data for scholars and history enthusiasts (Kantaros, Ganetsos, & Petrescu, 2023).

For instance, premium 3D printers can craft intricate items with sophisticated materials, whereas more budget-friendly models are apt for bulk production or straightforward tasks. Similarly, the range of 3D scanning devices offers varying degrees of detail, accuracy, and rapidity, making them adaptable for diverse scanning needs. Figure 3 illustrates a schematic representation of how the integration of 3D scanning and 3D printing processes results in the final manufactured product.

Figure 3. The integration of 3D scanning and 3D printing techniques results in the completed manufactured product



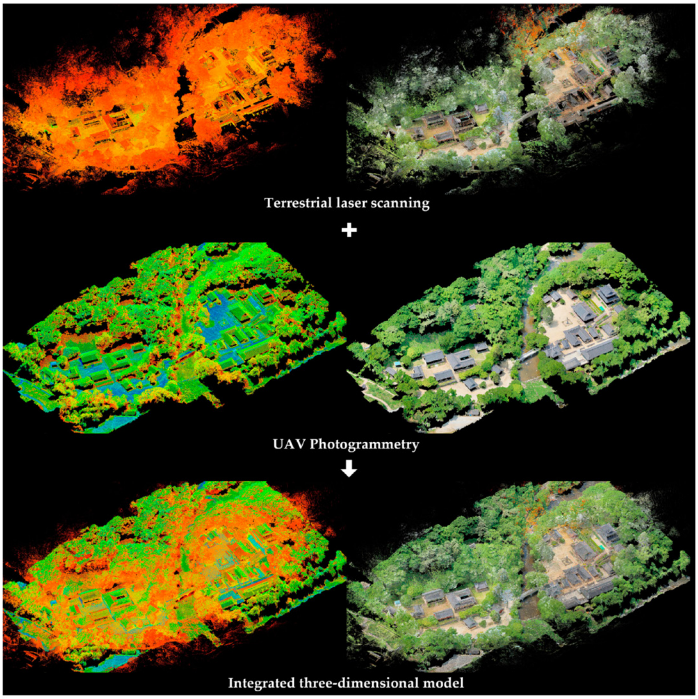
Source: Kantaros, A., Ganetsos, T., & Petrescu, F. I. T. (2023). Three-Dimensional Printing and 3D Scanning: Emerging Technologies Exhibiting High Potential in the Field of Cultural Heritage. Applied Sciences, 13(8), 4777.

File format ".stl" is a file format native to the stereolithography CAD software created by 3D Systems. STL is widely used for computer-aided design and manufacturing to represent 3D models for 3D printing and other operations. A "mesh file" refers to a type of digital data file that contains a geometric description of a three-dimensional object in the form of a mesh. The mesh is composed of vertices, edges, and faces that define the shape of the object in 3D space. Mesh files are commonly used in computer graphics, 3D modelling, and computer-aided design (CAD). The "slicing process" is a crucial step in the 3D printing workflow.

In recent times, the use of 3D LiDAR technology has expanded within the realm of built heritage. The introduction of 3D scanning, precise measurements, and reconstruction techniques has enhanced built heritage preservation methods. As a result, the standard of heritage conservation has seen notable improvements. 3D LiDAR has surpassed the constraints of singular technological applications. It's now more influential in heritage preservation across various scales. By integrating multiple technologies, 3D LiDAR demonstrates its prowess. These technologies include 3D printing, digital mapping, the internet of things, machine learning, smart sensors, close-range photogrammetry, infrared detection, stress wave tomography, material analysis, XR technology, reverse engineering, and more (Li et al., 2023).

The finished 3D form (Figure 4) showcased flawless flat and right-angle geometries, encompassing wooden structures and the adjacent surroundings. This precision in representation provides a comprehensive view of the entire area.

Figure 4. Process and result of integrated 3D modelling



Source: Jo, Y. H., & Hong, S. (2019). Three-dimensional digital documentation of cultural heritage site based on the convergence of terrestrial laser scanning and unmanned aerial vehicle photogrammetry. ISPRS International Journal of Geo-Information, 8(2), 53.

