Augmented Reality for Interactive Experiences in Museums: A Review

Yunzhen Shi[1], *Maszura binti Abdul Ghafar[2], and Mohd Faiz Yahaya[3]

[1,2]*Architecture Department, Faculty of Design and Architecture, Universiti Putra Malaysia, Selangor, Malaysia*
[3]*Industrial Design Department, Faculty of Design and Architecture, Universiti Putra Malaysia, Selangor, Malaysia*

shiiiieshi@gmail.com[1], *maszu@upm.edu.my[2], mfaizy@upm.edu.my[3]
*Corresponding author

ABSTRACT

Declining interest of visitors towards museum exhibits are causing museum to be vestige and dire. There is a need to personalized museum experiences through the exhibited artifacts display value. This desktop study uses a systematic review from the Scopus and IEEE XPLORE databases over ten years (2014 to 2023). The purpose of the paper is to identify what is the best Augmented Realities (AR) interaction for museum spaces. The discussion will be based on methods or tools to AR interactions, manifestations of AR interaction in museum spaces, and interaction modalities in museum spaces. This study found that when intelligent terminals are used to digitalize virtual exhibits together with wearable devices, it could create interactive gamified multi-mode interfaces for user-exhibit experiences. The outcomes of this paper would aid museums' design curators to utilize AR interaction and yield visitors interest toward learning and entertainment of museum artifacts.

Keywords: Augmented Reality; museum; digital technology; digital museum.

1 INTRODUCTION

Museums, as the heritage and cultural institutions aims to fulfilling visitors needs for learning, entertainment, and socializing (Russo & Peacock, 2009). Museums are facing downturn due to lower gratification towards museums artifacts resulting dire and low visitor numbers especially in China. China museums are lacking contemporary digital enable exhibition to offer enjoyable learning and entertainment towards cultural museum artifacts. The cultural heritage could gain a new perspective and achieves a higher position in the community when delivered through digital technology (Chandini Pendit et al., 2015). Utilizing digital technology in museum exhibition halls could be one of the methods employed for educational process in museums that enable access to information resources, preservation, and distribution of exhibitions themes (Aziz, 2017). Allison (2008) suggested that human-computer interaction could enhance user experiences and contribute to intuitive systems that help to re-conceptualize the history narration through the artifacts. To efficiently and effectively share content and context with visitors, museums are rapidly adopting state-of-the-art technologies (Guazzaroni & Pillai, 2019), and confronted with technological developments and sophisticated customer demands, museums must adapt their roles, develop new capabilities, and stay true to their mission and identity (Pine & Gilmore, 2013; Padilla-Melendez, 2013).

Our main objective in this review is to determine the most effective techniques for augmented reality interactions in museums. There is a need to personalized museum visits in order to maximize the display value of exhibited artefacts. Consequently, the research can assist developers and designers in comprehending the possibilities and difficulties associated with creating exhibitions that effectively integrate augmented reality interactions. The conclusions drawn from the analysis suggest that employing augmented reality technology can enhance visitors' overall museum experiences.

2 METHODOLOGY

This desktop study conducted a systematic review of the Scopus and IEEE XPLORE databases over a ten-year period (2014 to 2023). The discussion and arguments will be based on methods or tools for AR interactions, manifestations of AR interaction in museum spaces, and interaction modalities in museum spaces. The bibliometric data consisted of 695 documents, and the results were encoded and synthesized using multiple criteria with Microsoft Excel tools (refer to Figure 1).
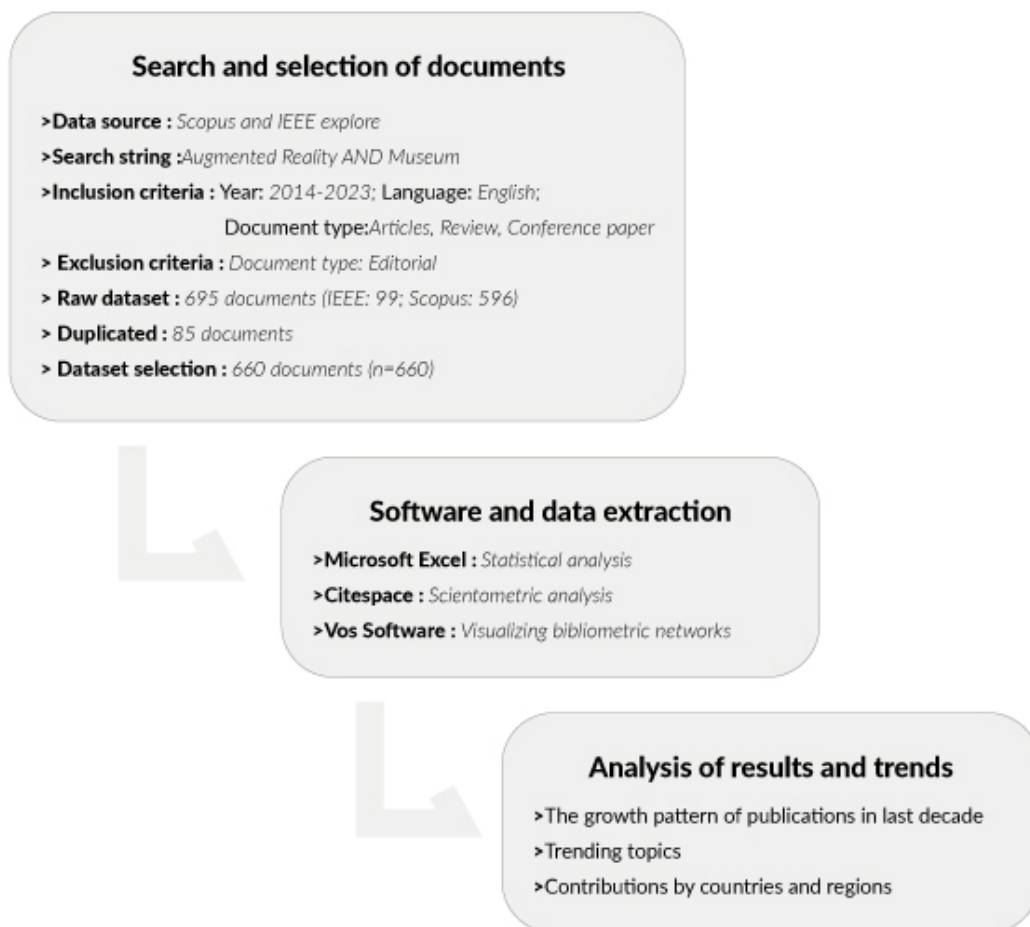
Search and selection of documents

