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APPLICATION OF ARTIFICIAL INTELLIGENCE IN CULTURAL HERITAGE CONSERVATION AND DISSEMINATION: A SYSTEMATIC SURVEY

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ABSTRACT

Cultural heritage is one of the major national and collective indicators of identity. It has historical, artistic, and social aspects. Nevertheless, heritage objects are becoming increasingly affected by environmental degradation, climate change, rapid urbanization, and armed conflict which make the need for new and large-scale preservation methods very urgent. Artificial intelligence (AI) in recent years has become a significant facilitator of the heritage conservation, documentation, interpretation, and dissemination processes. This paper details a comprehensive review of current AI deployment in the area of cultural heritage, focusing on the practices of conservation of cultural heritage, archaeological analysis, digital reconstruction, museum engagement, and public dissemination. The review compiles recent scholarly writings on the topic and discusses the implementation of machine learning, deep learning, computer vision, remote sensing, digital twins, and user-centered AI in different heritage contexts. Besides discussing technical aspects, the survey also covers ethical, cultural, and societal aspects (like authenticity, transparency, inclusiveness, and AI governance in heritage practice) which will be critically analyzed, and the arguments for and against AI technologies in preservation practices will be highlighted. By classifying current research into topical and application-based categories, this research points out the dominant methodological practices, the areas of research that need more attention, and new paths for investigation that will soon be opened up. The study results show that AI is no longer a mere technical tool and more and more takes on the role of a socio-technical mediator that influences the interpretation of heritage, the making of decisions, and the engagement of the public. On one hand, AI-

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powered methods present substantial benefits for the documentation, conservation predictions, and access improvements; on the other hand, they come with the problems of explainability, cultural representation, and sustainability over time.

KEYWORDS: Cultural Heritage, Artificial Intelligence, Digital Heritage, Archaeology, Virtual Museums, Ethics, Digital Dissemination.

1. INTRODUCTION

Cultural heritage covers the full range of human past, the most common features being the archaeological sites, the monuments, the artifacts, and the bequest of museum collections. Various factors such as environmental degradation, climate change, political instability, and changes in land use have come together and raised the risk levels for these treasures, thus, the urgency of preserving their economic, ecological, and social value has also been increased (Fiorucci et al., 2020; Sharma, 2025). The need for traditional methods in heritage management still exists but it is mainly due to their inability to predict accurately and thus their incapacity to deal with complex large-scale preservation problems.

The combination of machine learning, computer vision, and data-driven modeling has made it possible to not only perform automated analysis but also to document large amounts of heritage data and interpret them better (Landeschi, 2023; Gîrbacia, 2024). AI applications now extend across multiple domains including archaeological site detection, structural health monitoring, digital reconstruction, museum curation, and public accessibility.

Nevertheless, rapid technological development has not been accompanied by a consolidated body of literature; instead, existing studies remain fragmented across the fields of archaeology, architecture, computer science, and digital humanities. Moreover, a systematic approach is needed to tackle the ethical issues related to cultural misrepresentation, authenticity and algorithmic authority (Tiribelli et al., 2024; Pansoni et al., 2023). The current study provides a comprehensive review of AI applications in the cultural heritage conservation and dissemination area reporting the latest research trends, methodological advances, and future directions. Figure 1 represents the conceptual framework of AI in cultural heritage.

