ETHICAL DIMENSIONS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN THE FIELD OF CULTURAL HERITAGE

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Abstract

This study aims to systematically analyze the ethical challenges posed by artificial intelligence applications in cultural heritage preservation, interpretation, and transmission, and to propose potential solutions. The research examines the interrelationship between AI technology, cultural heritage ethics, and sustainable preservation practices, revealing tensions between technological advancement and ethical responsibility. Through a systematic literature review of Web of Science, Scopus, and Google Scholar databases, complemented by case analyses of prominent AI cultural heritage projects, the study evaluates ethical dimensions across multiple contexts. The results indicate significant imbalances between technical and ethical aspects in current applications, with critical concerns including data privacy, algorithmic bias, and cultural representation. The study contributes both a comprehensive ethical framework tailored to cultural heritage AI applications and practical guidelines for stakeholders, emphasizing the need to balance technological innovation with ethical imperatives.

Keywords: Ethics; Cultural heritage; Artificial intelligence; Sustainable tourism.

DIMENSÕES ÉTICAS DAS APLICAÇÕES DE INTELIGÊNCIA ARTIFICIAL NO CAMPO DO PATRIMÔNIO CULTURAL

Resumo

Este estudo tem como objetivo analisar sistematicamente os desafios éticos apresentados pelas aplicações de inteligência artificial na preservação, interpretação e transmissão do patrimônio cultural, e propor soluções potenciais. A pesquisa examina a inter-relação entre a tecnologia de IA, a ética do patrimônio cultural e as práticas de preservação sustentável, revelando tensões entre o avanço tecnológico e a responsabilidade ética. Por meio de uma revisão sistemática da literatura nas bases de dados Web of Science, Scopus e Google Scholar, complementada por análises de casos de projetos proeminentes de patrimônio cultural com IA, o estudo avalia dimensões éticas em múltiplos contextos. Os resultados indicam desequilíbrios significativos entre aspectos técnicos e éticos nas aplicações atuais, com preocupações críticas incluindo privacidade de dados, vieses algorítmicos e questões de representação cultural. O estudo contribui tanto para uma estrutura ética abrangente, especificamente adaptada para aplicações de IA em patrimônio cultural, quanto para diretrizes práticas para as partes interessadas, enfatizando a necessidade de equilibrar a inovação tecnológica com os imperativos éticos.

Palavras-chave: Ética; Patrimônio cultural; Inteligência artificial; Turismo sustentável.

DIMENSIONES ÉTICAS DE LAS APLICACIONES DE INTELIGENCIA ARTIFICIAL EN EL CAMPO DEL PATRIMONIO CULTURAL

Resumen

Este estudio tiene como objetivo analizar sistemáticamente los desafíos éticos planteados por las aplicaciones de inteligencia artificial en la preservación, interpretación y transmisión del patrimonio cultural, y proponer soluciones potenciales. La investigación examina la interrelación entre la tecnología de IA, la ética del patrimonio cultural y las prácticas de preservación sostenible, y revela tensiones entre el avance tecnológico y la responsabilidad ética. Mediante una revisión sistemática de la literatura en las bases de datos Web of Science, Scopus y Google Scholar, complementada con el análisis de casos de proyectos prominentes de patrimonio cultural con IA, el estudio evalúa las dimensiones éticas en múltiples contextos. Los resultados indican desequilibrios significativos entre los aspectos técnicos y éticos en las aplicaciones actuales, con preocupaciones críticas que incluyen la privacidad de los datos, los sesgos algorítmicos y las cuestiones de representación cultural. El estudio contribuye tanto con un marco ético integral, específicamente adaptado para aplicaciones de IA en el patrimonio cultural, como con directrices prácticas para las partes interesadas, enfatizando la necesidad de equilibrar la innovación tecnológica con los imperativos éticos.

Palabras clave: Ética; Patrimonio cultural; Inteligencia artificial; Turismo sostenible.

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1 INTRODUCTION

Cultural heritage represents the accumulation of experiences, values, and knowledge transmitted by human societies from the past to the present, serving as a cornerstone of societal resilience. It enables us to understand the values of the past, shape contemporary identity, and ensure cultural continuity for the future. Preserving cultural heritage and passing it on to future generations not only safeguards historical knowledge but also ensures the sustainability of humanity's collective memory.

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Artificial intelligence (AI) and machine learning (ML) - based algorithms provide various opportunities to safeguard, analyze, and share this heritage. These technologies can encode information about cultural heritage, adapt it to user needs, and simulate the consequences of preserving or neglecting specific human experiences. In recent years, artificial intelligence (AI) and machine learning (ML) algorithms have brought transformative changes to the processes of preserving, interpreting, and transmitting cultural heritage to future generations (Capgemini Research Institute, 2020; Gîrbacia, 2024; Fontanella et al., 2020; Yu et al., 2022).

While this transformation highlights the potential of technology in cultural heritage preservation, it also raises significant ethical concerns. Ethics in AI applications aims to ensure not only technical success but also accountability with respect to human rights, cultural diversity, and societal benefit. Upholding ethical principles in cultural heritage preservation is crucial for assessing the impact of technological innovations on local communities, ensuring the accurate representation of cultural values, and maintaining sustainability principles throughout these processes.

Artificial intelligence applications in cultural heritage provoke noteworthy ethical debates. Neglecting ethical principles in data selection and algorithm training can lead to risks such as market-driven decision-making dominating heritage preservation, data privacy violations, and algorithmic biases (Nanetti, 2021; Pansoni et al., 2023; Korobenko et al., 2024; Khan et al., 2022).

Issues such as preserving cultural diversity, protecting the rights of local communities, and addressing digital access inequalities emerge as critical ethical considerations that require careful attention (Manžuch, 2017; Boast, 2011; Garcia-Lara & Bugueño-Cordova, 2023).

Additionally, the digitization of cultural heritage carries the risk that traditional knowledge transmission methods will disappear due to rapid technological advancements. This amplifies the responsibility to preserve humanity's heritage sustainably. An ethical perspective requires approaching the values of different cultures and generations with empathy, ensuring their preservation and transmission in digital formats (Nanetti, 2021).