> **Data source :** *Scopus and IEEE explore*

> **Search string :** *Augmented Reality AND Museum*

> **Inclusion criteria :** *Year: 2014-2023; Language: English;*
  Document type: Articles, Review, Conference paper

> **Exclusion criteria :** *Document type: Editorial*

> **Raw dataset :** *695 documents (IEEE: 99; Scopus: 596)*

> **Duplicated :** *85 documents*

> **Dataset selection :** *660 documents (n=660)*

Software and data extraction

> **Microsoft Excel :** *Statistical analysis*

> **Citespace :** *Scientometric analysis*

> **Vos Software :** *Visualizing bibliometric networks*

Analysis of results and trends

> The growth pattern of publications in last decade

> Trending topics

> Contributions by countries and regions

Figure 1 The desktop methodology in this study

3 LITERATURE REVIEW

This section explores about methods or tools for AR interactions, manifestations of AR interaction in museum spaces, and interaction modalities in museum spaces.

3.1 Methods or tools to AR interactions

The latest technologies for creating, visualizing, and interacting with digital 3D heritage content have become more readily available in public education, entertainment venues, and academic/research units. Consequently, there is an increasing exploration of the potential use of wearables in museum exhibits. Jung et al (2020) identified that wearing Virtual realities (VR) or AR multimodal devices could help visitors navigate a heritage site better, whilst Google Cardboard VR headset could give immersion experience of an artifact. Dieck & Jung (2017) supported that by using handheld AR, it could enhance user satisfaction while still preserving cultural heritage and offering a user-adapted learning experiences.

Modern approaches such as interaction design incorporation, interactive storytelling, and artificial intelligence could direct a new paradigm for museum experience design (Dal Falco & Vassos 2017; Vermeeren et al., 2018; Harada et al., 2018). The use of human-computer interaction for museum artifacts can offer a unique interactive and storytelling experience (Zidianakis et al., 2022; Benko et al., 2016). When AR replicas were visualized in real time, visitors could interpret historical figures through narrative-based setups (Rizvić et al. (2021). This study agrees that augmented museum exhibitions together with supplementary information could contribute to creation of an 'animated archive of cultural materials' (Patti,.2020) (refer to Figure 2). In the same vein, this initiative could catalogue objects alongside their descriptions and identify multiple representations of the same artifact.

Figure 2 A 3D-augmented book titled Constitutio Criminalis Theresiana (Nemesis Theresiana). Courtesy of Duguleană M.
(Source: Duguleană, M. 2018, Copyright Consent: Permissible to Publish)

Additionally, Lehto et al. (2020) found that incorporating stories is advantageous for younger guests. Thus, by enhancing the learning process, we can improve the storytelling experiences of historical locations, thereby piquing tourists' curiosity about the past. In the digital presentation of content related to museum items, augmented reality devices can offer a variety of experiences and styles. Research has shown that wearable technology increases user satisfaction (Dieck et al., 2018). Additionally, heritage routes can become more approachable and user-friendly through the use of mobile applications with digital narrative content (Basaraba et al., 2019). Despite the numerous benefits of augmented reality

(AR) technology, one drawback is the time-consuming process of creating AR applications (Viinikkala et al., 2016). This leads to increased production costs and poses challenges for widespread AR promotion.

3.2 Manifestations of AR interaction in museum spaces

Furthermore, Lehto et al. (2020) found that incorporating stories is advantageous for younger guests. Thus, while enhancing the learning process, it improves the storytelling experiences of historic locations. This, in turn, piques tourists' curiosity about the past. In the digital presentation of content related to museum items, augmented reality devices can offer a variety of experiences and styles. Wearable technology has been shown to increase user satisfaction (Dieck et al., 2018). Additionally, heritage routes can become more approachable and user-friendly by using mobile applications with digital narrative content (Basaraba et al., 2019). Despite the numerous benefits of augmented reality (AR) technology, one drawback is that creating AR applications is time-consuming (Viinikkala et al., 2016), increasing production costs and posing challenges to widespread AR promotion.

For instance, AR is applied in the restoration of damaged sacred objects, contributing to the rejuvenation of these culturally significant heritage artifacts (Boboc et al., 2017). It aids in determining the most effective restoration strategy to create a precise replica, thereby reducing costs and expediting the restoration process. Through the use of 3D reconstruction technology, a digital model of the damaged object can be generated (Parfenov et al., 2022) (refer to Figure 3). Subsequently, the optimal restoration strategy is identified by implementing an AR application developed based on this digital model (Abate et al., 2018; Blanco-Pons et al., 2019). Despite its advantages, augmented reality technology encounters challenge due to the lack of clear guidelines on its utilization. Another substantial obstacle to the widespread adoption of AR technology in the reconstruction process is the limited experience with AR applications.

