REVIEW

Virtual reality and virtual worlds: a favorable setting for the preservation of cultural heritage

Realidad virtual y mundos virtuales: un escenario propicio para la preservación de la herencia cultural

Guillermo Alfredo Jiménez Pérez[1] 📧, Alfredo Javier Pérez Gamboa[2] 📧, Carlos Alberto Gómez Cano[3] 📧

[1]Universidad de Matanzas. Matanzas, Cuba.
[2]Universidad de Ciego de Ávila, Ciego de Ávila, Cuba.
[3]Corporación Unificada Nacional de Educación Superior - CUN. Florencia, Caquetá, Colombia.

Corresponding author: Carlos Alberto Gómez Cano 📧

ABSTRACT

This article analyzes the literature regarding virtual reality (VR) and virtual worlds in cultural heritage preservation during the period 2018-2022. Through a hermeneutic review of specialized literature, key trends were identified that reveal how these technologies have evolved from visualization tools to active participation platforms. The findings reveal significant advances in the reconstruction of at-risk heritage, the documentation of intangible cultural expressions, and the creation of immersive educational experiences. However, tensions persist between technological innovation and accessibility, as well as ethical challenges surrounding the authentic representation of cultural contexts. The study highlights the need for collaborative frameworks that involve local communities in virtualization processes, ensuring that these initiatives not only preserve but also strengthen the emotional and identity-based connection with heritage. It concludes that while VR offers promising solutions, its implementation requires rigorous protocols that balance technical accuracy, social inclusion, and long-term sustainability.

Keywords: Virtual Reality; Cultural Heritage; Digital Preservation; Community Engagement; Technology Ethics.

RESUMEN

El artículo analiza la literatura sobre la realidad virtual (RV) y los mundos virtuales en la preservación del patrimonio cultural durante el periodo 2018-2022. A través de una revisión hermenéutica de literatura especializada, se identificaron tendencias clave que indican cómo estas tecnologías han evolucionado desde herramientas de visualización hacia plataformas de participación activa. Los hallazgos revelan avances significativos en la reconstrucción de patrimonios en riesgo, la documentación de expresiones culturales intangibles y la creación de experiencias educativas inmersivas. Sin embargo, persisten tensiones entre la innovación tecnológica y la accesibilidad, así como desafíos éticos en torno a la representación auténtica de contextos culturales. El estudio destaca la necesidad de marcos colaborativos que involucren a las comunidades locales en los procesos de virtualización, asegurando que estas iniciativas no solo preserven, sino que también fortalezcan la conexión emocional e identitaria con el patrimonio. Se concluye que, si bien la RV ofrece soluciones prometedoras, su implementación requiere protocolos rigurosos que equilibren precisión técnica, inclusión social y sostenibilidad a largo plazo.

Palabras clave: Realidad Virtual; Patrimonio Cultural; Preservación Digital; Participación Comunitaria; Ética Tecnológica.

INTRODUCTION

The preservation of cultural heritage faces unprecedented challenges in the 21st century.[1] Due to armed conflicts, natural disasters, accelerated urbanization processes, and the effects of climate change, numerous tangible and intangible cultural assets are at risk of disappearing.[2,3,4] This context has prompted the search for innovative solutions that transcend traditional conservation methods.

In this sense, the technological advances of recent decades have opened up new possibilities for documenting, studying, and disseminating endangered heritage.[5,6] In particular, the development of immersive technologies such as virtual reality (VR) and virtual worlds has demonstrated their potential for digitally preserving cultural elements and reinventing their ways of interacting.[7,8] Among their main advantages and contributions is that these tools allow us to overcome physical and geographical limitations to offer interactive experiences adapted to diverse educational and social contexts.