A review of the literature on the intersection of artificial intelligence and cultural heritage reveals that studies predominantly focus on technical applications, while ethical dimensions are insufficiently addressed (Jobin et al., 2019; Hagendorff, 2020; Ntoutsi et al., 2020; Floridi & Strait, 2021; Korobenko et al., 2024; Tiribelli et al., 2024). For instance, literature frequently emphasizes technical topics such as image processing (Fontanella et al., 2020), 3D modeling (Malinverni et al., 2019), text recognition (Ly et al., 2020), and digital restoration (Cao et al., 2020).

Researchers like Huggett (2021) and Stacchio et al. (2024) highlight the insufficient examination of the ethical aspects of AI applications. Similarly, Khan et al. (2022) and Pansoni et al. (2023) emphasize the need for a systematic evaluation of the ethical implications of artificial intelligence in cultural heritage. An approach that insufficiently addresses ethical principles risks disregarding cultural sensitivities and misrepresenting cultural heritage.

Therefore, it is essential to systematically examine topics such as the impact of AI applications on local communities, their role in cultural diversity, and data privacy. In this regard, the need to thoroughly examine the ethical aspects of AI technologies in cultural heritage is growing, as existing research struggles to bridge gaps. Such an analysis would serve as a key reference for safeguarding and sustainably passing down cultural heritage to future generations.

Although technical and preservation-oriented AI literature has grown rapidly in recent years, ethical reflections within the cultural heritage domain remain fragmented. Prior work has addressed general ethical concerns in AI (Floridi et al., 2018; Jobin et al., 2019), yet few have examined how these concerns manifest uniquely in heritage contexts, where memory, authenticity, and identity are central values. This paper addresses that gap by systematizing ethical dilemmas specific to AI applications in cultural heritage and proposing a structured interpretive framework grounded in both global and regional perspectives.

The originality and contribution of this study to the literature emerge in three key aspects. First, it adopts a systematic literature review to comprehensively address ethical issues in the intersection of artificial intelligence and cultural heritage, evaluating the topic through various case studies. Prominent projects such as *Portrait of Edmond Belamy, The Museum of the Lost, The Last Goodbye*, and *Chauvet: The Dawn of Art* provide concrete examples that illustrate the ethical implications of AI in the cultural heritage domain (Christie's, 2018; Hutson & Fulcher, 2023; Zalewska, 2020; Tanant, 2020).

Second, the study provides comprehensive recommendations on ethical governance and principles. Drawing from the six core ethical principles outlined by Pansoni et al. (2023) - including shared responsibility, cultural preservation, economic inclusivity, the right to be forgotten, dependability, and the emphasis on physical spaces - this study explores their practical implementations and potential ramifications.

Third, the study addresses the legal and regulatory framework for AI applications. It evaluates international standards, including the European Union's AI Act (EU AI Act, 2023) and UNESCO's ethical framework (UNESCO, 2021a, 2021b), within the scope of its analysis.

This study aims to systematically explore the use of artificial intelligence technologies in cultural heritage from an ethical standpoint, highlighting challenges and proposing possible solutions. The research was conducted using a systematic literature review methodology. Articles, conference papers, and institutional reports published in academic databases such as Web of Science, Scopus, and Google Scholar were analyzed.

Additionally, in-depth analyses were performed on selected case studies. The findings of this research aim to serve as a guide for decision-makers, technology developers, and cultural heritage experts in developing and implementing AI applications in cultural heritage.

Ethical frameworks need to be developable and applicable to guide the use of AI in the cultural heritage sector. In doing so, the paper aims to identify specific ethical dilemmas arising from the application of AI in cultural heritage

and propose a set of applicable principles and evaluation criteria to inform responsible design, deployment and governance practices.

The study contributes to the field by (1) critically analyzing the limitations of existing general AI ethics frameworks when applied to cultural heritage, (2) integrating Latin American scholarly perspectives into this discussion, and (3) proposing a contextualized evaluative model for institutions working at the intersection of AI, ethics, and heritage preservation. The study's outcomes are expected to provide an ethical framework for future research and applications in this field.

2 METHODOLOGY

This study employs a qualitative, exploratory approach, combining a systematic literature review with selected case analyses to examine the ethical dimensions of artificial intelligence (AI) applications in cultural heritage. The primary objective of this methodology is to synthesize fragmented insights, identify thematic ethical challenges, and propose a structured framework for future ethical governance in heritage-related AI deployments.

To ensure methodological rigor and transparency, a systematic literature review was conducted across major academic databases, including Scopus, Web of Science, Google Scholar, and SciELO. Boolean logic – a method of structuring search queries using logical operators such as AND, OR, and NOT – was used to combine key search terms and refine the scope of the literature search.

The following search strings were applied: "artificial intelligence" AND "cultural heritage" AND "ethics"; "AI" AND "ethics" AND "heritage preservation"; "machine learning" AND "tourism" AND "Latin America"; "artificial intelligence" AND "tourism" AND "cultural ethics"; "AI" AND "museum" AND "bias"; "digital heritage" AND "ethical challenges" AND "Latin America".

The search covered the publication period from 2010 to 2024, focusing on peer-reviewed journal articles, institutional reports, and relevant conference proceedings.
The inclusion criteria required sources to (1) directly address AI applications in cultural heritage or tourism contexts; (2) present or discuss ethical implications explicitly. Studies that were exclusively technical, lacking ethical engagement, or unrelated to cultural domains were excluded.

This review led to the identification of key analytical categories, such as privacy, algorithmic bias, authenticity, governance principles, and transparency. The findings were interpreted through a qualitative thematic synthesis, aiming not at generalization but at conceptual clarity and theoretical insight.

It is important to note that the case studies cited in the analysis represent a selective subset of AI applications and serve to illustrate, rather than statistically validate, the ethical dilemmas in context. As such, caution is warranted when extrapolating conclusions to different sociotechnical or cultural settings. Nonetheless, the combination of systematic review procedures and illustrative case-based insights provides a coherent and context-sensitive foundation for reflecting on the ethical implications of AI in cultural heritage.

