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Artificial Intelligence for the Preservation and Transmission of Non-Material Cultural Heritage: Opportunities, Ethical Challenges, and Future Directions

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Abstract. Non-Material Cultural Heritage (ICH), encompassing vital traditions, knowledge, and skills, faces significant threats from modernization and declining transmission. Although traditional conservation methods have fundamental value, they are often insufficient in terms of scale, accessibility and dynamic presentation. This paper explores the potential of Artificial Intelligence (AI) technologies to offer innovative approaches for the documentation, preservation, and transmission of ICH. We identify several promising AI application areas, including intelligent documentation, virtual representation, personalized learning, and assisted creation. While AI applications offer significant potential, this paper concludes that their responsible deployment necessitates addressing critical ethical risks such as data ownership and authenticity. Therefore, a conceptual framework understanding AI's dual role, coupled with community-centric ethical guidelines, is vital. This research ultimately highlights that interdisciplinary collaboration is crucial for ensuring AI genuinely empowers and vitalizes ICH for future generations.

Keywords: Artificial Intelligence, Non-Material Cultural Heritage, Digital Preservation, Cultural Transmission, Ethical Challenges

1. Introduction

Non-Material Cultural Heritage (ICH), officially recognized by the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage since 2003, encompasses a rich array of living traditions, oral expressions, performing arts, social practices, rituals, and traditional craftsmanship. Unlike static tangible heritage, ICH is inherently dynamic and continually recreated through community participation, serving as a fundamental pillar for human identity, creativity, and social cohesion across generations.

However, the vitality and continuity of ICH face increasing threats from globalization, urbanization, and demographic shifts, which often disrupt traditional social structures and break intergenerational transmission lines. Traditional documentation methods, while foundational, frequently prove insufficient in capturing the full complexity and interactive depth of living heritage, thereby limiting effective transmission to future generations. This creates an urgent global demand for innovative and scalable solutions to complement conventional preservation efforts.

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In parallel, Artificial Intelligence (AI) has experienced revolutionary advancements, driven by breakthroughs in deep learning and exponential growth in computational power and data. AI's burgeoning capabilities in analyzing complex datasets, recognizing patterns, understanding language, and interpreting visual information present unprecedented opportunities across various sectors. This technological progress necessitates a critical inquiry into its potential applications within the nuanced and culturally rich domain of ICH.

Therefore, the primary purpose of this paper is twofold. Firstly, it aims to explore the potential applications of AI technologies to enhance the documentation, preservation, and transmission of diverse forms of ICH. This involves identifying how AI can offer innovative approaches for intelligent archiving, virtual reconstruction, personalized learning, and assisted creation, thereby addressing some limitations of traditional methods. Secondly, and critically, this paper seeks to analyze the unique ethical challenges and societal risks inherent in deploying AI within these culturally sensitive contexts. This includes a critical examination of concerns related to data ownership, authenticity, cultural appropriation, and the potential exacerbation of the digital divide. By synthesizing insights from cultural heritage studies and AI ethics, this paper endeavors to propose initial considerations for the responsible and culturally sensitive development and deployment of AI in ICH. The ultimate aim is to foster an informed discourse that ensures AI serves to empower and vitalize ICH, rather than inadvertently harming it, emphasizing community-centric approaches and a balance between digital innovation and the enduring vitality of living traditions.

2. Research questions

Based on the synthesis of existing literature concerning ICH preservation challenges, the capabilities of relevant AI technologies, and the critical ethical considerations inherent in their intersection, this paper aims to answer the following detailed and nuanced research questions:

• Question 1: How can specific AI technologies—such as Natural Language Processing for oral traditions, Computer Vision for crafts and performing arts, and AI-generated content for virtual reconstructions—be responsibly and creatively used to improve the documentation, preservation, accessibility, and intergenerational transmission of diverse forms of Intangible Cultural Heritage (ICH)?

• Question 2: What are the key ethical and societal risks associated with the use of AI in ICH, including misrepresentation, decontextualization, loss of authenticity, data ownership, cultural appropriation, algorithmic bias, and the digital divide?

