Transformation Of Wedding Invitations Through Augmented Reality With Android-Based 3d Models

Dedi Purwanto

Abstract
This research focuses on the development of an Augmented Reality (AR)-based wedding invitation application with a 3D model that can be accessed via Android devices. This application transforms traditional invitation cards into interactive media by displaying the bride and groom in three dimensions, which can be rotated, enlarged, and accompanied by music and other additional features. The system is built using Unity 3D, Vuforia SDK, and Character Creator 3, and implements a marker-based tracking method to detect markers on invitation cards. This research aims to enhance the visual experience and efficiency of sending invitations, while offering an environmentally friendly alternative by reducing dependence on physical printed materials. Test results show that this application has a high success rate in detecting markers, with an accuracy of 99%, and provides an adequate interactive experience for users.

Keywords : Augmented Reality, Character 3D , Marker Based Tracking

Dedi Purwanto
Bachelor of Computer Science, Universitas Pembangunan Panca Budi, Indonesia e-mail:
dedipurwanto@pancabudi.ac.id

2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era
https://proceeding.pancabudi.ac.id/index.php/ICIE/index

Introduction

The rapid development of digital technology has brought significant changes to various aspects of human life, including communication and information delivery. One innovation that is now being applied in various sectors is Augmented Reality (AR), a technology that combines two- or three-dimensional virtual objects into the real environment in real time through digital devices such as smartphones. This technology is capable of providing a more interactive and immersive experience than conventional media.

One form of communication that still has high social and cultural value is the wedding invitation card. Until now, invitation cards have generally been in printed form and have only served as a medium for information about the time, place, and wedding event. However, with the development of technology and the trend towards a more digital modern society, there is a need for a more creative, efficient, and visually appealing form of invitation. This is where Augmented Reality technology plays a role as a medium of transformation.

Through the implementation of Android-based AR, wedding invitation cards can be transformed into interactive media that display 3D models of the bride and groom, animations, music, or video messages that appear when users scan the card with their phone camera. This not only enhances the aesthetic value and exclusive impression of the invitation, but also serves as a more personal and modern means of digital expression for the bride and groom.

In addition, transforming conventional invitation cards into AR-based digital forms also supports efficiency and environmental sustainability. By reducing dependence on physical printing materials, the use of digital invitations can save production costs while reducing paper usage, thus aligning with the concept of eco-friendliness.

Seeing this potential and benefits, this study focuses on developing an Android-based Augmented Reality application capable of displaying interactive 3D models as representations of modern wedding invitations. It is hoped that the results of this study can contribute to the innovation of digital invitation media that is more creative, informative, and adaptive to current technological developments.

Literature Review Augmented Reality

Augmented Reality (AR) is a technology that combines elements from the virtual world with the real environment, creating an immersive interactive experience for users. This technology is used in various fields, including education, marketing, and cultural preservation. According to Larashati and Faisal, the application of AR in learning can facilitate the delivery of historical information, as shown in a study on the Pagaruyung Royal Palace, where AR was used to provide educational information to children [1]. Ghozali et al.'s research also emphasizes the AR method for introducing Indonesia's endemic fauna, aiming to enrich the user experience in learning about biodiversity [2]. This shows how AR can increase understanding and interest in more complex subject matter.

[3]In the context of education, AR has great potential in supporting interactive and enjoyable learning methods. Rachmi et al. show that AR can increase user interaction in learning, allowing children to learn through games and interesting applications. Habibti et al. emphasize that the use of AR in learning media can create innovative learning experiences, combining three-dimensional visual elements with the real environment [4]. Furthermore, research by Fathoni et al. establishes that AR-based English language learning can transform the learning experience into a more enjoyable and effective one, especially for children [5].

In addition to education, AR also plays a significant role in marketing and promotion. Madani et al. discuss how AR can be used to display products in three dimensions, providing an attractive visual experience for consumers [6]. The application of AR in promotion, as demonstrated by Waluyo and Permana, can create greater appeal for brands. This is in line with the analysis by Ashari et al., which explains the importance of training in the use of AR,

especially for teachers, to maximize the potential of this technology in the context of education and marketing [7].