3 THEORETICAL REVIEW

3.1 Artificial Intelligence Applications in Cultural Heritage

Artificial intelligence (AI) applications in cultural heritage have brought significant transformations and facilitated various tasks in this domain. AI methods have been extensively used to uncover, analyze, categorize, and safeguard cultural heritage (Gîrbacia, 2024). In this context, applications such as artifact identification using convolutional neural networks (CNNs), segmentation of historical building point clouds, and classification of ancient coins have been developed. CNNs, in particular, have proven highly effective in areas such as image completion, art style classification, and video restoration (Fontanella et al., 2020).

Optical Character Recognition (OCR) methods are widely used in the digitization of historical documents. For instance, deep learning-based encoder-decoder models have been developed for text recognition in historical Japanese documents (Ly et al., 2020). Domingo and Casacuberta (2020) utilized neural machine translation (NMT) to translate historical documents into modern languages. Tested through both automated and human evaluations, the system enhances the accessibility and comprehensibility of historical texts.

AI is used to automate the classification and cataloging of cultural heritage assets. Deep neural networks (CNNs) have been particularly effective at achieving high accuracy in classifying cultural heritage images. For instance, GlyphNet, developed for the classification of ancient Egyptian hieroglyphs, outperformed other CNN models in terms of performance (Barucci et al., 2021). Computer vision techniques have also been successfully applied in areas such as damage detection in historical structures, surface modeling, and segmentation of mosaic images. For example, the YOLOv4 algorithm has proven effective in identifying various types of damage to historical buildings (Yang et al., 2023).

Photogrammetry and artificial intelligence are employed in creating three-dimensional models of historical artifacts and sites. Models such as PointNet++ have demonstrated effectiveness in classifying and segmenting 3D point clouds. Furthermore, studies utilizing Mask R-CNN have improved the efficiency and accuracy of the photogrammetric modeling process (Malinverni et al., 2019; Wenyuan et al., 2022).

Machine learning techniques are also used to preserve dance, music, and traditional games. For instance, CNNs have been applied to classify movements in traditional Greek dances, yielding successful results. Additionally, frameworks such as MAGIS (Multimedia Adaptive Geo-referenced Information System) incorporate natural language processing (NLP) techniques to link semantic content to geographic maps (Fugini et al., 2022).

Casillo et al. (2021) developed a content-based recommendation system for promoting Italian cultural heritage, leveraging the Singular Value Decomposition (SVD) algorithm. By analyzing user preferences and contextual factors, the system presents cultural sites through digital storytelling. It features a three-layer structure

encompassing data collection, elaboration, and presentation, achieving superior results in rating prediction compared to previous methods.

Platforms that integrate big data and virtual systems are also used to support the preservation of cultural heritage and to enhance related skills. For instance, a study on Huaer music in Northwest China used machine learning algorithms for data mining and proposed new methods to sustain this musical tradition (Huang & Song, 2022). Deep learning models employed at the Mogao Caves in Dunhuang, China, facilitate the digital restoration of artifacts, while object detection systems simplify archaeological analyses.

Virtual restoration methods prevent physical damage, and style transfer applications bridge cultural heritage with modern society (Yu et al., 2022). AI offers significant opportunities for the preservation and accessibility of cultural heritage. For example, Cao et al. (2020) explored the use of generative adversarial networks (GANs) in the restoration of ancient artifacts, while Wang (2022) analyzed the role of AI in the preservation of traditional cultural heritage.

In Brazil, the historic center of São Luís - a UNESCO World Heritage Site-has undergone significant transformations through urban and tourism policies. Santos et al. (2022) document how heritage squares such as João Lisboa and Largo do Carmo have been reshaped by tourism-driven urban interventions that redefine both the landscape and its socio-cultural functions. These transformations illustrate how heritage can be commodified or revitalized through strategic planning, raising crucial ethical questions about the balance between preservation, access, and modernization.

Another significant aspect of AI applications is the virtualization of archaeological excavation processes. Virtual reality technology enables the detailed and multilayered modelling of excavation sites. Additionally, advanced image processing techniques can be employed to restore and analyze cultural objects (Lu et al., 2018; Hassabis, 2017).

In recent years, haptic (tactile) interfaces have become increasingly prevalent in museums. These technologies provide visually impaired visitors with opportunities to experience objects and navigate within the museum. For instance, *the London Science Museum* designed a multisensory experience to explain cosmological concepts, which proved successful. Similarly, *the Pure Form Museum* project allowed visitors to touch sculptures using exoskeletons and haptic interfaces (Trotta et al., 2020; Coelho et al., 2020).

This section highlights the transformative impact of artificial intelligence technologies on the preservation, promotion, and accessibility of cultural heritage. AI technologies not only address technical challenges but also play a crucial role in making cultural heritage more accessible and meaningful to broader audiences. However, it is emphasized that the ethical, cultural, and social dimensions of these technologies must be carefully considered.

Technological innovations should not only be utilized for preserving and promoting heritage but also for creating more meaningful experiences by connecting societies with their past. In conclusion, while AI applications offer innovative opportunities for cultural heritage preservation, their ethical, social, and societal impacts must be carefully addressed.

3.2 Ethical Challenges in Preserving Cultural Heritage with Artificial Intelligence

Artificial intelligence (AI) offers unique opportunities in the fields of cultural heritage (CH) and creative industries (CI) by transforming processes of digitization, analysis, and preservation. Neural Rendering (NR) techniques enable the reconstruction of lost or difficult-to-preserve artifacts by creating 3D models from 2D images (Stacchio et al., 2024). However, the use of these technologies raises a range of ethical issues, particularly in the context of UNESCO-protected assets and intellectual property rights. Questions concerning authenticity and ownership of digital assets emerge during the creation of digital replicas using NR (European Commission, 2020; UNESCO, 2021a).

One primary area of concern is the reliance of these technologies on intensive data collection processes. The gathering of users' biometric, behavioral, and cognitive information poses substantial risks concerning privacy and data protection. For instance, when AI and extended reality technologies are used to create cultural heritage experiences, tracking users' eye movements or facial expressions raises serious privacy concerns.

