Implementation of augmented reality on historical monuments in Gorontalo Province

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Article Info

ABSTRACT

Several historical monument buildings in the city of Gorontalo with important colonial historical features have been designated as cultural reserves. The unavailability of information media that can be accessed by visitors so that visitors do not know in detail about the historical place visited, by implementing augmented reality (AR) technology as access to information media using multimedia development life cycle (MDLC) methods, visitors can access information freely and in real time, by presenting information and also displaying three-dimensional (3D) monument buildings with android devices. Based on research conducted, the design of AR applications is used to create an information media, and also one of the methods of introducing gorontalo historical monuments that can be used for prospective visitors outside the area and within the area. Implementing AR on historical monuments in Gorontalo Provides a new alternative, in utilizing technology by providing an information medium for historical monuments in Gorontalo.

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1. INTRODUCTION

Several historical monuments in Gorontalo City with important colonial historical characteristics have been designated as cultural heritages [1], [2]. Monument is a type of building made to commemorate a person or event that is considered important by a social group as part of commemorating events in the past [3], [4]. Some examples of historical monuments in Gorontalo are Otanaha Fort, Nani Wartabone Monument, Bung Karno Amphibious Aircraft Landing Museum, Saronde Statue, Nani Wartabone Tomb.

The problem faced by visitors is that they do not know in detail about the historical places visited, only the name of the place. Currently, most of the visitors to the historical monuments of Gorontalo, most do not know detailed information regarding the monuments they visit, and also most of these monuments, there is no available information media that can be accessed by visitors, by implementing augmented reality (AR) technology as access to this information, visitors can access information freely and in real time, by presenting information and also displaying 3D monument buildings that can be displayed from the smartphone application of visitors or potential visitors, also this AR application is expected to be a special attraction for visitors or potential visitors who want to know more information about historical monument [5], [6].

For this reason, it is necessary to use dimensions that are projected into the real world using AR. The AR information visualization function brings a real impression on the monument object. AR is an effort to combine digital elements with physical objects, by presenting information media on an object [7]-[9]. with AR applications, images of an object in 3D are displayed according to their original environment [10]-[12].

Therefore, this study aims to design an application that can provide AR-based information in providing detailed information on historical monuments in Gorontalo. Based on the problems and advantages of AR technology in this study, an application will be designed by implementing AR technology on historical monuments in Gorontalo, this application can present detailed information, and also display 3D models of historical monuments, so that visitors can access information easily either currently in the region and outside the region.

2.   METHOD
2.1.   Augmented reality

AR is used as a combination of real and virtual objects in a real environment, runs interactively, and there is integration between objects in three dimensions, namely virtual objects integrated in the real world. Merging real and virtual objects is possible with appropriate display technology, interactivity is possible through certain input devices, and good integration requires effective tracking [13].Cameras and sensors are used to collect user collaboration information and send it for processing. The camera on the gadget has the ability to examine the environment and can use this data to locate physical items and generate 3D models. AR uses a camera and various visual markers, such as QR/2D codes. This technique produces output only if the reader sees the sign. Marker-based applications use the camera on the device to distinguish markers from other physical objects. Simple patterns like QR codes are used as markers because they are easy to identify and don't require a lot of reading effort. You can also calculate locations and directions, then certain types of content or information will be weighted by multiple markers [14], [15].

2.2.   Multimedia development life cycle (MDLC)

The method used in this research is the multimedia development life cycle. The multimedia development life cycle of this research has the aim of developing a more attractive and efficient learning media using augmented reality by utilizing the camera features of the Android/iOS Smartphone. As shown in Figure 1, where the MDLC method has 6 stages, namely concept, design, material collection, assembly, testing and distribution [16]-[18].
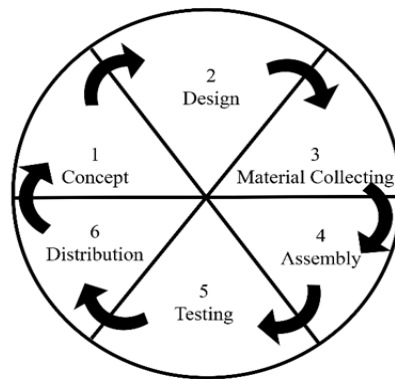