In cultural development and heritage preservation, AR also offers new ways to present information in museums and tourist attractions. Research by Nazhar and Rosid covers the application of AR to create interactive exhibition spaces at the Gedung Sate Museum in Bandung, making the content more informative and interesting for visitors [8]. Through this approach, AR not only preserves culture but also introduces history in a more interesting and accessible way to the wider community.

Overall, Augmented Reality as a technology that combines the real and virtual worlds offers vast potential in various sectors. From education to marketing and cultural preservation, AR provides interactive experiences that are not only engaging but also educational. Thus, it is important for educators, marketers, and cultural practitioners to continue exploring and implementing this technology to improve effectiveness and engagement in their respective fields.

Augmented Reality Tracking Methods

In the context of Augmented Reality (AR) application development, tracking methods are one of the key aspects that determine the effectiveness and accuracy of the experience presented to users. One commonly used tracking method is marker-based tracking, which uses physical markers to trigger the display of virtual objects in the real environment. In this case, markers act as references recognized by the camera on a mobile device to track the position and orientation of digital objects.

Marker-based tracking has been implemented in various applications. For example, Rahmat et al. describe the development of an AR application used at the Bengkulu State Museum, where this method helps introduce cultural heritage to visitors through interactive visualization [9]. In addition, Gunawan and Romli also demonstrate educational applications in the automotive field that integrate marker-based tracking to visualize 3D models on Android devices [10]. Something similar can also be seen in Kusuma's research, who designed a solar system learning application that utilizes books as markers [11]. The application of this method allows users to learn in a more interactive and enjoyable way [12].

The effectiveness of the marker-based tracking method in education is also confirmed by the work of

Hakim et al., who researched the use of AR to help students understand provincial profiles through an Android-based application supported by this method [13]. Mursyidah , and Ramadhona showed that this technology enables the visualization of traditional Acehnese houses in the form of attractive 3D objects, supporting the teaching and learning process [14]. Other research dedicated to children, such as that conducted by Wulandari et al., again underlines the role of this method in attracting children's attention to the marine world through the introduction of ornamental fish using the same technique [15].

Each of these applications highlights how marker-based tracking can enhance the learning experience and provide information in a more engaging way. In addition, this technique has also been adopted in the context of marketing, as demonstrated in a study by Ashidik et al., who adapted AR technology to promote coffee products interactively [16]. With the increasing use of this technique in various fields, marker-based tracking has proven to be a powerful tool in increasing user engagement and interaction.

Overall, marker-based tracking methods in Augmented Reality offer a dynamic approach to integrating virtual objects with the real environment, providing great opportunities in education, promotion, and other sectors. With technology continuing to evolve, the expectation

for the future is that we will see further innovations in how markers are used to enrich the user experience.

Marker-Based Method

Overall, marker-based tracking methods in Augmented Reality offer a dynamic approach to integrating virtual objects with the real environment, providing great opportunities in education, promotion, and other sectors. With technology continuing to evolve, the expectation for the future is that we will see further innovations in how markers are used to enrich the user experience. 3D character modeling and image-based modeling are fundamental parts of the animation and video game development industries. [17]3D character modeling produces digital representations of characters that can be animated, while image-based modeling enables the creation of more realistic 3D objects by using images from the real world as references.

In the context of 3D character modeling, one of the methods often used is polygon modeling. This method utilizes polygons to design character shapes, which directly affects the visual quality and performance of the resulting animation [18]. In addition, rigging is also an important process in character modeling. Rigging is done to add a bone structure to the model to facilitate animation and can improve efficiency in creating movements, as discussed by Satriawan and Apriyani [8], [19].

Another relevant technique is motion capture integrated with 3D modeling. Motion capture is a technology that allows the recording of movements from real objects to be applied to digital characters. This produces animations that are closer to natural human movements, although its adoption in Indonesia is still limited due to cost and equipment availability factors. Kurniawan also points out that the use of the right technology in modeling is crucial to producing high-quality results, although his references focus more on software models rather than specifically on 3D modeling [19].

