BENEFIT OF MIXED REALITY ON CULTURAL EDUTAINMENT

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ABSTRACT

Mixed Reality (MR) technology has the potential to transform the dissemination of Heritage Urban Landscape (HUL) through edutainment. By blending virtual and physical environments, MR offers an immersive experience that enhances both the educational and entertainment aspects of cultural learning. This study examines the impact of MR on cultural edutainment for disseminating HUL, drawing on literature reviews and case studies employing Extended Reality (XR) applications. The research underscores the various advantages of MR implementation in cultural contexts while also addressing its limitations in edutainment settings. Furthermore, it emphasizes the importance of integrating MR technology into cultural edutainment for effective HUL dissemination. Through qualitative methods, this study identifies the strengths and weaknesses of MR in cultural heritage (CH) and develops a cultural MR prototype, using Jugra HUL as a case study element. Leveraging the MR approach in cultural heritage edutainment facilitates the dissemination of Jugra HUL, fostering a deeper connection with the heritage site.

Keywords: Cultural Heritage; Edutainment; Extended Reality; Heritage Urban Landscape; Mixed Reality

1. Introduction

Rosli, Hafizah, Norfadilah, and Badrul (2023) highlighted the need for improved digital presentation of museums and heritage sites in Malaysia, emphasizing the successful adoption of digital platforms by renowned museums and heritage tourism worldwide. However, limited expertise and high implementation costs have hindered the widespread use of extended reality (XR) technologies in Malaysian museums and heritage tourism sites (Wahid, 2022). Another limitation to accurate cultural heritage (CH) dissemination is the lack of comprehensive and detailed records, often resulting from a lack of research expertise in the field (Wahid, 2022). Bekele & Eric Champion (2019) stress the importance of staying updated with technological advancements and acquiring content development skills in the cultural sector. To enhance learning experiences, Vargas, Juan, Ramon, Angela, & Teodor (2020) recommend integrating XR technologies, particularly Mixed Reality (MR), into educational and cultural institutions to create immersive and interactive environments. By combining traditional storytelling with digital tools, the collaboration between academia, museum, the heritage tourism industry, and technology experts can provide innovative approaches for disseminating CH effectively.

The issue of this study is Heritage Urban Landscape (HUL) dissemination through MR technologies in cultural edutainment at heritage tourism sites in Malaysia. This research aims to assess the influence and effectiveness of HUL dissemination through MR in cultural edutainment, addressing the challenges, opportunities, stakeholder collaboration, visitor experience, best practices, sustainability, and the role of cultural institutions and academia in implementing HUL and MR initiatives. The scope of the study encompasses two main

areas. Firstly, a researcher conducted a literature review to identify the influence and limitations of MR applications in CH edutainment. Secondly, the study will focus on developing an MR prototype based on the Jugra HUL case study. The prototype will serve as a practical application of MR technology in CH edutainment.

2. Literature review

2.1 Benefits of MR in Cultural Edutainment

Atzeni, Marcello, Giacomo, and Jessica (2022) found that satisfaction, attachment to extended reality (XR) applications, and attention during visits significantly impact affective responses toward object-based authenticity. Paul Milgram & Fumio Kishino are credited with introducing the term "mixed reality (MR)" in 1994 (Milgram & Kishino, 1994). While the roots of mixed reality can be traced back to the development of augmented reality (AR) and virtual reality (VR) technologies in earlier decades, its adoption in the cultural heritage industry began to gain momentum around the early 2010s (Rauschnabel, 2021). MR technologies are relevant in enhancing the overall visitor experience and positively influencing satisfaction and loyalty during the post-trip phase of cultural and heritage tourism (Atzeni et al., 2022). MR technology in cultural heritage (CH) also plays a vital role in motivating students in educational institutions and museum and heritage tourism sites to actively engage with and learn about CH (Wood, William, & Copeland, 2019). Virtual representations enhance visitor experiences by preparing them for upcoming visits or providing opportunities to engage with and expand upon previous experiences using digital technologies (Atzeni et al., 2022).

MR in CH introduces novel concepts for visitor engagement, capturing attention by offering an alternative approach that sparks curiosity in exploring culture (Barrado-Timón & Hidalgo-Giralt, 2019). It improves the emotional connection and creates meaningful visitor experiences (Chunga, Chavarri, & Beltran, 2021). Adopting MR with intuitive navigation and easy access to content creates a pleasant visitor experience (Martins et al., 2021). MR can provide tourists with distinctive and authentic experiences in the context of digital heritage tourism (Atzeni et al., 2022). MR digital technology enriches visitors' understanding and enjoyment of the site (Bekele, 2019).