2.3. Virtual and augmented reality

Augmented Reality (AR) tools are becoming more popular for offering immersive experiences to cultural site attendees, primarily by overlaying interactive digital components onto real-world settings. There's a growing interest in using Audio AR (AAR) at heritage locations, allowing visitors to hear location-specific sounds, akin to 'speaking' historical objects. Simultaneously, cultural institutions are adopting AI chatbots in their audience engagement strategies, facilitating meaningful conversations by answering various user queries (Tsepapadakis & Gavalas, 2023).

A chatbot can comprehend natural language, encompassing both written text and vocal messages, providing accurate responses and executing tasks as designed by the website and/or information system (Vukomanović et al., 2022; Matić et al., 2022).

The cultural tourism sector is shifting to fully cater to the desires of travellers. Tourists increasingly seek an immersive role in their experiences, blending the cultural aspects of their visits with their own personal content and sharing it with their peers. Lately, the transition has been from purely dialogue-based interactions to the use of chatbots, where text, visuals, and action buttons come together (Casillo et al., 2020).

The concept of using Artificial Intelligence (AI) and natural language to convey information about displays in museums and cultural locations has been explored for some time. Earlier efforts saw bots engaging with audiences through online platforms, but newer strategies have harnessed the versatility and sensory features of mobile gadgets to offer tailored user experiences during in-person visits. The surge in affordable chatbot solutions allows cultural entities to integrate chatbot tech without heavy investment in manpower, finances, or IT infrastructure. Implementing chatbots at cultural venues has enhanced user interaction, providing a more dynamic, enjoyable, and consistently available alternative to conventional museum tours or structured visits.

The rise of multimedia technologies is reshaping digital heritage, especially within Virtual Museum platforms. 3D interactive content, pivotal for future information dissemination, requires research for seamless integration and to cater to users' cognitive needs. By leveraging diverse media and ICT platforms (Figure 5), museums can offer immersive experiences, enhancing the understanding and appreciation of cultural heritage (Jung, Behr, & Graf, 2012).

Figure 5. Examples of on-site mobile Augmented Reality (AR) Cultural Heritage applications

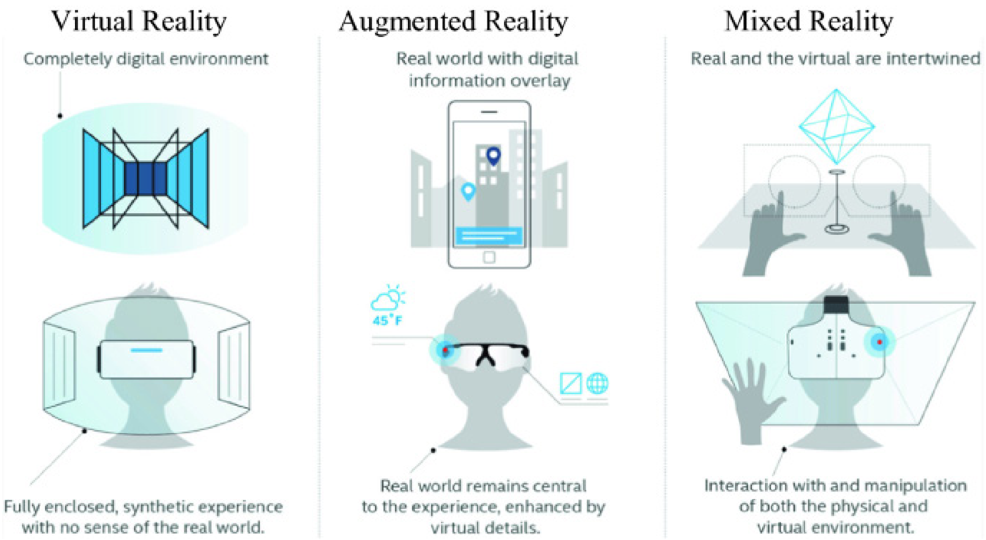
Source: Jung, Y., Behr, J., & Graf, H. (2012). X3DOM as carrier of the virtual heritage. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 38, 475-482.

Virtual Reality (VR) immerses users in a fully digital environment, shutting out the physical world. Augmented Reality (AR) overlays digital elements onto the real world through devices, without replacing it. Mixed Reality (MR) merges real and virtual worlds, allowing physical and digital objects to coexist and interact in real-time.

