Artificial Intelligence in the Museum Experience: Comparative Perspectives from Beijing, Turin, and Harvard

This article examines how artificial intelligence is transforming the contemporary museum from a static repository of objects into a dynamic system of interpretation, participation, and imagination. Through a qualitative comparative analysis of three emblematic case studies from Beijing, Turin, and Cambridge, the study explores how different cultural, political, and epistemological frameworks shape the integration of AI in museological practice. The Beijing case illustrates a state-led infrastructural model in which AI supports large-scale heritage governance and digital sovereignty. The Turin case highlights a participatory and human-centered approach, where AI functions as a mediator aligned with ethical design, community engagement, and sustainability. The Cambridge case, represented by Harvard University's Chinese Art Media Lab, presents an experimental paradigm in which AI operates as a creative and imaginative partner in immersive reconstruction and algorithmic aesthetics. Drawing on digital hermeneutics, phenomenology, and actor-network theory, the article argues that AI acts simultaneously as technological infrastructure and interpretive agent, redistributing authority among curators, visitors, and machines. The intelligent museum thus emerges as a cognitive ecosystem where cultural meaning is co-produced through human–machine collaboration, raising new ethical, epistemological, and aesthetic questions for the future of digital museology.

Keywords: *Artificial Intelligence; Digital Museology; Cultural Heritage; Human Computer Interaction; Immersive Media*

Introduction

The twenty-first-century digital transformation of museums can be used to showcase how societies are reshaping the creation and dissemination of cultural knowledge using computational technologies (Nanetti, Razdi, & Benvenuti, 2021). Artificial intelligence has become a vital element in this process, widening the museum's role from merely storing objects to actively engaging in content interpretation and co-creation of new knowledge. The incorporation of intelligent systems into museum practice alters both institutional logic and visitor experience, introducing new forms of curation, conservation, and narrative interaction (Parry & Dziekan, 2021).

Museums have historically mediated between memory and imagination, between the tangible presence of artifacts and the symbolic frameworks that give them meaning (Hooper Greenhill, 1992; Nanetti, 2021; Murawska-Muthesius & Piotrowski, 2015). With the rise of artificial intelligence, the museum becomes a dynamic network where objects, data, and human experiences interact (Caramiaux, 2023). This transformation reflects what Fiona Cameron describes

as a broader heritage complex, in which digital objects and technologies are embedded within an institutionalized culture of practices and ideas that actively shape value, interpretation, and mediation in museums (Cameron, 2007, p. 51). In 2021, Andrea Nanetti, Zaqeer Razdi, and Davide Benvenuti reviewed the secondary literature in English on the strengths and weaknesses of web-based learning tools in museum systems, as highlighted by the COVID-19 pandemic in 2020 (Nanetti, Razdi, & Benvenuti, 2021).

Artificial intelligence contributes to this evolution by enabling predictive conservation, automated classification, and adaptive storytelling that adjusts to audience behavior (Caramiaux, 2023). The redefinition of the museum through artificial intelligence signifies not only an institutional change but also a philosophical one. The lines between material and digital heritage are blurring as algorithms contribute to the creation of meaning. As Rafael Capurro explains, digital culture necessitates a hermeneutic approach where understanding develops through the interaction between human and artificial intelligences (Capurro, 2010). Museums can therefore be seen as dynamic cognitive ecosystems in which visitors, curators, and intelligent systems collaboratively generate experiences and knowledge.

Our research team compared three notable case studies from different cultural contexts and museographical approaches (Beijing, China; Turin, Italy; and Cambridge, Mass., USA) to demonstrate how artificial intelligence is reshaping the technological, ethical, and epistemological roles of cultural institutions. Each case study embodies a distinct paradigm of technological integration. The Beijing case study illustrates a state-led model in which artificial intelligence serves as cultural infrastructure, integrating heritage preservation with national digital strategies (Peng, 2022). The Turin case study examines the I-Muse project, which embodies a participatory, human-centered model that links artificial intelligence to ethical design, community engagement, and environmental sustainability (Politecnico di Torino, 2023). The Cambridge case study highlights Harvard University's Chinese Art Media Lab (CAMLab), which offers an experimental aesthetic model in which artificial intelligence serves as a creative partner in reconstructing lost cultural experiences through immersive visualization (Kenderdine, 2021).

The comparison of these three models highlights the diversity of approaches to artificial intelligence in museology and the different cultural, political, and ethical assumptions underlying them. It addresses three central research questions. First, how does artificial intelligence reshape the epistemological and ethical dimensions of museums? Second, how do different sociocultural frameworks influence the adoption and interpretation of intelligent technologies? Third, what theoretical paradigms emerge from the comparative study of Eastern, European, and North American experiences? By situating artificial intelligence within the broader field of cultural production, this article aims to develop a critical theory of the intelligent museum. The analysis is rooted in the intersection of media studies, cultural theory, and digital humanities. It argues that integrating artificial intelligence into museology is not merely a technical process but a redefinition of the museum's communicative and cognitive

functions. As Elisa Giaccardi notes, in a participatory culture heritage is less a static collection of artifacts than an ongoing, socially constructed process sustained through repeated interactions among people, places and digital media (Giaccardi, 2012, pp. 1–3).