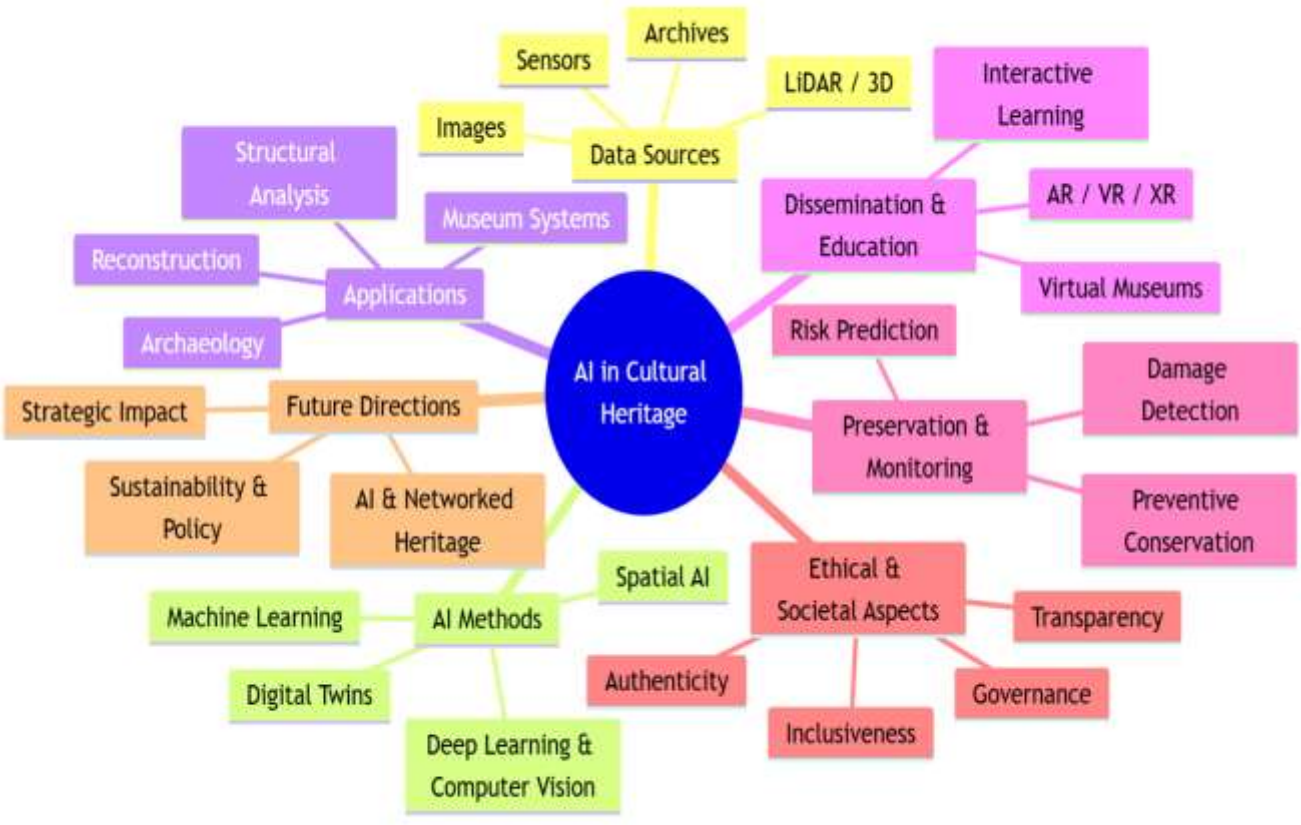

Figure 1: Conceptual Framework of AI in Cultural Heritage.

1.1. Review Methodology

The review period was 2015 to 2025, and peer-reviewed journal articles, conference proceedings, and scholarly books from relevant academic databases such as Scopus, Web of Science, IEEE Xplore, and Google Scholar were selected. The search queries consisted of combinations of such words as

"artificial intelligence," "cultural heritage," "archaeology," "digital reconstruction," "remote sensing," and "museums."

The relevance of selected studies for cultural heritage in the areas of conservation, documentation, interpretation, or dissemination was the main criterion for screening them. The classification of the final corpus according to AI techniques, application domains, and thematic contribution enabled synthesis across domains and detection of research trends and gaps.

1.2. Screening And Selection Process

The primary exploration in Scopus, Web of Science, IEEE Xplore, and Google Scholar resulted in 412 records within the period of 2015 to 2025. Out of these records, 368 remained after the duplicates were removed and were subjected to screening. During the title and abstract screening stage, 247 records were dropped that did not have a direct link to the application of artificial intelligence technologies in cultural heritage conservation, archaeology, digital reconstruction, museums, or dissemination. The complete texts of 121 studies were evaluated for their applicability considering the criteria of relevance, peer-review status, and technical contribution. After this evaluation, 92 studies were chosen to be the final corpus for this systematic survey. This organized workflow is in line with PRISMA-style screening and guarantees transparency and reproducibility of the review process.