By overlaying additional 2D and 3D graphics, MR technologies enhance visitors' perception of their surrounding environment (Vargas et al., 2020). MR creates an imaginary world with extraordinary features, enabling visitors to immerse themselves and interact with virtual and real-time applications. The technology aims to provide a natural and authentic visitor experience by simulating real-world sensations, making the interaction with virtual elements more lifelike and engaging (Kumawat et al., 2020). By overcoming physical and geographical barriers, MR allows individuals with limited mobility or those far from cultural sites to participate in the experience actively. MR technology will enable visitors to delve into the past and provides them with a sense of mobility, allowing them to explore heritage sites that would otherwise be inaccessible (Dieck, Jung, & Michopoulou, 2019). Additionally, tourism operators utilise advanced media to enhance the visitor's experience, giving tourists convenient and early access to the destination or site experiences (Atzeni et al., 2022).

By harnessing MR technologies, tourists engage in interactive and immersive interactions with attractions, leading to more memorable experiences (Dieck et al., 2019). These immersive and interactive encounters enrich their memories (Barrado-Timón & Hidalgo-Giralt, 2019). MR aims to enhance real-world experiences by seamlessly blending digital content with the physical environment through digital devices (Merchán, Merchán, & Pérez, 2021). MR plays a significant role in presenting the past and showcasing diverse cultural practices, opening up new sensations and meanings, and incorporating immersive storytelling techniques to entertain and engage visitors (Gavalas et al., 2020).

Using MR for digital documentation enhances the preservation and longevity of ancient heritage sites, especially those in remote locations (Hajirasouli et al., 2021). It provides an alternative means of accessing and experiencing these sites, which is particularly valuable when physical access is limited or threatened by natural disasters, warfare, uncontrolled tourism, or urbanisation (Hajirasouli et al., 2021). MR technology in CH allows the combination of physically distant exhibits or the exhibition of digitally born objects without their physical presence. It provides valuable support for the digital preservation of heritage sites and cultural collections and research, communication, education, entertainment, and tourism promotion (Gavalas et al., 2020). Furthermore, MR can incorporate games where virtual actions are superimposed on reality, adding an interactive element to the digital documentation (Luna, Rivero, & Vicent, 2019). The recent advancements in hand-held devices have made XR content more accessible (Merchán et al., 2021) and opened up new possibilities for documenting valuable architectural and cultural monuments, objects, or sites using MR technology. XR technology, including MR, can bridge the gap between the past and the present (Dieck et al., 2019).

MR offers significant economic benefits in cultural edutainment. MR can expand target markets (Barrado-Timón & Hidalgo-Giralt, 2019), increasing the customer base and generating additional business revenue. To enhance the overall tourism experience and appeal to a broader audience by exploring the potential of incorporating game elements such as challenges, rewards, and interactivity into MR experiences—a trend known as gamification (Chunga et al., 2021). This approach can optimise tourism development and marketing efforts. The incorporation of game-like elements and gamification into MR designs for CH, as proposed by Bekele (2019, 2021), serves to enhance the user experience in heritage exploration. Integrating MR technology into CH encourages collaboration and social interaction among visitors, creating an environment that avoids feelings of isolation and enhances the overall social experience (Vargas et al., 2020). Incorporating MR technology into CH makes the visit more appealing and worth revisiting, leading to an enriched social experience (Dieck et al., 2019). Through shared experiences and interactions, visitors can exchange knowledge, perspectives, and insights, improving their cultural edutainment process.

By incorporating game-like elements and personal stories into MR designs, CH sites become more engaging and exciting, thus increasing interest in history and promoting cultural preservation (Barrado-Timón & Hidalgo-Giralt, 2019; Theodoropoulos & Antoniou, 2022). MR technology can also provide virtual tours and personalised museum and heritage tourism experiences, enabling interactions with critical cultural artifacts and enhancing the learning experience (Gavalas et al., 2020). MR technology can also support engagement with cultural content for remote audiences, allowing

people to learn about CH from anywhere, anytime (Theodoropoulos & Antoniou, 2022). Moreover, virtual applications such as MR can also allow for interactions with intangible CH and promote sustainability strategies, providing an opportunity for people to learn about and engage with intangible CH in an immersive way (Theodoropoulos & Antoniou, 2022; Vargas et al., 2020).