Figure 1. Multimedia development life cycle stages [19]

To support the MDLC stages in this research, the stages of this research that have adopted the stages of MDLC are made[18], [19] as shown in:
-    Concept: the concept is to determine the purpose and who is the user of the program (identification audience), the type of application, the purpose of the application, and general specifications. This application uses the android operating system which was developed using the C# programming language on the unity engine in its design
-    Design: design is to make detailed specifications regarding the application architecture, style, appearance and material/material requirements for making applications. The author makes the design of the application simple so that users have no difficulty when using the application [20], [21]. At this stage the researcher makes a design that includes system architecture, storyboards and interfaces that are applied in making this application. The system architecture includes an overview of the workings of the application design that has been applied in making the application.

- Material collecting: after carrying out the design stage, the authors collected material from several journals related to the implementation of AR in tourist objects that were made visually using AR [22], [23]. As for pictures of historical monument objects, it can be obtained from the location of the object that the author planned. Data collection based on needs in making applications, including information, application materials, and databases. In the manufacturing process, several supporting applications are used, including designing display components from the menu and also the background using Photoshop cs 2016. To create 3D objects, the Blender application is used to model the object components created in the process of making 3D objects in terms of appearance and effects light in the object.
- Assembly: the assembly stage is making an application based on the planning, flow, and navigation structure that comes from the design stage, for making the application the author uses Unity and Blender software, as well as markers made in 2D models designed using Photoshop applications. As for the 3D object which is one of the important components in the design of this application, the object is made based on the results of the author going to the field to conduct interviews related to the object that will be made the object created using the Blender aplication
- Testing: at this stage, the AR application was tested using the black box method. Alpha testing is a test that aims to ensure that the application being tested can run smoothly without interruptions or errors. Therefore, the program must be tested first to find errors that may occur, this test uses the black box testing method. This test is direct in the environment so that conclusions can be drawn on the assessment of the application being built.
- Distribution: at this stage, where the application is tested and in accordance with the purpose of manufacture, and is ready to be operated for publication and introduced to visitors or potential visitors.

To support the MDLC process in this study, the stages of the MDLC process in this study were carried out by determining how the stages were carried out as shown in Figure 2.
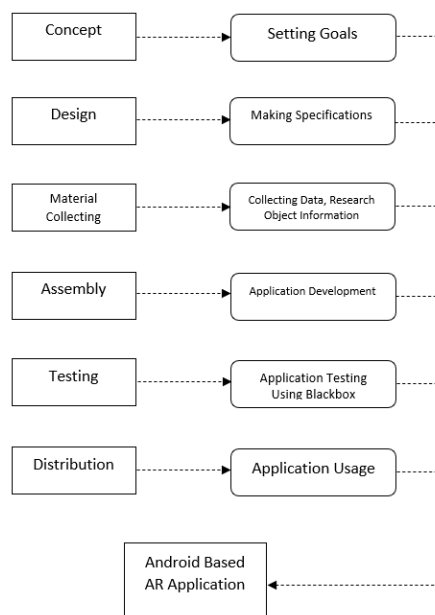
Figure 2. Stages of the MDLC process in research

3. RESULTS AND DISCUSSION
3.1. Result

Based on the research conducted, the AR application design is used to create an information media, and also one of the methods of introducing Gorontalo historical monuments that can be used for potential visitors outside the area and inside the area. The unavailability of information media at every location of historical monuments in Gorontalo that can be accessed by visitors both inside and outside the area is one of the obstacles in providing information. By implementing AR technology on historical monuments in Gorontalo as an access to this information media, visitors can access information, and also display 3D monument buildings that can be displayed from the smartphone application of visitors or potential visitors as shown in Figure 3 and Figure 4.
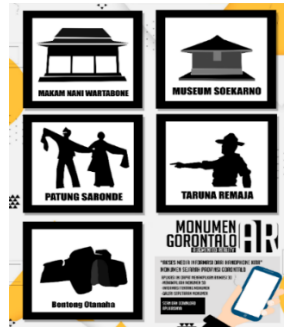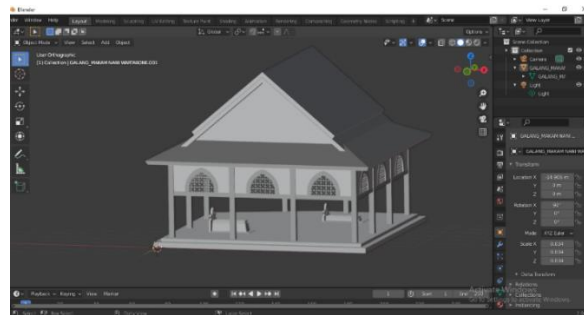
Figure 3. Application of markers on posters