Ensuring the ethical use of AI and extended reality in this context requires transparency and robust data management policies regarding how user data is collected, stored, and utilized. Moreover, these technologies have the potential to exacerbate access inequalities. Individuals without access to adequate financial or technological infrastructure may be excluded from these innovative experiences, contradicting the principle of democratic access to cultural heritage.

Additionally, ethical risks such as manipulative advertising and the dissemination of misinformation should be considered when applying AI and extended reality in the cultural heritage domain (Kourtesis, 2024). Among the most prevalent ethical concerns in the field of cultural heritage are algorithmic discrimination and biases. For instance, models used to analyze cultural data may focus exclusively on the history or heritage of certain groups, thereby marginalizing others. In this context, ensuring diversity and inclusivity in the datasets used to train algorithms is an ethical imperative (Hagendorff, 2019; Daly et al., 2019).

Cultural and historical biases pose a significant risk in the training data used for AI models. This issue is particularly concerning when documenting and interpreting artifacts representing the history of local communities or minorities. For example, metadata schemas developed from a Western-centric perspective risk misinterpreting or failing to adequately represent minority cultural heritage. Additionally, a top-down approach to digitization that neglects the needs and values of local communities may lead to neo-colonialist practices (Manžuch, 2017; Boast, 2011).

Attributing responsibility presents challenges in determining accountability for outcomes generated by algorithms used in AI decision-making processes. The question of whether algorithms can be considered ethical agents or if full responsibility lies with programmers and users remains a topic of debate. In this context, it is emphasized that AI must adhere to principles of transparency and explainability (Huggett, 2021).

High economic investment poses a significant barrier to the implementation of AI technologies. Public-private partnerships often influence content selection and analysis, raising concerns that the priorities of financial stakeholders could shape the process. Additionally, restricting digitized content to paid access risks undermining the principle of public benefit (Pansoni et al., 2023; Manžuch, 2017).

The capacity of AI to enhance digital records through techniques like super-resolution and color prediction improves the quality of visual content but raises questions about how much of the original material is preserved in the digitization process. Additionally, the reinterpretation of indigenous cultural heritage through AI models and generative algorithms carries the risk of cultural appropriation.

In this process, it is crucial to seek input from the communities to which the material belongs and ensure that cultural values are used within an ethical framework. Furthermore, when disseminating newly created works, it is essential to protect the rights of these communities. It is emphasized that original artifacts and new products derived from them should not be seen solely as individual creations but as "co-creations" formed with AI's contribution (Garcia-Lara & Bugueño-Cordova, 2023).

Black box systems, where the processes behind algorithmic outcomes are not fully understood, can lead to ethical concerns and societal distrust (Quinn et al., 2021). The lack of transparency in these systems undermines users' and decision-makers' confidence in the results and makes it challenging to assess their accuracy. In sensitive domains such as cultural heritage, failure to disclose the datasets or analysis methods used can result in the misrepresentation or exclusion of certain communities (Ferretti et al., 2018; Abràmoff et al., 2020).

An ethical framework advocates documenting data sources and making algorithms explainable to ensure transparency and accountability. It also emphasizes the importance of promoting cultural diversity in training datasets to achieve unbiased outcomes and encourages the development of more efficient models to support energy conservation (European Commission, 2020; Pansoni et al., 2023).

The literature has explored the major ethical issues arising from the implementation of AI technologies in cultural heritage from multiple perspectives. Nakonieczna and Szczepanski (2024) define authenticity as a "transient phenomenon," while Reshetnikov (2022) explores the difficulties in the automated interpretation of artworks. Whaanga et al. (2015) emphasize the ethical sensitivities surrounding the digitization of indigenous communities' cultural heritage, and Asakawa et al. (2018) discuss issues related to accessibility. Researchers such as Flynn (2020) and Craig (2022) highlight the challenges AI poses for copyright and creativity.

Table 1. Critical Points in the Integration of Artificial Intelligence and Cultural Heritage

Category	Challenges	Solution Suggestions	Stakeholders
Ethical Challenges	Data Privacy Algorithmic Biases Access Inequality Cultural Appropriation Copyrights	Transparent Data Management Policies Inclusive Datasets Open Access Principles Licensing Frameworks	Users Local Communities Researchers Cultural Institutions
Technical Challenges	Black-Box Systems Infrastructure Requirements Data Quality Neural Rendering Challenges	Explainable AI Systems Technological Infrastructure Investments Quality Standards Enhanced Algorithms	Technology Developers Engineers IT Specialists System Administrators
Economic Challenges	High Costs Sustainability Funding Challenges Resource Allocation	Public-Private Partnerships Sustainable Business Models Funding Programs Cost Optimization	Investors Fund Providers Public Institutions Private Sector
Legal Challenges	Intellectual Property Rights Accountability Attribution Data Protection Regulations International Standards	Legal Framework Development Regulatory Policies International Collaborations Standard Protocols	Lawyers Policymakers Regulatory Bodies UNESCO
Social and Cultural Challenges	Social Acceptance Cultural Representation Digital Divide Traditional Values	Community Engagement Cultural Dialogue Educational Programs Cultural Sensitivity	Community Members Cultural Experts Educators Non-Governmental Organizations (NGOs)
Methodological Challenges	Lack of Standardization Evaluation Criteria Quality Control Certification	Methodology Development Quality Standards Monitoring Systems Best Practice Examples	Academics Research Institutions Experts

Source: Table edited by the authors.

Ethical considerations in the AI industry are not yet sufficiently widespread, and applicable tools, methods, or standards are lacking. This gap makes it difficult to address ethical values systematically. Moreover, applying AI in critical domains such as cultural heritage necessitates further research and regulation on the societal effects of these systems. AI applications should encourage collaboration with local communities in this process and ensure they have a say in how their heritage is utilized. Such ethical approaches

support the view of technology as an opportunity rather than a threat for local communities (Khan et al., 2022; Rahwan et al., 2019).

This section highlights that the use of artificial intelligence (AI) technologies in sensitive areas, such as cultural heritage, carries significant risks due to the lack of established ethical knowledge and standards. The societal impacts of AI applications have not been sufficiently studied, and regulations have yet to reach an adequate level to manage these impacts. Additionally, the importance of involving local communities in these processes is emphasized.

