

The Use of Augmented Reality Technology in Preserving Cultural Heritage: A Case Study of Old Jami Mosque of Palopo

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Abstract

This research aims to explore the use of Augmented Reality (AR) technology in the context of cultural heritage preservation, with a particular focus on the Old Jami Mosque of Palopo. This research uses a qualitative case study approach to investigate the application of AR in preserving the mosque's cultural heritage. Data were collected through observation, interviews, documentary analysis, and system testing using the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The findings from a questionnaire survey conducted with 50 respondents representing the general public, students, college students, traditional leaders, and tourists indicated a positive acceptance of the AR system, with an overall approval rating of 87% across various aspects. The results demonstrate that the developed AR application for the Old Jami Mosque Palopo enhances visitors' experience and understanding of the mosque's historical, architectural, and cultural values. The integration of AR technology has the potential to foster greater visitor engagement and contribute to the preservation of cultural heritage. This research provides insights into the potential and advantages of leveraging AR technology for cultural heritage preservation and provides an overview of the development of effective AR applications in cultural contexts.

Keywords: Augmented Reality, Cultural Heritage, Old Jami Mosque of Palopo, UTAUT Model.

Received: 11 January 2022

Revised: 29 March 2022

Accepted: 21 April 2022

Introduction

Augmented Reality (AR) technology was first implemented by Ivan Sutherland in 1962. Since then, AR has been widely developed by various parties and can be implemented on various devices (Joshi, Jain, & Vanjani, 2023; Nevarini, Agustiani, & Zahra, 2023). The implementation of AR does not require special additional devices that usually consume a lot of resources in terms of cost and installation time (Butsiarah, Ilham, Kamaruddin, & Supriadi, 2022). Based on these reasons, AR technology has been extensively developed by developers for mobile platforms such as Android and iOS (Meccawy, 2022).

AR can be implemented in various fields, including Medical Learning in the medical field (Pottle, 2019), E-books in education (Vu, 2019), machinery system design in the design field (Ramadhan, Arifitama, & Permana, 2021), as well as catalogue visualization (Rizal & Rusmin, 2018), virtual fitting rooms (Simarmata, Romindo, et al., 2022), and advertising media in the marketing field (Vilkinina & Klimovets, 2020).

The tourism sector is one of the foreign exchange-generating sectors with significant potential for development (Simanjuntak et al., 2023). The tourism sector has experienced rapid growth due to the increasing demand for tourism (Streimikiene, Svagzdiene, Jasinskas, & Simanavicius, 2021). In the long run, the tourism sector has become one of the growing and developing economic sectors in line with the progress and entertainment needs of the global society. Therefore, it is not surprising that many countries, including Indonesia, consider the tourism sector as a driving force for their future economy (Subawa, Widhiasthini, Astawa, Dwiatmadja, & Permatasari, 2021).

One of the factors hindering the development of tourism is the promotion patterns and tourism information management systems that are not well-established (He, Tuo, Lei, & Gao, 2023). As a result, sometimes tourist attractions are unknown and not considered destinations by tourists. The rapid increase in smartphone usage and the development of

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information technology should be optimally utilized in the development of the tourism industry in Indonesia. The utilization of information technology will facilitate information for tourists to recognize tourist attractions, routes, and the diversity of tourist locations.

According to (Park, Kim, Lee, & Woo, 2016), as cited in the journal “All in One Mobile Outdoor Augmented Reality Framework for Cultural Heritage Site,” the most important characteristics of AR are real-time interactivity and the ability to display content in 3D space. Furthermore, AR technology has been adapted to the domain of cultural heritage, such as applications and 3D acquisition that reconstruct cultural heritage sites as virtual 3D models in South Korea.

However, in the city of Palopo, there is a lack of tour guides specifically dedicated to introducing the cultural heritage of the city, particularly its historical relics (Aman et al., 2023). When visiting tourist attractions, especially the Old Jami Mosque of Palopo, tourists are often accompanied by mosque administrators who primarily communicate in the local Luwu dialect, which may pose challenges for visitors to understand.

The implementation of this application is expected to assist the local community and tourists in getting to know the history and grandeur of the Old Jami Mosque of Palopo. This way, the community will have a deeper appreciation of the history of Indonesia.

