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| RESEARCH ARTICLE

Digital Cultural Heritage in the Age of Data and AI: Trends, Challenges and Futures

Ivana Ćirić
The Nikola Tesla Museum, Serbia
Corresponding Author: Ivana Ćirić, **E-mail**: ivana.ciric@tesla-museum.org

| ABSTRACT

Digital Cultural Heritage (DCH) has developed a great deal beyond the initial idea of digitising cultural heritage objects, to become a highly complex and dynamic socio-technical ecosystem today. Beginning with preservation and access, DCH has now added sophisticated data infrastructures, smart systems and democratic structures that continually reinvent the ways in which cultural knowledge is created and engaged. This paper seeks to explore the current process of transformation of digital cultural heritage, with a specific focus on how artificial intelligence, all things data, immersive technologies and user participation are re-imagining the very nature of heritage practices. The research shows that new technologies like artificial intelligence, extended reality and digital twins are moving the experience of heritage from passive viewing to active participation, by providing more interactive and immersive interaction with cultural assets. Simultaneously, it examines the epistemological transition from object-based approaches to heritage to networked, process and co-created knowledge systems, where knowledge is produced through institutional, technological and community interactions. To highlight this shift, the paper offers a conceptual case of Nikola Tesla's legacy, a story that can be reimagined as a cooperative, interactive system in a digital space as opposed to a static archive. The legacy of Tesla is a powerful case study on how digital heritage can be used to interpret, engage, and continually re-imagine cultural narratives. The paper provides a synthesis on the nature of digital cultural heritage and concludes that it is becoming an intelligent, data-driven, participatory field which makes cultural heritage more accessible, engaging, and even changes the way cultural knowledge is produced and governed in the digital era.

| KEYWORDS

Digital Cultural Heritage; Artificial Intelligence; Digital Twins; Participatory Heritage; Immersive Technologies; Data Infrastructures; Nikola Tesla

| ARTICLE INFORMATION

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1. Introduction

In the last 20 years, the digitalization of cultural heritage has changed the ways in which cultural heritage is preserved, accessed and interpreted. The first projects in the field of Digital Cultural Heritage (DCH) were mostly focused on the digitalization of analogue materials like artefacts, archival documents, manuscripts, etc., that had to be preserved in the long term and made accessible to a broader audience. Much of this was technical and institutionally motivated, and was based on the idea that museums, libraries and archives held a monopoly over knowledge about culture. Digital technologies, however, as they evolved and developed, started to grow and evolve into more complex and networked systems (Poulopoulos & Wallace, 2022).

1.1 We are already beginning to see the creation of digital ecosystems in the world of digitisation

The digitisation of cultural heritage started with the digitisation of analogue information, mainly to make it more accessible and preserved. The beginnings were technical and institution-based, and museums and archives had control over cultural content. But over time, it has been transformed into increasingly complex digital ecosystems in which cultural heritage is no longer fixed, but is continually influenced, negotiated, and remediated by use and reuse. With all these ecosystems, data, technologies and users are linked, and heritage becomes a dynamic and evolving system, not a static collection (Poulopoulos & Wallace, 2022; Omol, 2024).

1.2 Data and Artificial Intelligence are playing an increasing part in the world

In the digital cultural heritage transformation, data and artificial intelligence (AI) play a key role. Data structures facilitate the organization, linkage and analysis of cultural assets across platforms, and AI aids in advanced processes like image restoration, metadata generation, and predictive conservation analysis. The technologies not only increase efficiency, but they also put new ways to explore and understand heritage on the table. Consequently, cultural heritage is increasingly being determined by data-driven systems which affect the processes of preservation and interpretation.

1.3 The research gap and problem statement

While digital transformation has seen significant technological progress, there is still a lack of understanding of the more conceptual aspects of digital transformation in heritage. While the existing research is mainly devoted to tools and applications, the reconfiguration of knowledge production, authority and cultural meaning as a result of these technologies is less often explored. Authenticity, control and the changing nature of institutions are important issues to consider as one shifts from an object-based approach to a participatory approach and a networked approach (Otero, 2022).