• Question 3: What principles or ethical frameworks should guide the responsible development and use of AI in ICH contexts? These should ensure cultural sensitivity, equity, and community control, while supporting the living transmission and vitality of ICH, rather than reducing it to static digital records.

3. Innovative and responsible AI applications for ICH enhancement

Artificial Intelligence (AI) technologies can be innovatively and responsibly applied to substantially enhance the documentation, comprehensive preservation, broader accessibility, and intergenerational transmission of diverse forms of Non-Material Cultural Heritage (ICH), addressing limitations where traditional methods often prove insufficient in capturing its full complexity and dynamic nature [1,2].

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3.1. Enhancing documentation and archiving

AI offers transformative tools for ICH documentation. For oral traditions, advanced Automatic Speech Recognition (ASR) systems, often powered by deep learning, accurately convert spoken data into text, including for endangered languages [3]. Beyond transcription, sophisticated Natural Language Processing (NLP) models perform deep semantic analysis on these texts, automatically identifying key themes, narrative structures, and significant entities, enabling richly indexed, searchable archives crucial for global access and interpretation [3,4].

For embodied knowledge like traditional craftsmanship, dances, and rituals, Computer Vision (CV) technologies, utilizing pose estimation and action recognition, meticulously analyze video recordings to quantify movements, their sequence, and variations [5-7]. This creates detailed "motion libraries" or "skill graphs," documenting knowledge difficult to capture otherwise and serving as invaluable references [7].

AI also facilitates multi-modal data integration, linking diverse data types (textual notes, audio, video, images) through deep learning architectures [2,4]. It can automate or assist in generating rich, descriptive metadata by applying content analysis for auto-tagging and categorization, significantly improving archive management and content discoverability [4].

3.2. Broadening accessibility and revitalizing engagement

AI, integrated with immersive technologies like Virtual Reality (VR) and Augmented Reality (AR), transcends passive consumption to create interactive experiences that can revitalize ICH engagement [1,6]. AI-Generated Content (AIGC) techniques can synthesize plausible virtual performance spaces and historical recreations from fragmented documentation (historical accounts, images, limited recordings), allowing users to experience past traditions immersivity [6,8].

Interactive virtual apprenticeships for traditional crafts, enhanced by AI analyzing expert demonstrations, can provide personalized learning through AR overlays or VR environments, simulating hands-on knowledge transfer vital for tacit skills [5]. Furthermore, AI can transform static digital narratives into dynamic, personalized storytelling experiences, with NLP adapting storylines based on user input, making ICH more engaging, especially for younger audiences, though requiring ethical oversight for authenticity [3].

3.3. Supporting intergenerational transmission and personalized learning

AI's capacity for pattern recognition and adaptive behavior makes it ideal for personalizing ICH educational pathways and recommending cultural content [4]. AI can power adaptive learning platforms for traditional skills, with AI tutors dynamically modifying curricula and providing targeted feedback based on learner progress [2,3,9]. This caters to individual learning paces, making complex ICH more accessible.

Intelligent recommendation engines analyze user interests and engagement to suggest relevant ICH content, practitioners, events, or learning opportunities from vast digital archives, enhancing discoverability and sustained engagement [2,3]. NLP-powered interactive Q&A systems and chatbots, trained on comprehensive ICH knowledge bases (potentially from KRR systems), can provide on-demand answers about traditions, overcoming geographical and linguistic barriers to knowledge.

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3.4. Assisting creative continuity and cross-cultural communication

While AI cannot replicate human creativity or the organic evolution of living traditions, it can be an assistive tool. AIGC models, trained on traditional datasets, can function as creative collaborators for contemporary artists and ICH practitioners, suggesting novel variations or compositions that bridge heritage with modern expression, fostering innovation while respecting tradition [6,8]. This application, however, demands ethical consideration to prevent commodification or appropriation.