Consequently, it can be inferred that further research, regulation, and local participation are required for the ethical management of AI, and that these efforts form the foundation for the reliable preservation of cultural heritage and the generation of societal benefits. Setting ethical guidelines and devising effective methodologies are crucial for promoting the responsible application of technology in these critical domains.

3.3 Ethical Management and Principles in Artificial Intelligence Applications in Cultural Heritage

The ethical aspects of AI applications in cultural heritage are primarily examined in terms of data privacy, human rights, bias, and security. Research highlights the critical importance of adhering to ethical principles during the data collection and processing stages of AI system development to protect human rights and security (Korobenko et al., 2024). In this regard, regulations like the European Union's *AI Act* seek to enforce ethical compliance by classifying AI systems according to their risk levels (EU AI Act, 2023).

In recent years, the impact of artificial intelligence technologies on culture, art, and ethics has become a significant focus of academic studies and international organizations. Huggett (2021) discusses the issue of accountability for decisions made by AI systems, while Epstein et al. (2023) examine the impact of generative AI in the field of art. Ocón (2021) addresses the potential threats posed by digitalization to the physical presence of cultural heritage. International documents such as UNESCO's (2021b) recommendations on AI ethics and the European Commission's ethical guidelines for trustworthy AI aim to establish an ethical framework in this area.

UNESCO's (2021b) recommendations emphasize the principle of accountability, highlighting the need for oversight, impact assessment, and verification mechanisms in AI systems. Additionally, it aims to contribute to creating more just and equitable societies, alongside preserving the environment, natural ecosystems, and biodiversity from a sustainability perspective. Another key emphasis of UNESCO (2021b) is on diversity and non-discrimination. In this context, it is emphasized that diverse cultural perspectives should be represented and that inclusive approaches should be adopted.

The European Commission's guidelines focus on the principle of explainability, emphasizing that decisions made by AI systems should be transparent and understandable even to non-technical users. These guidelines also highlight the importance of human oversight and control, as well as the necessity of incorporating expert opinions into the processes.

Within the framework of justice and equality, the aim is for systems to provide fair and equitable services while preventing economic and social inequalities. It is specifically noted that issues related to cultural heritage, such as authenticity, dignity, shared responsibility, and meaningful participation, do not fully align with existing ethical frameworks, indicating a need for specific regulations in this area (Tiribelli et al., 2024).

According to Alves (2010), the expansion of digital technologies and cultural consumption raised ethical concerns about homogenization and cultural standardization. In this context, AI applications in cultural heritage should align with UNESCO's normative instruments, which not only protect traditional cultural expressions but also advocate for technologies that foster, rather than erase, cultural diversity.

In designing AI-driven heritage experiences, it is essential to reflect on the ethical dimensions identified in tourism contexts. For example, Brazilian research has shown that tourists perceive ethical tourism as one rooted in justice, truth, solidarity, and mutual respect (Gomes & Magalhães, 2013). These same principles can inform the development of AI applications that shape digital interactions with cultural heritage.

Pansoni et al. (2023) outline six core ethical principles for governing AI usage: collective responsibility, cultural preservation, economic accessibility, the right to be forgotten, dependability, and the significance of physical space. These principles are designed to ensure that AI follows a human-centred and community-oriented approach in safeguarding cultural heritage. In particular, potential dangers such as data manipulation or misuse could undermine the economic and cultural value of heritage (Haque et al., 2023).

One of the principles identified by Pansoni et al. (2023), namely the right to be forgotten, raises particular tension within the field of cultural heritage. While this right is generally invoked to protect individual privacy by allowing data deletion, heritage institutions are, by nature, devoted to preserving collective memory. In this context, the uncritical application of this principle may conflict with goals such as documentation, historical transparency, and intergenerational transmission of knowledge.

However, reinterpretation is possible. Rather than deletion, responsible AI practices may include limiting algorithmic amplification, anonymizing sensitive information, or providing contextual framing for contentious data. Thus, in cultural heritage, the right to be forgotten becomes a question of how to ethically preserve memory without causing harm–suggesting that contextual safeguards, rather than erasure, may be the more ethical solution.

Applications of AI in cultural heritage have been analyzed using fundamental ethical principles, including transparency, accountability, justice, sustainability, and reliability. For example, transparency emphasizes that the processes and outcomes of AI systems should be explainable (Jobin et al., 2019). Justice and impartiality involve ensuring the representation of cultural diversity and minorities in natural language processing applications.

Biases in training data may lead to the systematic exclusion of certain cultures (UNESCO, 2021b).

Sustainability requires considering the high energy consumption and environmental impact of natural language processing techniques. In this context, the use of energy-efficient algorithms is recommended (Anthony et al., 2020).

For the ethical management of AI, it is recommended that developers adhere to ethical principles during system design. The literature emphasizes that ethical evaluation should be conducted at every stage of the system lifecycle (Saltz & Dewar, 2019). Particularly in cultural heritage projects, given the unique and sensitive nature of the data used, special precautions should be taken during data collection and use (Ntoutsi et al., 2020).

One proposed method for reducing ethical issues is independent auditing of systems. For example, the SMACTR framework provides guidance for conducting ethical audits at every stage, from system design through deployment and monitoring (Raji et al., 2020). Additionally, the "Glass-Box" approach is a method for translating ethical values into design requirements and assessing how well these requirements are met within the system (Tubella et al., 2019).

For the more responsible implementation of AI systems from an ethical perspective, it is recommended to develop methods that incorporate the views of actors from different segments of society, particularly in the context of cultural heritage. In this regard, methods such as ethical foresight analysis can support broader participation and informed decision-making processes (Floridi & Strait, 2021).

The application of AI in cultural heritage projects is emphasized as attainable through effective data management and algorithmic transparency. Practices such as data anonymization, obtaining user consent, and reducing algorithmic biases are essential in this context (Ashok et al., 2022). Integrating AI ethical principles into cultural heritage projects involves not only addressing technical requirements but also preserving cultural values and ensuring that AI systems align with societal norms (Huang et al., 2023). In this regard, it is critical for developers and decision-makers to take responsibility, guided by ethical principles, to maximize societal benefits and minimize potential harms (Bubinger & Dinneen, 2021).