Figure 4. Making 3D objects of Nani Wartabone's Tomb

In addition, this AR application is expected to be a special attraction for visitors or potential visitors who want to know more information about the historical monuments of Gorontalo [24]. The method used in this research is the MDLC. The multimedia development life cycle of this research has the aim of developing a more attractive and efficient learning media using Augmented Reality by utilizing the camera features of an Android Smartphone [25], [26]. Where this method has 6 stages, namely concept, design, collecting material, assembly, testing and distribution. This study resulted in an application that has several menu options, namely displaying 3D objects, information, galleries as a goal to utilize technology in the introduction and also media for presenting information that can be used by the Android operating system as shown on Figure 5. AR application design is used to create an information media [27], [28].
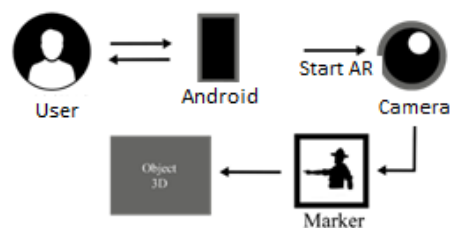

Figure 5. System architecture

By implementing AR technology on the historical monuments of Gorontalo, as a medium of information using the multimedia development life cycle (MDLC) method [29], [30]. The design of this application can be concluded that by implementing AR in the historical monuments of Gorontalo, it can be used as the latest innovation by creating a medium for accessing information for visitors and also as a realm of introduction for potential visitors who are curious about the uniqueness of Gorontalo, not only displaying information, but also being able to provide information. also displays 3D objects from every historical monument in Gorontalo [1], [31], [32].

3.2. Discussion

Based on the research conducted, the AR application design is used to create an information media, and also one of the methods of introducing Gorontalo historical monuments that can be used for potential visitors outside the area and inside the area. The method used in this research is the multimedia development diffusion dysle. The multimedia development life cycle of this research has the aim of developing a more attractive and efficient learning media using AR by utilizing the camera features of the Android Smartphone. where this method has 6 stages, namely concept, design, collecting material, assembly, testing and distribution [33], [34]. The initial stage carried out in this research is to determine the objectives to be achieved in this study, while the main purpose of this research is to design an AR application as a medium of information and also an introduction for potential visitors about historical monuments in Gorontalo.