Virtual Reality, Augmented Reality, and Mixed Reality all leverage digital technology to create or enhance immersive experiences within simulated or real-world environments. Virtual Reality often requires dedicated headsets and creates a completely simulated environment for the user. Augmented Reality can be experienced with simpler devices, such as smartphones or tablets, enhancing the real world with additional digital information. Mixed Reality blends the best of both VR and AR, offering dynamic interactions where virtual and real elements can influence each other (Figure 6).

Mixed Reality enhances the experience of cultural heritage by seamlessly blending the digital and physical worlds, offering immersive and interactive insights into the past.

Figure 6. Difference between Virtual Reality, Augmented Reality and Mixed Reality



Source: Jung, Y., Behr, J., & Graf, H. (2012). Buhalis, D., & Karatay, N. (2022). Mixed reality (MR) for generation Z in cultural heritage tourism towards metaverse. In Information and Communication Technologies in Tourism 2022: Proceedings of the ENTER 2022 eTourism Conference, January 11–14, 2022 (pp. 16-27). Springer International Publishing.

2.4. Big Data and data analytics

Big Data technologies offer the potential for in-depth analysis and interpretation of large datasets related to cultural heritage, enabling a better understanding and preservation of historical and cultural artefacts. Through digitisation and Big Data analysis, museums and archives can provide access to rare and sensitive collections to the wider public, whilst ensuring their long-term protection.

Big Data analytics can assist in identifying and tracking trends in cultural heritage, allowing experts to anticipate and respond to potential threats, such as climate change or urban development projects. The integration of Big Data with technologies like artificial intelligence and machine learning can enable the reconstruction of lost or damaged parts of cultural heritage, breathing new life into ancient masterpieces.

Whilst Big Data offers numerous opportunities for the enhancement and preservation of cultural heritage, it also raises ethical questions about privacy, data ownership, and the authenticity of digital reconstructions.

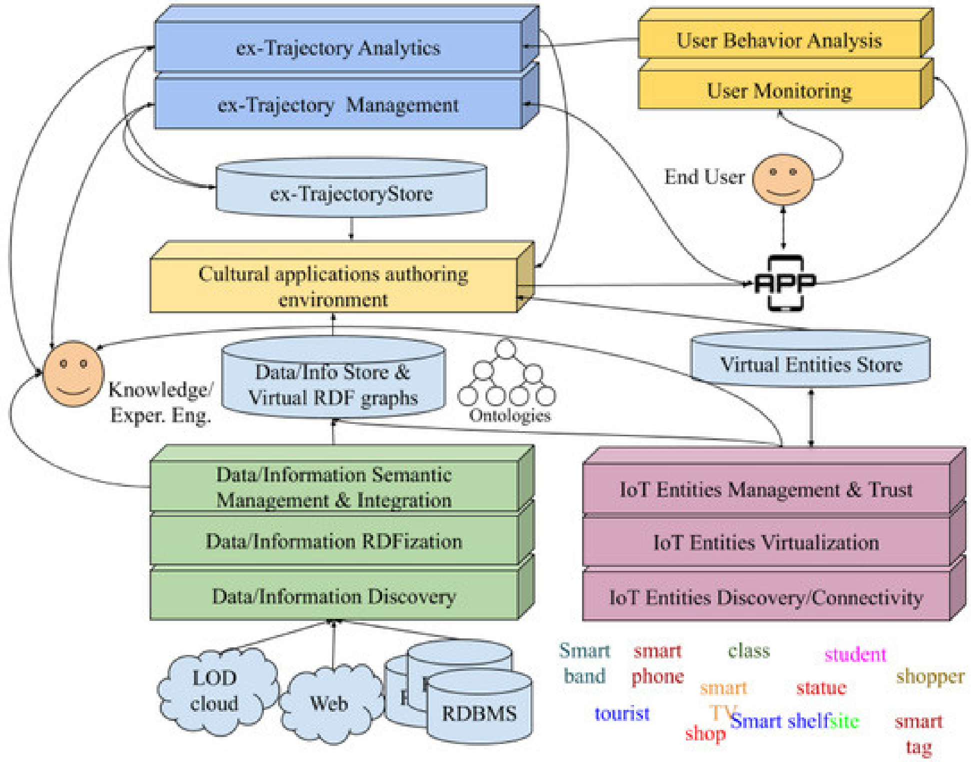
Recent studies (Amato et al., 2017; Zhao et al., 2020; Dimoulas, 2022; Poulopoulos & Wallace, 2022) are increasingly examining cultural informatics and heritage through the lens of big data. One might wonder why this perspective is now being adopted for longstanding issues in cultural informatics. Just as the internet once revolutionised museum engagement, Big Data is now driving a similar transformation. With global internet connectivity, individuals not only consume but also produce vast amounts of data, leading to the rise of the Big Data phenomenon. Museums and cultural entities must adapt to this shift, embracing big data technologies and recognising the influential role of social media in this evolution.