Contributions:

1. First, this survey creates a structured taxonomy of the AI techniques that are being used in various cultural heritage documentation, conservation, and also dissemination areas.
2. Second, this paper integrates the disciplines that literally encompass archaeology, architecture, computer science, and digital humanities thus pointing out the methodological trends and research gaps.
3. Finally, this review examines the ethical, societal, and governance issues associated with AI-based heritage practices and outlines pathways toward responsible adoption.

2. DIGITAL TRANSFORMATION OF CULTURAL HERITAGE

The arrival of digital technologies has changed cultural heritage practices, and although they have been used for multiple purposes, the most important ones are high-quality documentation, long-term monitoring, and global access to heritage sites. Heritage sites are recorded very accurately by such methods as photogrammetry, laser scanning, and digital archiving which in the end make AI-based analysis possible (Danesh and Rajabi, 2022; Masciotta et al., 2021).

The use of Digital Twin technology and Building Information Modeling has been highlighted as modern methods in conservation and preventive maintenance strategies of cultural sites (Cotella, 2023; Vuoto et al., 2023). The union of these digital models with geometric, material, and historical data enables AI systems to identify the patterns of deterioration and predict the risk in the future (Mazzetto, 2024). Provenance management and the long-term governance of data infrastructures in the cultural heritage area would benefit from the principles of Industry 6.0, where blockchain, AI, and IoT are being integrated for supports such as traceability, monitoring, and trusted decision-making (Bollimuntha and Baghavathi Priya, 2026). Thus, the passage from simply keeping documents to creating living digital ecosystems has created significant opportunities for AI integration.

2.1. Artificial Intelligence Techniques In Cultural Heritage

2.1.1. Machine Learning And Deep Learning

Machine learning is mainly used for the classification, clustering, and predictive analysis of heritage datasets. Convolutional neural networks have been widely adopted in deep learning models and their performance has been so great for visual pattern recognition tasks that can be artifact classification, material identification, and damage assessment (Fiorucci et al., 2020; Sharma, 2025).

From the year 2015, the number of articles concerning AI in cultural heritage started to grow very steeply and deep-learning-image-processing and data-fusion-techniques were analyzed to be the main research areas according to bibliometric and scientometric evaluations.

2.1.2. Computer Vision and Image Analysis

In the cultural heritage domain, computer vision is the main technology used. Vision-based methods allow for automated feature extraction from images, point clouds, and 3D models, which consequently support tasks such as artifact reconstruction and structural analysis (Cardarelli, 2024; Flagg and Frieder, 2022). Archaeology benefits the most from such processes. Especially in case of archaeology, large areas are often inaccessible or non-invasive methods are preferred, which then means that the archaeological sector is highly dependent on such technologies.

2.1.3. Remote Sensing and Spatial AI

The application of AI in remote sensing has completely changed the methods of archaeological research. The combination of the three types of data - satellite images, aerial photos, and LiDAR data – enable rapid and large-scale mapping of the archaeological sites and landscape features (Argyrou and Agapiou, 2022; Canedo et al., 2024). The growing trend suggests that archaeology is moving from the classic and predictive to the futuristic and space-based approaches, which by the same token, allows the heritage sites to realize their protective measures to be proactive (Luo et al., 2024).

2.1.4. Human-Centered and Explainable AI

The very essence of human-centric AI approaches is to metaphorically point to the humans as the major actors, the main contributors in the process. Subsequently, people will be the ones providing the input, then both the machine and the researchers will be involved and at the end of the process the whole system will be trusted to output human-like results. Such a context is typical of the cultural heritage area where the machine is expected to operate like a human and produce results that would be acceptable by the stakeholders (Pisoni et al., 2021). The combination of new human-machine interaction workflows that lead to both automation and expert judgment being applied in decision-making has been proposed in archaeology as well (Casini et al., 2023).

Renovating the past with the help of AI and discussing its use in archaeology have paved the way for new methodological improvements to take place (Mantovan and Nanni, 2020; Forte and de Castro, 2025). In figure 2, the unique characteristics of AI methods and their primary domains of use in the processes of documentation, analysis, conservation, and interpretation of cultural heritage are shown.