1.4 Aim and Objectives of the study

This paper is designed to investigate the changes in the digital cultural heritage as a technological and epistemological change. In particular, it aims to:

- Review the role of data and AI systems in heritage systems, and
- Examine the development of knowledge models of participation and networks,
- Use these understandings to re-imagine the legacy of Nikola Tesla in the digital world.

1.5 Structure of the Paper

The paper is divided into several sections. The evolution of digital cultural heritage is discussed in the next section, followed by an analysis of AI and immersive technologies and their technological drivers. Epistemological shifts, data infrastructures and a case study on Nikola Tesla are explored further. The paper ends with some major challenges, future directions and conclusions.

2. Evolution of Digital Cultural Heritage

2.1 Early Digitisation Phase

The development of Digital Cultural Heritage (DCH) started from the early digitisation phase, in which the main focus was to digitise the analogical cultural heritage. This encompassed manuscripts, artefacts, archival collections, as well as museum collections, the primary focus being the preservation and access to collections. In this era, the heritage institutions were a very strong institution that determined what was digitised and how it was presented to the public. Digital systems were mainly static, and were not interactive. This period, however, made way for the future transformations, by creating digital infrastructures and normalised approaches towards cultural documentation (Poulopoulos & Wallace, 2022).

2.2 The transition to Digital Ecosystems requires action

The second phase represents a major transition from digital archives to digital ecosystems. During this phase, cultural heritage systems were linked to other data infrastructures, allowing for interoperability between cultural institutions and digital platforms. Rather than being retained in isolation, heritage data is now being increasingly

connected, via semantic systems, databases, and networked platforms enabling complex forms of cultural analysis and access.

This shift is part of a wider socio-technical shift that sees digital cultural heritage viewed as an ecosystem that is formed, influenced, and sustained by different human and technological actors. They are systems which enable ongoing interaction, reinterpretation and sharing of cultural knowledge across platforms and communities. This change is a transition towards more dynamic and interconnected heritage environments that are co-produced by technology and human agency, as evidenced in research (Li et al., 2025; JiaXing et al., 2025).

2.3 Emergence of Smart Heritage

The latest phase in the development of digital cultural heritage is 'smart heritage', which combines the Internet of Things (IoT), automation, artificial intelligence (AI) and advanced data analysis in the management and interpretation of cultural heritage. Heritage systems are no longer "passive" repositories, but intelligent environments that can monitor, predict conservation, and respond to the user in real time.

AI tools assist in activities like automated restoration, pattern recognition, and cultural data interpretation, and immersive technology and digital twins create highly detailed virtual replicas of heritage sites. It is part of a wider trend of 'digital transformation', in which cultural heritage becomes a component of intelligent systems that are constantly evolving, adapting to the inputs of data and user engagement (Schnabel & Batchelor, 2026; Li et al., 2025).

Table 1: Evolution of Digital Cultural Heritage (DCH)

Phase	Key Characteristics	Technological Focus	Key Outcome
Early Digitisation Phase	Conversion of analogue cultural materials into digital formats; strong institutional control over heritage data and interpretation	Scanning, digitisation, digital archiving systems	Improved preservation and access, but limited interaction and participation (Poulopoulos & Wallace, 2022; Otero, 2022)
Transition to Digital Ecosystems	Shift from isolated digital archives to interconnected cultural systems; integration of multiple stakeholders and platforms	Data infrastructures, semantic systems, networked platforms	Emergence of interconnected heritage systems enabling data sharing and collaborative knowledge production (Li et al., 2025; JiaXing et al., 2025)
Emergence of Smart Heritage	Heritage becomes intelligent, adaptive, and interactive; increased user participation and real-time data use	Artificial Intelligence, IoT, automation, digital twins, immersive technologies	Smart, adaptive heritage systems enabling immersive experiences and predictive conservation (Schnabel & Batchelor, 2026; Li et al., 2025)

Recent studies also indicate that smart heritage systems can improve the accessibility, engagement and sustainability by facilitating more responsive and interactive cultural experiences. They also bring in new challenges of governance, ethics in the use of AI, and maintaining authenticity in digitally mediated environments. From this perspective, smart heritage not only is an opportunity but also a challenge in the continuous evolution of cultural heritage practices.