This adaptation not only ensures that cultural institutions remain relevant but also maximises their reach and impact in the digital age. By integrating big data strategies, museums can offer more personalised and immersive experiences to visitors, both online and offline. Furthermore, the insights derived from big data can guide institutions in curating collections and exhibitions that resonate more deeply with contemporary audiences.

Information and Communication Technologies have profoundly transformed the contemporary Cultural Heritage landscape. What used to be basic Information Systems for managing cultural artefacts have evolved into intricate systems. These advanced systems now present detailed information drawn from a diverse range of sources, including Sensor Networks, Social Networks, Digital Libraries, Multimedia Collections, and Web Data Services, among others (Amato et al., 2017).

A schematic view of Big Data analytics for Cultural Heritage is given in Figure 7.

Figure 7. Big Data analytics for Cultural Heritage



Source: BDCC, Special Issues: Big Data Analytics for Cultural Heritage, Available at: https://pub.mdpi-res.com/BDCC/BDCC-04-00006/article_deploy/html/images/BDCC-04-00006-g002-550.jpg?1587378290

Contemporary technologies have been pivotal in maintaining, curating, and repurposing our cultural heritage treasures. The newest strides in Artificial Intelligence (AI) and Big Data are believed to hold immense promise for the digital representation, conversion, and further utilisation of these assets (Zhao et al., 2020).

Today, the combination of Semantic Web and Big Data technologies offers the potential for simpler data analysis, categorisation of information, semantic understanding, and automated management of diverse content, which can be particularly beneficial for the delicate Cultural Heritage sectors. Specifically, these automated processes can serve as intermediaries, fostering communication and collaboration between businesses and individuals, thus hastening the initiation, upkeep, and longevity of appropriate Cultural Heritage archives for the benefit of all involved. For example, numerous invaluable personal collections, such as photographs, films, and other private artefacts, remain undiscovered, unarchived, or not fully restored. The creation of advanced digital crowdsourcing methods, backed by the essential technological and interdisciplinary collaboration, would enable the extraction, refinement, and public sharing of these unparalleled Cultural Heritage treasures (Dimoulas, 2022).

3. Challenges and Opportunities

The cultural heritage sector, traditionally seen as a bastion of historical preservation, is undergoing a seismic shift with the advent of new technologies. From augmented reality to advanced scanning techniques, the tools at our disposal are reshaping how we approach, experience, and preserve history.

3.1. Challenges in Technological Integration

For many institutions, the primary challenge lies in the adaptation to these technologies. Adapting to the rapid pace of technological advancement can be daunting, especially for establishments that have historically relied on conventional methods. The expertise required to integrate and manage advanced tools is often beyond the traditional skill set of heritage professionals. This necessitates not only an investment in the technology itself but also in training and capacity-building to ensure that staff can effectively harness its potential.

The financial implications of adopting new technologies can be significant, often requiring substantial investment upfront. Many institutions, especially those operating in resource-limited settings, grapple with these costs. The challenge is not just in acquiring the technology but also in maintaining and updating it over time. As a result, these establishments often find it daunting to secure adequate funding, potentially hindering their ability to leverage the benefits of technological advancements.

The digital realm, with its vast capabilities, inevitably raises concerns about the potential dilution of authenticity. As artefacts are reproduced or experienced virtually, there's a risk of losing the tactile and historical essence that physical interaction offers. While digital reproductions can make cultural heritage more accessible, they may not fully capture the nuances and intricacies of the original. This balance between accessibility and authenticity becomes a pivotal consideration for institutions venturing into the digital space.