In this context, artificial intelligence serves as both a medium and a metaphor. It enables museums to extend their reach beyond physical boundaries and to engage audiences in new ways, while also reflecting broader transformations in how societies conceptualize knowledge, memory, and creativity. The comparative perspective adopted here seeks to show that the museum is not only adapting to artificial intelligence but also contributing to its cultural meaning. Through this dialogue between technology and interpretation, the museum becomes a site where human understanding and machine cognition meet in the continuous re-creation of heritage.

Methodology and Theoretical Framework

The methodological structure of this study is based on a qualitative comparative approach that integrates interpretive analysis, critical hermeneutics, and actor-network theory. This study examines how artificial intelligence interacts with institutional, technological, and cultural systems across different national contexts. Instead of measuring the quantitative impact of technology, this research investigates how meaning, participation, and authority are renegotiated through intelligent mediation within museums (Latour, 2005).

Each of our three case studies (Beijing, Turin, and Cambridge) represents a distinct configuration of technology, governance, and cultural ideology. The study adopts a comparative case analysis method that enables the identification of convergences and divergences among these systems, showing how the museum's epistemological role changes under artificial intelligence. The approach is interpretive rather than positivist; it seeks to understand how artificial intelligence and automated systems operate as agents with their own forms of agency, intelligence, and cognition, reshaping the relations between humans and heritage (Cameron, 2021, pp. 3-8).

The first theoretical axis grounding this analysis is digital hermeneutics, which views understanding as an interactive process between human cognition and technological systems (Nanetti, 2023, 30-60). In this framework, artificial intelligence is not a neutral instrument but an interpretive partner that generates and transforms cultural meaning. Rafael Capurro argues that digital hermeneutics requires recognizing the co-agency of technology in the construction of knowledge, since interpretation increasingly occurs through algorithmic mediation (Capurro, 2010). Applied to museology, this means that algorithms, databases, and recommendation systems participate in the creation of historical and aesthetic narratives.

The second axis is actor-network theory, which conceptualizes museums as networks composed of human and nonhuman actors. Curators, visitors, digital interfaces, sensors, and machine learning models all contribute to the

construction of museum discourse. Artificial intelligence, within this perspective, is not external to the museum but part of its communicative and ontological fabric. Latour defines this relational ontology as one in which agency circulates among interconnected entities, dissolving the boundaries between subject and object (Latour, 2005). The museum thus becomes a distributed field of interpretation where knowledge emerges from interaction rather than instruction.

The third theoretical axis is phenomenology of experience, emphasizing that perception is the foundation of understanding. The French phenomenological philosopher Maurice Merleau-Ponty (1908-1961), in his seminal book *Phénoménologie de la perception* (1945), situates meaning in the embodied encounter between the subject and the world (Merleau-Ponty, 2010). Artificial intelligence expands this phenomenological domain by introducing interfaces that sense, respond, and adapt to human presence. In contemporary museums, interactive and socially networked media can shift visitors from passive spectators to active co-creators of meaning and shared experience (Giaccardi, 2012). Through these interactions, visitors no longer passively receive information but can participate in the production of cultural significance.

Our research combined documentary analysis, literature review, and case observation. Primary materials include institutional reports, exhibition records, and policy documents from the museums under examination. Secondary materials include recent peer-reviewed literature in museum studies, digital heritage, and artificial intelligence ethics (Peng, 2022; Zhu & Liu, 2025). These sources provide empirical and theoretical grounding for understanding how intelligent systems reshape conservation, accessibility, and participation in cultural institutions. The integration of these methodologies allows the research to go beyond merely descriptive analysis. By examining technological infrastructures alongside philosophical and social dimensions, the study situates artificial intelligence within a broader cultural framework. This interpretive approach recognizes that technology is never purely instrumental but always embedded in systems of meaning. Artificial intelligence in museums, therefore, functions as both a practical tool and a theoretical challenge, questioning traditional notions of authorship, authenticity, and authority.

Finally, our methodology approach follows a hermeneutic cycle, moving between the particular and the general. Insights from each case study inform the overall theoretical model, which in turn reframes the interpretation of local practices. This cyclical process reflects the mutual shaping of theory and observation. It also aligns with the epistemological assumption that artificial intelligence, as both an analytical and creative agent, modifies not only how museums operate but how they think. The museum, in this framework, is conceptualized as a living system where human interpretation and algorithmic reasoning interact continuously in the co-production of knowledge.