From this section, it can be inferred that ethical management and principles establish a fundamental framework for guiding AI applications in cultural heritage. This framework (Table 2) aims to ensure that technology is applied in a socially aligned, transparent, and accountable manner. It highlights the vital importance of ethical approaches in AI projects and underscores that these principles form the foundation for sustainable heritage management.

Furthermore, it becomes clear that the ethical use of AI technologies in cultural heritage is not solely about technical success but also about embracing societal responsibility, preserving cultural values, and adhering to ethical principles. Measures such as effective data management, algorithmic transparency, user consent, and data anonymization are essential to ensuring the secure and fair application of technology.

Table 2. Ethical Framework in the Integration of Cultural Heritage and Artificial Intelligence

Ethical Principles	Application Approaches	Regulatory Framework
Transparency	Glass-Box Approach Independent Audits System Monitoring Mechanisms	UNESCO Recommendations EU AI Act Ethical Guidelines
Accountability	SMACTR Framework Ethical Foresight Analysis Integration of Expert Opinions	Data Protection Laws Audit Mechanisms Accountability Protocols
Justice and Impartiality	Inclusive Datasets Bias Reduction Techniques Community Engagement	Equality Laws Representation Standards Access Policies
Sustainability	Energy-Efficient Algorithms Sustainable Design Long-Term Preservation	Environmental Regulations Energy Standards Preservation Protocols
Reliability	Data Anonymization Security Protocols Quality Control	Security Standards Data Protection Laws Audit Criteria
Cultural Values	Community-Based Approach Cultural Sensitivity Local Participation	Cultural Heritage Laws Ethical Standards Preservation Policies

Source: Table edited by the authors.

3.4 Case Studies and Application Areas

The fair representation of multi-perspective experiences, the prevention of oversimplification of complex situations, and the support of users with varying levels of knowledge emerge as critical issues requiring solutions in the design of Internationalized Domain Names (IDN). Additionally, it is essential to develop designs that enable users to understand the consequences of their actions (Barbara et al., 2021).

Virtual reality projects such as *The Last Goodbye, Nefertari: Journey to Eternity, Chauvet: The Dawn of Art,* and *The Book of Distance* serve as notable examples in this context. These projects stand out for their efforts to enhance users' sense of presence and emotional connection in historical narratives. *The Last Goodbye* aims to recreate Holocaust testimonies in a virtual environment, although the use of a drone-avatar has been noted to weaken users' sense of presence in the space (Zalewska, 2020).

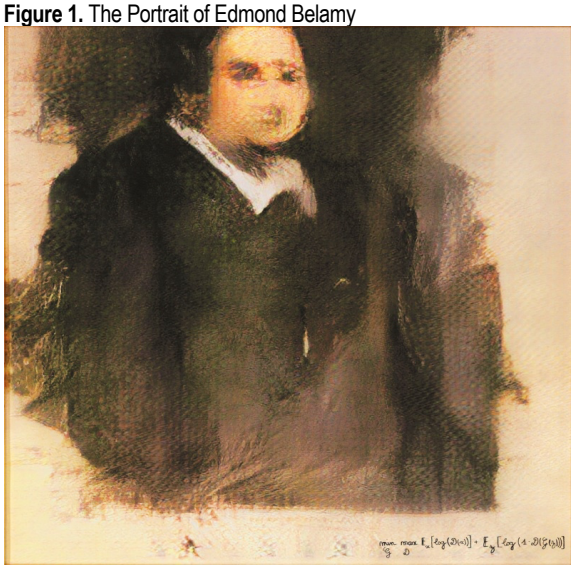
Nefertari: Journey to Eternity offers a detailed virtual experience of ancient Egypt, yet its unnatural teleportation navigation system negatively impacts the overall user experience (Experius & Stream, 2018). *Chauvet: The Dawn of Art* aimed to digitally showcase historical artworks by offering a virtual representation of the Chauvet Cave. However, the project was criticized for its weak spatial navigation system (Tanant, 2020).

In contrast, *The Book of Distance* distinguished itself by allowing users to take an active role in the narrative, giving them the opportunity to experience the consequences of physical actions. Nevertheless, the lack of a fixed player role and the absence of moral choices limited users' ability to form emotional connections with the characters and to develop empathy (Oppenheim & Okita, 2020).

The Portrait of Edmond Belamy case represents a significant event at the intersection of artificial intelligence and art. Produced by the Paris-based Obvious collective through a Generative Adversarial Network (GAN), the artwork was auctioned at Christie's in 2018 for $432,500. This event sparked debates about the originality and creativity of AI in art. The GAN was trained on a dataset of 15,000 classical portraits from the 14th to the 20th century, raising copyright and ethical concerns during the process.

The artwork's lower-right corner features the mathematical formula of the GAN algorithm, leading to perceptions of AI as an *autonomous artist*. However, many critics questioned this notion, citing the use of open-source code and Obvious's intervention in the creation process. This case has initiated a broad discussion on ownership, originality, and the ethical dimensions of AI technologies in art (Christie's, 2018; Cetinic & She, 2022).

Figure 1. The Portrait of Edmond Belamy



Source: Christie's. (2018). Obvious and the interface between art and artificial intelligence. Retrieved from: https://www.christies.com/en/stories/a-collaboration-between-two-artists-one-human-one-a-machine-0cd01f4e232f4279a525a446d60d4cd1

The VR game *The Museum of the Lost*, developed at Lindenwood University, addresses ethical issues related to the preservation of international cultural heritage and the restitution of looted artifacts. The game aims to help participants understand the complex ethical dilemmas faced by museums, individual collectors, governments, and the international community (Hutson & Fulcher, 2023). Moreover, projects like this demonstrate the effectiveness of gamifying ethics education.

The Museum of the Lost not only provides players with historical knowledge but also presents them with challenging ethical decisions about the restitution of looted artifacts. For instance, players must decide whether to sell artifacts on illegal markets, return them to their countries of origin, or leave them in the museums where they are displayed. These decisions offer participants an opportunity to develop their ethical reasoning skills (Sholihin et al., 2020).