After the concept stage has been determined, the next stage is the design stage. The following is the system architecture that has been designed in Figure 5. while the sequence diagram is a series of steps that describe the response between classes/objects in the application that is made. The sequence is listed in Figure 6. The third stage is the Unity Engine application is used to unify the results of several supporting applications that have been made, as well as the main process in making AR applications, including setting the camera, displaying animated information slides and galleries, setting markers so that they can be read so as to display 3D objects, as well as export applications that ready to use [35]-[38]. After that to manage the database of each display, Vuforia Engine is used as a database for the AR application, in this application the author uses the Device database type to make it faster to retrieve object tracking in the form of images compared to other types of databases.
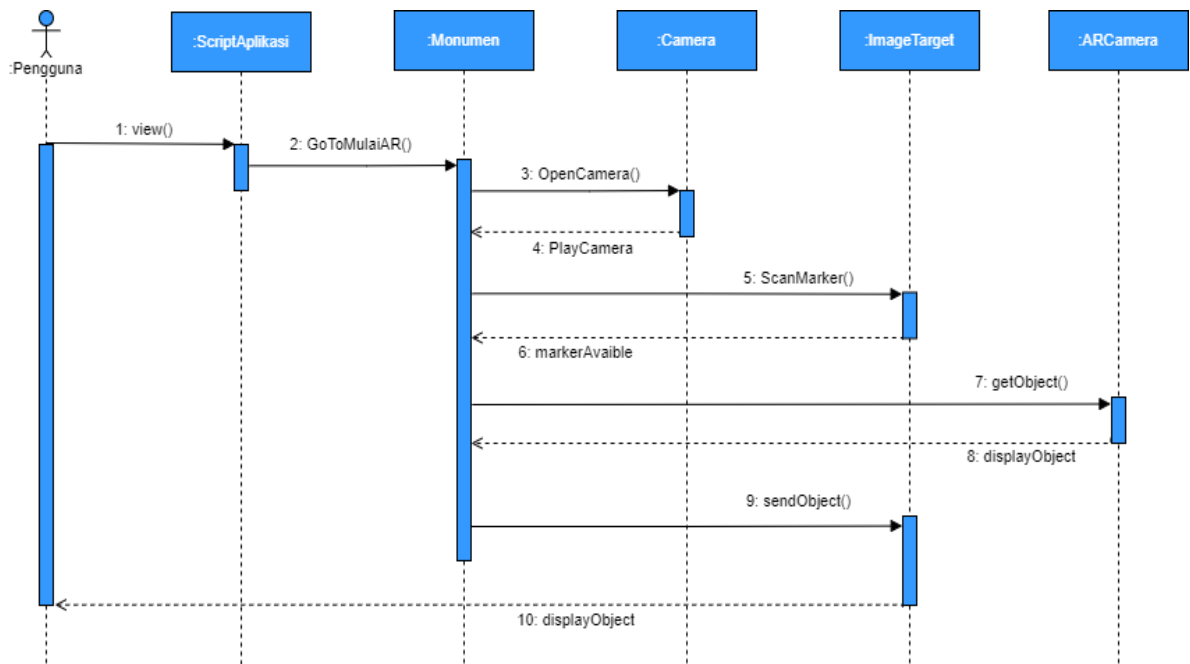

Figure 6. Sequence diagram displaying 3D objects

At the assembly stage, is the process of combining several components that have been made from the previous steps. The marker that has been created is uploaded to the Vuforia engine database media by selecting the target type, namely image target as a marker for the object that will be displayed in the following application is a marker image from the application in Figure 7. The Blender application which then the results will be exported in FBX format to be imported and combined with other components in Unity 3D. The stages in making 3D objects can be seen in Figure 8. Furthermore, merging the components that have been made in the previous stage, and making applications using the unity engine according to predetermined procedures, making data connections, making menu interfaces, function buttons, and determining markers and AR cameras, then adjusting 3D objects on markers and performing building on android device settings [39]. The following are some of the processes in designing AR applications which can be seen in Figure 9.
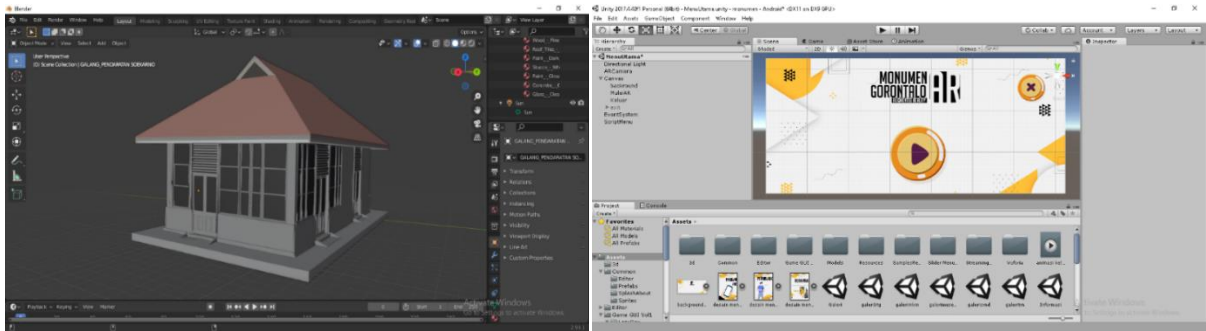
Figure 7. Object markers

Figure 8. Soekarno museum 3D object creation   Figure 9. Main menu creation process

At the testing stage, it is prioritized to evaluate the application that has been made as desired or not. Tests will be carried out by applying the black box method, with the aim of conformity in the fusional of each component of the application. At this stage, testing of the application is carried out whether the application functions to display 3D objects with markers that have been made and determines whether it is appropriate or not. In the last stage (distribution), the application will be stored in cloud storage, to make it easier for users to access the application, while the cloud storage used is Google Drive, users can access and download the application and can directly scan it via the barcode provided or you can go directly to the link that has been provided, the marker can be downloaded in google drive, the type of png file and can be printed, the application in the study has been used by approximately 5 people.