In the development of image-based modeling, this technique uses images to create more realistic 3D representations. By using images as textures on geometric models, developers can create more detailed and realistic appearances. However, there are no references that directly support this claim, so the statement does not have sufficient support [20]. The use of image processing and machine learning technologies, such as Convolutional Neural Networks (CNN), has also been introduced to improve accuracy in recognizing and producing more realistic character appearances. Relevant research on CNN in the context of viseme recognition and other applications can be found in existing references, although it is not directly related to 3D character modeling [21].

Overall, 3D character modeling and image-based modeling are important steps in creating more interactive and attractive animations and game development. With the ongoing development of technology, it is hoped that more innovations will be introduced in this field to improve the quality and efficiency of the production process.

Research Methodology

The initial step of the research began with the formulation of problems to identify the limitations of conventional invitation systems, which only function as non-interactive information media. Next, the research objectives were determined, focusing on the development of an AR system that can introduce the bride and groom digitally and interactively. A literature study was conducted to obtain a relevant theoretical basis related to AR technology, marker

design, 3D object modeling, and the use of the Unity 3D and Vuforia SDK platforms as the main development tools.

The next step is data collection, which is carried out through two approaches, namely literature study (library research) and field study (field research). Literature studies are used to obtain theoretical and technical references for AR development, while field studies are conducted through interviews and observations with parties related to weddings, such as event organizers and the Office of Religious Affairs (KUA), to obtain design requirements and photo data of prospective brides and grooms. The data collected includes marker designs with and without QR codes, invitation card designs, and other supporting data needed in the 3D character modeling process.

The application requirements analysis stage was conducted to determine the necessary components, both hardware such as Android-based smartphones and software such as Unity 3D Engine, Vuforia SDK, Character Creator 3, and Adobe Illustrator. Next, system design is carried out using UML diagrams (use case, activity, and sequence) to illustrate the interaction between users and the system, as well as an AR system flowchart to explain the process flow from marker detection to the appearance of 3D virtual objects on the user's device screen.

During the marker design stage, two categories of designs were created, namely markers with QR codes and markers without QR codes, in order to compare the accuracy and readability of each marker during the camera detection process. The designed markers were then uploaded to the Vuforia database to test their feasibility and keypoint values. The surface edge values of the markers were measured based on the level of texture detail and the number of detected edge points, which affect the stability of the 3D object rendering process.

The 3D character object design stage was carried out using Character Creator 3 software with the help of the Headshot plugin to produce facial features resembling the real bride and groom. The designs for the bride and groom's attire were created using sculpting techniques with the help of DAZ 3D software, then integrated into Unity 3D. After that, the system implementation stage was carried out by combining 3D objects, markers, and camera and lighting configurations in the Unity 3D Engine using the Marker-Based Tracking method.

The system that has been created is tested by running the application on an Android device. The system's workflow begins when the smartphone camera recognizes the invitation card marker stored in the Vuforia database. If the marker matches the data in the database, the system's will display a 3D bride and groom character object complete with interactive features such as auto play music, show/hide bride and groom photos, and access to a location map (bride and groom map). The rendering and positioning processes are performed in real-time so that the virtual object can appear precisely on top of the marker.

In addition, this research also adds a live chat or message sending feature, which allows users to interact directly within the application. This feature is designed using a special flowchart to illustrate the user communication process, both in general and privately. The entire system is designed to be easy to use by ordinary users with a simple yet elegant interface, in line with the nuances of a wedding event.

As a complement, the application interface design (UI/UX) includes five main pages, namely the home screen, main menu, help page (usage tutorial), about page, and AR main page to display 3D wedding objects. This application is named Wedding AR, with an ambigram logo and dominant gold and white colors that reflect the luxury and elegance of a wedding.

Results

This research resulted in the Wedding AR (Augmented Reality Wedding Invitation) application, which functions as an interactive digital invitation medium based on Android. This application was developed using the Unity 3D Engine with Vuforia SDK as the marker recognition system, as well as Character Creator 3 and DAZ 3D for creating 3D bride and groom characters.

1. Device Specifications and Implementation Environment

The system implementation was carried out using an MSI PS42-RC laptop with an Intel® Core™ i5-8250U processor, 8 GB RAM, 512 GB SSD, and NVIDIA Geforce 1050 Max-Q Design GPU, as well as a Vivo Y83 smartphone based on Android 8.1. The main software used was Unity 3D 2020.3.23f1 and Vuforia SDK 10.0.12. These specifications were chosen to support the rendering of 3D objects and AR testing optimally.