Beijing: Artificial Intelligence as Infrastructure

In Beijing, the application of artificial intelligence to the museum sector reflects a distinctive model in which technological innovation and cultural policy are integrated within a unified state vision. Artificial intelligence has become a structural component of China's cultural modernization, linking the preservation of national heritage to the strategic goal of digital sovereignty. Museums in Beijing thus operate as laboratories for testing the role of intelligent technologies in governance, education, and the formation of social identity (Peng, 2022).

The Chinese government has identified cultural heritage as a key domain for the implementation of artificial intelligence. National programs such as "Digital China" and the "Smart Museum Initiative" promote the use of machine learning, computer vision, and data analytics to manage vast collections and enhance public access. The Palace Museum, the National Museum of China, and the Capital Museum have all experimented with AI-driven tools such as image recognition, 3D modelling and advanced search interfaces to support restoration, cataloguing and interpretation of large collections, in line with broader developments in "smart museum" services in China (Peng, 2022). These initiatives transform the museum into a complex digital infrastructure where algorithms govern not only the classification of artifacts but also the ways in which audiences encounter them.

Artificial intelligence aids preventive conservation by constantly monitoring environmental conditions and detecting micro-deterioration. In collaboration with the Chinese Academy of Cultural Heritage, several Beijing museums have implemented intelligent sensors that gather real-time data on humidity, temperature, and light exposure. The integration of these systems has lowered restoration costs and improved the accuracy of conservation planning (Zhu & Liu, 2025). Through these mechanisms, artificial intelligence enhances the museum's ability to preserve material culture while also creating extensive data archives that contribute to national digital resources. At the same time, the Beijing model demonstrates how artificial intelligence fits within a broader ideological framework. The automation of curation and the personalization of digital experiences are aimed at strengthening the narrative of cultural continuity and national unity. Algorithms not only recommend exhibitions or generate multilingual captions but also shape interpretive hierarchies that align with state-approved historical narratives (Peng, 2022). Artificial intelligence thus functions both as a mechanism of access and as an instrument of cultural governance.

The Palace Museum's intelligent guide services exemplify this duality. In line with wider developments in smart museums, experimental systems combine computer vision, facial recognition, natural language processing and behavioural analytics to tailor information and routes to different visitor profiles, while simultaneously collecting data that can be used to redesign circulation patterns and exhibition layouts. This combination of personalization and surveillance reveals a tension inherent in Beijing's technological paradigm: the museum is both an open educational space and a managed environment of information exchange (Wen & Ma B, 2024).

From a theoretical perspective, the Beijing model demonstrates how artificial intelligence transforms the museum into a cybernetic institution. It aligns with Latour's concept of the networked actor, in which agency is distributed among humans, machines, and institutions (Latour, 2005). The museum's curatorial authority becomes a system of coordination among technical and human actors rather than an expression of individual expertise. Curators rely on predictive algorithms to identify audience interests, while administrators use analytics dashboards to allocate resources and measure engagement. In this environment, artificial intelligence becomes a co-author of cultural interpretation. This infrastructural paradigm has significant implications for accessibility and international collaboration. Online exhibitions powered by artificial intelligence, such as the "Virtual Forbidden City," have attracted millions of visitors worldwide, demonstrating the capacity of Chinese museums to expand cultural influence through digital diplomacy (Zhu & Liu, 2025). The project's immersive environments and AI-driven translation systems enable cross-cultural interaction, while simultaneously projecting a curated image of national heritage consistent with policy objectives.

The strength of the Beijing model lies in its coherence and scale. It mobilizes public institutions, universities, and technology companies in a shared effort to digitize heritage and educate citizens through intelligent media. Its limitation resides in the restricted openness of interpretation, which can reduce the diversity of perspectives and the autonomy of audiences. Artificial intelligence, in this context, reinforces the institutional framework rather than destabilizing it. Nevertheless, the model provides a powerful example of how technology can serve both cultural preservation and state strategy. The Beijing case reveals that artificial intelligence operates as infrastructure, governance, and ideology simultaneously. It integrates technological efficiency with symbolic production, turning the museum into an interface between culture and policy. Understanding this system is essential for evaluating the global future of artificial intelligence in museology, as it highlights both the possibilities of innovation and the risks of centralization. In Beijing, the intelligent museum is not only a site of knowledge but a site of power, where data and heritage converge in the construction of a digital civilization (De Masi, 2025).

Turin: Artificial Intelligence as Mediation

In contrast to Beijing's centralized and policy-driven approach, the Turin model represents a participatory and decentralized vision of how artificial intelligence can transform the museum experience. Italian museology has historically emphasized cultural heritage as a living process that connects communities, education, and place. In this participatory framework, digital technologies are conceived less as instruments of control and more as mediators of meaning within collaborative, human-centred heritage practices (Giaccardi, 2012). The most emblematic example of this approach is the I-Muse project, developed by the *Politecnico di Torino* in collaboration with several regional

museums and cultural organizations. The initiative integrates artificial intelligence and Internet of Things technologies to enhance accessibility, environmental sustainability, and audience participation (Politecnico di Torino, 2023). Through adaptive algorithms, the system analyzes visitor behavior and adjusts narrative content, lighting, and temperature to create a more responsive environment. The approach does not seek to predict or govern human behavior but to establish a dialogical relationship between visitors and space.