The use of MR technology in cultural and historical industries brings together the concepts of cultural edutainment, offering a range of advantages, including personalised learning experiences, learning at one's own pace, and the ability to save content for later, which improves learning performance and generates motivation (Barrado-Timón & Hidalgo-Giralt, 2019; Vargas et al., 2020). MR has become a popular immersive reality technology for cultural knowledge dissemination in Virtual Heritage (VH), and it offers unprecedented opportunities for learning, communication, and entertainment in cultural spaces (Bekele & Eric Champion, 2019; Gavalas et al., 2020). Studies have demonstrated that Extended Reality (XR) technologies, which include Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), offer a superior visitor experience and are informative. While traditional CH education relies primarily on museum and heritage tourism site displays, MR technology offers more interaction between humans and computers, creating a game-like environment that enhances the learning setting and can effectively enhance learners' learning impact and motivation (Zhang et al., 2021). Another added value of MR in CH is its potential to deliver tangible benefits in learning about diverse cultures (Chunga et al., 2021).

2.2 Limitations and Challenges of MR in Edutainment Contexts

High-end computers are required to develop and implement mixed relity (MR) prototypes in heritage institutions for cultural edutainment, as applications often involve heavy graphical computations, rendering, and low latency (Bekele, 2021). Additionally, technical challenges are associated with implementing MR, such as finding fully immersive and interactive MR applications due to their resource-intensive nature. This limitation is compounded by the installation cost, making MR dissemination within traditional museums and heritage sites challenging (Bekele, 2021; Bekele & Eric Champion, 2019).

Developing MR applications is limited by cost and economic factors, as it requires using head-mounted devices (HMDs) such as Microsoft Hololens, which can be expensive for CH institutions. Bekele et al., (2021) suggested customised and deployed AR/MR headsets as an alternative. Additionally, developing new software tools is challenging due to the high cost of funding, making such projects costly for heritage institutions (Luna et al., 2019). Compared to mobile phone-based systems, the high price per unit of HMDs limits the number of devices used in exhibitions (Schofield et al., 2018). Developing MR applications for cultural edutainment in traditional museums and heritage sites also presents a challenge regarding programming expertise (Bekele & Eric Champion, 2019). As the MR devices require prior knowledge and practice to operate, dissemination of the technology requires skilled personnel (Bekele et al., 2021). To address this, Bekele, Mafkereseb, Erik, David, & Hafizur, (2021) recommend researching the younger generation, who are more likely to find the interaction mechanisms relatively easy to learn. Younger participants, who are generally more

familiar with digital devices like smartphones, would benefit from visual CH tools suitable for visitors unskilled in multimedia technologies (Bekele et al., 2018).

To ensure the successful dissemination of MR applications within traditional museums and heritage sites, the level of realism achieved plays a crucial role. It requires significant historical knowledge to create a meaningful virtual world for visitors and allow them to explore history (Theodoropoulos & Antoniou, 2022). Effective reconstruction of heritage material in MR applications requires good technical skills to accurately mimic the existing material characteristics. The lack of attributes of MR can affect visitor satisfaction in cultural and artistic attractions. In traditional cultural exhibitions, learning experiences that rely solely on labels and descriptions may provide information but lack interactivity (Bekele et al., 2018). Therefore, it is crucial to involve the appropriate authority to validate the information and ensure accuracy and reliability to provide informative material in MR development (Chong et al., 2021). According to Bekele & Eric Champion, (2019), frequent technological advancements require cultural institutions and professionals to acquire new skills and stay up-to-date with the latest immersive reality technologies and devices. To address the high-cost issue of implementing MR applications for CH exhibitions, Bekele, Mafkereseb, Erik, David, & Hafizur (2021) have suggested customising and deploying the application to other MR headsets cheaper than the Microsoft Hololens device.

2.3 Architecture edutainment in disseminating HUL

Architecture education is a specialised field that trains students in the principles, theories, and skills necessary for designing and constructing buildings and structures. It encompasses various subjects, including architectural history, design principles, construction technology, sustainability, and urban planning (Embaby, 2014). Architecture education aims to produce qualified architects with the knowledge and skills to responsibly design projects that involve conservation initiatives' preservation, reuse, reconstruction, and implementation.