2. 3D Object Modeling Results

The 3D modeling of the bride and groom characters was done by dividing the objects into several parts, such as the face, clothing, pants/dress, and accessories.



Figure 1. 3D Character of Raja Pratama M. Daulay



Figure 2. 3D Character M. Ali Akbar Harahap

The male bride model consists of 2 characters: Raja Pratama M. Daulay, M. Ali Akbar Harahap



Figure 3. 3D Character Adelya Ifanny Iskandar Siregar



Figure 4. 3D Character Noni Pratiwi

The bridal model consists of four characters: Adelya Ifanny Iskandar Siregar, Noni Pratiwi, Gladis Amanda Daulay, and Namira. The faces were created using image-based modeling to produce similarities with the original photos, while the clothing and accessory elements were created using 3D scripting modeling.

3. Application Interface Display

The Wedding AR application consists of several main components, including

- Application Icon Display



Figure 5. Application Icon Display

This icon display is the result of a previously designed concept that has been implemented into the Wedding AR application.

- Icon and Splash Screen: displays the application logo as a branding element.



Figure 6. Splash Screen Display

This splash screen is designed to match the app's icon design, with the aim of making the app recognizable and memorable to many users.

- Main Menu: consists of four buttons, namely Scan, Tutorial, About, and Exit.

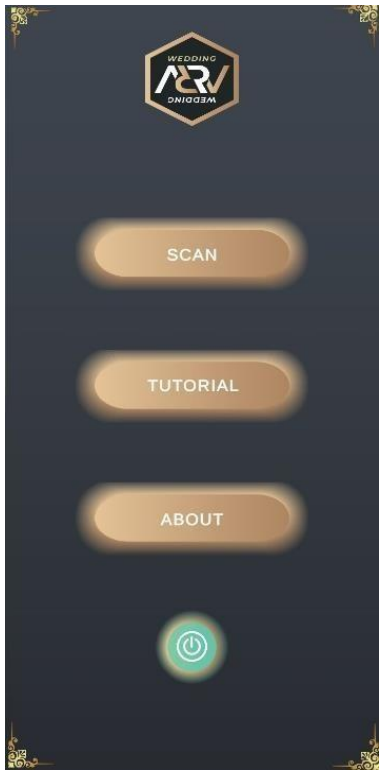


Figure 7. Main Menu Display

- Scan Menu

Scan Menu: the main AR page that displays a 3D bride and groom object after the marker is detected by the camera.





Figure 8. Scan Lost Warning Display

Figure 9. Object Interaction Display

- Message Send Display



Figure 10. Sender Name Input Screen



Figure 11. Message Input Screen

The message sending screen consists of a text box for entering names and a button for connecting to the server. Once connected, a chat area appears, along with a text box for tagging other users (private messages), a text box for typing messages, and a send button for sending messages.

- Tutorial Menu Interface



Figure 12. Tutorial Menu Interface

The tutorial page displays the steps for using the application, starting from installing Wedding AR, scanning the invitation card through the smartphone camera, to displaying the 3D

bride and groom objects. The feedback and suggestions button is located at the bottom of the page.

- Popup Exit: displays a confirmation to exit the application.