Advanced NLP, particularly machine translation and natural language generation, significantly improves the cross-cultural dissemination and understanding of ICH, translating complex oral histories, song lyrics, and craft descriptions into multiple languages, though capturing cultural nuance often requires human post-editing [3]. AI can also analyze audience engagement with heritage content online, helping institutions localize communication strategies and measure the impact of digital initiatives [4].

The responsible application of these AI models necessitates ensuring they complement living practices and are guided by robust ethical frameworks to prevent unintended harm.

4. Primary ethical challenges and societal risks of AI in ICH

The widespread integration and strategic deployment of AI within the culturally sensitive domain of ICH are inherently associated with primary, distinct, and potentially profound ethical challenges and foreseeable societal risks that demand meticulous navigation beyond generalized AI ethics [10-12].

4.1. Data ownership, sovereignty, and cultural appropriation

A critical ethical concern revolves around data ownership and the potential for cultural appropriation [6,13]. ICH is often collectively owned by specific communities, not individuals or external institutions [14,15]. When AI systems process ICH data (e.g., sacred rituals, proprietary craft techniques, oral narratives), questions arise about control over the digital representations and insights generated. Without clear, culturally informed consent mechanisms and robust data governance, there's a risk of dispossessing communities of their digital cultural assets, potentially perpetuating historical colonial extraction patterns where knowledge is taken without equitable benefit-sharing or originator control [12,13,15]. The development of Indigenous Data Governance frameworks offers a crucial model [13].

Furthermore, AI-Generated Content trained on cultural styles can lead to digital cultural appropriation if created or exploited by external parties without proper attribution, understanding of cultural significance, or equitable benefit-sharing with the originating community [8,12]. These risks decontextualizing sacred expressions and allowing profit from community-tied assets. The "black box" nature of some AI models can complicate accountability for how cultural patterns are learned or biases incorporated.

4.2. Authenticity, "digital doppelgangers," and misrepresentation

ICH is inherently living and dynamic, its authenticity rooted in continuous practice and human interaction [1]. AI's tendency to create fixed digital representations or "generate" new versions poses challenges. An over-reliance on sophisticated digital documentation or AI-powered virtual representations might inadvertently devalue living practitioners and direct intergenerational transmission [16,17].

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AI-generated content or virtual reconstructions, while compelling, are algorithmic products, risking an "illusion of authenticity" that could mislead audiences and dilute the meaning of lived practice [1,18]. Ethical guidelines must mandate clear labeling of AI-generated content as representations, not substitutes for original living heritage. The generative power of AI also carries the risk of intentional or unintentional manipulation or misrepresentation, potentially causing irreversible damage to heritage integrity. Ensuring truthfulness and provenance of data for AI is paramount.

4.3. Digital divide, algorithmic bias, and cultural exclusion

Advanced AI implementation in ICH is linked to access, equity, and inclusion, risking exacerbation of existing societal inequalities [12,15,19]. Effective AI application often requires technological infrastructure, digital literacy, and resources that many ICH-bearing communities, especially in disadvantaged regions, lack [19]. This can create a two-tiered system, marginalizing less-connected communities from safeguarding their own heritage.

Algorithmic bias is a significant concern. AI algorithms trained on biased, incomplete, or unrepresentative datasets (often favoring dominant cultural narratives) can perpetuate or amplify these biases, leading to misrepresentation, marginalization, or invisibility of less documented ICH forms [10,11]. AI tools predominantly developed in Western linguistic and cultural contexts might also be ineffective or culturally inappropriate for diverse ICH, reinforcing technological hegemony.

4.4. Erosion of emotional connection, humanistic value, and over-dependence

ICH transmission often involves deep personal relationships, shared embodied experiences, and emotional connections within a community [16,17]. AI, as a technological tool, cannot replicate the full spectrum of human connection, mentorship, and communal bonding vital for genuine cultural transmission [1,18]. Over-reliance on sophisticated AI tools could lead to dependence on digital interfaces, potentially diminishing motivation for real-world community engagement and the social functions of ICH.