4. CONCLUSION

AR application design is used to create an information media, and also one of the methods of introducing Gorontalo historical monuments that can be used for potential visitors both outside the area and inside the area. The method used in this research is the MDLC, this research has the aim of developing a more attractive and efficient learning media using AR by utilizing the camera features of the Android Smartphone. where this method has 6 stages, namely concept, design, collecting material, assembly, testing and distribution. By implementing AR on historical monuments in Gorontalo, it provides a new alternative, in utilizing technology by providing an accessible medium of information for visitors both within and outside the region, as a realm of introduction for potential visitors who are curious about the uniqueness of Gorontalo. However, in this study devices that can use applications currently can only operate on Android devices, and the size capacity of the application is still very large, and animations and 3D models presented in AR applications still use a basic and simple display.

REFERENCES

[1]   F. Medda and F. Lipparini, "Impact investment for urban cultural heritage," *City, Culture and Society*, vol. 26, p. 100413, Sep. 2021, doi: 10.1016/j.ccs.2021.100413.

[2]   C. Melis and D. Chambers, "The construction of intangible cultural heritage: a foucauldian critique," *Annals of Tourism Research*, vol. 89, p. 103206, Jul. 2021, doi: 10.1016/j.annals.2021.103206.

[3]   J. M. Mehta, "Monument volumes and viewshed analysis at the Carson mounds site (22CO505), coahoma County, Mississippi," *Journal of Archaeological Science: Reports*, vol. 42, p. 103409, Apr. 2022, doi: 10.1016/j.jasrep.2022.103409.

[4]   N. Motevalian and M. Yeganeh, "Visually meaningful sustainability in national monuments as an international heritage," *Sustainable Cities and Society*, vol. 60, p. 102207, Sep. 2020, doi: 10.1016/j.scs.2020.102207.

[5]   O. Rogla, G. A. Patow, and N. Pelechano, "Procedural crowd generation for semantically augmented virtual cities," *Computers and Graphics (Pergamon)*, vol. 99, pp. 83–99, Oct. 2021, doi: 10.1016/j.cag.2021.06.014.

[6]   F. Z. Kaghat, A. Azough, M. Fakhour, and M. Meknassi, "A new audio augmented reality interaction and adaptation model for museum visits," *Computers and Electrical Engineering*, vol. 84, p. 106606, Jun. 2020, doi: 10.1016/j.compeleceng.2020.106606.

[7]   M. Hincapié, C. Díaz, M.-I. Zapata-Cárdenas, H. de J. T. Rios, D. Valencia, and D. Güemes-Castorena, "Augmented reality mobile apps for cultural heritage reactivation," *Computers & Electrical Engineering*, vol. 93, p. 107281, Jul. 2021, doi: 10.1016/j.compeleceng.2021.107281.

[8]   Y. Liu, V. E. Sathishkumar, and A. Manickam, "Augmented reality technology based on school physical education training," *Computers and Electrical Engineering*, vol. 99, p. 107807, Apr. 2022, doi: 10.1016/j.compeleceng.2022.107807.

[9]   M. K. Rohil and Y. Ashok, "Visualization of urban development 3D layout plans with augmented reality," *Results in Engineering*, vol. 14, p. 100447, Jun. 2022, doi: 10.1016/j.rineng.2022.100447.

[10]   Q. Conley, R. K. Atkinson, F. Nguyen, and B. C. Nelson, "MantarayAR: Leveraging augmented reality to teach probability and sampling," *Computers and Education*, vol. 153, p. 103895, Aug. 2020, doi: 10.1016/j.compedu.2020.103895.

[11]   E. E. Cranmer, C. Urquhart, M. Claudia tom Dieck, and T. Jung, "Developing augmented reality business models for SMEs in tourism," *Information and Management*, vol. 58, no. 8, p. 103551, Dec. 2021, doi: 10.1016/j.im.2021.103551.