In Brazil, VR-supported immersive tourism initiatives have demonstrated this technology's potential to deliver cultural experiences without physical displacement. For example, the Itaipu Binacional Hydroelectric Plant utilizes 360-degree videos and virtual tours to provide educational and emotional engagement through technological mediation (Taufer & Ferreira, 2019). These projects reveal how VR technologies can support cultural dissemination while raising new ethical and experiential considerations.

Ethical dilemmas are not limited to institutional actors; they also arise among individual professionals in training. In a study of tourism students in Southern Brazil, Oliveira (2021) found that over one-third would be willing to act unethically if required to protect a business interest. These findings underline the importance of embedding ethical reasoning within AI applications that mediate cultural heritage experiences - ensuring such systems do not normalize instrumental, profit-oriented decision-making.

In this context, the copyright status of AI-generated artworks has become increasingly complex, particularly ofbecause to the inclusion of third-party content in GAN training datasets. AI-generated works, therefore, require reevaluation from both legal and ethical perspectives. Specifically, careful consideration must be given to who can use such data and the impact of these technologies on different cultural communities (Bekele & Champion, 2019; Cetinic & She, 2022).

These projects highlight the strengths of VR and IDN technologies while also revealing areas for improvement in ethical design. This underscores the need for more effective designs to enable users to establish meaningful connections with cultural heritage experiences. Developing designs that do not require users to have prior knowledge to understand cultural contexts, quickly integrating new discoveries, and respecting traditions while acknowledging modern values are critical. In this framework, the establishment of international standards will contribute to both the preservation of cultural heritage and the provision of ethically responsible experiences (Barbara et al., 2021).

From the case studies presented in this section, it is clear that artificial intelligence and virtual reality technologies bring a new dimension to cultural heritage experiences, but they also exhibit significant shortcomings in ethical design, user experience, and representation. While these projects demonstrate the immense potential of AI and VR technologies, they also reveal that poor design can lead to the loss of cultural meanings, user disengagement, and even misrepresentation of cultural heritage.

In this context, the examples highlight the necessity of a holistic design approach that incorporates cultural sensitivity, user accessibility, and sustainability, rather than focusing solely on technological advancements. Additionally, the cases emphasize the importance of ensuring that cultural heritage experiences are accessible to all user groups and of aligning with international standards throughout the process.

These case studies underscore that the use of technology in the preservation and representation of cultural heritage must be guided by ethical and user-friendly practices. This calls for a more careful and sensitive approach to AI and VR applications, underscoring the importance of responsible and inclusive design in these fields.

4 DISCUSSION AND CONCLUSIONS

This study systematically explores the ethical aspects of AI implementations within cultural heritage. The findings indicate that while AI provides valuable opportunities to safeguard, analyze, and pass down cultural heritage, it also presents notable ethical challenges.

The literature review and case analyses in this study demonstrate that AI applications have yielded effective results, particularly in areas such as image processing, 3D modelling, text recognition, and digital restoration. However, the use of these technologies has also raised ethical issues, including data privacy, algorithmic biases, copyright, and cultural representation. Notable cases such as Portrait of Edmond Belamy and The Museum of the Lost illustrate how the use of AI in art and cultural heritage has sparked new debates regarding originality, ownership, and ethical responsibility.

The findings of this research highlight the need for a comprehensive framework to manage the ethical implications of AI applications. While initiatives such as UNESCO's ethical recommendations and the EU's AI Act provide a valuable starting point, the lack of specific ethical principles tailored to cultural heritage remains evident. Pansoni et al. (2023) highlight principles like shared responsibility, cultural continuity, economic accessibility, the right to be forgotten, reliability, and the importance of physical space, which appear to be inadequately addressed in contemporary practices.

This observation is supported by the studies of Huggett (2021), Khan et al. (2022), and Tiribelli et al. (2024). Similarly, Korobenko et al. (2024) and Stacchio et al. (2024) also emphasize the inadequate implementation of ethical principles in AI applications.

These transformations are not unique to Europe or North America. In Latin America, particularly Brazil, immersive technologies such as Virtual Reality have begun to redefine how cultural heritage is experienced. As Taufer and Ferreira (2019) suggest, VR in tourism is no longer limited to entertainment, but may represent a shift in the tourism paradigm - where presence, movement, and cultural engagement are reinterpreted through digital mediation.

Studies from Latin America, including Oliveira (2021), reinforce that ethical considerations in tourism and cultural heritage are shaped not only by formal codes but also by the personal values and market perceptions of professionals. Therefore, AI systems that are deployed in these sectors must be guided by a nuanced understanding of ethical subjectivity, social responsibility, and institutional transparency.

The reviewed case studies and literature indicate that the increasing use of AI technologies in the cultural heritage sector has amplified threats, including data manipulation, misuse, and the erosion of heritage's economic and cultural value. Additionally, current practices have been found to fall short in addressing the rights of local communities, digital access inequalities, and the preservation of cultural diversity.

This study identifies a recurring duality in the application of AI to cultural heritage: while it holds vast potential to democratize access, enhance preservation, and support interpretation, it simultaneously raises critical ethical concerns-including algorithmic bias, cultural misrepresentation, surveillance, and privacy erosion.

Through a synthesis of the reviewed literature and illustrative case studies, three major insights emerge: (1) a persistent imbalance between technological innovation and ethical foresight; (2) the absence of domain-specific ethical frameworks; and (3) the need for context-sensitive governance mechanisms that incorporate regional, cultural, and institutional diversity.

In conclusion, a significant imbalance between the technical and ethical dimensions of AI applications in the cultural heritage field has been identified, with the ethical framework still underdeveloped. This poses considerable risks to the processes of preserving cultural heritage and passing it on to future generations. One of the key findings of this study is the need to reassess and regulate existing practices in light of ethical principles.

4.1 Synthesis of Findings

The analysis of the literature and case studies revealed a persistent tension between the promises of AI technologies and the ethical risks associated with their deployment in cultural heritage contexts. Three key findings emerged from the synthesis:

A notable imbalance between technical development and ethical deliberation, particularly regarding privacy, algorithmic bias, and cultural authenticity.