3. Technologies that drive Digital Cultural Heritage

3.1 Artificial Intelligence in Heritage

AI is a game-changer in the post-world of cultural heritage management, protection, and interpretations. Advances in AI techniques have been documented in various sectors related to image processing, restoration of deteriorated artefacts, and the generation of metadata, ultimately enhancing the efficiency and accuracy of heritage documentation (Gîrbacia, 2024; Wang & Chen, 2025). AI-powered systems can also facilitate pattern recognition

and predictive conservation, aiding in the prediction of deterioration risks and the optimisation of the conservation strategy.

AI is not just a tool for research tasks; it's also driving the research agenda in cultural heritage studies. According to bibliometric analysis, heritage research related to AI has been increasing more quickly, with evidence showing its transformative impact on digital preservation practices and where it can be used to improve the data-driven decision-making process (Harisanty et al., 2024; Li et al., 2025). But questions persist on how transparent algorithms are, how they are biased based on training datasets, and how interpretable the cultural products produced by AI will be.

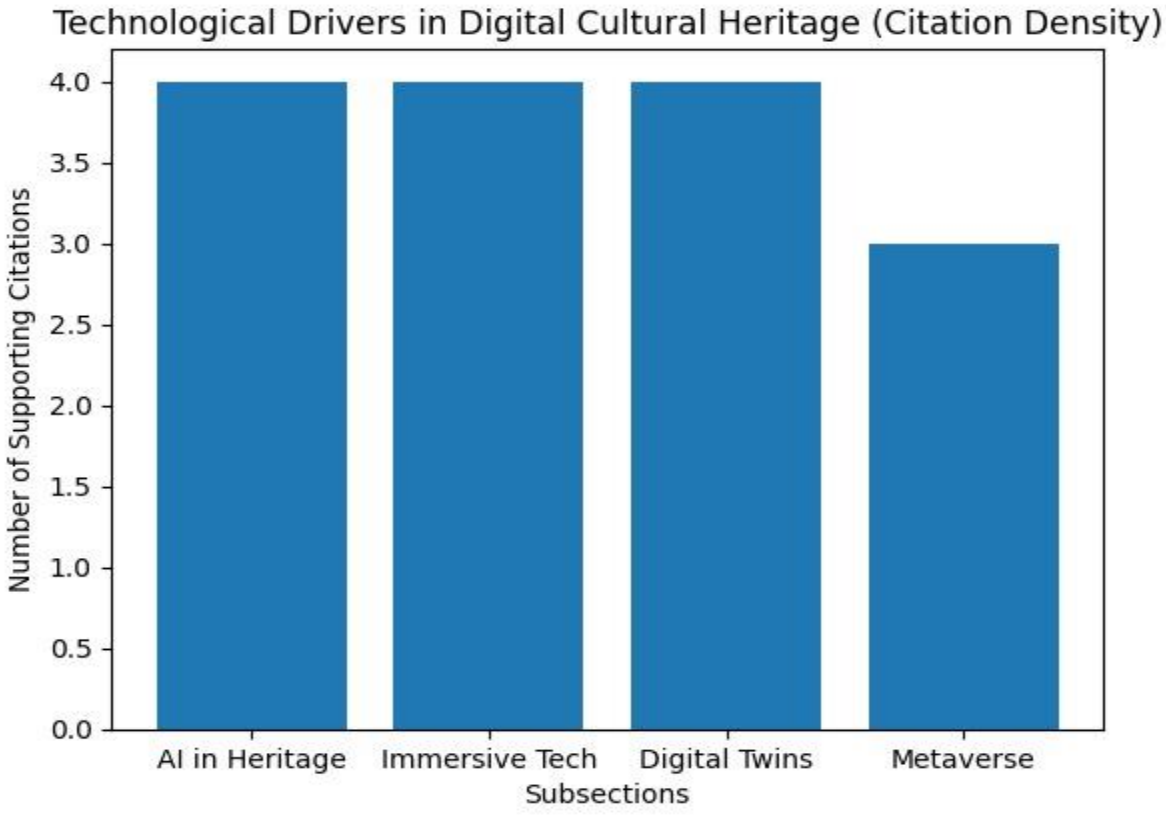
3.2 Immersive Technologies: (XR, VR, AR)

Immersive technologies (XR, VR, AR) are changing the way that users connect with cultural heritage. The technologies enable a highly immersive interactive, and multisensory experience of historical environments, in which reconstructed spaces and artefacts can be explored as these technologies are fully understandable for the user (Luther et al., 2023).