The Italian framework aligns closely with the European Union's Ethics Guidelines for Trustworthy Artificial Intelligence, which stress transparency, accountability, and human oversight (European Commission, 2021). These principles shape both the technological architecture and the philosophical foundations of projects like I-Muse. Artificial intelligence is treated as a collaborator in interpretation, assisting curators and educators in organizing content while preserving the human dimension of decision-making. This approach contrasts sharply with models that prioritize efficiency over participation, positioning ethical design as an integral component of digital transformation.

Participation in Turin extends beyond the museum's physical boundaries. Local schools, universities, and cultural associations contribute to the creation of digital materials, ensuring that communities remain active producers of heritage. Workshops and training programs encourage citizens to generate new content and reinterpret existing collections, making the museum a participatory hub of cultural production (Russo, , 2025). This co-creative structure supports what Ross Parry defines as the "distributed museum," a networked ecosystem where authority is shared among institutions, professionals, and the public (Parry, 2010; Parry & Dziekan, 2021). Artificial intelligence also contributes to environmental and operational sustainability. Machine learning algorithms monitor energy consumption, predict maintenance needs, and optimize climate control systems, reducing both costs and ecological impact (Politecnico di Torino, 2023). In this sense, technological innovation becomes part of a broader ecological ethic that connects digital efficiency to environmental awareness. The intelligent museum in Turin thus emerges as a hybrid system in which cultural, social, and ecological sustainability reinforce each other.

A key characteristic of the Turin model is its interdisciplinary collaboration. Engineers, designers, historians, and sociologists work together throughout the design process, ensuring that artificial intelligence applications reflect both technical feasibility and cultural sensitivity. The design process is iterative and participatory, incorporating user and stakeholder feedback, so that digital technologies support an ongoing, reflexive relationship in which heritage institutions learn from their interactions with the public (Giaccardi, 2012). Artificial intelligence becomes not only a tool for personalization but also a mirror that reveals how institutions engage with their communities.

From a theoretical perspective, the Turin model embodies what Rafael Capurro describes as the hermeneutic dimension of digital culture, in which understanding emerges from continuous interpretation between humans and machines (Capurro, 2010). Algorithms in I-Muse do not replace curatorship but

extend it, providing insights into audience engagement that curators reinterpret within broader cultural narratives. This process preserves the interpretive autonomy of human actors while recognizing the analytical power of intelligent systems. The result is a balanced model of co-agency between technology and human creativity. Ethical responsibility remains central to this model. Transparent data management, informed consent, and algorithmic explainability are treated as non-negotiable conditions for technological adoption. These practices reflect a European commitment to cultural democracy and digital citizenship (European Commission, 2021). In Turin, artificial intelligence is not merely a technical innovation but an ethical statement about the values that guide the relationship between culture and technology.

The Turin case demonstrates that artificial intelligence can enrich rather than replace human mediation. Its focus on participation, transparency, and sustainability positions it as a counterpoint to Beijing's infrastructural model. If the Chinese museum represents artificial intelligence as a system of governance, the Italian museum represents it as a space of dialogue. In both cases, technology transforms the relationship between culture and public, but the Turin model shows that such transformation can remain deeply human, inclusive, and ethically grounded.

Cambridge: Artificial Intelligence as Imagination

The case of Cambridge, represented by the Chinese Art Media Lab (CAMLab) at Harvard University, illustrates a third paradigm in the relationship between artificial intelligence and the museum: the paradigm of imagination. Unlike the infrastructural orientation of Beijing or the participatory mediation of Turin, CAMLab approaches artificial intelligence as a philosophical and aesthetic instrument. Here, technology is not limited to management or accessibility but becomes a creative medium for reinterpreting historical consciousness and visual culture (Kenderdine, 2021).

CAMLab’s research explores how digital reconstruction and algorithmic visualization can reanimate lost or fragmented cultural experiences. Projects such as the Cave Dance project and the Embodied Architecture reconstruction of the Shakya Pagoda harness artificial intelligence to synthesize data from mural depictions, archaeological surveys, photographic archives, and art historical documentation. These reconstructions use machine-learning models trained on datasets of Dunhuang mural figures and motion-capture recordings of professional dancers to generate human–computer collaborative choreographies and immersive environments that allow audiences to experience ancient artistic spaces in new ways. The result is not a simple replication of historical reality but a creative translation of it into new sensory and cognitive forms (Cavedance, 2021).