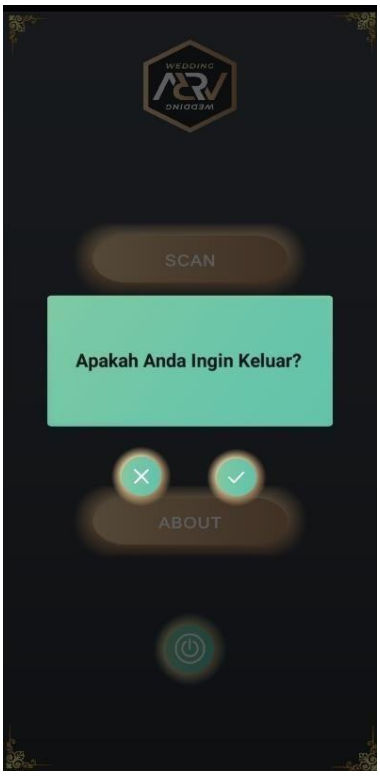


Figure 13. Application Exit Popup Display

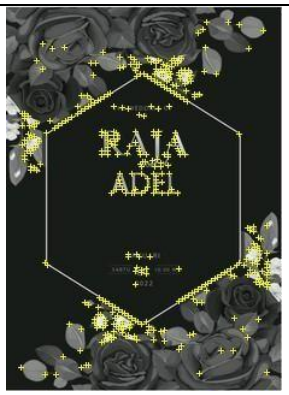
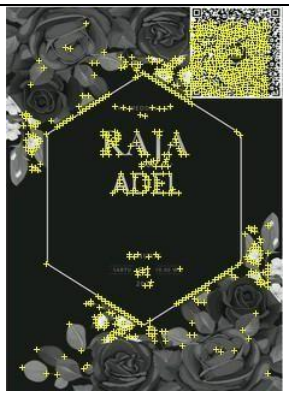
The exit popup display is combined with a blur effect in the background, and simple UI buttons make the application easy to use.

4. Marker and AR System Testing

Tests were conducted on invitation markers with and without QR codes. Based on the keypoint rating test results in Vuforia, all markers received an augmentable rating of 5, indicating an excellent level of readability.

Table 1. Keypoint Rating of Markers in Vuforia

No	Invitation Card Name	Without QR Code	With QR Code

1	Adel & Raja	 Augmentable: 5	 Augmentable: 5
2	Ali & Noni	 Augmentable: 5	 Augmentable: 5

Next, distance and lighting tests were conducted, with a range of 20 cm to 40 cm and bright and dim conditions. The results showed that all markers could be read well in bright conditions, but in dark conditions there was a slight decrease in accuracy due to reduced marker edge detection.

Table 2. Marker Detection Testing Against Camera Distance and Light

No	Marker	Number of Tests	Light	Distance		Accuracy
				20 cm	40 cm	
1	King & Adel	10	Bright			
		10	Dark			
2	Ali & Noni	10	Light			
		10	Dark			

In testing the interaction of 3D objects, the application successfully executed the drag, rotate, zoom in/out, and autoplay music features with a 100% success rate under normal conditions.

Table 3. Interaction Testing on Objects

No	Test Target	Expected Results
1	3D Wedding Object Drag Test	The position of the 3D Wedding Object displayed can shift along the Z-axis.

2	Rotation Test of 3D Wedding Object	The position of the displayed 3D Wedding Object can rotate on the Zaxis.
3	Test Zoom In/Zoom Out of the 3D Bride Object	The 3D object can be enlarged (zoom in) and reduced (zoom out).
4	Autoplay Music Test	When the 3D wedding object appears, music will automatically play and stop when the object is no longer detected.

Interaction testing with objects showed that the 3D bride and groom objects can be moved, enlarged, reduced, rotated, and play music automatically.

Table 4. Marker Test Results

Success Accuracy (%)	Interaction				Angle °				Distance		Light	Number of Tests	Marker
	Rotate	Zoom Out	Zoom In	Drag	90°	60°	30°	0°	40 cm	20 cm			
100	10	10	10	10	10	10	10	10	10	10	Bright	10	King & Adel
97	10	10	10	10	10	10	10	8	9	10	Dark	10	
100	10	10	10	10	10	10	10	10	10	10	Bright	10	Ali & Noni
98	10	10	10	10	10	10	10	9	9	10	Dark	10	
99	TOTAL												

Overall, the AR system achieved a success rate of 99%, meaning that the application was able to recognize markers and display 3D objects well under various test conditions.