Several relevant studies can be identified about the conducted research. (Han, Yoon, & Kwon, 2021) investigated the impact of various aspects of Augmented Reality (AR) experiential value, including visual appeal, entertainment, enjoyment, and escapism, on destination-related behaviour. The study examined how these factors influenced destination authenticity, AR satisfaction, and the supportive behaviour of individuals.

(Ahmad, Rahmanto, Pratama, & Borman, 2021) conducted research that resulted in the development of an augmented reality application for introducing tangible cultural heritages at the Lampung Museum. The application successfully displayed 3D objects when the user's camera was directed towards the museum's collections, providing relevant information about these objects. This application aimed to assist visitors in accessing information about the cultural heritage collection, especially during periods of high visitor volume when the availability of museum guides was limited.

(Llerena-Izquierdo & Cedeño-Gonzabay, 2019) combined photogrammetry and augmented reality technologies to promote the religious and cultural heritage of San Pedro Cathedral in Guayaquil, Ecuador. The research involved the development of a mobile application called "My Cathedral," which allows users to access historical information and view photogrammetric images in augmented reality, especially those related to important objects within the cathedral. The app facilitates an interactive and educational experience for visitors, encouraging them to learn more about the cathedral's religious and cultural heritage.

(Sudipa, Aditama, & Yanti, 2022) focused on the implementation of Augmented Reality (AR) technology in digitising Balinese lontar prasi, a tangible cultural heritage in Bali. The research aims to preserve, promote, and develop Balinese art and cultural heritage using a research and development approach, which involves creating 3D objects and character animations using Blender, developing applications using Unity software, and creating markers for lontar praise sheets.

Based on the identified issues and related studies, the researcher explores the use of Augmented Reality (AR) technology in the context of cultural heritage preservation, focusing on a case study of the Old Jami Mosque of Palopo. This research aims to enhance visitors' understanding of cultural attractions in Palopo City through the implementation of Augmented Reality technology and to assess the impact on tourist visits in Palopo City when Augmented Reality is applied to tourism information.

Augmented Reality

Augmented Reality works by combining digital components of an object/subject or from the computer side to the real world in real-time, while adapting to the surrounding environment of the recipient (Andryanto et al., 2022). Interaction with digital objects is achieved using several techniques such as marker-based tracking and markerless-based tracking (Iskandar, A, Amiruddin, & Habum, 2021).

Marker-based tracking technique involves using a combination of black and white colours for the presented object, typically a black box on a white background. Marker-based tracking illustrates the three-dimensional shape in the X, Y, and Z coordinates (Simarmata, Raja, et al., 2022).

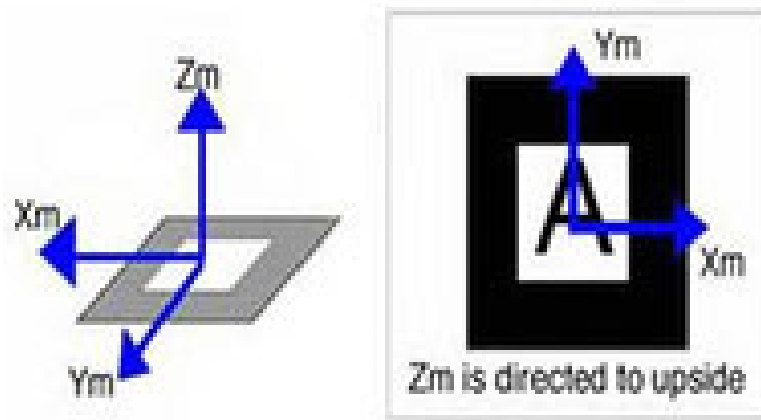


Figure 1 Marker-Based Tracking Technique (Laswi & A, 2018).

Meanwhile, markerless-based tracking is an improvement over the previous marker-based tracking technique. With this technique, users no longer need to use markers to enjoy augmented reality technology. Markerless-based tracking is widely implemented in various fields, including human face recognition, motion tracking, GPS-based tracking, and 3D objects.

Several examples of AR implementation to introduce tourist attractions in various regions can be seen, such as the one depicted in Figure 2, the use of AR applications for tourist attractions in Makassar City. The design of the AR-based Makassar Tourism Application using Area Markers aims to facilitate tourists visiting Makassar in finding nearby tourist locations and providing information about related attractions in the form of augmented reality.