Recent studies have focused on the unique advantage of XR technology to deliver emotional engagement and learning through more realistic and participatory heritage experiences (Buragohain et al., 2024; Lin et al., 2025). Users engage in the stories and narratives of culture with their own agency, rather than passively observing them, leading to deeper cognitive and affective engagement. The new paradigm is reshaping the definition of heritage communication, especially as it takes place in education, museums, and tourism, increasingly opting for engagement and accessibility, as indicated by Sánchez-Martín et al. (2025).

3.3 Digital Twins and Data Systems

Digital twin is a big leap in the technology of digital preservation and management of cultural heritages. A digital twin is a virtual replica of a heritage asset, continuously updated with real-time information on which simulations, monitoring and predictive analysis can be carried out (Darwish & Hassanien, 2022; Mazzetto, 2024).



We can create an accurate digital representation of monuments (or even archaeological sites) and continue managing it over time through digital twins to the point of their being reconstructed in detail and observed over time in heritage contexts. These systems can aid in conservation decision-making through the simulation of environmental impacts, structural degradation and restoration scenarios. A recent study indicated that the use of digital twin technology with AI and sensor networks could improve the accuracy and sustainability of heritage conservation strategies (Shehata et al., 2024) as well as another recent study (Yu et al., 2025). This integration is reflective of a bigger transformation that aims at becoming data-driven heritage ecosystems in which the physical and the digital realm are closely intertwined.

3.4 Metaverse and Emerging Platforms

Entry of metaverse technologies is creating new paradigms in the presentation of cultural heritage and in its interaction. In a metaverse context, heritage assets can be recreated as fully immersive virtual environments that allow users to walk through time and experience historical scenarios by interacting with virtual people and objects (Buragohain et al., 2024).

The platforms hold three concepts together: AI, XR and digital twin, fostering persistent, shared virtual spaces to explore and co-create cultural stories. A recent study by Mazzetto (2024) and a more detailed study by Li et al. (2025) indicate that metaverse-based heritage systems can improve accessibility and worldwide participation by enabling the real-time access to cultural content that users can experience from various geographical areas.

Yet in spite of these platforms' potential, there are major questions about authenticity, data management and culture representation. As generative AI becomes further woven throughout the experience in the metaverse, the issue of authorship and historical accuracy becomes a more complex matter, and governance structure is vital to sustainable development.

4. Epistemological Shift in Digital Cultural Heritage

Digital Cultural Heritage (DCH) is not merely a technological change, but an epistemological shift which involves changes in the production, structuring, and interpretation of cultural knowledge. In recent years, more and more scholarship has focused on the shift from static object centred models of digital heritage systems to the more dynamic, networked, participatory knowledge construction model (Zhang & Dong, 2024; Fenlon et al., 2025).

4.1 From Object-Centered to Networked Heritage

So far the traditional cultural heritage framework was mostly an object-oriented approach which worked on a collection of artefacts, documents, collections and expected them to be preserved and interpreted in an institutional framework like museums and archives. This one was a type of model where the meaning was more or less stable and mediated by the expert decision makers in charge of categorisation and conservation.

Modern electronic environments, by contrast, have bricolaged heritage into network-based architecture structured by interactions between the data, electronic users, and technologies. Heritage is not considered as a fixed entity, but as a network of relations, constituting part of digital infrastructures. This is representative of the transformation of cultural heritage into a socio-technical system characterised by connectivity, interoperability and digital mediation (Jaillant & Caputo, 2022).

In these moments of continuous updating, restructuring and reinterpretation of knowledge, through the flows of a digital networked system, the nature of heritage is dynamic, rather than fixed.

4.2 Participatory and Co-Created Knowledge

One of the major aspects of this epistemological shift is the growth of participatory knowledge producing concepts. The use of digital platforms is becoming a growing opportunity for people to participate directly in the production, interpretation and conservation of cultural heritage. Knowledge about heritage is now disseminated at community levels using crowdsourcing operations, user generated content and participatory online heritage repositories.