However, applying these technologies in the heritage field has its complexities. Among the most visible and pressing are the tensions between historical fidelity and pedagogical needs, between technological innovation and accessibility, as well as between digital preservation and the cultural rights of indigenous communities. [9] On the other hand, the rapid development of these tools has often exceeded the capacity of cultural and academic institutions to evaluate their medium- and long-term impacts critically.[10]

This article arises from the need to analyze how virtual reality and virtual worlds can reconfigure cultural preservation practices. Based on a hermeneutic review of the specialized literature, the study seeks to understand the conceptual and methodological transformations that have emerged in this field and the ethical and technical challenges they pose. The research is justified by the urgency of establishing critical frameworks to guide the responsible use of these technologies and ensure that their implementation genuinely contributes to safeguarding heritage without compromising its integrity or excluding the communities involved.

The period 2018-2022 was selected as it corresponds to a technological and conceptual maturation phase in the field, marked by the convergence of technical advances, critical reflections, and experiences applied in diverse cultural contexts.[11] This study aims to provide a solid conceptual basis for future research and practical applications in this constantly evolving field.

METHOD

Between 2018 and 2022, a hermeneutic approach was adopted to critically analyze the academic and technical literature on virtual reality and cultural heritage preservation. This methodology allowed us to interpret the sources' discourses, tensions, and consensuses beyond a descriptive synthesis.

Firstly, the documentary corpus was delimited based on clear selection criteria: We worked exclusively with articles indexed in Scopus in the identified time range and whose thematic relevance was clear. Priority was given to documents that addressed both the technical potential and the social, educational, or ethical dimensions of the application of these technologies. In addition, for triangulation purposes, author 2 reviewed reports from international organizations (UNESCO, Europeana) and emblematic case studies published in the defined period.

Subsequently, an in-depth reading of the sources was carried out to identify emerging categories. These emerged inductively from recurring patterns, such as "immersive reconstruction," "community participation," or "digital ethics." The process was not limited to extracting data but sought to understand the historical and theoretical context behind each trend.

The analysis was enriched by cross-sectional methodological triangulation. To this end, perspectives from different disciplines (both recognized by Scopus and others) were contrasted, focusing on sources from digital anthropology, computer science, and museology. This approach made it easier to avoid interpretive biases and allowed for examining the contradictions between techno-utopian discourses and preservationist critiques, which added depth to the study.

Finally, the findings were organized into a coherent narrative highlighting opportunities and challenges. Hermeneutics made it easier to connect technical trends with their socio-cultural impact, avoiding reductionism and contributing to the contextualization of the analysis.

RESULTS

Trends in virtual reality and virtual worlds for the preservation of cultural heritage

The analysis revealed that in recent years, virtual reality (VR) and virtual worlds have begun to establish themselves as key tools for safeguarding cultural heritage.[12,13] The initiatives consulted suggest that these technologies are not exclusively instruments for recreating historical spaces, given that they also encourage the active participation of communities, with particular benefits for the new generations. For example, virtual travel projects allow exploring historical periods in their splendor through immersive reconstructions based on archaeological evidence.[14] These experiences, in addition to attracting digital tourists, constituted a vital integration project for teaching history in specialized university classrooms.

Another relevant trend was the use of VR to document heritage at risk.[15] Between 2019 and 2021, international organizations promoted 3D scans of sites threatened by conflict or climate change, such as Palmyra in Syria or monuments in Nepal.[16,17] By their purpose, these digital archives now serve as publicly accessible backups and educational material. In addition, some metaverse platforms host collaborative exhibitions where users interact with cultural artifacts from anywhere in the world.

The democratization of technology also marked a milestone. Tools such as Unreal Engine or Blender made it easy for small teams — even indigenous communities — to create their own immersive experiences without great expense.[18] In Mexico, the Pueblos Mágicos Virtuales (Virtual Magical Towns) project (2020) allowed locals to design tours of their heritage, combining oral narratives with 3D models.[19] This approach represents an effort to preserve traditions and generate new sources of income through virtual tourism.[20,21,22]

Likewise, a significant advance was the incorporation of artificial intelligence to personalize visits. Case studies showed that museums such as the Louvre and the British Museum tested VR systems that adapted explanations according to the visitor's interests, using data from previous interactions.[23] These experiences, although still in the experimental phase, showed the potential to make heritage more inclusive, especially for people with disabilities.