The process of digitisation, while offering numerous benefits, also introduces vulnerabilities in the form of cyber threats. As institutions transition to digital platforms, they become potential targets for hackers and malicious entities. The data housed within these platforms, often invaluable and irreplaceable, requires the utmost protection. Consequently, it becomes imperative for institutions to implement robust security protocols, ensuring the safety and integrity of their digital assets. In the paper (Deretić & Samardžić, 2022), the fundamental concepts related to cybercrime are described. In addition to this, nine types of cyberattacks are detailed, even though there are many more varieties.

The integration of modern technologies into the realm of cultural heritage brings with it certain conservation challenges. Some technologies, when misapplied or used without proper understanding, have the potential to inadvertently damage artefacts. This potential risk highlights the paramount importance of thorough consideration before implementing any technological solution. Additionally, it underscores the necessity for comprehensive training for professionals to ensure the safe and effective use of these tools in preserving heritage items.

3.2. Opportunities Afforded by Technology

Digital platforms are revolutionising the way cultural heritage is presented and consumed. With the power of the internet and digital tools, cultural heritage can now be showcased to audiences far beyond its physical location. This digital shift allows for a broader, global audience to engage with and appreciate artefacts and histories that were once limited by geographical constraints. As a result, the stories, lessons, and values of diverse cultures can be shared and understood on a truly global scale.

The advent of modern technologies, particularly augmented reality, has ushered in a new era for visitor engagement in cultural heritage spaces. These tools have the capability to breathe life into static exhibits, offering visitors an immersive journey through time and place. By overlaying digital information onto the physical world, interactions become not only more engaging but also deeply informative. As a result, visitors can gain a richer, more nuanced understanding of the artefacts and stories they encounter.

The fields of preservation and restoration are witnessing transformative changes with the introduction of advanced scanning and 3D printing techniques. These cutting-edge technologies enable professionals to capture intricate details of artefacts, creating precise digital replicas. Furthermore, 3D printing allows for the recreation of damaged or lost parts of artefacts, ensuring their restoration to near-original states. As a result, these innovations not only safeguard our cultural heritage but also ensure its longevity for future generations to appreciate.

In today's digital age, the capability to gather and dissect visitor data has become a cornerstone for cultural heritage institutions. By understanding patterns, preferences, and behaviours, institutions can gain a deeper insight into what resonates with their audience. This invaluable information can then directly influence exhibit design, ensuring displays are both engaging and relevant. Ultimately, these data-driven strategies lead to enriched visitor experiences, fostering a deeper connection between the audience and the cultural narrative being presented.

The digital landscape has ushered in unprecedented opportunities for collaboration among cultural heritage institutions. With the ease of online communication and data sharing, institutions can pool resources, merge research efforts, and even co-curate exhibits. This collaborative approach not only amplifies the reach and impact of individual collections but also fosters a sense of global community in preserving and celebrating cultural heritage. As a result, diverse audiences can benefit from a richer, more interconnected understanding of history and culture.

4. Conclusion

While the challenges of integrating technology in the cultural heritage sector are real, the opportunities are transformative. As we navigate this evolving landscape, a balanced approach, recognising both the potential and the pitfalls, will be crucial in ensuring that our shared history is both preserved and made accessible in novel, engaging ways.

The research underscores the transformative potential of new technologies in reshaping the cultural heritage landscape. As we move further into the digital age, the integration of these technologies will be paramount in ensuring the protection, accessibility, and relevance of cultural artefacts and narratives.

The importance of 3D printing and scanning in the realm of cultural heritage is profound. These advanced technologies offer vast opportunities for the conservation, examination, and display of global cultural treasures. 3D printing, in particular, has emerged as an indispensable instrument in cultural heritage conservation, enabling the creation of detailed and precise replicas of artifacts.

The application of the Internet of Things (IoT) framework to the realm of Cultural Heritage introduces a fresh approach that combines smart objects, sensors, services, and applications in fixed cultural settings. The aim is to evolve these areas into Intelligent Cultural Heritage spaces.

In the future, the synergy of 3D LiDAR and multi-technology collaboration will deepen, ensuring enhanced preservation outcomes, with the evolving technologies driving the advancement of built heritage protection.

While the application of new technologies in cultural heritage presents a myriad of opportunities, it also brings forth challenges that need careful consideration. Continued research in this domain will be pivotal in guiding institutions as they navigate this evolving landscape, ensuring that our cultural heritage is not only preserved but also made accessible and relevant for generations to come.