In this framework, artificial intelligence acts as a co-creator. Algorithms analyze patterns of color, motion, and composition to generate plausible reconstructions that extend the interpretive process beyond human limitation.

This collaboration between human imagination and computational inference exemplifies what Kenderdine defines as "algorithmic aesthetics," a mode of artistic production in which data becomes a medium of expression (Kenderdine, 2021). The museum is increasingly conceptualized as a site of simulation and performance, where visitors engage with cultural heritage not as passive spectators but as participants in a process of re-creation.

CAMLab's work is grounded in the philosophy of digital phenomenology, which treats technological mediation as an extension of perception. The immersive installations produced by the laboratory do not aim to reproduce the past but to evoke its experiential essence. Through artificial intelligence, the act of viewing becomes an act of remembering and imagining at once. As Bolter and Grusin argue, digital media function through remediation, continually translating old forms into new interfaces (Bolter & Grusin, 1999). CAMLab's installations exemplify this principle by transforming the archive into an event of presence, where history becomes performative.

The laboratory's interdisciplinary orientation reinforces its theoretical depth. Collaborations among art historians, computer scientists, engineers, and philosophers foster a research environment that bridges humanistic inquiry and technical experimentation. This synthesis embodies what Ross Parry calls the "epistemology of participation," in which knowledge emerges through the interaction between disciplines, tools, and sensibilities (Parry, 2010; Parry & Dziekan, 2021). Artificial intelligence, within this ecology, operates as a cognitive partner that amplifies rather than replaces human creativity.

One of CAMLab's most significant contributions lies in its exploration of AI-driven storytelling. Using natural-language generation and visual synthesis, the lab creates adaptive narratives that evolve in real time based on audience input. These interactive systems can be understood as what Cameron and Kenderdine call "multi-perspectival narratives", in which meaning is not predetermined but dynamically constructed (Cameron & Kenderdine, 2007). The museum thus becomes a dialogical field of interpretation, where visitors negotiate their own understanding through continuous engagement with data and simulation.

The imaginative potential of this model raises critical philosophical questions about authenticity and authorship. Traditional museology associates authenticity with the originality of objects and the authority of curators. In contrast, the AI-driven museum redefines authenticity as a relational quality that emerges through interaction. The German philosopher and media theorist Walter Benjamin (1892-1940), reflecting on the "aura" of the artwork, suggested that technological reproduction diminishes the uniqueness of artworks (Benjamin, 2019). Within the context of artificial intelligence, this same aura can instead be reinterpreted as the affective intensity generated by the digital presence. Authenticity, in this sense, resides not in the object itself but in the network of relations that constitutes its meaning.

CAMLab's projects also engage with ethical and epistemological issues surrounding the simulation of cultural heritage. The use of predictive algorithms to fill gaps in incomplete artifacts raises questions about interpretation and

responsibility that resonate with broader debates on AI-driven restoration and neural rendering in cultural heritage. Rather than treating algorithmic outputs as neutral reconstructions, CAMLab foregrounds the speculative nature of its interventions, emphasizing that any digital restoration or immersive visualization is a reversible, virtual layer added to the historical record. The lab addresses these challenges by maintaining transparency about its methods, documenting datasets, workflows, and aesthetic choices, and explicitly presenting its installations as interpretive experiments rather than definitive restitutions. This reflexivity positions CAMLab's practice within the emerging field of critical digital heritage, which insists on linking technical innovation with accountability, explainability, and respect for the plurality of historical interpretations (Colace, 2025).

The Cambridge model demonstrates that artificial intelligence can expand the museum's ontological boundaries. It shifts attention from the preservation of material objects to the cultivation of experiential knowledge. The integration of immersive environments, data visualization, and interactive storytelling transforms the museum into a space of epistemic experimentation. This aligns with Rafael Capurro's concept of hermeneutic dialogue between human and artificial cognition, where meaning arises from reciprocal interpretation (Capurro, 2010). The museum becomes an arena, in which the past, the present, and the virtual coexist within a single dynamic field of imagination.

In contrast to Beijing's emphasis on infrastructure and Turin's focus on mediation, Cambridge proposes an aesthetic and speculative engagement with artificial intelligence. Its strength lies in the ability to transform data into experience and experience into thought. By integrating art, science, and philosophy, CAMLab articulates a new role for the museum in the digital age: not as a container of memory but as a generator of possible worlds. The laboratory's practice suggests that the future of museology may depend not only on how technology preserves the past but on how it enables humanity to reimagine it.

Comparative Insights and Global Implications

The comparative analysis of Beijing, Turin, and Cambridge reveals that artificial intelligence functions simultaneously as infrastructure, mediation, and imagination. These three models correspond to different configurations of cultural values and institutional priorities; however, they share a common tendency to redefine the museum as a dynamic network of human and nonhuman actors. The convergence of algorithmic systems, sensory environments, and participatory design demonstrates that artificial intelligence is not merely a technological upgrade but reshapes the epistemological foundations of museums and digital heritage (Cameron, 2021).