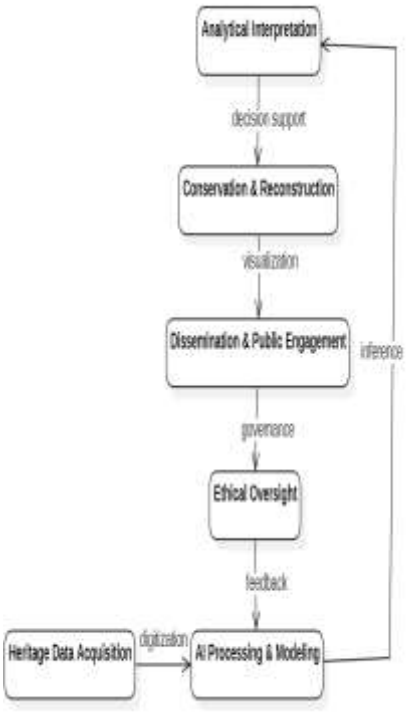

Figure 2: Taxonomy of artificial intelligence techniques and their primary applications across cultural heritage documentation, analysis, conservation, and interpretation.

Besides, the most researched AI techniques applied in cultural heritage studies are summarized in Table 1, together with their respective domains, data sources, contributions, and difficulties. The mapping of AI techniques to essential cultural heritage tasks has been illustrated in Figure 3, where the tasks are documentation, monitoring, reconstruction, and interpretation.

Table 1: Overview Of Artificial Intelligence Techniques, Application Domains, Data Types, And Key Challenges in Cultural Heritage Research.

AI Technique	Primary Application Domains	Typical Data Sources	Key Contributions	Main Challenges
Machine Learning	Preventive conservation, damage monitoring	Sensor data, environmental data, historical records	Predictive analysis, anomaly detection, risk assessment	Limited labelled data, model generalization
Deep Learning & Computer Vision	Artifact analysis, structural damage detection, digital reconstruction	Images, photographs, 3D scans, point clouds	Automated feature extraction, high-accuracy visual analysis	Data-intensive training, interpretability
Remote Sensing & Spatial AI	Archaeological site detection, landscape analysis	Satellite imagery, aerial imagery, LiDAR	Large-scale site discovery, non-invasive analysis	Resolution constraints, false positives

Digital Twins	Conservation planning, monitoring, visualization	HBIM models, sensor data, historical documentation	Dynamic simulation, predictive maintenance	High computational cost, data integration complexity
Human-Centered & Explainable AI	Decision support, heritage governance, interpretation	Multimodal heritage datasets	Transparency, trust, expert–AI collaboration	Balancing accuracy and explainability

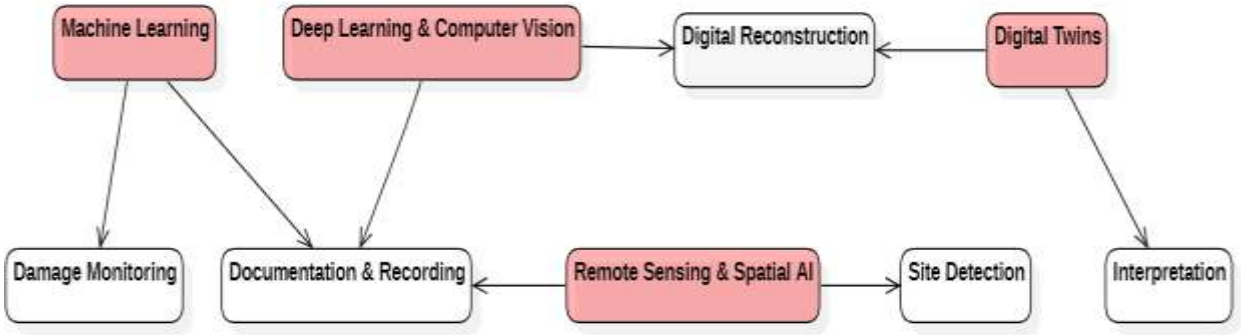

Figure 3: Mapping of functional artificial intelligence techniques to the major cultural heritage tasks, such as documentation, damage monitoring, site detection, digital reconstruction, and interpretative support.