Research recently underscores the value of crowdsourcing beyond just the volume of data, also emphasizing diversity in communities can become engaged in cultural memory-making processes via distributed authorship (

Zhang & Dong, 2024). This participatory approach is in keeping with other developments in digital humanities, in which the concept of heritage is now recognised as a negotiated, co-created process, as opposed to a one-way broadcast of authority.

But in the process, this transition also brings with it epistemic challenges over the reliability, validation and authority of knowledge produced by users in heritage systems, as well as challenges to the act of 'owning' the knowledge. But at the same time this transition presents epistemic questions about reliability, validation and authority of what users generate in heritage systems, and questions around the act of 'owning' knowledge.

4.3 Knowledge Infrastructures and Community Roles

Digital cultural heritage transformation is also closely linked with the development of knowledge infrastructure, which combines technological systems, institutional arrangements and the mobilisation of a community. These infrastructures are not just a neutral environment; they actively influence the acquisition, conservation, interpretation and utilization of cultural information.

Table 2: Epistemological Shift in Digital Cultural Heritage

Dimension	Traditional Model	Digital / Emerging Model	Key Focus
Heritage Structure	Object-centered (artefacts, archives)	Networked systems of data and interactions	From fixed objects to connected knowledge systems
Knowledge Production	Expert-led, institutional authority	Participatory and co-created knowledge	Crowdsourcing and user-generated content (Zhang & Dong, 2024)
Governance & Roles	Centralized institutions (museums, archives)	Distributed communities and hybrid governance	Community-driven stewardship (Fenlon et al., 2025)
Knowledge Infrastructure	Static archival systems	Dynamic, interoperable digital infrastructures	Socio-technical systems shaping knowledge flow (Jaillant & Caputo, 2022)

The "Oyster Model" showcases integration of communities of interest and contributions as a key component of sustaining digital cultural knowledge infrastructures, even though it might not be realized in institutional settings alone (Fenlon et al., 2025). This underscores an emerging paradigm of distributed management of an ecosystem called Cultural Knowledge System, in which communities function as co-managers of such ecosystems.

Moreover, digital archives and heritage platforms serve as dynamic knowledge infrastructures which facilitate the relationship between data producers and users. These systems depend on ongoing relationship and interaction between the technological systems and the human subjects involved, further reinforcing the concept of knowledge production as being socio-technical and relational in digital heritage (Jaillant & Caputo, 2022).

5. Datafication and Digital Heritage Infrastructures

The rapid expansion of Digital Cultural Heritage (DCH) has increasingly repositioned cultural heritage as a data-driven domain, where art facts, archives, and intangible heritage are transformed into structured, interoperable, and computable datasets. This process often referred to as *datafication* enables cultural heritage materials to be processed, analysed, and shared across digital platforms, thereby expanding their accessibility and analytical potential (Chen et al., 2025; Shehata et al., 2024).

Recent studies emphasize that this shift is not merely technical but structural, as cultural heritage collections are now embedded within broader research and information ecosystems. In this context, heritage institutions are evolving from custodians of art facts into producers and managers of complex data infrastructures that support interdisciplinary research and computational analysis (Purwati & Hamzah, 2025; Li et al., 2025).

5.1 Heritage as Data

One of the most significant developments in DCH is the conceptualisation of heritage as structured data. Cultural objects are increasingly represented through metadata schemas, semantic frameworks, and digital cataloguing systems, enabling them to be integrated into computational environments and knowledge graphs.

This "collections-as-data" paradigm allows heritage materials to be reused beyond traditional archival functions, supporting advanced applications such as machine learning, digital reconstruction, and large-scale cultural analytics. Recent research highlights that this transformation enhances not only accessibility but also the analytical depth of heritage studies, as cultural datasets become central to interdisciplinary inquiry (Chen et al., 2025).

At the same time, this shift raises critical questions about representation, standardisation, and interpretive bias, as the structuring of heritage data inevitably influences how cultural meaning is encoded and retrieved.

5.2 Integration with Global Systems

Digital cultural heritage systems are increasingly integrated into global data ecosystems**,** enabling cross-domain applications that extend beyond the cultural sector. Heritage data is now linked with urban planning systems, tourism platforms, educational infrastructures, and environmental monitoring frameworks, demonstrating its expanding interdisciplinary relevance.