In Beijing, artificial intelligence operates as a technological and political infrastructure. It embodies the logic of centralized coordination, aligning cultural preservation with national strategy. The emphasis is on scale, efficiency, and the

integration of heritage into the broader framework of digital governance. Algorithms manage vast datasets and construct narrative coherence within a state-defined horizon. This system reinforces cultural identity by synchronizing narratives of heritage with narratives of modernization, producing a museum that exemplifies technological mastery yet remains constrained by institutional hierarchy.

In Turin, artificial intelligence serves as a mediator. It connects technology with ethics, data with community, and innovation with sustainability. The I-Muse project demonstrates that artificial intelligence can operate as a dialogical tool that enhances transparency and inclusion rather than authority (Politecnico di Torino, 2023). This model embodies a European humanistic tradition that prioritizes participation, empathy, and ecological responsibility. It reflects the belief that technology should enrich human experience rather than replace it.

Cambridge, by contrast, represents artificial intelligence as imagination. Through CAMLab's research, the museum becomes a site of creative speculation and philosophical inquiry. Algorithms reconstruct lost cultural experiences, generating immersive encounters that blend historical fidelity with artistic experimentation (Kenderdine, 2021). The Cambridge model thus extends museology beyond preservation toward the creation of new interpretive and sensory realities. Artificial intelligence is redefined as a cognitive collaborator that expands human perception and creativity.

Taken together, the three models outline a comparative topology of digital museology. They demonstrate how artificial intelligence simultaneously supports material conservation, ethical participation, and aesthetic innovation. These dimensions can be mapped onto the technical, interpretive, and existential layers of digital hermeneutics (Capurro, 2010). The technical layer corresponds to Beijing's focus on infrastructure and automation; the interpretive layer corresponds to Turin's participatory mediation; the existential layer corresponds to Cambridge's imaginative exploration of perception and meaning. The intelligent museum thus emerges as a stratified system in which technology, ethics, and art are inseparable.

Despite their differences, the three contexts reveal several shared challenges. One is the question of authenticity. In all cases, artificial intelligence destabilizes traditional notions of originality and authority. Authenticity becomes a relational quality that arises from interaction rather than a property inherent in the object (Benjamin, 2019). Another shared issue is transparency. As intelligent systems mediate interpretation, it becomes necessary to ensure that algorithms remain accountable and comprehensible. The European model has addressed this through public documentation of algorithmic design (European Commission, 2021), whereas in the Chinese model, transparency is subordinated to governance priorities.

A third challenge concerns ethics. The use of artificial intelligence to personalize cultural experience raises questions about surveillance, consent and data ownership. In both China and Europe, cultural institutions face the dilemma of balancing innovation with privacy, especially as AI systems collect and process sensitive behavioural data from visitors (Zhu & Liu, 2025). As Ludovica

Russo noted in a recent essay on AI and museums, initiatives such as Historica imagine AI as an infrastructure for mapping cultural objects, mediating visitor attention and enabling decentralized participation across borders (Russo, 2025).

At the same time, the three models share a common aspiration to democratize culture through digital means. Whether through Beijing's online exhibitions, Turin's participatory networks, or Cambridge's immersive reconstructions, artificial intelligence expands access to knowledge and fosters new forms of intercultural dialogue. Chinese initiatives such as large-scale digitization of the Palace Museum's collections and "Digital Dunhuang" have increased the international visibility of national heritage by making high-resolution images, 3D models, and immersive experiences accessible to global audiences. Similarly, European and North American institutions increasingly collaborate across borders, creating hybrid platforms for shared research, co-curated exhibitions, and online educational programs (State Council Information Office of the People's Republic of China, 2021).

From a theoretical standpoint, the comparison suggests that artificial intelligence is producing a new kind of museological consciousness. The museum is no longer confined to the display of artifacts but extends into a distributed cognitive environment where knowledge is generated through interaction among people, technologies, and institutions (Latour, 2005). This shift requires a rethinking of curatorial authority, which becomes less about control and more about facilitation. Curators now act as mediators between algorithmic systems and human audiences, translating data into meaning and meaning into experience.

The global implications of these transformations are profound. The intelligent museum challenges the traditional separation between technology and culture, revealing that digital infrastructures are not neutral but carry ideological, aesthetic, and ethical dimensions. It also calls for new forms of professional training that combine humanistic sensitivity with computational literacy. As Ross Parry demonstrated, the success of digital heritage depends not only on technological sophistication but also on institutions' capacity to cultivate reflective and inclusive practices (Parry, 2010).