Figure 3 The example of 3D reconstructed Prejmer Fortified Church, a UNESCO monument from Transylvania, Romania. (Source: Voinea et al., 2019, Copyright Consent: Permissible to Publish)

Many discussions have been sparked by the emergence of cutting-edge technology, such as multi-touch displays, mobile and portable electronics, and their innovative applications. According to applied pioneering research, the revolutionary impact of modern technologies on creative and cultural heritage continues to be a central focus in academia (Wang, 2021). These cutting-edge technologies are essential for museums to effectively utilize digital technologies, enhance visitor experiences, and create new opportunities for digital exhibitions (Darzentas et al., 2022). Despite the opportunities presented by indoor environments, many recent augmented reality experiences—such as discovering cultural heritage locations (Bujari et al., 2017) and enhancing experiential learning (Vlizos et al. 2021) —have been designed using smartphones and tablets as supporting hardware, particularly for outdoor settings (Slavec et al., 2021; Tzima et al., 2021). A mixed reality system with geoinformatics support was described by Evangelidis et al. (2020) as a means of bringing historical events back to life. Today's travelers anticipate using integrated tools to share and document their experiences during and after their visit, as well as to obtain crucial information prior to, during, and following their trip. Museums can now readily reach their audiences through digital technologies and possibilities, thanks to the development of new websites, mobile applications, and social media (Sookhanaphibarn et al., 2015). With digital technology, viewers have a wide range of options and sources to choose from when enjoying excursions and experiences.

Overall, digital museums are revolutionizing the museum experience, with many new technologies enhancing the quality of the encounter and enabling visitors to immerse themselves in profound learning. Therefore, a thorough exploration of the application of integrated AR interaction can optimize the display space and form of exhibits through the 3D reconstruction of cultural relics (Zhu, et al., 2023) and protect intangible cultural heritage data and images by using fused intelligent terminal apparatus and realistic video images in the scene (Christopoulos, et al., 2011).

3.3 Interaction modalities in museum spaces

With AR gaining attention in museums, AR technology has subverted the traditional way of museum display, making it more 'humane'—a trend that helps visitors deeply understand and explore the culture of historical artifacts rather than simply observe and browse (Mason, 2020). Digital technology, which is popular with younger users, can change the way museums are visited.

The interactive mode of implementing virtual animations for cultural relics through mobile applications is highly attractive to visitors. Among the mobile application developed are 'Seek Out Katipunan' that allows users to view 3D animations of displayed artifacts within the museum's environment (Colcol et al., 2017); Research has shown that applications for augmented reality (Fenu & Pittarello, 2018), 3D holographic interfaces, and integration with the Meta platform can be advantageous even for senior individuals (Pedersen, 2020). Furthermore, augmented reality technologies have been implemented in galleries, libraries, archives, and museums (GLAMs) to engage visitors with cultural heritage contents (Hoang & Cox, 2018). A literary museum is enhanced by an augmented reality online application that uses storytelling techniques to transport visitors to the virtual world of Svevo's scholarly work This study predicts that interactions between humans and computers will intertwine two seemingly unrelated narratives—one virtual and the other authentic. For instance, visitors visualize and engage with the virtual narrative during real-time encounters. Another illustration is The Museum Coffee Table (Teneketzis, 2020), an augmented physical surface that enables access to information about artists and their creations through tangible objects. This arrangement makes it possible for the whole family to spend quality time together at the table, sip coffee, and learn new information while enjoying the museum.

One interactive method to acquire knowledge about cultural artifacts more efficiently is through the use of wearable technology. Utilizing markers, projection mapping, and animations to present folklore heritage, national traditions, and legends, AR technology can create virtual try-on experiences for traditional costumes and accessories in digital Intangible Cultural Heritage (ICH) content (Wen & Chen, 2016). It can also immerse users in a traditional setting (Xie & Tang, 2018) and measure user adoption

of AR-specific devices (Laštovička-Medin, 2019; Han et al., 2019; Litvak & Kuflik, 2020). Regarding the smart glasses themselves, this study assumes that, although novelty was viewed favorably, some users found the interface challenging. Nevertheless, they integrated the smart glasses into their everyday usage and perceived pleasure as a beneficial outcome. The extended time required to develop AR applications is a drawback of AR technology, despite all its benefits (Viinikkala et al., 2016). Combining gamification with human-computer interaction may help create immersive user experiences (Liarokapis et al., 2017). For example, the Hellenic Maritime Museum enhances learning and makes it more engaging by offering students interactive, gamified educational activities during their visits (Rammos & Bratitsis, 2019).

The utilization of mobile learning processes significantly enhances academic results. The objective of the mobile augmented reality multi-user gaming application provided in (Angelopoulou et al., 2011) is to acquire historical information while playing, both indoors and outdoors. Serious games, commonly known as "games with educational purposes," serve as valuable teaching tools in the humanities by allowing players to actively engage and fully immerse themselves in a virtual world, as noted by Mortara et al. (2014). Differentiating the various serious games reviewed (Damala et al., 2016), one can use different game genres (such as adventure, strategy, or puzzle games) and additional learning objectives. These objectives may include games focused on historical reconstruction (like The Playing History or The Battle of Thermopylae (Christopoulos et al., 2011) or Discover Babylon) and games designed to raise awareness of cultural diversity (such as Time Explorer or Tate Trumps).