The combination of Figures 2 and 3 along with Table I presents a thorough analytical approach to the alignment of artificial intelligence techniques with various cultural heritage tasks, data modalities, and the methodological challenges they impose.

3. AI APPLICATIONS IN CULTURAL HERITAGE PRESERVATION AND ARCHAEOLOGY

3.1 Preventive Conservation and Monitoring

The environmental conditions and the structural integrity of the heritage sites are being monitored with the help of AI systems which are gaining more and more acceptance in the field. Predictive models are helping to forecast early deterioration signs and to plan maintenance strategies effectively (Gattiglia, 2025; Casillo et al., 2025).

3.2. Archaeological Site Detection and Analysis

AI-powered processes have demonstrated their effectiveness in detection and analysis of sites when processing remote sensing data. By combining machine learning with expert validation, Zeynali et al. (2025) present studies that, on the one hand, show the accuracy and efficiency of this method as compared to traditional survey techniques and, on the other hand, emphasize the importance of interactive interpretation and validation of the algorithms especially when working with difficult cases.

3.3. Reconstruction and Interpretation

Generative AI methods create digital reproductions of fragmented artifacts and ruined structures with the result that academic interpretation happens without the physical presence of intervention (Cardarelli, 2024). This type of work not only aids in conservation research but also enhances the public perception through visualization of virtual art.

3.4. Cross-Domain Challenges and Integration Issues in AI-Based Heritage Preservation

The application of AI technologies in the cultural sector and especially in the preservation of cultural heritage has not been without troubles and raised questions. One major area of concern is the rarity and the quality of the heritage-specific data. Cultural heritage datasets are most of the time in different formats, incomplete or not widespread, especially for the sites that are not only endangered but also inaccessible. The lack of annotated data limits the learning and generalization of machine learning and deep learning models that are trained for specific tasks making it a challenge to even apply AI solutions across different heritage contexts and reliably.

A different crucial matter has to do with the incorporation of AI technologies into the existing conservation and archaeological practices. A number of the cultural heritage institutions are still dependent on the traditional ways of documenting the past, and thus the communication between tools that are AI-based on one hand and traditional or

legacy systems on the other hand is quite limited. Furthermore, such issues as data standardization, model compatibility, and the coupling of different sources of data like historical archives, sensor data, and 3D models are among the main challenges that would have to be dealt with while scaling up the implementation. To overcome these issues, a multidisciplinary teamwork comprising of heritage specialists, IT experts, and policy makers is a must.

Moreover, reliability and interpretability are at the same time seen as drawbacks in AI-assisted heritage decision-making. Even though the output from AI models can be used for site monitoring and damage assessment, over-reliance especially on automated outputs without expert validation may lead to the misinterpretation of the contexts and hence affect the very foundation of the culture.

Consequently, hybrid human–AI frameworks, wherein domain experts are constantly part of the decision-making process, are being increasingly emphasized to secure trust, accountability, and cultural sensitivity.

On the one hand, the long-term sustainability of AI-based heritage systems is still an unresolved question. Rapidly changing technology could make AI models, software platforms, and digital formats out of date, which would, in turn, endanger the preservation of digital heritage assets. The long-term preservation would necessitate not only continuous updating of the models but also digital infrastructure planning for the long run and policies that will allow the operating of AI-driven heritage ecosystems for a long time.

3.5. AI-Driven Dissemination, Museums, And Education

AI has enabled diverse and innovative approaches for the public to learn about culture and heritage, such as virtual museums, immersive environments, and intelligent user interfaces. Moreover, AI-assisted curation systems and virtual assistants are indeed capable of making more engagement, accessibility, and personalization possible for the visitors (Duguleană et al., 2020; Jo et al., 2022).

Research indicates that AI will take on a larger and larger role in the coming period as it will help with the creation of both virtual and augmented reality museum experiences, thus making education more inclusive and interactive (De Carolis et al., 2023; Li et al., 2024). Digital twins and smart exhibits are other instances of how physical and digital heritage worlds are getting closer to each other (Luther et al., 2023; Shlyakhetko et al., 2025). The earlier research on the subject of intelligent virtual museums, XR-based engagement, and AI-assisted curatorial practices has laid the groundwork for today's dissemination models (Nisiotis and Alboul, 2021).