In conclusion, the comparative analysis of Beijing, Turin, and Cambridge illustrates that artificial intelligence is redefining the ontology of the museum. It transforms conservation into prediction, exhibition into interaction, and curation into collaboration. Each model contributes a different dimension to the global evolution of museology: the structural intelligence of Beijing, the ethical intelligence of Turin, and the imaginative intelligence of Cambridge. Together, they outline a new paradigm in which the museum becomes an active participant in the ongoing dialogue between humanity and technology.

The Future of Museums in the AI Era

The integration of artificial intelligence into museum practice marks a decisive shift in the cultural and epistemological functions of these institutions.

The museum is evolving from a repository of memory into an intelligent system that generates, organizes, and communicates knowledge through interactive and adaptive technologies. Artificial intelligence introduces a reflexive dimension in which museums become laboratories for exploring cognition, emotion and collective imagination (Cameron & Kenderdine, 2007; Cameron, 2021).

The future of museums shaped by artificial intelligence will depend on three interrelated dimensions: cognition, participation, and sustainability. In the cognitive dimension, artificial intelligence will act as a collaborator in research and interpretation. Algorithms capable of analyzing visual, textual, and contextual data will assist curators in identifying patterns and connections that were previously invisible. The process of meaning-making will thus become a hybrid dialogue between human interpretation and machine inference (Capurro, 2010). This collaboration will not diminish human creativity; instead, it will expand the interpretive horizon of museums by incorporating computational insights into historical and aesthetic understanding.

The participatory dimension concerns the democratization of cultural experience. Intelligent systems can personalize interaction without erasing collective meaning. Emerging AI techniques such as natural language interaction and adaptive, emotionally aware interfaces can be understood as new tools for making museum communication more responsive, furthering the shift from spectatorship to participatory engagement that Giaccardi associates with social media–driven heritage practices (Giaccardi, 2012). However, this transformation also entails ethical responsibility. As Derda and Predescu argue, the use of artificial intelligence in cultural institutions must remain human-centred, ensuring transparency, inclusivity and accessibility. The success of the intelligent museum will depend on how effectively it balances personalization with public accountability (Derda & Predescu, 2025). The success of the intelligent museum will depend on how effectively it balances personalization with public accountability.

Sustainability will constitute the third and increasingly urgent dimension of future museology. The environmental impact of digital infrastructures and large-scale computation cannot be ignored. Projects such as I-Muse have demonstrated that artificial intelligence can support sustainable management by optimizing energy use and monitoring environmental conditions (Politecnico di Torino, 2023). Future museums will need to adopt “green AI” principles that promote energy efficiency and ethical hardware production while maintaining the creative and educational functions of technology. Sustainability, in this context, refers not only to ecology but also to the long-term cultural and social viability of digital heritage.

The ethical dimension will continue to shape the future of the intelligent museum. The questions of privacy, authorship, and authenticity will require continuous reflection and negotiation. Artificial intelligence challenges conventional notions of authority by redistributing agency among curators, visitors, and machines. It also introduces new forms of authorship in which creative responsibility becomes shared. As Benjamin reminds us, technological reproduction alters the “aura” of the artwork, but in the digital age, this alteration

can lead to new forms of emotional and cognitive engagement (Benjamin, 2019). Authenticity in the intelligent museum will not depend on the originality of objects but on the integrity of the interpretive process that connects them to audiences.

Global collaboration will define the next stage of digital museology. The networked nature of artificial intelligence facilitates exchanges of data, expertise, and creativity among institutions across continents. Transnational initiatives linking China, Europe, and North America are already demonstrating the potential for shared infrastructures that support cross-cultural understanding. Chinese digital heritage projects increasingly participate in international networks, contributing datasets, technical expertise, and immersive content to global platforms for cultural exchange. At the same time, European and North American museums experiment with AI-enabled touring exhibitions, joint digital catalogues, and shared research infrastructures, indicating that the intelligent museum can become a central platform for global cultural dialogue (Hawthorne, 2025).

From a theoretical perspective, the future of museums will require a synthesis between technological rationality and humanistic imagination. Latour's concept of actor networks provides a valuable framework for this synthesis, showing that meaning arises through the interaction of diverse agencies rather than through unilateral control (Latour, 2005). As Ross Parry observes, digital technologies have broadened participation and widened museums' creative horizons, helping to define a new cultural role for museums rather than serving efficiency alone (Parry, 2007, p. xii).

Conclusions

The findings presented in this article suggest that artificial intelligence is not simply being "added" to museums as a new layer of technological enhancement. Rather, it is reconfiguring the museum's epistemic architecture by shifting how cultural knowledge is produced, validated, and experienced. Across Beijing, Turin, and Cambridge, AI appears less as a neutral tool than as an interpretive infrastructure that redistributes agency across institutions, datasets, interfaces, and publics. The museum increasingly operates as a dynamic cognitive ecosystem, where interpretation emerges through relations among human and nonhuman actors rather than through a one-directional transmission of expert knowledge (Latour, 2005; Capurro, 2010). This transformation compels a reframing of digital museology: the decisive issue is not whether AI improves efficiency, but how it reorganizes authority, authenticity, and cultural meaning within the museum field.