5. Application Feasibility Testing

Feasibility testing was conducted through a questionnaire given to 25 respondents, with 12 statements related to visual aspects, ease of use, system stability, and user experience. The test results show:

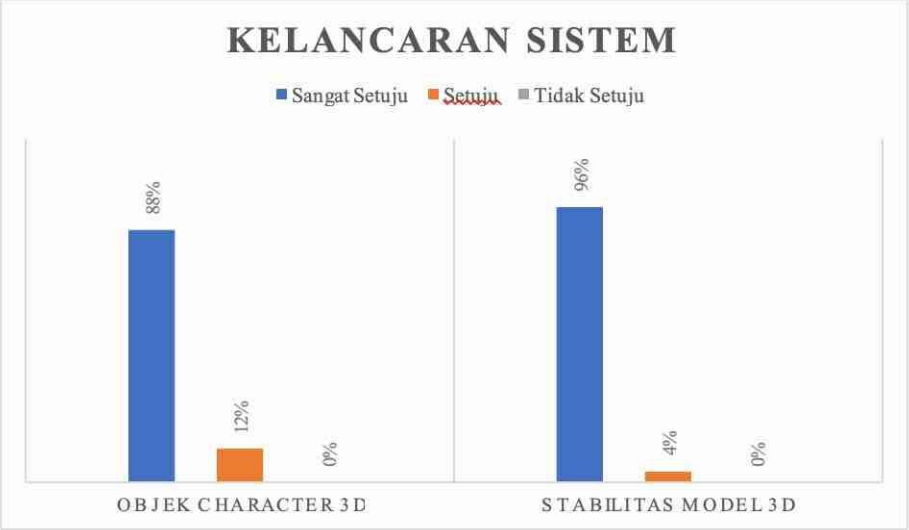


Figure 14. System Smoothness Graph

Based on Figure 4.19, 88% of the 25 respondents strongly agreed that the 3D bride and groom characters were clearly displayed in the application, while 12% agreed or were neutral. In addition, 96% of respondents strongly agreed that the stability of the 3D bride model on the marker was good, while 4% agreed or were neutral because the 3D object sometimes moved when scanning was performed in a dark room, resulting in a less than optimal scanning process.



Figure 15. Feature Graph on the Application

Based on Figure 4.20, 92% of the 25 respondents strongly agreed that the application features ran smoothly, while 8% agreed or were neutral. In addition, all respondents (100%) strongly agreed that the drag, rotate, zoom in–zoom out features on 3D objects, as well as autoplay music, worked well.

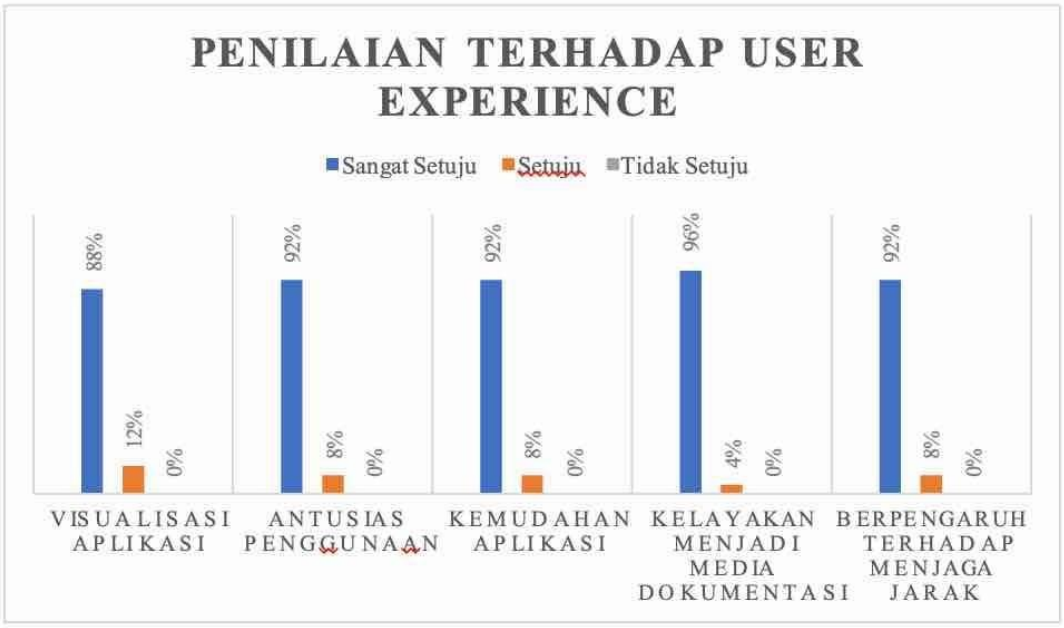


Figure 16. User Experience Assessment Chart

Based on Figure 4.21, 88% of the 25 respondents strongly agreed that the application's visualization was attractive, while 12% agreed. Some respondents only agreed because the compression process on 3D objects caused the visual display to be slightly lower than the original version.