3.6. Personalisation, Accessibility, and Inclusive Heritage Experiences

AI-driven dissemination systems have already considered personalization and accessibility as the main factors to increase the public engagement with culture in a broader perspective. Algorithms based on recommendations, flexible interfaces, and user modeling are the main technologies that empower museums and digital platforms to provide content customized for each visitor based on their preferences, mental skills, and cultural background. Such personalization not only increases the learning results but also offers more pleasure to the visitors which is especially helpful in big-scale online museum settings.

Accessibility has become an essential aspect of the AI-assisted heritage communication process. AI tools like speech to text, real-time translation, image description, and interaction through different channels have considerably enhanced the access for people who are physically challenged, and those who speak different languages. Such technologies help cultural heritage institutions to achieve their inclusivity objectives because they provide digital heritage content that is accessible at all times and under all conditions, no matter whether the users have physical, sensory, or cognitive limitations. Recent cultural AI frameworks also support the interpretation of intangible heritage like classical dance forms through the use of multiple modes of communication (Veena et al., 2025).

Moreover, AI-enabled dissemination systems encourage co-creation and community-based interpretation of heritage. With the help of the interactive systems, the users can post annotations, stories, and interpretations, thus supporting the diverse representations of cultural identity. The methodology that includes bringing in the audience with the use of technology makes the AI the promoter of cultural dialogue rather than just letting it passively through its dissemination tool function. The combination of AI personalization and user interaction analytics at a large scale can improve digital dissemination but on the condition that the design is fairness-aware to diminish the bias and echo-chamber effects (Nedungadi et al., 2025).

3.7. Intelligent Interaction, Immersive Technologies, and User Engagement

AI has not only improved personalization and accessibility but also has greatly transformed the way the interaction between the user and the cultural heritage content takes place. Intelligent interaction systems are the combination of AI and immersive technologies like virtual reality (VR), augmented reality (AR), and extended reality (XR). They are creating experiential learning environments that users can participate in. Users, for instance, can virtually tour and experience the heritage spaces in a way that they do not need to worry about getting in, the places being too far to go, or causing any damage that might be the reason for them not being able to see the artifacts or places.

Moreover, the AI-powered immersive environment also increased the user interactions through the use of adaptive storytelling and context-aware interaction methods. The machine learning models continually analyze user activity, their trails on the web, and their interactions and accordingly change the depth of the narrative, the complexity of the visuals, and the amount of information provided. This kind of interaction encourages both expert users like academic researchers and teachers, and lay audiences such as kids and the general public, as it is capable of adjusting the content presentation according to the engagement levels of each individual.

Moreover, conversational AI and intelligent virtual agents have started to become more common in digital heritage platforms. These agents will be a user's guide, educator, and interpreter all at the same time. The artificial intelligence-based agents can reply to inquiries, provide explanatory background, and enable the user to learn through practice. The interaction based on dialogue that AI-created agents allow, apart from the usual exhibition texts, results in higher retention of knowledge and user satisfaction in online museum environments.

3.8. Evaluation, Impact Assessment, and Sustainability of AI-Based Dissemination

AI-powered dissemination methods have very great advantages, yet their effectiveness in the long run still needs to be evaluated through systematic evaluation and impact assessment. The qualitative and context-related nature of the cultural heritage experiences makes it difficult, if not impossible, to measure engagement of the audience, learning outcomes, improvements in accessibility, and the extent of cultural inclusivity. Nevertheless, AI analytics tools allow the collection and processing of user interaction data which can then be used for evidence-based assessment through support.

The frameworks for impact assessment are becoming a major force in determining not just the frequency of use and the length of time spent interacting as the only quantitative metrics, but also the likes of user perception, interpretative understanding and cultural sensitivity as qualitative indicators. The institutions are each empowered by AI-assisted feedback analysis, sentiment detection, and behavior modeling when it comes to improving their dissemination strategies in line with educational and societal goals.