The absence of tailored ethical frameworks that reflect the specificities of cultural heritage, including community representation and symbolic value.

The need for context-sensitive governance mechanisms that empower local communities and recognize interpretive diversity.

These findings align with the analytical categories developed in the methodology and support the call for a more robust, inclusive, and dynamic approach to ethical AI governance in the heritage sector.

4.2 Theoretical Contribution

This study systematically examines the ethical aspects of AI technologies in cultural heritage, offering three key theoretical contributions to the literature.

The first theoretical contribution is the holistic examination of ethical issues at the intersection of artificial

intelligence and cultural heritage. In the literature, AI applications in the cultural heritage field have predominantly been analyzed from a technical perspective (Fontanella et al., 2020; Malinverni et al., 2019; Ly et al., 2020; Cao et al., 2020), while ethical dimensions have been addressed in a fragmented and limited manner.

This study aims to fill this gap by systematically addressing ethical issues through comprehensive literature review and case analyses. It provides a thorough response to the need for ethical evaluation emphasized in the works of Huggett (2021), Khan et al. (2022), and Pansoni et al. (2023).

The second theoretical contribution is the reconceptualization of ethical principles in the context of artificial intelligence and cultural heritage. In the existing literature, ethical principles have largely been discussed within the general framework of AI ethics (Jobin et al., 2019; Hagendorff, 2020), without adequately addressing the unique requirements of the cultural heritage domain.

This study provides an original conceptual framework by reinterpreting and expanding upon the six fundamental principles proposed by Pansoni et al. (2023) - shared responsibility, cultural continuity, economic accessibility, the right to be forgotten, reliability, and the centrality of physical space - within the cultural heritage context.

The third theoretical contribution is the analytical examination of the legal and regulatory dimensions of AI applications in the cultural heritage field. In the literature, legal regulations have primarily been addressed in terms of technical standards (EU AI Act, 2023; UNESCO, 2021a, 2021b), with insufficient focus on their connection to ethical considerations.

This study provides a novel perspective by analyzing the relationship between legal frameworks and ethical principles and highlighting their implications for the cultural heritage domain. It offers a systematic response to the need for an integrated legal-ethical framework, as emphasized by Tiribelli et al. (2024) and Korobenko et al. (2024).

These theoretical contributions offer new research directions for future studies in artificial intelligence and cultural heritage, laying the groundwork for a more comprehensive understanding of the subject.

4.3 Practical Contribution

This study offers three key practical contributions to the implementation of AI technologies in cultural heritage.

The first practical contribution is the provision of a concrete evaluation framework for cultural heritage institutions and decision-makers. Detailed analyses of projects such as Portrait of Edmond Belamy, The Museum of the Lost, The Last Goodbye, and Chauvet: The Dawn of Art highlight ethical challenges and potential solutions encountered during the development and implementation of similar projects. These analyses serve as a practical guide for museums, archives, and cultural heritage institutions to assess AI projects.

The second practical contribution is the provision of concrete examples for technology developers and practitioners on implementing ethical principles. By analyzing challenges and successful practices in areas such as data privacy, algorithmic transparency, cultural representation, and accessibility, this study serves as a guiding resource for developers. It particularly offers practical solutions regarding the rights of local communities, digital access inequalities, and the preservation of cultural diversity.

The third practical contribution is the provision of a systematic approach for policymakers and regulatory bodies to evaluate the impact of AI applications in the cultural heritage field. By analyzing the application of frameworks such as UNESCO's ethical guidelines and the EU's AI Act within the cultural heritage domain, the study offers practical recommendations for future regulations. This analysis highlights key considerations that policymakers should address when developing regulations for the use of AI in cultural heritage.

To address concerns of digital neocolonialism, ethical AI governance in cultural heritage must go beyond participatory rhetoric and adopt models of co-governance and community-led stewardship. This includes ensuring that local communities not only contribute input but also hold decision-making power in the design, implementation, and oversight of AI tools that affect their heritage. Mechanisms such as community advisory boards, culturally specific consent protocols, and capacity-building programs for digital sovereignty can provide more equitable alternatives to top-down technological imposition. These approaches align with principles of procedural justice and epistemic inclusion.

While total transparency may be technically infeasible in advanced AI models such as GANs or neural rendering frameworks, sufficient explainability remains a non-negotiable ethical requirement. This does not imply full algorithmic disclosure, but rather the provision of interpretable outputs, clear metadata, and contextual justifications that are meaningful to different stakeholders.

For curators, this may involve traceability of data sources; for communities, assurances that their cultural narratives are not distorted; and for general audiences, interfaces that communicate uncertainty and interpretation boundaries. Ultimately, explainability should be proportionate to the risks and tailored to the interpretive nature of cultural content.

These practical contributions play a crucial role in promoting the ethical and responsible application of AI technologies in cultural heritage.

4.4 Limitations

The findings of this study seek to provide a thorough analysis of the ethical implications of AI technologies in cultural heritage. However, the research includes certain limitations. The case studies represent only a specific segment of existing AI applications, and caution is necessary when generalizing the findings to applications in different geographical, cultural, or technological contexts.

The proposed ethical framework is developed based on a literature review, and its practical applicability should be validated through future empirical research. Additionally, direct participation by local communities and other stakeholders was not achieved, so the needs and expectations of these groups were not fully reflected in the study.

The rapid evolution of AI technologies may affect the long-term validity of the findings, underscoring the need for ongoing ethical considerations and regulatory updates. These limitations should be carefully addressed to ensure that the study's findings retain their value and applicability.

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CRediT author statement

Term	Definition	Author 1	A2
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims	x	
Methodology	Development or design of methodology; creation of models	x	x
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components	x	
Validation	Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs	x	x
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data	x	
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection	x	
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	x	
Data Curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	x	x
Writing - Original Draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)	x	x
Writing - Review & Editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or post-publication stages	x	x
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation	x	x
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team		x
Project administration	Management and coordination responsibility for the research activity planning and execution	x	x
Funding acquisition	Acquisition of the financial support for the project leading to this publication	x	x

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