A total of 92% of respondents strongly agreed that guests were enthusiastic about the application, and 8% agreed. This was because the information about the 3D objects displayed was still limited and not explained in detail. In addition, 92% of respondents strongly agree that the application is easy to use, while 8% agree. Some respondents experienced difficulties because the application still relies on markers; an inaccurate camera position can cause 3D objects to become unstable or disappear.

Furthermore, 96% of respondents strongly agreed that the application should be used as an additional documentation medium, while 4% agreed. This is because 3D objects are still limited to the application and cannot be exported to other media, and the quality of 3D designs decreases after compression. Finally, 92% of respondents strongly agreed that the application had an impact on the implementation of physical distancing, and 8% agreed. The existence of neutral respondents was due to the low awareness of some users in maintaining physical distancing during the pandemic.

Conclusion

Based on the results of discussions and testing, it can be concluded that the Wedding AR application runs well on Android devices using the Vuforia SDK as an augmented reality engine. The visualization of the 3D bride and groom characters can be clearly displayed on the invitation card design and is interactive through drag, zoom, rotation, autoplay music, and show/hide photo features. Markers with or without QR codes have the same key point rating due to the complex invitation design with many angles. Testing for distance and lighting shows a high success rate of 99%, although in low light conditions some markers are difficult to detect. For further development, it is recommended that the application be equipped with additional features such as export to Instagram effects and AR GPS-based tracking to display the bride and groom's location, and a solution needs to be found so that 3D objects are not compressed in order to maintain high visual quality.

References

[1] M. Firman Ghozali, H. S. Setiawan, and B. J. Tama, "DESIGNING AN EDUCATIONAL APPLICATION FOR INTRODUCING INDONESIA'S ENDEMIC FAUNA BASED ON AUGMENTED REALITY," Journal of Research and Application of Informatics Students (JRAMI), vol. 02, 2021.

[2] P. Studi, "Presentation of a History Exhibition Space Using Augmented Reality Technology at the Gedung Sate Museum in Bandung 1 Ryanty Derwentyana Nazhar| 2 Yosep Sulaeman Rosid." [Online]. Available: https://ojs.unikom.ac.id/index.php/wacaciptaruang/index

[3] M. Madani, A. Setyanto, and A. F. Sofyan, "Application of Augmented Reality in Promotional Media (Brochures) for STMIK Bumigora Mataram Based on Android," Journal of Information Technology, vol. 3, 2018.

[4] H. Ashari et al., "Augmented Reality (AR) Training to Improve Teacher Competence in the Digital Age," TEKNOVOKASI: Journal of Community Service, vol. 2, no. 1, 2024, [Online]. Available: http://journal.unm.ac.id/index.php/TEKNOVOKASIhttp://journal.unm.ac.id/index.php/TEKNOVOKASI

[5] H. W. Habibti, B. Wibisana, I. Komputer, and I. Al-Azhar, "Development of Augmented Reality-Based Learning Media," 2023. [Online]. Available: https://sakira.unizar.ac.id/index.php/jurnal/index

[6] H. Rachmi, R. Suryadithia, A. Hamid, and P. M. Basa, "Introduction and Training in Augmented Reality for Digital Community Empowerment in the Bogor Mengabdi Community," JPKMI (Journal of Community Service in Indonesia), vol. 3, no. 3, pp. 201–209, Aug. 2022, doi: 10.36596/jpkmi.v3i3.454.

[7] K. Fathoni, R. Yuniar Hakkun, M. U. Pamenang, P. Elektronika, and N. Surabaya, "Designing an Augmented Reality-Based English Learning Application," vol. 4, no. 1, pp. 73–80, 2020, [Online]. Available: https://www.researchgate.net/publication

[8] M. A. Farooq and P. Corcoran, "Generating Thermal Image Data Samples Using 3D Facial Modeling Techniques and Deep Learning Methodologies," pp. 1–5, 2020, doi: 10.1109/qomex48832.2020.9123079.