Another important aspect to consider in AI based dissemination is sustainability. The digital heritage platforms will call for the revealing of continuous maintenance, software updates, and data preservation strategies among which the operational life of the platform will depend. The swift change in AI technologies causes the risk of obsolescence, especially in the case one is using proprietary platforms or closed data formats. It is for this reason that opening standards, interoperable architectures, and long-term digital preservation policies have increasingly become the norm in the industry as the ways of combating these risks.

In addition, building capacity in institutions is very important for the long-term maintenance of AI-powered dissemination programs. It is very important to train the professionals that deal with cultural heritage in AI literacy, data governance, and ethics because these are the three domains in which smart systems would be responsible and effective. If there are no competent professionals to work with, the advantages of AI-based dissemination will either be underutilized or will not be in line with the goals of the institution.

4. ETHICAL AND SOCIETAL IMPLICATIONS

The use of AI in cultural heritage has raised major ethical issues related to the authenticity of the artifacts, the management of data as well as the representation of various cultures. Moreover, responsible AI deployment in heritage research and documentation would call for very vigorous academic integrity protection mechanisms, and these would include not only the use of AI-based plagiarism detection and identity accountability tools but also the generative AI, which is getting more and more common in scholarly workflows (Baghavathi Priya et al., 2025). The ethical debates surrounding AI in archaeology, for example, highlight the same questions of who is allowed to

interpret the findings and whether or not the process is open to public scrutiny (Arantes, 2025). One of the main challenges of the sustainable management of cultural heritage is that AI should always be the tool that supports the human expert rather than taking over the human expert's role.

The ongoing discourse that questions the ethicality of using AI for creative purposes and in the cultural sector makes it even more essential that the governments come up with the frameworks that are transparent and accountable and the ones in which they operate (Flick and Worrall, 2022).

4.1. Research Gaps and Future Directions

Research efforts have been considerable, yet there remains a list of existing problems. The majority of the literature pays attention to the verification of technical aspects rather than long-term sustainability and policy integration. The unevenness of the geographical distribution of studies is still an issue; the heritage contexts of the developing areas are the least represented (Li, 2024).

The following research topics are recommended for future study:

1. Heritage-specific ethical and explainable AI.
2. Heritage policy and governance integration with AI.
3. Datasets reflecting various cultural narratives and inclusiveness.
4. Heritage digital infrastructures' long-term preservation.

Alongside that, coming studies are to be aimed at the creation of standardized evaluation frameworks for AI applications in the field of cultural heritage that bring together the technical performance metrics and the cultural, ethical, and societal indicators. The lack of a common assessment method restricts the comparison of studies and creates a barrier for the establishment of policies based on the evidence. The introduction of standard benchmarks along with the best-practice guidelines would be a significant contribution to the improvement and reproducibility of research in this specific domain.

5. CONCLUSION

The present systematic review of the literature shows that AI is a decisive factor in the area of cultural heritage conservation and dissemination. Artificial intelligence allows for and opens up to the new, unprecedented ways of doing things, such as large-scale documentation, predicting conservation, and engaging the public in an innovative manner. At the same time, it raises and puts forward ethical and cultural dilemmas. In a way, the synthesis of the latest research serves as a beacon that points to responsible AI adoption in culture as a whole, which in turn is seen as a significant contribution to the science culture development in the digital age. The present survey, however, does not only focus on technical efficiency, but rather it captures the increasing importance of AI as a socio-technical mediator that affects the interpretation, ruling, and public notice of heritage.

To begin with, establishing common benchmark datasets that accurately reflect the different heritage types and cultural backgrounds is a must for the reproducible evaluation and fair comparison of AI models. Second, an evaluation framework that will integrate the technical performance metrics with cultural, ethical, and interpretative indicators is also needed so that AI systems can be judged not only on their accuracy. Lastly, to oversee the eco-friendly use of AI in heritage institutions, there should be tougher and clearer regulations and policies concerning transparency, accountability, long-term maintenance, and building institutional capacity. It will be very essential to confront these challenges to move AI in cultural heritage from being an experimental application to a trustful, policy-oriented practice.

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