Finally, ethical debates arose about authenticity and access. While some activists and academics argue that digital recreations distort the essence of historical sites, new studies highlight their role in preserving contexts that have already disappeared. For example, platforms such as Europeana worked on standards to guarantee academic accuracy in these projects, ensuring that technology was complemented, not replaced, by traditional conservation efforts. These advances reflect a paradigm shift: technology is no longer a luxury but an ally in enabling heritage to transcend borders and generations. In summary, the five key trends were:

1. Immersive reconstructions for educational and tourism purposes (Virtual Angkor).
2. Digitization of heritage at risk through 3D scanning (CyArk/UNESCO).
3. Empowerment of local communities to create their own experiences (e.g. Pueblos Mágicos Virtuales).
4. Personalization of visits with AI in museums (Louvre, British Museum).
5. Development of ethical frameworks to balance innovation and authenticity (Europeana).

Results of the auxiliary search

To triangulate the findings made in Scopus, an auxiliary search focused on the application of virtual reality and virtual worlds for the preservation of cultural heritage. This process prioritized academic documents in Spanish and Portuguese, emphasizing empirical research and theoretical reviews.

Firstly, studies were identified that analyzed the use of immersive environments to reconstruct deteriorated or disappeared cultural assets.[24,25,26,27] In this sense, the research addressed how these technologies can facilitate access to heritage that is difficult to visit physically while serving as educational tools in formal and informal contexts.[28,29]

Secondly, we found works that explore the relationship between virtual worlds and collective memory. Some of the literature examined cases where local communities actively participated in creating digital representations of their cultural heritage, which generated processes of social appropriation of the technology.[30,31]

Thirdly, articles addressed the technical and ethical challenges of preserving heritage through virtual reality.[32,33] There is an agreement with an important line of publications that questions the risk of simplifying complex historical contexts in digital reconstructions. However, the potential for documenting intangible traditions in danger of disappearing is also recognized.[34,35,36] This debate is fundamental because, although the participation of experts in heritage and culture can facilitate the rigor of the designs, initiatives aimed at monetization can also distort the result.

The search revealed that, although significant progress has been made in Latin America, there are still gaps in the documentation of experiences outside the museum environment. In this regard, studies on specific applications dominated compared to less theoretical work that critically analyzes the long-term impacts of these technologies on heritage conservation.

Key findings:

1. Emphasis on vulnerable heritage (architectural and intangible)
2. Duality between technological innovation and accessibility
3. Emergence of collaborative models with native communities
4. Lack of standardized evaluative frameworks
5. Tension between historical fidelity and pedagogical adaptation

DISCUSSION
Virtual reality as a socio-technical phenomenon in cultural preservation

The review allowed us to identify a significant conceptual shift in the five years analyzed. Immersive

technologies were no longer perceived as mere visualization tools but became spaces for cultural negotiation.[37] This paradigm shift manifested itself in three interrelated dimensions.

In the technical sphere, the virtualization of heritage evolved from unidirectional models - where institutions "translated" the physical into the digital - towards collaborative schemes.[38] In the future of this field, it is crucial to develop projects that document the representation of indigenous rituals. However, it should also be considered that previous research indicates that this process may require ethical protocols as sophisticated as 3D reconstruction algorithms.[39] The paradox lies in that while tools are democratized (with low-cost software), new forms of digital exclusion may arise, particularly in rural communities.

In another direction, the tension between authenticity and adaptability marked the academic debate during the period.[40] On the one hand, scholars questioned the loss of aura in digital reproductions. On the other hand, educators emphasized how these versions facilitated emotional connections with digital native generations.[41,42] The cases analyzed illustrated how VR not only replicates physical structures but also reconstructs lost historical layers, which creates a stratigraphic experience impossible in the material world.[34,43]

From a social perspective, an unexpected conflict emerged: the gap between the speed of technological innovation and cultural timescales.[44] While developers worked with obsolescence cycles of 18-24 months, traditional communities required extensive deliberative processes to authorize the digitization of their living heritages.[45,46] This asynchrony generated fractures in several projects analyzed, where the technically possible collided with the culturally acceptable.