Storytelling is another form of gamification that has the potential to fundamentally transform how users interact with cultural heritage (CH). The evolution from traditional storytelling to digital storytelling (DS) integrates the age-old craft of storytelling with the latest technological advancements (Vert et al., 2021). In interactive digital storytelling (DS) applications, extended reality (XR) technologies have proven effective in enabling users to immerse themselves in historical events, interact with historical figures (Rizvić et al., 2021), and gain a deeper appreciation for traditional Chinese poetry (Zhao & Ma, 2020).

Human-computer interaction can take various forms, including wearables, museum exhibits, gamification of locations to encourage interaction, and more. However, immersive technologies also demonstrate strong potential to serve the public interest in heritage, encompassing both intangible and tangible aspects such as objects, structures, and historic locations. Improving people's experiences and encouraging learning and collaboration are closely related to how well augmented reality (AR) performs in human-computer interaction. The many ways that augmented reality (AR) will be used in museums—including content, locations, types of interactions, and environments—will enable multi-sensory experiences (Marto et al., 2022).

Furthermore, Ferdani et al. (2020) suggest that the dynamic enhancement of user knowledge, enjoyment, and engagement can be achieved through the combination of non-game mechanisms and interactive gamification. Users are immersed in an interactive experience when digital immersive elements are incorporated into museum displays (Lisi et al., 2019) through the interactive gamification of multimodal interfaces (Liarokapis et al., 2017). In conclusion, findings from several studies indicate that mobile augmented reality-mediated engagement activities have a beneficial effect on visitors' interactions with cultural material in museums and are a crucial component of the storytelling experience in this setting. The reason this approach is popular is that stories captivate and immerse consumers in a way that makes them feel more personally connected to historical events and cultural heritage. As far as storytelling is concerned, the most common is using characters, often associated with a place, to inform the user about history, stories, or legends.

In terms of the impact of implementing AR interactions within the historical context of various museum artifacts, participatory activities can enhance visitors' experiences at historic sites, improve the learning process, and heighten their interest in historical locations. In this context, the study predicts that utilizing augmented reality interactions might be a solution to enhance the user experience in museums.

Visitors can engage with cultural heritage in a sensual, affective, and constructive way by immersing themselves in historical culture. A very immersive experience can be created by including interactive activities into augmented reality interactions, which will increase visitor engagement. Thus, wearable technology is paired with intelligent terminals to create interactive, gamified interfaces that digitize virtual exhibits. As a result, users would have more and more immersive experiences.

4 DISCUSSION

In this section it will discuss on the commonly used methods or tools of AR interaction in museums, the optimal performance of AR interaction in museum spaces, and interactive modes suitable for museum environments

4.1 Common methods or tools for AR interaction in museum

The traditional museum exhibit has been transformed by AR technology, rendering it more "humane." Instead of mere observation and browsing, this approach encourages visitors to fully understand and explore the culture of historical items. Wearable technology, such as smart glasses, is widely available and well-received by museum visitors (Litvak & Kuflik 2020). For instance, the Hecht Museum in Israel enhanced its outdoor displays with audio and visual aids using smart glasses (tom Dieck et al., 2018). Focusing on the 19th-century British Painting Museum exhibition, Google Glass was employed to assess the impact of wearable technology on users' learning experiences. The results indicated improvements in users' satisfaction, comprehension, knowledge, and abilities. Although the study identified some challenges specific to outdoor contexts, such as illumination, wearables received positive feedback. Addressing these challenges will be essential for future advancements.

Regarding the technological components, a number of considerations come into play when choosing the tracking method. One important consideration is the application's intended use area, which includes both indoor and outdoor environments. The quantity of research that has been done on tablets and smartphones is consistent with what we anticipate will happen to the common display technology. Mobile devices are unquestionably among the most widely utilized instruments for experiencing augmented reality due to their ubiquitous ownership—nearly every potential user possesses one (Craig, 2013). Head-mounted displays, on the other hand, are more frequently utilized indoors compared to other display types, and their adoption rate is lower outdoors, which could be attributed to site layout considerations.

4.2 The best performance of AR interaction in museum

About the results of each study, we obtained some interesting results regarding the impact of using AR interactive forms on the experience of historical artifacts in museums. The apparent prevalence of 3D modeling is evident in content types. 3D modeling is widely used because it is easier to entertain than natural images/videos, can reproduce the original model faithfully, and even because of the lack of what the author intended to portray as accurate. The comparison of Koo et al.'s (2020) produced application with independent and guided tour types highlights the potential for the mobile app visit experience to emerge as a competitive alternative. Moreover, they claim that the app markets itself as more beneficial and adaptable because it can handle an infinite number of users and does away with the requirement for reservations, unlike guided tours. For the demand, it is always adequate (Koo et al., 2020). To round off this list of advantages, companies can avoid paying exorbitant fees for purchasing and maintaining gadgets by allowing employees to use their own devices (Sprung & Haxha, 2020).

Upon closer examination of the integration of participatory activities, game mechanics emerge as the most commonly employed. Varinlioglu & Halici (2019) found support for the use of game elements in gamified environments, as these components enhance user immersion during visits. Confirming this, the study by Lehto et al. (2020) established a correlation between users' interest in the app and their

preexisting interest in the game. Notably, the application received higher ratings from users already interested in the game compared to those with no prior interest (Lehto et al., 2020).