The emphasis on integrating conservation principles and processes into architectural education, as highlighted by Embaby (2014), establishes a strong relationship between architecture and heritage conservation. This concerted effort at the international level, supported by organisations like the International Council on Monuments and Sites (ICOMOS) and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), aims to recognise the significance of preserving CH. By facilitating conferences and publications, these specialised programs become avenues for sharing research findings, best practices, and innovative approaches to heritage conservation. The guidelines established by ICCROM, ICOMOS, and United Nations Educational, Scientific and Cultural Organization (UNESCO) serve as crucial frameworks for designing theoretical, applied, and training courses in architectural education. Educational institutions and educators can align their curricula with these guidelines, ensuring that students have the necessary knowledge and skills to adhere to the best practices in heritage conservation. The field of architecture and urbanism recognises the urgent need to expand educational ideas through smart learning spaces driven by the inherent hereditary nature of architecture (Embaby, 2014). XR experiences have already demonstrated their value in various

aspects of CH, including preservation, reconstruction, reproduction, and damage assessment (Ioannidis et al., 2021).

3. Methodology

The research methodology for this study will involve several steps as shown in Figure 1.1. The first phase is to conduct an extensive literature review of relevant literature on CH education, MR technology, and its applications in education. This review will help identify the benefits and challenges associated with MR technology in cultural edutainment. The next phase is to analyse of MR applications in cultural edutainment to understand their effectiveness in enhancing learning outcomes in educational contexts. The third phase is to develop a prototype of MR application for the HUL of Jugra.

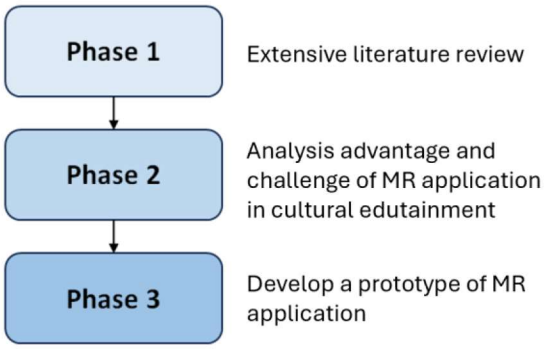

Figure 1.1: Research methodology flow chart

4. Discussion of analysis and findings

4.1 Significance of MR in edutainment for disseminating HUL

Based on the literature review, mixed reality (MR) technology offers a range of benefits in cultural edutainment:

Table 1.1: Significant role of MR edutainment in disseminate HUL

No	Items	The advantage of HUL dissemination
1	Motivating and engaging visitors	MR applications create immersive and interactive environments that motivate visitors to explore heritage sites and foster a deeper connection and interest in CH
2	Improved engagement and experience	MR in cultural edutainment captures visitors' attention, sparks curiosity, and provides meaningful and memorable experiences.
3	Enhanced visitor perception and realistic interaction	MR technologies overlay additional graphics and create an imaginary world that enhances visitors' perception of their surroundings. It simulates real-world sensations and enables lifelike and engaging interactions with virtual elements.
4	Increased accessibility	MR technology overcomes physical and geographical barriers, allowing individuals with limited mobility or those

		residing far from cultural sites to participate in the experience actively.
5	Novel and memorable experiences	MR provides learners with distinct and memorable learning experiences that ignite curiosity and motivation.
6	Enabling digital documentation	MR technology facilitates the digital documentation of architectural and cultural monuments, objects, and sites.
7	Economic benefits in heritage industries	MR expands target markets, attracts new audiences, and generates additional revenue.
8	Facilitating social benefits	MR fosters social interaction, collaboration, and the sharing of experiences.
9	Dissemination of tangible and intangible heritage	MR technology makes CH more engaging and exciting, promoting cultural preservation and increasing historical interest.
10	Enhancing cultural edutainment	MR technology improves the learning experience by offering personalised learning experiences, learning at one's own pace, and incorporating game-like elements.

Overall, Table 1.1 shows MR in cultural edutainment plays a significant role in enhancing the learning and engagement experience, improving accessibility, facilitating digital documentation, contributing to the economy, fostering social benefits, and promoting the dissemination of tangible and intangible heritage. It can revolutionise how we interact with and learn about HUL, making them more accessible, engaging, and memorable for many audiences.