The analysis revealed that the most successful models adopted a glocal approach, combining international digital preservation standards with local adaptations. However, a structural limitation persisted: most impact assessments measured immediate results (number of users, graphic resolutions) but lacked long-term metrics on cultural appropriation or attitudinal changes.

At a regional level, Ibero-American studies showed a particularity: VR was frequently used as a tool for symbolic reparation, especially in cases of heritage damaged by social conflicts or natural disasters.[15] This therapeutic function, little explored in the Anglo-Saxon literature, opened up innovative lines of research into the links between immersive technology, collective memory, and epistemic justice.

Finally, it was found that the emergence of the metaverse in the heritage field introduced new layers of complexity to the debate on digital preservation.[47] Unlike isolated virtual reality experiences, metaverse-based environments raised the possibility of creating persistent cultural ecosystems where heritage is preserved, collectively inhabited, and transformed.[48] This qualitative leap reconfigured three fundamental dimensions of the field of study.

The first was the temporality of cultural experiences. While traditional VR projects tended to recreate static historical moments, platforms such as Decentraland demonstrated how heritage could evolve through layers of contemporary reinterpretation.[49] This dynamism generated fruitful tensions between conservation and creation, where authenticity ceased to be a fixed attribute and became a negotiated process.

In the sociocultural sphere, the metaverse amplified both opportunities and risks. On the one hand, it facilitated the convergence of geographically dispersed communities around shared heritages; on the other, it reproduced the asymmetries of the physical world in terms of technological access and cultural representation.[50,51] Cases such as the digitization of sacred Indigenous sites revealed how persistence in virtual environments required new digital governance frameworks that respected traditional knowledge protocols.

Technologically, the open architecture of the metaverse allowed experimentation with hybrid preservation models. Integrating blockchain to certify digital replicas, using NFTs to manage cultural rights, or combining generative AI with historical archives pointed to innovative ways to solve the eternal dilemma between institutional control and community appropriation.[52,53]

However, the analysis showed that these potentialities came up against structural limitations. The gap between the promises of the corporate metaverse and current technical realities made it clear that many projects prioritized spectacle over cultural substance. In addition, the lack of interoperable standards threatened to fragment the digital heritage into incompatible technological silos.

This discussion suggests that the metaverse's actual value for cultural preservation could lie not in its mimetic capacity but in its potential to generate new digital rituals that transcend the original/copy dichotomy. The most successful cases were those that understood the virtual environment not as a substitute but as a dialogic extension of physical heritage, thus creating a third category: living-digital heritage.

CONCLUSIONS

VR emerged as a multidisciplinary tool for cultural preservation, surpassing its initial function as a simple digital repository. The cases analyzed demonstrated its capacity to reactivate heritage at risk through stratigraphic reconstructions that integrate material and immaterial dimensions, although challenges persist in documenting complex socio-historical contexts.

The tension between technological innovation and cultural sustainability emerged as a critical axis. While

immersive platforms enabled new forms of community participation, they also revealed asymmetries in access and appropriation, particularly in rural communities and Indigenous groups. This raised the need for dynamic ethical protocols that balance technical precision with cultural sensitivity.

The period studied marked a turning point in preservation models, moving from unidirectional institutional approaches towards glocal collaborative schemes. However, the review showed deficiencies in long-term evaluation systems, suggesting the urgency of developing metrics that transcend fundamental quantitative indicators to measure cognitive, emotional, and social impacts on recipient communities.

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CONTRIBUTION OF AUTHORSHIP
Conceptualization: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Data curation: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Formal analysis: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Research: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Methodology: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Project administration: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Resources: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Software: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Supervision: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Validation: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Visualization: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Writing - original draft: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.
Writing – revision and editing: Guillermo Alfredo Jiménez Pérez, Alfredo Javier Pérez Gamboa, Carlos Alberto Gómez Cano.