This integration is largely driven by advancements in interoperability standards and digital infrastructure design, allowing heritage datasets to be shared, combined, and analysed across institutional and national boundaries (Shehata et al., 2024). Such developments contribute to the emergence of scalable and networked heritage ecosystems that operate at both local and global levels.

Table 3: Integration of Digital Heritage within Global Systems

Dimension	Description	Applications	Key Contribution
Data Interoperability	Standardisation of heritage datasets across platforms	Museums, archives, research databases	Enables cross-institutional data sharing
Cross-domain Integration	Linking heritage with external sectors	Urban planning, tourism, education	Expands usability of heritage data
Computational Analysis	Use of AI and big data tools	Pattern recognition, predictive modelling	Enhances analytical capacity
Infrastructure Connectivity	Networked digital systems	Cloud platforms, knowledge graphs	Supports global accessibility

5.3 Communication and Cultural Dissemination

The datafication of heritage has also transformed how cultural knowledge is communicated and disseminated globally. Digital platforms now function as primary channels through which heritage content is shared, interpreted, and experienced by diverse audiences.

Social media, virtual exhibitions, and AI-enhanced platforms enable rapid dissemination of cultural narratives, expanding heritage visibility beyond institutional boundaries. This global circulation of cultural content contributes to increased cultural exchange and public engagement, while also reshaping traditional authority structures in heritage interpretation (Purwati & Hamzah, 2025).

However, this global accessibility introduces challenges related to cultural representation, digital inequality, and information authenticity. As heritage becomes increasingly mediated through digital infrastructures, ensuring ethical communication and culturally sensitive dissemination becomes a central concern in contemporary DCH discourse (Chen et al., 2025; Shehata et al., 2024).

6. Case Study: Reinterpreting the Legacy of Nikola Tesla

The legacy of Nikola Tesla provides a compelling case for understanding how digital cultural heritage transforms historical knowledge into dynamic, participatory systems. His scientific contributions, archival materials, and cultural mythos illustrate the shift from static preservation to networked, data-driven interpretation within contemporary digital heritage environments.

6.1 Traditional Archival Representation

Traditionally, Tesla's legacy has been preserved through physical and institutional archives, including handwritten manuscripts, patent documents, laboratory notes, and museum collections. These materials are typically curated within controlled environments such as libraries and scientific institutions, where interpretive authority is concentrated in expert communities. While this model ensures preservation and scholarly validation, it often limits accessibility and restricts the diversity of interpretations associated with his work (Poulopoulos & Wallace, 2022).

6.2 From Archive to Network

With the rise of digitisation, Tesla's archival materials have been transformed into globally accessible digital resources. This transition enables distributed access to patents, research documents, and historical records, allowing users across different regions to engage with his scientific legacy. In this networked environment, cultural heritage becomes interconnected through data infrastructures rather than isolated institutional repositories. This reflects broader trends in digital transformation, where heritage is increasingly embedded within interconnected digital ecosystems (Omol, 2024; Li et al., 2025).

6.3 Co-Creation and Participatory Narratives

Digital platforms and online communities have further expanded the interpretation of Tesla's legacy through participatory engagement. Enthusiasts, researchers, and educators contribute to discussions, reconstructions, and reinterpretations of his inventions and theories. This process of co-creation reflects a broader shift toward participatory heritage systems, where meaning is collectively produced rather than solely defined by experts. Such collaborative environments align with emerging models of crowdsourced heritage knowledge production and distributed interpretation (Zhang & Dong, 2024; Fenlon et al., 2025).

6.4 Tesla as a "Living Heritage System"

In digital cultural heritage contexts, Tesla's legacy can be understood as a "living system" of knowledge that evolves through continuous interaction between data, users, and technologies. Rather than existing as a fixed historical figure, his contributions are reinterpreted through simulations, visualisations, digital reconstructions, and AI-assisted analyses. This dynamic representation reflects the broader epistemological shift in heritage studies, where knowledge is no longer static but continuously reconstructed within socio-technical environments (Gîrbacia, 2024; Wang & Chen, 2025).