The comparative framework developed here clarifies that AI-driven museology is evolving along at least three ideal-typical paradigms: infrastructure, mediation, and imagination. The Beijing model demonstrates the infrastructural paradigm, where AI is integrated into large-scale governance frameworks that connect heritage preservation with national digital strategies. In this context,

intelligence is primarily institutional and cybernetic, expressed through system-wide coordination, predictive conservation, and algorithmic management of access and interpretation. The Turin model illustrates AI as mediation, where intelligent systems are designed to support participation, transparency, and human oversight, aligning technological innovation with social responsibility and sustainability principles (European Commission, 2021; Politecnico di Torino, 2023). The Cambridge case develops AI as imagination, where immersive reconstruction, simulation, and algorithmic aesthetics reposition the museum as a laboratory of possible worlds, extending heritage from preservation toward experiential knowledge and speculative interpretation (Cameron & Kenderdine, 2007; Kenderdine, 2021). Considered together, these paradigms show that the "intelligent museum" is not a single destination but a plural field of institutional choices, shaped by political cultures, ethical norms, and epistemological traditions.

These models also highlight a shared tension around authenticity and interpretive legitimacy. As AI contributes to restoration, narrative adaptation, and immersive simulation, authenticity becomes less a property of the object and more a quality of the interpretive process and its transparency. The museum's authority is increasingly grounded in the credibility of its workflows: the visibility of data provenance, the disclosure of algorithmic assumptions, and the capacity to communicate uncertainty and multiplicity to publics. In this sense, AI does not merely challenge the museum's traditional aura, it displaces the locus of aura from the uniqueness of the artifact to the affective intensity and relational meaning generated by the encounter, whether physical or digital (Benjamin, 2019). This shift can enrich cultural experience, but it also increases institutional responsibility, since algorithmic outputs may harden speculative reconstructions into seemingly "objective" truths if epistemic humility is not structurally built into exhibition design.

Ethics therefore cannot remain an external constraint applied after implementation. The analysis suggests that ethical governance must be treated as part of museological design itself, particularly in relation to personalization, behavioural data collection, and the risk of turning cultural experience into a space of implicit surveillance. Visitor-centred systems can deepen engagement and accessibility, yet they can also introduce asymmetries of power when data ownership, consent, and algorithmic explainability are insufficiently addressed (European Commission, 2021; Derda & Predescu, 2025). This is not only a matter of privacy compliance. It is a question of cultural citizenship: the museum's public mission is undermined if visitors cannot understand how their behaviours are translated into curated pathways, recommendations, or interpretive hierarchies. For this reason, the intelligent museum should be conceived as a pedagogical institution not only about heritage, but also about algorithmic mediation itself, fostering public literacy concerning how AI shapes perception and meaning.

Sustainability further expands the scope of responsibility. The museum sector increasingly faces a dual obligation: to protect heritage while acknowledging the environmental footprint of digital infrastructures. AI-enabled

optimisation of climate control, energy consumption, and maintenance systems indicates real potential for reducing ecological costs, but this potential must be evaluated against the broader material and energetic demands of computation, storage, and hardware cycles (Politecnico di Torino, 2023). The future of digital museology will therefore require a more explicit convergence between ethical AI and green AI principles, in which computational ambition is balanced with ecological accountability. Sustainability should be understood in a comprehensive way that includes environmental impact, institutional resilience, and the long-term integrity of digital heritage preservation.

Several limitations of this study should also be acknowledged. The comparative design, while conceptually productive, is based on a limited number of emblematic cases rather than on a broad quantitative mapping of global practices. In addition, the rapid evolution of generative AI, multimodal interfaces, and immersive infrastructures means that institutional models are likely to change faster than scholarly frameworks. Future research should therefore extend this comparative topology by including additional regions and governance regimes, with particular attention to the Global South, where infrastructural constraints and cultural priorities may generate alternative paradigms of intelligent museology. Further work is also needed on evaluation methods capable of measuring not only usability or satisfaction, but interpretive pluralism, perceived legitimacy, and ethical trust. Longitudinal studies would be especially valuable for understanding how repeated exposure to AI-mediated heritage reshapes learning, memory, and cultural identity over time.

Ultimately, the central implication of this article is that the success of AI in museums will not be determined by the sophistication of algorithms alone. It will depend on the institutional capacity to integrate technological innovation with epistemic transparency, ethical governance, participatory legitimacy, and ecological responsibility. The museum of the AI era can preserve the past while generating new interpretive futures, but only if it treats intelligence as a cultural relation rather than as an automated substitute for human meaning-making. The intelligent museum, in this sense, is best understood as a continuously negotiated interface between memory and prediction, where the renewal of cultural meaning remains the primary criterion of progress.

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