Future research should prioritize evaluating the long-term effects of technology on artefact preservation and how it influences visitor interactions. It's essential to address the ethical concerns arising from digitising cultural artefacts, particularly regarding authenticity and ownership. As technological tools become more integrated, the emphasis on effective training for staff becomes paramount. The confluence of technology and cultural heritage necessitates interdisciplinary collaborations, bringing together experts from various fields. Lastly, understanding the sustainability of these technological investments, both environmentally and financially, is of utmost importance.

References

1. Amato, F., Moscato, V., Picariello, A., Colace, F., Santo, M. D., Schreiber, F. A., & Tanca, L. (2017). Big data meets digital cultural heritage: Design and implementation of scrabs, a smart context-aware browsing assistant for cultural environments. *Journal on Computing and Cultural Heritage (JOCCH)*, *10*(1), 1-23.
2. BDCC, Special Issues: Big Data Analytics for Cultural Heritage, Available at: https://pub.mdpi-res.com/BDCC/BDCC-04-00006/article_deploy/html/images/BDCC-04-00006-g002-550.jpg?1587378290 Accessed: August 20, 2023
3. Bin Abu Bakar, M. S., bin Zulkifli, M. A. H., binti Harun, K. N., & Shuki, M. S. B. M. (2020). Exploring Digital Platforms, Cultural Tourism and Online Learning of Museums Worldwide. *International Journal of Academic Research in Business and Social Sciences*, *10*(6), 633-642.
4. Buhalis, D., & Karatay, N. (2022). Mixed reality (MR) for generation Z in cultural heritage tourism towards metaverse. In *Information and Communication Technologies in Tourism 2022: Proceedings of the ENTER 2022 eTourism Conference, January 11–14, 2022* (pp. 16-27). Springer International Publishing.
5. Casillo, M., Clarizia, F., D'Aniello, G., De Santo, M., Lombardi, M., & Santaniello, D. (2020). CHAT-Bot: A cultural heritage aware teller-bot for supporting touristic experiences. *Pattern Recognition Letters*, *131*, 234-243.

6. Chen, F., Guo, H., Tapete, D., Cigna, F., Piro, S., Lasaponara, R., & Masini, N. (2022). The role of imaging radar in cultural heritage: From technologies to applications. *International Journal of Applied Earth Observation and Geoinformation*, *112*, 102907.
7. Chianese, A., Marulli, F., Piccialli, F., Benedusi, P., & Jung, J. E. (2017). An associative engines based approach supporting collaborative analytics in the internet of cultural things. *Future generation computer systems*, *66*, 187-198.
8. Deretić, N., & Samardžić, N. (2022). A brief overview of the types of attacks caused by cyber crime. *The first international scientific and professional conference Belecon* (445-456). *Belgrade: BAPUSS*.
9. Deretić, N., Samardžić, N., & Milošević, P. (2023). Application of the internet of things in environmental protection. *The second international scientific and professional conference Belecon* (84). *Belgrade: BAPUSS*.
10. Dimoulas, C. A. (2022). Cultural Heritage Storytelling, Engagement and Management in the Era of Big Data and the Semantic Web. *Sustainability*, *14*(2), 812.
11. Georgopoulos, A. (2018). CIPA's perspectives on cultural heritage. In *Digital Research and Education in Architectural Heritage: 5th Conference, DECH 2017, and First Workshop, UHDL 2017, Dresden, Germany, March 30-31, 2017, Revised Selected Papers 1* (pp. 215-245). Springer International Publishing.
12. Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Industrial perspectives of 3D scanning: features, roles and it's analytical applications. *Sensors International*, *2*, 100114.
13. Jo, Y. H., & Hong, S. (2019). Three-dimensional digital documentation of cultural heritage site based on the convergence of terrestrial laser scanning and unmanned aerial vehicle photogrammetry. *ISPRS International Journal of Geo-Information*, *8*(2), 53.
14. Jung, Y., Behr, J., & Graf, H. (2012). X3DOM as carrier of the virtual heritage. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *38*, 475-482.
15. Kantaros, A., Ganetsos, T., & Petrescu, F. I. T. (2023). Three-Dimensional Printing and 3D Scanning: Emerging Technologies Exhibiting High Potential in the Field of Cultural Heritage. *Applied Sciences*, *13*(8), 4777.
16. Lerario, A., & Varasano, A. (2020). An IoT Smart Infrastructure for S. Domenico Church in Matera's "Sassi": A Multiscale Perspective to Built Heritage Conservation. *Sustainability*, *12*(16), 6553.
17. Levoy, M., Pulli, K., Curless, B., Rusinkiewicz, S., Koller, D., Pereira, L., Ginzton, M., Anderson, S., Davis, J., Ginsberg, J., Shade, J., & Fulk, D. (2000, July). The digital Michelangelo project: 3D scanning of large statues. In *Proceedings of the 27th annual conference on Computer graphics and interactive techniques* (pp. 131-144).
18. Li, Y., Zhao, L., Chen, Y., Zhang, N., Fan, H., & Zhang, Z. (2023). 3D LiDAR and multi-technology collaboration for preservation of built heritage in China: A review. *International Journal of Applied Earth Observation and Geoinformation*, *116*, 103156.
19. Maksimović, M., & Ćosović, M. (2019, March). Preservation of cultural heritage sites using IoT. In *2019 18th International Symposium INFOTEH-JAHORINA (INFOTEH)* (1-4). IEEE.