6.5 Challenges: Myth vs Scientific Accuracy

Despite the benefits of digital reinterpretation, Tesla's legacy also highlights significant challenges related to misinformation and epistemic distortion. Digital environments often amplify myths, speculative narratives, and unverified interpretations of his inventions, blurring the boundary between scientific fact and cultural imagination. The increasing role of generative AI further complicates this issue by enabling the production of plausible but potentially inaccurate reconstructions of historical knowledge (Spennemann, 2024a; Spennemann, 2024b). As a result, ensuring authenticity, scholarly validation, and responsible curation becomes essential in maintaining the integrity of digital heritage systems.

7. Future Directions of Digital Cultural Heritage

The future of Digital Cultural Heritage (DCH) is increasingly shaped by the convergence of intelligent systems, immersive technologies, and socially embedded digital infrastructures. As the field continues to evolve, emerging paradigms are redefining not only how heritage is preserved, but also how it is experienced, interpreted, and integrated into everyday life.

7.1 Smart and Adaptive Heritage Systems

Future heritage systems are expected to become increasingly "smart," leveraging artificial intelligence, machine learning, and sensor-based technologies to enable real-time monitoring, predictive conservation, and adaptive content delivery. These systems will move beyond static digital repositories toward dynamic infrastructures capable of responding to environmental changes, user behavior, and contextual data. This aligns with the broader development of smart heritage frameworks that integrate automation and data-driven decision-making (Schnabel & Batchelor, 2026; Shehata et al., 2024).

7.2 Phygital Integration (Physical + Digital)

A key emerging direction is the integration of physical and digital heritage spaces, often described as "phygital" environments. This approach blends tangible cultural artefacts and sites with immersive digital layers, enabling hybrid experiences through augmented reality (AR), virtual reality (VR), and mixed reality (MR). Such integration allows users to interact with heritage in both physical and virtual dimensions, creating continuous and enriched engagement with cultural content (Buragohain et al., 2024; Luther et al., 2023). This shift is redefining how authenticity and presence are experienced in cultural heritage contexts.