There's also a risk of eroding the agency and creative input of ICH practitioners if AI becomes a primary tool for analysis or "creation," potentially reducing practitioners to "data providers" rather than active custodians and innovators of their tradition.

4.5. Data security and privacy protection

The digitization and AI-driven processing of ICH data raise significant concerns regarding data security, individual privacy, and community confidentiality [10,11]. ICH documentation frequently involves sensitive personal information (about elders, practitioners) and private details about community rituals or beliefs [15]. Aggregation and processing of such data by AI, without diligent management and robust security, could expose confidential information, leading to privacy breaches or harm.

Large digital archives and AI platforms storing ICH data are vulnerable to cyberattacks, which could lead to irreversible loss or unauthorized dissemination of irreplaceable data, damaging heritage and trust [4,10]. Robust cybersecurity, stringent access controls, and comprehensive consent management for data collection and AI processing are non-negotiable, especially for vulnerable communities [11].

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Addressing these multifaceted challenges necessitates human-centered, culturally sensitive, and participatory approaches in AI deployment for ICH.

5. Guiding principles and frameworks for responsible AI in ICH

The ethical development, responsible deployment, and sustainable management of AI technologies in ICH contexts require comprehensive principles and robust ethical frameworks. These should ensure cultural sensitivity, promote equity, respect community rights and sovereignty over their heritage, and genuinely support the vitality and authentic intergenerational transmission of living traditions, rather than merely creating static digital archives. This involves navigating AI's dual potential: its immense technological capacity and its significant ethical risks.

Responsible AI in the context of Intangible Cultural Heritage (ICH) must be grounded in ethical frameworks that respect cultural sensitivity, equity, and community rights, ensuring technology supports living traditions rather than mere digital archives. Essential principles include community-centered co-design and decision-making power to guarantee genuine participation and equitable benefit-sharing [6,13]; transparent and culturally appropriate data governance that upholds informed consent and community data sovereignty [10,11,15]; balancing digital preservation with reinforcement of human-to-human transmission and intergenerational learning [17,18]; embedding ethics by design with proactive bias mitigation and ongoing ethical audits involving communities [10,12]; enhancing AI explainability to foster understanding and oversight by community members [10]; addressing the digital divide and promoting digital literacy to ensure equitable access and empowerment [12,15]; and fostering deep interdisciplinary and cross-cultural collaboration to navigate AI’s complex technical, cultural, and ethical challenges [6].

6. Conclusion

Artificial Intelligence (AI) presents transformative opportunities for the documentation, preservation, accessibility, and transmission of Non-Material Cultural Heritage (ICH), offering innovative solutions such as intelligent archiving, immersive virtual experiences, personalized learning, and assisted creation to address the limitations of traditional methods. This paper has explored these AI applications, demonstrating their potential to enhance the vitality and continuity of diverse living traditions.

However, the integration of AI into this culturally sensitive domain is fraught with significant ethical challenges and societal risks. Key concerns identified include issues of data ownership and cultural appropriation, the complexities of authenticity in digital representations, the potential exacerbation of the digital divide and algorithmic bias, the erosion of humanistic values and emotional connections, and critical data security and privacy vulnerabilities. Addressing these challenges proactively is paramount to prevent unintended harm and ensure AI serves to empower rather than undermine heritage communities.

Therefore, this research concludes that the responsible and beneficial deployment of AI in ICH necessitates a robust ethical framework and guiding principles. These principles must prioritize community empowerment and participation, establish transparent data governance with community sovereignty at its core, balance digital innovation with the primacy of living transmission, embed ethics by design to mitigate bias, promote explainability, bridge the digital divide, and foster deep interdisciplinary collaboration.

Ultimately, the future of AI in ICH hinges not merely on technological advancement, but profoundly on its culturally sensitive, ethically informed, and community-centric application. By

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navigating AI's dual potential with foresight and collaboration, it can become a powerful ally in the global mission to sustain and celebrate humanity's invaluable living cultural heritage for generations to come.

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