[12]   Y. Su *et al.*, "A multi-plane optical see-through holographic three-dimensional display for augmented reality applications," *Optik*, vol. 157, pp. 190–196, Mar. 2018, doi: 10.1016/j.ijleo.2017.11.081.

[13]   G. Bozzelli *et al.*, "An integrated VR/AR framework for user-centric interactive experience of cultural heritage: The ArkaeVision project," *Digital Applications in Archaeology and Cultural Heritage*, vol. 15, p. e00124, Dec. 2019, doi: 10.1016/j.daach.2019.e00124.

[14]   H. Takenaka and M. Soga, "Development of a support system for reviewing and learning historical events by active simulation using AR markers," *Procedia Computer Science*, vol. 159, pp. 2355–2363, 2019, doi: 10.1016/j.procs.2019.09.410.

[15]   A. Pauls and A. Karsakov, "The concept of using augmented reality technology to present interactive calligraphic objects," *Procedia Computer Science*, vol. 193, pp. 407–414, 2021, doi: 10.1016/j.procs.2021.10.042.

[16]   F. N. Kumala, A. Ghufron, P. P. Astuti, M. Crismonika, M. N. Hudha, and C. I. R. Nita, "MDLC model for developing multimedia e-learning on energy concept for primary school students," *Journal of Physics: Conference Series*, vol. 1869, no. 1, p. 012068, Apr. 2021, doi: 10.1088/1742-6596/1869/1/012068.

[17]   A. A. Khan, A. A. Laghari, A. A. Shaikh, M. A. Dootio, V. V. Estrela, and R. T. Lopes, "A blockchain security module for brain-computer interface (BCI) with multimedia life cycle framework (MLCF)," *Neuroscience Informatics*, vol. 2, no. 1, p. 100030, Mar. 2022, doi: 10.1016/j.neuri.2021.100030.

[18]   S. L. Rahayu, Fujiati, and R. Dewi, "Educational games as a learning media of character education by using multimedia development life cycle (MDLC)," in *2018 6th International Conference on Cyber and IT Service Management, CITSM 2018*, Aug. 2019, pp. 1–4, doi: 10.1109/CITSM.2018.8674288.

[19]   R. V. Winarsim, Y. Amaliah, and Suprianto, "Virtual reality-based height simulation with method multimedia development life cycle," in *3rd International Conference on Cybernetics and Intelligent Systems, ICORIS 2021*, Oct. 2021, pp. 1–6, doi: 10.1109/ICORIS52787.2021.9649608.

[20]   S. R. Nikhashemi, H. H. Knight, K. Nusair, and C. B. Liat, "Augmented reality in smart retailing: A (n) (A) Symmetric Approach to continuous intention to use retail brands' mobile AR apps," *Journal of Retailing and Consumer Services*, vol. 60, p. 102464, May 2021, doi: 10.1016/j.jretconser.2021.102464.

[21]   L. Yi, M. Glatt, S. Ehmsen, W. Duan, and J. C. Aurich, "Process monitoring of economic and environmental performance of a material extrusion printer using an augmented reality-based digital twin," *Additive Manufacturing*, vol. 48, p. 102388, Dec. 2021, doi: 10.1016/j.addma.2021.102388.

[22]   A. M. Baabdullah, A. A. Alsulaimani, A. Allamnakhrah, A. A. Alalwan, Y. K. Dwivedi, and N. P. Rana, "Usage of augmented reality (AR) and development of e-learning outcomes: An empirical evaluation of students' e-learning experience," *Computers and Education*, vol. 177, p. 104383, Feb. 2022, doi: 10.1016/j.compedu.2021.104383.

[23]   V. Matukumalli *et al.*, "Augment reality chatbot using cloud," *Materials Today: Proceedings*, vol. 46, pp. 4254–4257, 2020, doi: 10.1016/j.matpr.2021.03.058.

[24]   D. Roopa, R. Prabha, and G. A. Senthil, "Revolutionizing education system with interactive augmented reality for quality education," *Materials Today: Proceedings*, vol. 46, pp. 3860–3863, 2020, doi: 10.1016/j.matpr.2021.02.294.

[25]   A. Alobaid, "ICT multimedia learning affordances: role and impact on ESL learners' writing accuracy development," *Heliyon*, vol. 7, no. 7, p. e07517, Jul. 2021, doi: 10.1016/j.heliyon.2021.e07517.