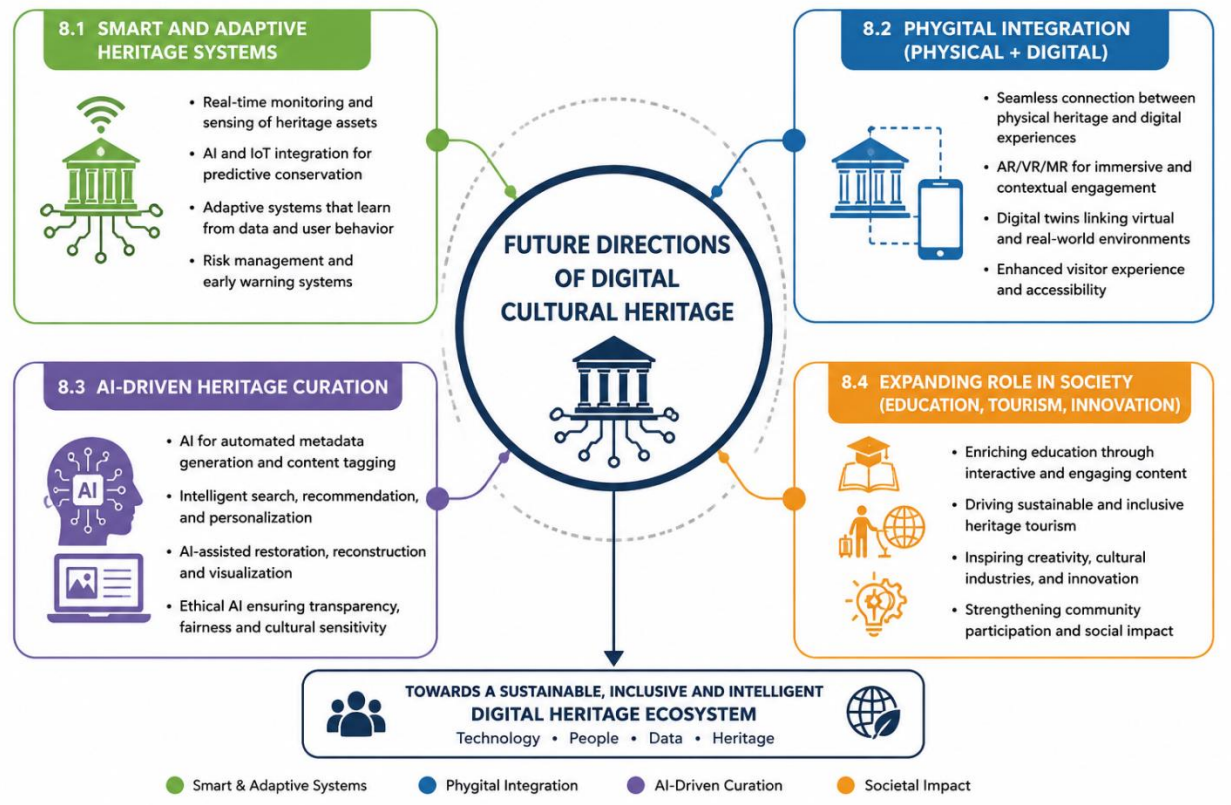
7.3 AI-Driven Heritage Curation

Artificial intelligence is expected to play an increasingly central role in heritage curation. AI systems are being developed to automate classification, restoration, recommendation, and narrative reconstruction of cultural assets. These technologies enable more efficient management of large-scale heritage datasets while also supporting personalized user experiences. However, they also introduce critical concerns regarding interpretive authority, bias, and transparency in cultural representation (Gîrbacia, 2024; Wang & Chen, 2025; Spennemann, 2024).

7.4 Expanding Role in Society (Education, Tourism, Innovation)

Digital cultural heritage is also expanding its societal influence beyond preservation into education, tourism, and innovation ecosystems. In education, immersive heritage platforms support experiential learning and cross-cultural understanding. In tourism, AI-enhanced and XR-based experiences are transforming cultural engagement into interactive journeys that increase accessibility and global participation. Furthermore, heritage data is increasingly being integrated into innovation systems, supporting creative industries, digital economies, and cultural entrepreneurship (Sánchez-Martín et al., 2025; Chen et al., 2025; Purwati & Hamzah, 2025).

Figure 1: Future directions of digital heritage systems



Overall, the future of DCH is characterized by increasing intelligence, interactivity, and integration, positioning cultural heritage as a living and adaptive system embedded within broader technological and societal networks.

8. Conclusion

Digital Cultural Heritage (DCH) has undergone a profound transformation from a preservation-oriented practice focused on digitising cultural artefacts into a dynamic, data-driven, and participatory ecosystem. This evolution reflects the increasing integration of artificial intelligence, immersive technologies, and advanced data infrastructures into heritage systems, fundamentally reshaping how cultural knowledge is created, accessed, and sustained. As highlighted across recent studies, these developments position digital heritage not merely as a repository of information but as an active and continuously evolving knowledge environment (Poulopoulos & Wallace, 2022; Li et al., 2025).

The analysis demonstrates that AI and data-centric systems are now central to cultural heritage processes, enabling automated analysis, restoration, interpretation, and large-scale knowledge organisation. At the same time, immersive technologies such as XR, digital twins, and metaverse environments are redefining user engagement by shifting cultural interaction from passive observation to active participation (Luther et al., 2023; Buragohain et al., 2024). These innovations collectively signal a transition toward "smart heritage" systems that are adaptive, interconnected, and responsive to real-time data (Schnabel & Batchelor, 2026).

However, beyond technological advancement, the most significant shift lies at the epistemological level. Cultural heritage is increasingly understood as a networked and co-created system of knowledge rather than a fixed collection of objects. This shift challenges traditional institutional authority and introduces more pluralistic and participatory forms of meaning-making, where communities actively contribute to heritage interpretation and preservation (Fenlon et al., 2025; Zhang & Dong, 2024).

Within this evolving landscape, the legacy of Nikola Tesla serves as a conceptual illustration of how historical knowledge can be reinterpreted within digital ecosystems. Rather than remaining confined to static archival records, Tesla's contributions can be reimagined as part of a living, participatory heritage system shaped by global digital interaction, reinterpretation, and technological mediation.

In conclusion, digital cultural heritage is transitioning into an intelligent, participatory, and ethically complex domain that integrates technological innovation with cultural interpretation. While these developments offer unprecedented opportunities for access, engagement, and preservation, they also raise critical challenges related to authenticity, governance, and sustainability. Addressing these challenges will be essential to ensuring that digital heritage systems remain both technologically advanced and culturally responsible in the future.

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