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Augmented Reality Application for Waruga Cultural Heritage Recognition

Aplikasi *Augmented Reality* Pengenalan Cagar Budaya Waruga

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***Abstract* — Waruga is one of the cultural heritages which is the ancestral tomb of the Minahasa tribe which is made of sedimentary rock called tufa, the local language is called apela/domato. The lack of easily accessible information and the lack of interest in the information presented has resulted in a decrease in interest in getting to know the waruga cultural heritage. Augmented reality technology offers great potential in enriching the user experience and facilitating understanding of waruga. This study uses the image target tracking method so that target detection is based on images. For the development method using the multimedia development life cycle which has 6 stages and produces an application *augmented reality* introduction to the waruga cultural heritage which includes 13 markers and 12 3D objects. Based on the test results involving 31 respondents in a questionnaire with 10 questions regarding understanding of waruga cultural heritage, the average answer was 94.19 out of 100 points with a range of 70-100 points. By employing augmented reality technology, we can develop an application for recognizing the cultural heritage of Waruga.**

***Key words*— *Augmented reality*, *Cultural Heritage*, *Image target*, Waruga**

***Abstrak* — Waruga adalah salah satu cagar budaya yang merupakan makam leluhur suku Minahasa yang terbuat dari batuan sedimen yang bernama tufa, bahasa daerahnya disebut apela/domato. Kurangnya informasi yang mudah diakses serta kurang menariknya informasi yang disajikan menyebabkan menurunnya minat untuk mengenal cagar budaya waruga. Teknologi *augmented reality* menawarkan potensi yang besar dalam memperkaya pengalaman pengguna dan memfasilitasi pemahaman tentang waruga. Penelitian ini menggunakan metode pelacakan image target sehingga pendeteksian target berdasarkan gambar. Untuk metode pengembangan menggunakan multimedia development life cycle yang memiliki 6 tahap dan menghasilkan aplikasi *augmented reality* pengenalan cagar budaya waruga yang meliputi 13 marker dan 12 objek 3D. Berdasarkan hasil pengujian yang melibatkan 31 responden pada kusioner dengan 10 pertanyaan mengenai pemahaman tentang cagar budaya waruga, didapatkan rata-rata jawaban 94,19 dari 100 poin dengan rentang 70-100 poin. Sehingga dengan menerapkan teknologi augmented reality didapatkan suatu aplikasi pengenalan cagar budaya waruga.**

***Kata kunci* — *Augmented reality*, Cagar Budaya, *Image target*, Waruga**

I. Introduction

Cultural Heritage is a tangible cultural asset such as cultural artifacts, historic buildings, historic structures, historic locations, and historic areas on land or in waters that must be protected and preserved because they have significance in history, knowledge, education, religion, and culture through an official recognition process. . [1].

Waruga is a cultural site located in the Minahasa region, which functions as the final resting place of the ancestors of the Minahasa tribe. Waruga consists of stone tombs made of tufa, a type of sedimentary rock, which in local language is called apela/domato. In the past, waruga stone graves were spread throughout Minahasa Regency, but in 1817 they were relocated to several different complexes. One of the waruga complexes that has been developed by the government as a tourist attraction is located in Sawangan Village, Airmadidi District, North Minahasa Regency. In this cultural heritage complex, there are 144 waruga with different sizes and decorative motifs [2]. The Waruga cultural reserve in Sawangan village has a tourist attraction so it has become a cultural tourism destination.

However, even though waruga has high historical value, people's knowledge and understanding of waruga is often limited. The lack of easily accessible information and the lack of interesting information presented about waruga has resulted in decreased interest in getting to know and curiosity about this cultural heritage.

In the current era of digital technology, technology*augmented reality* (AR) offers great potential in enriching user experience and facilitating understanding of waruga. AR is a technology that allows combining the real world with virtual elements, so that users can see and interact with digital objects that are integrated with the surrounding environment.

By utilizing AR technology, an application can be built which aims to increase public recognition and understanding of the Waruga cultural heritage. This application will also provide an interactive visual experience to users, allowing them to see waruga directly, learn history and get relevant information about existing waruga culture.

A. Related research

1) Technology-based Temple Information Application Design*Augmented Reality* on an Android Smartphone (Case Study: Ngetos Temple, Nganjuk). In research designing applications*augmented reality* as a medium for information on temple ngetos and using methods*image target* which can display 3D objects in the form of ngetos temples [3].
2) 3D Exploration*Photorealistic* Waruga Heritage Site uses*virtual reality*. This research designs an application*virtual reality* waruga so that users can indirectly explore waruga and get to know waruga through this application [4].