[9] J. P. Ashidik, S. Waluyo, and I. Susanti, "Application of Android-Based Augmented Reality Technology Using Marker-Based Tracking Method as a Product Marketing Medium at Haus Coffee," Skanika Computer Systems and Information Technology, vol. 4, no. 1, pp. 51–57, 2021, doi: 10.36080/skanika.v4i1.1936.

[10] Wulandari, S. Andryana, and A. Gunaryati, "Introduction to Marine Ornamental Fish for 3-Year-Old Children Using the Augmented Reality-Based Marker-Based Tracking Method," Journal of Information Technology and Management, vol. 5, no. 2, 2019, doi: 10.26905/jtmi.v5i2.3711.

[11] M. Mursyidah and R. Ramadhona, "Augmented Reality Application for Recognizing Traditional Houses and Historical Objects in Aceh," Jurnal Infomedia, vol. 2, no. 2, 2018, doi: 10.30811/.v2i2.513.

[12] L. Hakim, T. Rosandy, and H. Wibowo, "Implementation of Augmented Reality in Provincial Profiles on the Island of Sumatra for Students of SDN 2 Kutadalom Based on Android," Journal of Restikom Research in Information Technology and Computer Science, vol. 5, no. 2, pp. 209–221, 2023, doi: 10.52005/restikom.v5i2.159.

[13] A. A. Ushud, "Learning Media on Types of Cacti with the Application of Marker-Based Tracking Augmented Reality," Unikom Scientific Journal, vol. 18, no. 1, pp. 23–28, 2020, doi: 10.34010/miu.v18i1.3827.

[14] S. D. Y. Kusuma, "Designing an Augmented Reality Application for Learning about the Solar System Using Marker-Based Tracking," Pamulang University Informatics Journal, vol. 3, no. 1, p. 33, 2018, doi: 10.32493/informatika.v3i1.1428.

[15] Gunawan and Moh. A. Romli, "Automotive Learning Media Using Android-Based Augmented Reality," Indonesian Journal of Computer Science, vol. 12, no. 6, 2023, doi: 10.33022/ijcs.v12i6.3484.

[16] I. Rahmat, D. Andreswari, and Y. Setiawan, "Designing an Augmented Reality Application for Historical Artifact Collections as an Interactive Information Medium and Promotional Medium (Case Study: Bengkulu State Museum)," Electrician Journal of Electrical Engineering and Technology, vol. 16, no. 1, pp. 81–93, 2022, doi: 10.23960/elc.v16n1.2229.

[17] M. A. A. Fikri and S. Supriyanto, "3D Modeling of Costumes and Avatar Attributes in Virtual Academy Games," Jstie (Journal of Information Technology) (E-Journal), vol. 10, no. 1, p. 1, 2022, doi: 10.12928/jstie.v10i1.21068.

[18] Nasuha, T. A. Sardjono, and M. H. Purnomo, "Introduction to Dynamic Viseme of Indonesian Language Using Convolutional Neural Network," National Journal of Electrical Engineering and Information Technology (Jnteti), vol. 7, no. 3, 2018, doi: 10.22146/jnteti.v7i3.433.

[19] T. A. Kurniawan, "Use Case Modeling (UML): Evaluation of Several Errors in Practice," Journal of Information Technology and Computer Science, vol. 5, no. 1, pp. 77–86, 2018, doi: 10.25126/jtiik.201851610.

[20] J. Pratama and F. Frenky, "Design and Application of Motion Capture on 3D Characters in Videos," Scientific Journal of Informatics, vol. 10, no. 01, pp. 35–43, 2022, doi: 10.33884/jif.v10i01.4613.

[21] Satriawan and M. E. Apriyani, "Analysis and Creation of 3D Character Rigging in the 3D Animation 'Jangan Bohong Dong,'" Journal of Informatics Engineering, vol. 9, no. 1, 2016, doi: 10.15408/jti.v9i1.5580.