4.3 Interactive mode suitable for museum

According to Dunleavy et al. (2009), augmented reality technology can aid users in comprehending abstract concepts by providing visual assistance. Wu et al. (2013) have highlighted that augmented reality (AR) enables the overlay of virtual items and data onto the real world. Leveraging information science and technology, exhibitions can now offer a more interactive experience, allowing visitors to engage with touchscreen computer displays and hands-on activities. Exhibition strategies should surpass the expectations of younger visitors to capture their interest and encourage exploration of museums and appreciation for archives. Incorporating interactive display technologies into cultural heritage museums is recommended to transform the perception of artifact exhibitions.

Digital resources enhance the enjoyment of visiting a cultural heritage site by providing visitors with access to relevant, engaging, and user-driven learning opportunities (Longo et al., 2018). Additionally, Lin & Lin (2017) suggest an emerging trend in cultural tourism is the use of technology to enhance visitor experiences. This increases the flexibility and educational value of visits to digital museums, allowing visitors to design customized tours based on their interests and time constraints. Utilizing interactive media for digital exhibitions and artwork in digital museums is a key aspect of digital technology. Furthermore, interactive entertainment and art are increasingly prevalent in public spaces. A notable trend is the rise of digital public art, blending digital and public art (Narumi et al., 2016). All things considered, the experience of visiting digital museums is undergoing a significant transformation due to the continual introduction of new technology.

5 CONCLUSION AND FUTURE WORK

An emerging field that leverages the array of mobile devices available and the services offered by museums in daily life is the use of engagement activities in the context of implementing augmented reality technology in museums. This literature study explores the types of augmented reality technology suitable for museums and potential future applications.

In conclusion, the results from various studies suggest that participatory activities using augmented reality interactions have a positive impact on the museum visitor experience. Analysing the engagement levels of different visitors, augmented reality digital means can effectively maximize the protection and presentation of Intangible Cultural Heritage (ICH). The seamless integration of content with real video images in the scene is achieved using intelligent terminals. The public can engage more effectively with historical events and cultural heritage through intuitive and visually striking virtual object presentations.

Museums and visitors can now engage and connect on a deeper level thanks to augmented reality interactive technologies. Creating AR experiences involves using various interactive techniques to present complex information about relevant artifacts, with the widespread use of portable mobile devices being a common approach. In this way, AR interaction allows for dynamic access and exchange of detailed information about exhibited artifacts. The promotion and application of AR interaction in museums aim to facilitate the transition for visitors from a physical to a digital mode of experiencing exhibits.

However, there are still limitations to the use of AR interaction, most of which are associated with the sophisticated technological know-how needed to create these applications. One of the most viable and approachable ways for individuals to experience cultural heritage using augmented reality is still through mobile technologies. The availability of AR content, clear visualization, and user interface design are all important factors to consider, ensuring that AR applications provide a positive user experience. The use of smart glasses stands out as the best option when considering users' flexibility to interact with AR technology, ensuring both enjoyment and practicality. As an alternative to engaging

with a mobile touchscreen display, this allows users to free up their hands and achieve experience goals based on gestures.

Gamification patterns are widely utilized in electronic educational resources. The AR tools used for developing exhibits seamlessly integrate game-like behaviors, employing serious game methods or narrative storytelling forms. By incorporating game-related concepts into applications showcasing cultural artifacts, user engagement and collaboration can be heightened. Gamification, as a viable tool, allows participants not only to engage with real elements of cultural artifacts but also to experience deeper layers of cultural heritage content in virtual environments. Utilizing smart glasses in conjunction with portable mobile devices to achieve gamified AR interaction forms, combined with user behaviors, can enhance users' "cultural immersion" experience in museums. Obstacles encountered in the development process of augmented reality interaction technology have led to extended time requirements for development, primarily focused on the need for caution in dealing with specific environments in different locations. This is due to considerations of creative quality, limited financial and time resources, issues related to cultural heritage preservation, or current technological limitations.

While this paper presents a research approach, there are limitations that indicate potential future research directions. The analysis is limited to research on museums published in Scopus and IEEE XPLORE databases, categorizing this article as a literature type. Future researchers may wish to examine conference papers, reviews, editorials, papers, and theses, and it is necessary to include articles from before 2014. This not only broadens the scope of the article but also evaluates whether there have been significant changes in the application of AR interactive technology in museums.

From the perspective of future work, designers can consider creating mobile augmented reality applications that are narrative-driven and gamified, combined with the use of smart glasses. Clouding is also enhancing the visitor's experience in museums. This will be a progression in the field of human-computer interaction.

ACKNOWLEDGEMENT

FUNDING

AUTHOR CONTRIBUTIONS / SUMBANGAN PENULIS

All the authors have contributed to the paper meticulously.

CONFLICT OF INTEREST / KONFLIK KEPENTINGAN

There is no conflict of interests.

REFERENCES

Aggarwal, R., & Singhal, A. (2019, January). Augmented Reality and its effect on our life. In 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence) (pp. 510-515). IEEE.

Angelopoulou, A., Economou, D., Bouki, V., Psarrou, A., Jin, L., Pritchard, C., & Kolyda, F. (2012). Mobile augmented reality for cultural heritage. In Mobile Wireless Middleware, Operating Systems,

and Applications: 4th International ICST Conference, Mobilware 2011, London, UK, June 22-24, 2011, Revised Selected Papers 4 (pp. 15-22). Springer Berlin Heidelberg.