4.2 Challenges of implementing MR in edutainment

Table 1.2 summarises the limitations and challenges of implementing mixed reality (MR) in edutainment contexts:

Table 1.2: Limitation in implementing MR for cultural edutainment

No	Items	Limitation	Suggestions
1	Required high-end computer systems	MR applications often involve heavy graphical computations and rendering, requiring high-performance computer systems.	Use low-polygon (low-poly) versions of 3D models (Plecher, Wandinger, & Klinker, 2019) to reduce the strain on high-end computer systems and make the MR rendering process faster and more efficient.
2	High cost for the device	Head-mounted devices (HMDs) such as Microsoft Hololens, often required for MR applications, can be expensive for CH institutions.	Using the Meta Quest HMD as a more affordable alternative for MR applications can help overcome the cost limitations of implementing MR in cultural edutainment contexts.

3	Less programming expertise	Developing MR applications for cultural edutainment requires programming expertise, which may challenge traditional museums and heritage sites.	Collaborating with academia, specifically architecture education programs and ICT (Information and Communication Technology) programs, in developing MR applications for cultural edutainment
4	Realism for reconstructio n materials	Achieving a high level of realism in MR applications is crucial for their effectiveness in CH contexts. The lack of natural characteristics in MR applications can impact visitor satisfaction.	The collaboration among experts from diverse backgrounds, including content experts, artists and designers, technologists and programmers, visitor experience (UX) specialists, educators and pedagogy experts, and evaluation and feedback professionals, plays a crucial role in achieving immersive and informative 3D models in MR applications (Pistola et al., 2021)
5	Informative material	The lack of interactive content and materials can negatively impact visitor engagement in digital learning.	Involving appropriate authorities to validate the information and ensure accuracy and reliability is crucial for providing informative material in MR development (Chong et al., 2021).

In conclusion, addressing the limitations and challenges associated with MR implementation in edutainment contexts requires acquiring new skills, staying updated with immersive reality technologies, collaborating with experts from various fields, and exploring more affordable headset options. Continued research and comprehensive case studies are necessary to fully explore the potential impact of MR in traditional museums and heritage sites.