20. Matić, R., Kabiljo, M., Deretić, N., & Vukomanović, A. (2022). Application of Chatbot at a Higher Education Institution in Republic of Serbia. In: Šprajc, P. et al., (Eds.), *41st International Conference on Organizational Science Development Society's Challenges for Organizational Opportunities* (605–616). *Portorož: University of Maribor Press*.

21. Perles, A., Pérez-Marín, E., Mercado, R., Segrelles, J. D., Blanquer, I., Zarzo, M., & Garcia-Diego, F. J. (2018). An energy-efficient internet of things (IoT) architecture for preventive conservation of cultural heritage. *Future Generation Computer Systems*, *81*, 566-581.

22. Piccialli, F., & Chianese, A. (2018). Editorial for FGCS special issue: the internet of cultural things: towards a smart cultural heritage. *Future Generation Computer Systems*, *81*, 514-515.

23. Poulopoulos, V., & Wallace, M. (2022). Digital technologies and the role of data in cultural heritage: The past, the present, and the future. *Big Data and Cognitive Computing*, *6*(3), 73.

24. Ramya, A., & Vanapalli, S. L. (2016). 3D printing technologies in various applications. *International Journal of Mechanical Engineering and Technology*, *7*(3), 396-409.

25. Remondino, F. (2011). Heritage recording and 3D modeling with photogrammetry and 3D scanning. *Remote sensing*, *3*(6), 1104-1138.

26. Reshma, M. R., Kannan, B., Raj, V. J., & Shailesh, S. (2023). Cultural heritage preservation through dance digitization: A review. *Digital Applications in Archaeology and Cultural Heritage*, e00257.

27. Salleh, S. Z, & Bushroa, A.R. (2022). Bibliometric and content analysis on publications in digitization technology implementation in cultural heritage for recent five years (2016–2021). *Digital Applications in Archaeology and Cultural Heritage*, *25*, e00225.

28. Tsepapadakis, M., & Gavalas, D. (2023). Are you talking to me? An Audio Augmented Reality conversational guide for cultural heritage. *Pervasive and Mobile Computing*, *92*, 101797.

29. Zhang, J., Guo, M., Li, B., & Lu, R. (2021). A transport monitoring system for cultural relics protection based on blockchain and internet of things. *Journal of Cultural Heritage*, *50*, 106-114.

30. Zhao, M., Wu, X., Liao, H. T., & Liu, Y. (2020, April). Exploring research fronts and topics of Big Data and Artificial Intelligence application for cultural heritage and museum research. In *IOP Conference Series: Materials Science and Engineering* (Vol. 806, No. 1, p. 012036). IOP Publishing.

31. Vukomanović, A., Deretić, N., Kabiljo, M., & Matić, R. (2022). An example of chatbot in the field of education in the Republic of Serbia. *Journal of process management and new technologies*, *10*(1-2), 125-139.

32. Wachowiak, M. J., & Karas, B. V. (2009). 3D scanning and replication for museum and cultural heritage applications. *Journal of the American Institute for Conservation*, *48*(2), 141-158.