Abate, A. F., Barra, S., Galeotafiore, G., Díaz, C., Aura, E., Sánchez, M., ... & Vendrell, E. (2018). An augmented reality mobile app for museums: virtual restoration of a plate of glass. In Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection: 7th International Conference, EuroMed 2018, Nicosia, Cyprus, October 29–November 3, 2018, Proceedings, Part I 7 (pp. 539-547). Springer International Publishing.

Aziz, M. N. A. (2017). Preserving Intangible Cultural Heritage Knowledge: A Framework for Tangible User Interface in Malaysian Museums. Idealogy Journal, 2(2), 13-31.

Benko, H., Holz, C., Sinclair, M., & Ofek, E. (2016, October). Normaltouch and texturetouch: High-fidelity 3d haptic shape rendering on handheld virtual reality controllers. In Proceedings of the 29th annual symposium on user interface software and technology (pp. 717-728).

Basaraba, N., Conlan, O., Edmond, J., & Arnds, P. (2019). Digital narrative conventions in heritage trail mobile apps. New Review of Hypermedia and Multimedia, 25(1-2), 1-30.

Blanco-Pons, S., Carrión-Ruiz, B., Lerma, J. L., & Villaverde, V. (2019). Design and implementation of an augmented reality application for rock art visualization in Cova dels Cavalls (Spain). Journal of Cultural Heritage, 39, 177-185.

Boboc, R. G., Gîrbacia, F., Duguleană, M., & Tavčar, A. (2017, March). A handheld Augmented Reality to revive a demolished Reformed Church from Braşov. In Proceedings of the Virtual Reality International Conference-Laval Virtual 2017 (pp. 1-4).

Bujari, A., Ciman, M., Gaggi, O., & Palazzi, C. E. (2017). Using gamification to discover cultural heritage locations from geo-tagged photos. Personal and Ubiquitous Computing, 21(2), 235-252.

Chandini Pendit, U., Zaibon, S. B., & Abu Bakar, J. A. (2015). Conceptual model of mobile augmented reality for cultural heritage site towards enjoyable informal learning aspect. Jurnal Teknologi, 77(29), 123-129.

Christopoulos, D., Mavridis, P., Andreadis, A., & Karigiannis, J. N. (2011, May). Using Virtual Environments to Tell the Story:" The Battle of Thermopylae". In 2011 Third International Conference on Games and Virtual Worlds for Serious Applications (pp. 84-91). IEEE.

Craig, A. B. (2013). Understanding augmented reality: Concepts and applications.

Damala, A., Hornecker, E., Van Der Vaart, M., & Ruthven, I. (2016). The Loupe: tangible augmented reality for learning to look at Ancient Greek art. Mediterranean Archaeology and Archaeometry, 16(5), 73-73.

Darzentas, D., Cameron, H., Wagner, H., Craigon, P., Bodiaj, E., Spence, J., ... & Benford, S. (2022). Data-inspired co-design for museum and gallery visitor experiences. AI EDAM, 36, e3.

Dal Falco, F., & Vassos, S. (2017). Museum experience design: A modern storytelling methodology. The Design Journal, 20(sup1), S3975-S3983.

Duguleană, M. (2018). eHERITAGE Project–Building a Cultural Heritage Excellence Center in the Eastern Europe. In Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection: 7th International Conference, EuroMed 2018, Nicosia, Cyprus, October 29–November 3, 2018, Proceedings, Part II 7 (pp. 215-223). Springer International Publishing.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. Journal of science Education and Technology, 18, 7-22.

Dolan, R., Conduit, J., Fahy, J., & Goodman, S. (2016). Social media engagement behaviour: a uses and gratifications perspective. Journal of strategic marketing, 24(3-4), 261-277.

Evangelidis, K., Sylaiou, S., & Papadopoulos, T. (2020). Mergin'mode: Mixed reality and geoinformatics for monument demonstration. Applied Sciences, 10(11), 3826.

Fenu, C., & Pittarello, F. (2018). Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum. International Journal of Human-Computer Studies, 114, 20-35.

Ferdani, D., Fanini, B., Piccioli, M. C., Carboni, F., & Vigliarolo, P. (2020). 3D reconstruction and validation of historical background for immersive VR applications and games: The case study of the Forum of Augustus in Rome. Journal of Cultural Heritage, 43, 129-143.

Guazzaroni, G., & Pillai, A. S. (Eds.). (2019). Virtual and augmented reality in Education, Art, and Museums. IGI Global.

Han, D. I., tom Dieck, M. C., & Jung, T. (2018). User experience model for augmented reality applications in urban heritage tourism. Journal of Heritage Tourism, 13(1), 46-61.

Hoang, T. N., & Cox, T. N. (2018). Alternating reality: an interweaving narrative of physical and virtual cultural exhibitions. Presence, 26(4), 402-419.

Colcol, H. C. R., Padilla, J. V., Buella, Y. D. V., Barrientos, I. E., Calimlim, V. T. V., & Fernando, M. C. G. (2017, November). Seek out Katipunan: a mobile augmented reality for museum visualization. In Proceedings of the 3rd International Conference on Communication and Information Processing (pp. 72-76).

Hollebeek, L. D., & Macky, K. (2019). Digital content marketing's role in fostering consumer engagement, trust, and value: Framework, fundamental propositions, and implications. Journal of interactive marketing, 45(1), 27-41.

Harada, T., Hideyoshi, Y., Gressier-Soudan, E., & Jean, C. (2018). Museum experience design based on multi-sensory transformation approach. In DS 92: Proceedings of the DESIGN 2018 15th international design conference (pp. 2221-2228).