Figure 2 Marketing Media using Augmented Reality (Asbara, 2021)

Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model consists of four constructs that play a crucial role as direct determinants of behavioural intention and use behaviour (Rajapakse, 2011). These constructs are performance expectancy, effort expectancy, social influence, and facilitating conditions (definitions can be seen in the explanations below).

1. *Performance Expectancy*. The level of confidence an individual has in how the systems are used will help them gain performance benefits in their work.
2. *Effort Expectancy*. The level of ease associated with using the system.
3. *Social Influence*: The extent to which an individual feels that important people in their life believe they should use the system.
4. *Facilitating Conditions*. The level of an individual's belief in the availability of technical and organizational infrastructure to support the system's use.
5. *Interface Design*. The design for computers, equipment, machines, mobile communication devices, and software applications that focus on user experience and interaction.

Unity 3D

Unity 3D is a powerful and versatile software platform that has gained wide popularity in the field of game development, virtual reality (VR), and augmented reality (AR). Its powerful features and user-friendly interface make it an ideal choice for creating immersive and interactive experiences (Santi, Ceruti, Liverani, & Osti, 2021).

Vuforia

Vuforia is an augmented reality (AR) software development kit that provides tools and resources for developers to create interactive and immersive AR experiences (Dengel, Iqbal, Grafe, & Mangina, 2022). Developed by PTC, Vuforia has become a popular choice for AR application development due to its powerful features and ease of use (Purnomo, Santosa, Hartanto, Pratisto, & Purbayu, 2018).

Old Jami Mosque of Palopo

Old Jami Mosque of Palopo is a mosque dating back to the Luwu Kingdom, located in Palopo City, South Sulawesi. The mosque was established in 1604 AD by Raja Luwu, known as Datu Payung Luwu XVI Pati Pasaung Toampanangi Sultan Abdullah Matinroe (Awaluddin & Sumarni, 2021).

The mosque, which covers an area of 15 square meters, is named "Old" due to its age. The name "Palopo" is derived from the Bugis and Luwu languages, with two meanings: firstly, a snack made from a mixture of sticky rice and sugar water; secondly, inserting pegs into the holes of a building's pillars. Both of these meanings are related to the construction process of the Old Jami Mosque of Palopo (Ilyas, 2022).

Method

Needs Analysis and Research Type

This research was conducted to test the system built using the UTAUT model approach. With this method, the factors that influence the intention to use the cultural recognition application will be analysed.

The research population includes the general public, students, students, traditional leaders, and tourists who have mobile devices (feature phones, smartphones, or tablets). The sampling technique used in selecting research samples is random sampling. This research belongs to the type of quantitative research, which involves processing data from questionnaires.

Data Collection Method

In the research topic of "The Use of Augmented Reality Technology in Preserving Cultural Heritage: A Case Study of Old Jami Mosque of Palopo" several stages will be conducted, including data collection.

Data collection for this research will involve multiple methods. Firstly, a literature review will be conducted to gather relevant information from books and journals on Augmented Reality. Additionally, direct observation will be employed, where the research team will visit the research location to observe and document the existing conditions. Lastly,

interviews will be conducted to obtain valuable insights and firsthand information directly from the sources involved. These data collection methods aim to provide comprehensive and reliable data for the research study.

Table 1. Research instruments.

Construct	Questionnaire Items
Perceived Usefulness	[PU1] Using cultural recognition applications can enhance my productivity. [PU2] Cultural recognition applications help accelerate the completion of my tasks. [PU3] Cultural recognition applications are beneficial for my daily activities.
Perceived Ease of Use	[PEU1] Learning to use cultural recognition applications is relatively easy for me. [PEU2] The cultural recognition application I use is user-friendly. [PEU3] It is easy for me to become proficient in using cultural recognition applications.
Social Influence	[SI1] Important individuals in my life influence me to use cultural recognition applications. [SI2] Influential friends encourage me to choose/use cultural recognition applications. [SI3] People whose opinions I value tend to suggest/encourage me to use cultural recognition applications (replaced by [SI4]). [SI4] People I encounter daily influence me to use cultural recognition applications.
Interface Design	[ID1] Colour design influences my use of cultural recognition applications. [ID2] Layout design affects my experience when using cultural recognition applications. [ID3] Menu design influences my use of cultural recognition applications.
Facilitating Conditions	[FC1] I always have internet access to install cultural recognition applications. [FC2] When facing difficulties in using cultural recognition applications, I can easily seek help from friends/other people. [FC3] I have sufficient information to obtain the cultural recognition applications I desire.
Behavioural Intention	[BI1] I intend to try more new cultural recognition applications in the future. [BI2] I will make an effort to access cultural recognition applications every day. [BI3] I intend to continue using cultural recognition applications in the future.