4.3 Development of the MR prototype using the JUGRA HUL site

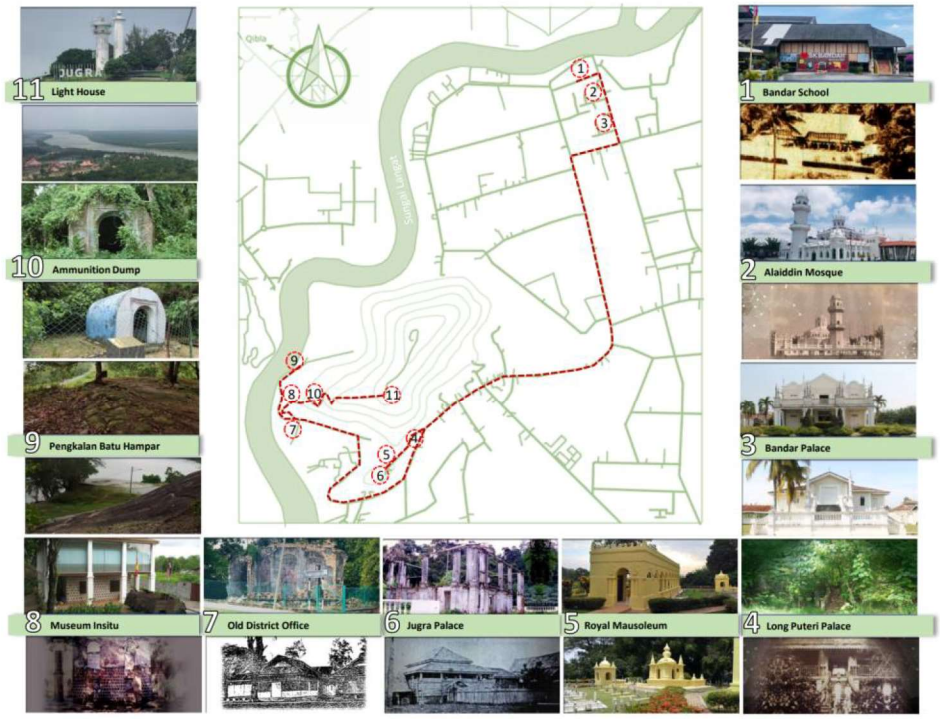

Figure 1.2: Mapping heritage element in Jugra

The above Figure 1.2 illustrates the existing landmarks of heritage elements in Jugra that remain accessible today. Jugra, situated near Kuala Lumpur, served as the third royal seat of Selangor and holds immense tourism potential due to its diverse Malay historical urban landscape. The region boasts remarkable landmarks like Jugra Mountain, River Langat, Istana Bandar, Sultan Alauddin Mosque, and numerous others. With its historical significance, Jugra's place in the history of the Malay Archipelago is notable, having been ruled by the sultanate of Melaka and later the sultanate of Johor Riau before a sultan of Bugis descent took charge of the state of Selangor. Preserving Jugra's historical value is crucial for the benefit of future generations, as the area retains intact historical elements, such as the Istana Bandar—the sole remaining old palace in Selangor. Ensuring the conservation of Jugra's heritage will honor its rich history and provide an opportunity for visitors to experience and appreciate the cultural legacy of this significant location.

By actively promoting Jugra as a heritage tourism destination, it can attract more visitors and get recognition nationally and internationally, thereby supporting its preservation and dissemination. Leveraging 3D modeling skills and architectural knowledge in MR can achieve Industrial Revolution 4.0 transformation. Transferring research project data from Architecture Program's heritage study course is a collaborative effort between academia and cultural institutions. This collaboration aims to disseminate CH to the public using MR digital technology. Developing an MR application for Jugra HUL involves several key phases, each contributing to creating an immersive and interactive digital exhibition. These phases are as follows:

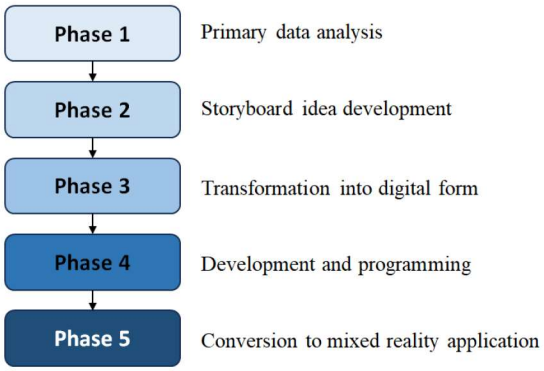

Figure 1.3: The development process of an MR application for Jugra Heritage Urban Landscape (HUL)

Figure 1.3 illustrates the data analysis phase, where the development process begins with primary data analysis derived from a literature review, such as collected from architectural studies, cultural learning materials, and heritage building measured drawings. This step provides the foundational information required for the MR application. The second stage is storyboarding and idea development. In this phase, the narrative of the digital exhibition is conceptualized and translated into storyboards. The team outlines the sequence of events and interactions users will experience while digitally exploring the heritage content. In the third phase, data transformation and 3D Modeling, the collected data is converted into digital and 3D modeling format. Skilled 3D modeling experts use software like AutoCAD, SketchUp, and Cinema 4D to transform 2D data into lifelike and detailed 3D models used in the application.

In the development programming phase, the Unity3D software compiles and programs the 3D models, creating an immersive mixed reality environment. Interactive elements are integrated into the exhibition, ensuring a dynamic and engaging user experience. The desired functionality, such as interactive hotspots and guided tours, is implemented at this stage. Adobe Photoshop is employed to enhance the application's user interface (UI) and user experience (UX). Designers work on refining visual elements to ensure a visually appealing and user-friendly experience. In the final stage, Android application conversion, the developed system is converted into an Android application compatible with Meta Quest 2 Head-Mounted Display (HMD). This allows users to access the MR application on the supported platform, enabling them to explore Jugra HUL's heritage in an immersive and interactive manner. By following these phases, the development team can create a compelling MR application that effectively showcases the cultural heritage of Jugra HUL, providing visitors with a novel and enriching experience.

5. Conclusion and future research

The paper emphasises the numerous benefits of implementing Mixed Reality (MR) in cultural edutainment, including enhanced learning experiences, improved accessibility, realistic interactions, digital heritage documentation, economic growth, social advantages, and widespread dissemination and preservation of cultural heritage. The study explores the limitations and challenges of using MR in edutainment contexts, emphasising the need to

acquire new skills, keep abreast of immersive reality technologies, foster interdisciplinary collaborations, and explore cost-effective options for headsets. The successful development of an effective MR prototype to enhance user experience in heritage cultural edutainment requires the collaboration of multi-disciplinary expertise. The convergence of diverse skill sets, and knowledge areas contributes from academia in architecture and cultural institutions to create a comprehensive and engaging MR experience. It plays a crucial role in disseminating the heritage urban landscape (HUL) of Jugra tourist sites.

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