Ibrahim, R. (2011). Demystifying the arduous doctoral journey: The eagle vision of a research proposal. Electronic Journal of Business Research Methods, 9(2), pp130-140.

Jung, K., Nguyen, V. T., Piscarac, D., & Yoo, S. C. (2020). Meet the virtual jeju dol harubang—The mixed VR/Ar application for cultural immersion in Korea's main heritage. ISPRS International Journal of Geo-Information, 9(6), 367.

Koo, S., Kim, J., Kim, C., Kim, J., & Cha, H. S. (2019). Development of an augmented reality tour guide for a cultural heritage site. Journal on Computing and Cultural Heritage (JOCCH), 12(4), 1-24.

Lehto, A., Luostarinen, N., & Kostia, P. (2020). Augmented reality gaming as a tool for subjectivizing visitor experience at cultural heritage locations—case lights on!. Journal on Computing and Cultural Heritage (JOCCH), 13(4), 1-16.

Litvak, E., & Kuflik, T. (2020). Enhancing cultural heritage outdoor experience with augmented-reality smart glasses. Personal and ubiquitous computing, 24, 873-886.

Liarokapis, F., Petridis, P., Andrews, D., & de Freitas, S. (2017). Multimodal serious games technologies for cultural heritage. Mixed reality and gamification for cultural heritage, 371-392.

Lu, W., Wang, M., & Chen, H. (2020, June). Research on intangible cultural heritage protection based on augmented reality technology. In Journal of Physics: Conference Series (Vol. 1574, No. 1, p. 012026). IOP Publishing.

Laštovička-Medin, G. (2019, June). The Materiality of Interaction & Intangible Heritage: Interaction Design. In 2019 8th Mediterranean Conference on Embedded Computing (MECO) (pp. 1-6). IEEE.

Longo, F., Nicoletti, L., & Padovano, A. (2018). An interactive, interoperable and ubiquitous mixed reality application for a smart learning experience. International Journal of Simulation and Process Modelling, 13(6), 589-603.

Lin, F. T., & Lin, Y. C. (2017, November). An ontology-based expert system for representing cultural meanings: An example of an Art Museum. In 2017 Pacific Neighborhood Consortium Annual Conference and Joint Meetings (PNC) (pp. 116-121). IEEE.

Mortara, M., Catalano, C. E., Bellotti, F., Fiucci, G., Houry-Panchetti, M., & Petridis, P. (2014). Learning cultural heritage by serious games. Journal of Cultural Heritage, 15(3), 318-325.

Mason, M. (2020). The elements of visitor experience in post-digital museum design. Design Principles and Practices, 14(1), 1-14.

Marto, A., Gonçalves, A., Melo, M., & Bessa, M. (2022). A survey of multisensory VR and AR applications for cultural heritage. Computers & Graphics, 102, 426-440.

Narumi, T., Yabe, H., Yoshida, S., Tanikawa, T., & Hirose, M. (2016). Encouraging people to interact with interactive systems in public spaces by managing lines of participants. In Human Interface and the Management of Information: Applications and Services: 18th International Conference, HCI International 2016 Toronto, Canada, July 17-22, 2016. Proceedings, Part II 18 (pp. 290-299). Springer International Publishing.

Nisi, V., Cesario, V., & Nunes, N. (2019). Augmented reality museum's gaming for digital natives: Haunted encounters in the Carvalhal's palace. In Entertainment Computing and Serious Games: First IFIP TC 14 Joint International Conference, ICEC-JCSG 2019, Arequipa, Peru, November 11–15, 2019, Proceedings 1 (pp. 28-41). Springer International Publishing.

Padilla-Meléndez, A., & del Águila-Obra, A. R. (2013). Web and social media usage by museums: Online value creation. International journal of information management, 33(5), 892-898.

Paliokas, I., Patenidis, A. T., Mitsopoulou, E. E., Tsita, C., Pehlivanides, G., Karyati, E., ... & Tzovaras, D. (2020). A gamified augmented reality application for digital heritage and tourism. Applied Sciences, 10(21), 7868.

Patti, I. (2020, November). Standard Cataloguing of Augmented Objects for a Design Museum. In IOP Conference Series: Materials Science and Engineering (Vol. 949, No. 1, p. 012054). IOP Publishing.

Panou, C., Ragia, L., Dimelli, D., & Mania, K. (2018, March). Outdoors Mobile Augmented Reality Application Visualizing 3D Reconstructed Historical Monuments. In GISTAM (pp. 59-67).

Parfenov, V., Igoshin, S., Masaylo, D., Orlov, A., & Kuliashou, D. (2022). Use of 3D laser scanning and additive technologies for reconstruction of damaged and destroyed cultural heritage objects. Quantum Beam Science, 6(1), 11.

Pedersen, I., Gale, N., Mirza-Babaei, P., & Reid, S. (2017). More than meets the eye: The benefits of augmented reality and holographic displays for digital cultural heritage. Journal on Computing and Cultural Heritage (JOCCH), 10(2), 1-15.

Pine, B. J., & Gilmore, J. H. (2013). The experience economy: past, present and future. Handbook on the experience economy, 1, 21-44.

Rammos, D., & Bratitsis, T. (2021). Museum Exhibits that Interact with Pupils' Mobile Devices. The Case of Hellenic Maritime Museum. In Internet of Things, Infrastructures and Mobile Applications: Proceedings of the 13th IMCL Conference 13 (pp. 189-201). Springer International Publishing.

Rizvić, S., Bošković, D., Okanović, V., Kihić, I. I., Prazina, I., & Mijatović, B. (2021). Time travel to the past of bosnia and herzegovina through virtual and augmented reality. Applied Sciences, 11(8), 3711.