Table 1 presents the research instrument used in the study. It consists of several constructs and their corresponding questionnaire items. The constructs include perceived usefulness, perceived ease of use, social influence, interface design, facilitating conditions, and behavioural intention. Each construct is measured through a set of questions designed to gather data and insights from the respondents. The questionnaire items aim to assess the respondents' perceptions, attitudes, and intentions regarding the use of cultural recognition applications.

Results and Discussion

Result

After obtaining data from the research location, the system was developed using Unity 3D and Vuforia software. Unity 3D provided a platform for generating immersive augmented reality technology, while Vuforia was used for barcode-based image recognition and tracking.



Figure 3. Main Page.

Figure 3 illustrates the implementation result of the main menu in the cultural recognition application for the Old Jami Mosque of Palopo. The menu offers several user-accessible pages, including the AR Camera menu, 3D Design menu, marker download menu, system usage instructions menu, and About menu.

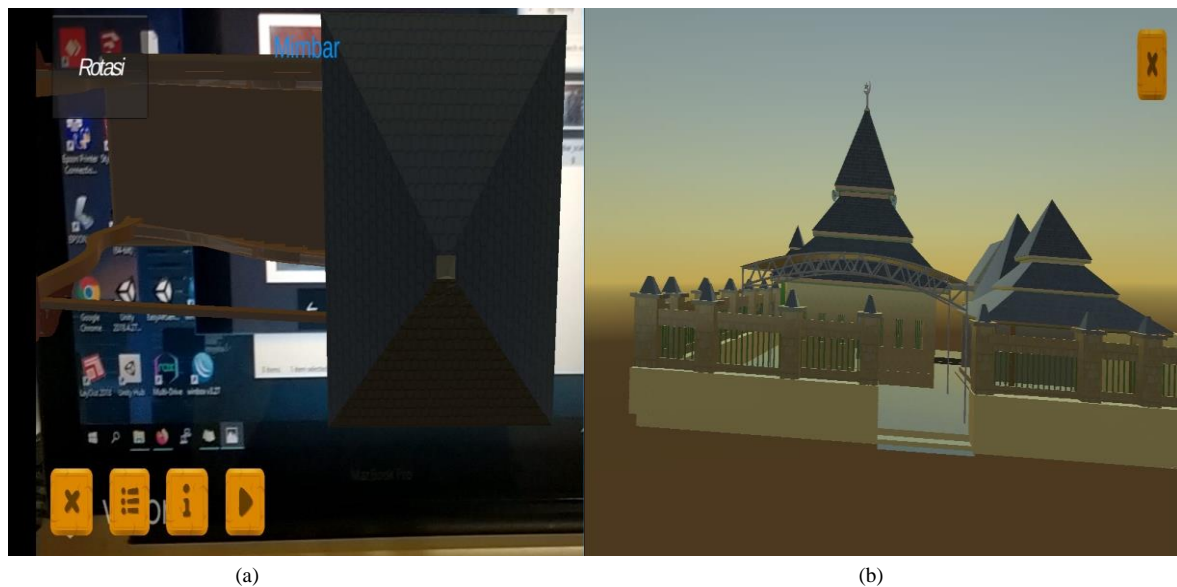


Figure 4 displays an Augmented Reality 3D object.

In Figure 4, part (a) illustrates the process of displaying a 3D object, specifically the Minbar, which is one of the architectural components of the Old Jami Mosque of Palopo, by scanning the registered barcode in Vuforia. In part (b) of Figure 4, the complete 3D model of the Old Jami Mosque of Palopo is showcased, enabling users to explore the overall architectural structure of the mosque through the presented object.



Figure 5. Application Description and User Instructions

In Figure 5, part (a) provides developer information and a description of the application. Part (b) of Figure 5 displays the user instructions for the application, including selecting the AR Menu, preparing the Marker, aligning the camera with the marker, performing rotations, featuring the exit button and returning to the main menu function.

The evaluation of the system using the UTAUT framework involved gathering responses from various groups of participants, including the general public, students, university students, cultural stakeholders, and tourists who possess mobile devices such as smartphones, tablets, or handphones.