[26]   J. Zhang, X. Xia, R. Liu, and N. Li, "Enhancing human indoor cognitive map development and wayfinding performance with immersive augmented reality-based navigation systems," *Advanced Engineering Informatics*, vol. 50, p. 101432, Oct. 2021, doi: 10.1016/j.aei.2021.101432.

[27]   F. Morosi, I. Carli, G. Caruso, G. Cascini, E. Dekoninck, and J. F. Boujut, "Exploring tablet interfaces for product appearance authoring in spatial augmented reality," *International Journal of Human Computer Studies*, vol. 156, p. 102719, Dec. 2021, doi: 10.1016/j.ijhcs.2021.102719.

[28]   A. Aschauer, I. Reisner-Kollmann, and J. Wolfartsberger, "Creating an open-source augmented reality remote support tool for industry: challenges and learnings," *Procedia Computer Science*, vol. 180, pp. 269–279, 2021, doi: 10.1016/j.procs.2021.01.164.

[29]   C. Sun, Y. Fang, M. Kong, X. Chen, and Y. Liu, "Influence of augmented reality product display on consumers' product attitudes: A product uncertainty reduction perspective," *Journal of Retailing and Consumer Services*, vol. 64, p. 102828, Jan. 2022, doi: 10.1016/j.jretconser.2021.102828.

[30]   I. B. K. Manuaba, "Mobile based Augmented reality application prototype for remote collaboration scenario using ARCore cloud anchor," *Procedia Computer Science*, vol. 179, pp. 289–296, 2021, doi: 10.1016/j.procs.2021.01.008.

[31] S. Copple, "Making simulations real through augmented reality," *Journal of Obstetric, Gynecologic & Neonatal Nursing*, vol. 48, no. 3, p. S78, Jun. 2019, doi: 10.1016/j.jogn.2019.04.134.

[32] V. Sangiorgio, S. Martiradonna, F. Fatiguso, and I. Lombillo, "Augmented reality based - decision making (AR-DM) to support multi-criteria analysis in constructions," *Automation in Construction*, vol. 124, p. 103567, Apr. 2021, doi: 10.1016/j.autcon.2021.103567.

[33] S. M. C. Loureiro, J. Guerreiro, and F. Ali, "20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach," *Tourism Management*, vol. 77, p. 104028, Apr. 2020, doi: 10.1016/j.tourman.2019.104028.

[34] A. Harikrishnan, A. Said Abdallah, S. K. Ayer, M. El Asmar, and P. Tang, "Feasibility of augmented reality technology for communication in the construction industry," *Advanced Engineering Informatics*, vol. 50, p. 101363, Oct. 2021, doi: 10.1016/j.aei.2021.101363.

[35] F. Ali, "Augmented reality enhanced experiences in restaurants: Scale development and validation," *International Journal of Hospitality Management*, vol. 102, p. 103180, Apr. 2022, doi: 10.1016/j.ijhm.2022.103180.

[36] H. N. Do, W. Shih, and Q. A. Ha, "Effects of mobile augmented reality apps on impulse buying behavior: An investigation in the tourism field," *Heliyon*, vol. 6, no. 8, p. e04667, Aug. 2020, doi: 10.1016/j.heliyon.2020.e04667.

[37] O. Allal-Chérif, "Intelligent cathedrals: Using augmented reality, virtual reality, and artificial intelligence to provide an intense cultural, historical, and religious visitor experience," *Technological Forecasting and Social Change*, vol. 178, p. 121604, May 2022, doi: 10.1016/j.techfore.2022.121604.

[38] P. Rupprecht, H. Kueffner-Mccauley, M. Trimmel, M. Hornacek, and S. Schlund, "Advanced adaptive spatial augmented reality utilizing dynamic in-situ projection in industrial site assembly," *Procedia CIRP*, vol. 107, pp. 937–942, 2022, doi: 10.1016/j.procir.2022.05.088.

[39] A. Asadzadeh, T. Samad-Soltani, and P. Rezaei-Hachesu, "Applications of virtual and augmented reality in infectious disease epidemics with a focus on the COVID-19 outbreak," *Informatics in Medicine Unlocked*, vol. 24, p. 100579, 2021, doi: 10.1016/j.imu.2021.100579.

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