Russo, A., & Peacock, D. (2009). Great expectations: Sustaining participation in social media spaces. Museums and the Web 2009: Proceedings, 23-36.

Sookhanaphibarn, K., Chatuporn, U., & Nakornphanom, K. N. (2015). User modeling on social media for art museums and galleries. In Social Computing and Social Media: 7th International Conference, SCSM 2015, Held as Part of HCI International 2015, Los Angeles, CA, USA, August 2–7, 2015, Proceedings 7 (pp. 89-95). Springer International Publishing.

Slavec, A., Sajinčič, N., & Starman, V. (2021). Use of smartphone cameras and other applications while traveling to sustain outdoor cultural heritage. Sustainability, 13(13), 7312.

Sebastiani, A. (2021). Digital Artifacts and Landscapes. Experimenting with Placemaking at the Impero Project. Heritage, 4(1), 281-303.

Sprung, G., & Haxha, A. (2020). IFAR: MobileAR for cultural heritage. CEUR Workshop Proceedings, 2618(April), 1-4.

Tzima, S., Styliaras, G., & Bassounas, A. (2019). Augmented reality applications in education: Teachers point of view. Education Sciences, 9(2), 99.

tom Dieck, M. C., Jung, T. H., & tom Dieck, D. (2018). Enhancing art gallery visitors' learning experience using wearable augmented reality: generic learning outcomes perspective. Current Issues in Tourism, 21(17), 2014-2034.

tom Dieck, M. C., & Jung, T. H. (2017). Value of augmented reality at cultural heritage sites: A stakeholder approach. Journal of destination marketing & management, 6(2), 110-117.

Teneketzis, A. (2020). Exploring the emerging digital scene in Art History and museum practice. Esboços: histórias em contextos globais, 27(45), 187-206.

Varinlioglu, G., & Halici, S. M. (2019). Gamification of Heritage through augmented reality. Ecaade Sigradi, 513-518.

Viinikkala, L., Yli-Seppälä, L., Heimo, O. I., Helle, S., Härkänen, L., Jokela, S., ... & Lehtonen, T. (2016, October). Reforming the representation of the reformation: Mixed reality narratives in communicating tangible and intangible heritage of the protestant reformation in Finland. In 2016 22nd International Conference on Virtual System & Multimedia (VSMM) (pp. 1-9). IEEE.

Voinea, G. D., Girbacia, F., Postelnicu, C. C., & Marto, A. (2019). Exploring cultural heritage using augmented reality through Google's Project Tango and ARCore. In VR Technologies in Cultural Heritage: First International Conference, VRTCH 2018, Brasov, Romania, May 29–30, 2018, Revised Selected Papers 1 (pp. 93-106). Springer International Publishing.

Vlizos, S., Sharamyeva, J. A., & Kotsopoulos, K. (2021). Interdisciplinary Design of an Educational Applications Development Platform in a 3D Environment Focused on Cultural Heritage Tourism. In Emerging Technologies and the Digital Transformation of Museums and Heritage Sites: First International Conference, RISE IMET 2021, Nicosia, Cyprus, June 2–4, 2021, Proceedings 1 (pp. 79-96). Springer International Publishing.

Vert, S., Andone, D., Ternauciuc, A., Mihaescu, V., Rotaru, O., Mocofan, M., ... & Vasiu, R. (2021). User evaluation of a multi-platform digital storytelling concept for cultural heritage. Mathematics, 9(21), 2678.

Vermeeren, A. P., Calvi, L., Sabiescu, A., Trocchianesi, R., Stuedahl, D., Giaccardi, E., & Radice, S. (2018). Future museum experience design: crowds, ecosystems and novel technologies (pp. 1-16). Springer International Publishing.

Wang, E. (2021). Creating an Augmented Reality Museum Experience for Cultural Heritage Using a Textile-Based Capacitive Sensor as the Interactive Input. Drexel University.

Wen, Y., & Chen, J. (2016). Intangible cultural heritage display using augmented reality technology of Xtion PRO interaction. IJSSST, 17(40), 29-1.

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & education, 62, 41-49.

Xie, X., & Tang, X. (2018). The application of augmented reality technology in digital display for intangible cultural heritage: The case of cantonese furniture. In Human-Computer Interaction. Interaction in Context: 20th International Conference, HCI International 2018, Las Vegas, NV, USA, July 15–20, 2018, Proceedings, Part II 20 (pp. 334-343). Springer International Publishing.

Zhao, Z. (2017, October). Digital protection method of intangible cultural heritage based on augmented reality technology. In 2017 International Conference on Robots & Intelligent System (ICRIS) (pp. 135-138). IEEE.

Zhao, Z., & Ma, X. (2020). ShadowPlay2. 5D: A 360-degree video authoring tool for immersive appreciation of classical Chinese poetry. Journal on Computing and Cultural Heritage (JOCCH), 13(1), 1-20.

Zidianakis, E., Partarakis, N., Kontaki, E., Kopidaki, S., Xhako, A., Pervolarakis, Z., ... & Stephanidis, C. (2022, June). Web-Based Authoring Tool for Virtual Exhibitions. In International Conference on Human-Computer Interaction (pp. 378-385). Cham: Springer Nature Switzerland.

Zhu, C., Fong, L. H. N., & Gan, M. (2023). Rethinking the consequences of postmodern authenticity: The case of a World Cultural Heritage in Augmented Reality. Current Issues in Tourism, 26(4), 617-631.