The questionnaire aimed to assess the respondents' perceptions and attitudes towards different aspects of the system. These aspects included performance expectancy, which measures the extent to which the system is perceived to enhance productivity and performance. Effort expectancy assessed the ease of use and user-friendliness of the system. Social influence explored the impact of important individuals or peers in encouraging the use of the system. Facilitating conditions examined the availability of technical and organizational infrastructure to support the system's use. The design interface focused on the influence of design elements, such as colour, layout, and menu, on the usability of the system. Finally, behavioural intention gauged the respondents' intention to use the system in the future.

Feedback and evaluations from 50 respondents, including representatives from the general public, students, university students, traditional leaders, and tourists, were collected and analyzed. The results showed an overall positive acceptance of the system, with an approval rate of 87% across various aspects. These findings demonstrate the wide appeal and effectiveness of applying Augmented Reality for tourism information in Palopo City, especially in the Old Jami Mosque of Palopo.

Discussion

The findings of this study align with previous research conducted in the field of preserving cultural heritage using Augmented Reality (AR) technology. (Han et al., 2021) investigated the impact of AR experiential value on destination-related behaviour and found that factors such as visual appeal, entertainment, and enjoyment positively influence destination authenticity and AR satisfaction. These findings support the notion that AR can enhance the visitor experience and engagement with cultural heritage sites. (Ahmad et al., 2021) developed an AR application for introducing tangible cultural heritages at the Lampung Museum, demonstrating the feasibility and effectiveness of using AR technology in providing interactive and informative experiences to visitors. The successful display of 3D objects and the provision of relevant information through the AR application align with the goals of the present study, which focused on using AR to enhance understanding and engagement with the cultural heritage of the Old Jami Mosque of Palopo. Furthermore, (Llerena-Izquierdo & Cedeño-Gonzabay, 2019) combined photogrammetry and AR to promote

the religious and cultural heritage of San Pedro Cathedral in Guayaquil. The utilisation of AR technology to display 3D virtual models and provide historical information aligns with the current study's goal of utilising AR to preserve and promote cultural heritage. Both studies demonstrate the potential of AR in enhancing the visitor experience, increasing accessibility to cultural information, and fostering a deeper understanding of cultural heritage sites. In addition, (Sudipa et al., 2022) focused on the digitisation of Lontar Prasi Bali, a form of cultural heritage in Bali, using AR technology. The goal of preserving, promoting, and developing Bali's artistic and cultural heritage through AR is aligned with this study's goal of preserving the cultural heritage of the Old Jami Mosque of Palopo. Both studies emphasise the need to utilise technology to preserve and disseminate cultural heritage for future generations. By considering the findings and contributions of these previous studies, it becomes evident that the current research on utilizing AR technology in preserving the cultural heritage of the Old Jami Mosque of Palopo adds to the existing body of knowledge. It further validates the potential and benefits of using AR in cultural heritage preservation, enhances visitor experiences and understanding, and contributes to the development of effective practices and applications in the field of cultural heritage conservation.

Conclusions and Suggestions

Conclusions

Based on the findings of this research, it can be concluded that the implementation of Augmented Reality (AR) technology in cultural heritage preservation, particularly in the context of the Old Jami Mosque of Palopo, has shown positive results. The developed AR application proved effective in enhancing the visitor experience, providing a deeper understanding of the historical, architectural, and cultural values associated with the mosque. The study involved 50 respondents representing the general public, students, college students, traditional leaders, and tourists, and their high agreement rate (87%) regarding the effectiveness of the AR application indicates a positive acceptance and embrace of the technology. The findings also demonstrate the potential of AR technology in increasing public interest and participation in preserving cultural heritage.

Suggestions

Based on the research findings, the following recommendations are provided:

1. Continuous improvements and refinements should be made to the AR app to include more interactive features, additional historical information, and a wider range of cultural artefacts.
2. Efforts should be made to educate and promote the AR app among local communities, tourists, and educational institutions.

Acknowledgements: The researcher would like to thank Old Jami Mosque of Palopo, AMIK Ibnu Khaldun Palopo, and Universitas AMIKOM Yogyakarta for their support in this research. Their assistance and collaboration were invaluable in the successful completion of this research. We would also like to thank all the participants who have contributed their time and knowledge to this research.

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