3) Application for introducing historical tourist attractions in the old city of Jakarta*augmented reality*. This research designs an application*augmented reality* with tracking*markerbased* to introduce historical tourist attractions in the old city of Jakarta which can display historical buildings in the form of 3D objects [5].
4) Application*Augmented Reality* Based on Android to introduce Tountemboan traditional clothing. This research designs an application for recognizing Tountemboan Minahasa traditional clothing by applying technology*agumented reality* and tracking methods*markerbased*. The application can display 3D objects in the form of Tountemboan traditional clothing [6].
5) Application*user defined target* on*augmented reality* as a medium for introducing the GMIM Sentrum Manado Church. This research designs media for introducing the GMIM Sentrum Manado church by applying technology*augmented reality* and tracking methods*markerless user defined target* so that users can use the application without using markers [7].
6) Application of Augmented Reality in the "Pandukawan" Application (Introduction to Pandawa and Punakawan Puppets). This research designs an application for puppet recognition using the tracking method*markerbased.* This application displays 3D objects in the form of puppets that can be selected [8].
7) Application for introducing Sumatran traditional houses based on augmented reality on Android devices. This research designed an application to introduce Sumatran traditional houses by displaying 3D objects of traditional houses and sound information [9].
8) Mobile Augmented Reality Introduction to Historical Sites in the Old Banten Area using the Marker Based Tracking Method. This research designs an application for recognizing historical places in Banten by displaying buildings in the form of 3D objects [10].

B. Cultural heritage

Cultural Heritage is a tangible cultural asset such as cultural artifacts, historic buildings, historic structures, historic locations, and historic areas on land or in waters that must be protected and preserved because they have significance in history, knowledge, education, religion, and culture through an official recognition process. [1]. Cultural heritage is a manifestation of cultural results that arise from interactions between humans and their environment. Culture and its products are an inseparable part of the human life cycle. Cultural heritage plays a role in strengthening the identity of a nation because it contains cultural products that are unique and shared by that nation [11].

C. Waruga

The Waruga cemetery is a structure made from sedimentary rock called tufa in the local language, and this structure is also often referred to as apela or domato. This megalithic object is a unique and distinctive cultural heritage left by the ancestors of the Minahasa people. Waruga itself comes from two words "waru" which means "house" and "ruga" which means "body". In a literal sense, waruga describes "a residence for the body that will return to heaven". When a corpse is placed in the waruga, the body will be in a position with the heels approaching the buttocks and the mouth as if kissing the knees, just like the position of a baby in the womb [12]. Waruga is a type of megalith characterized by a cube-shaped box with a hole in the inside. To cover the burrow, the top is equipped with a trapezoidal cover. Both the container and the lid are often decorated with decorative motifs, either human figures or geometric motifs. Waruga is the most common type of burial found in Indonesia.[13].

D.Augmented Reality

Augmented reality (AR) technology is one of the significant innovations that is often used in interactions today. The application of Augmented Reality (AR) plays a key role in conveying information to users. AR is an interactive technology in the multimedia domain that combines real world elements with virtual elements. AR technology is a very useful innovation and can be applied to Android-based mobile devices to display three-dimensional (3D) animations. Augmented Reality has the following characteristics [14].

1. Combining real and virtual environments
2. Runs interactively in real time
3. Integration in three dimensions (3D).

Azuma explained that in simple terms, augmented reality (AR) can be defined as the integration of virtual objects into a real environment. This combination of real and virtual objects can occur through the use of appropriate display technology. Additionally, interactivity in AR can be achieved through the use of special input devices [14].

E. Sawangan Waruga Cultural Reserve

In the past, waruga stone graves were widespread throughout almost the entire Minahasa Regency area, but in 1817, they were moved to several different locations. One of the waruga complexes that has been made a tourist attraction by the government is located in Sawangan Village, Airmadidi District, North Minahasa Regency. This waruga complex has been officially recognized as a Cultural Heritage Site through the Decree of the Minister of Culture and Tourism No: PM.22/PW.007/MKP/2007 [2]. The remains of monumental works from the Megalithic era, namely Waruga, can be found in the Waruga Sawangan cultural heritage complex. In this complex, there are around 143 Waruga that can be found. Waruga are grouped based on their size, including small Waruga which has a height of 0-100 cm with a total of 10 units, medium Waruga with a height of 101-150 cm with a total of 52 units, and large Waruga which has a height of 151-250 cm with a total of 81 units [12].

F. Marker Augmented Reality

There are two types of marker recognition algorithms in augmented reality (AR), namely marker and markerless. Markers are special markers that are often shaped like barcodes or certain black frames, while markerless are markers that are directly connected to the object. The evolution in the use of markers is marked by a shift from the barcode form to a form more closely related to objects in everyday life. These markers are divided into two categories, namely markers (also known as technical markers) such as barcodes, QR codes, and printed AR markers, and markerless (also known as natural markers) such as printed natural markers and markers that correspond to objects in real life [3].

G. Metode Image Target

The image tracking method is a way to detect and track targets based on images. In contrast to traditional markers such as matrix codes or QR codes which require a special pattern of black lines and white areas for identification, this method recognizes and tracks natural features contained in images directly by comparing them with images that have been stored in a database. Once the Image Target is detected, the system will continue to track the image, provided that part of the marker is still visible in the camera view when the scanning process is carried out [15].

H. Android

Android is an operating system derived from Linux, designed for use on mobile devices with touch screens such as smartphones and tablet computers. The Android project was first developed by a company called Android, Inc., with financial support from Google, which then bought the company in 2005. This operating system was officially released in 2007, after the formation of the Open Handset Alliance, a consortium consisting of companies- companies in the fields of hardware, software and telecommunications, aiming to advance open standards in the mobile device industry. Android phones first went on sale in October 2008[16].

I. Vuforia

Vuforia SDK Engine is a platform or software plugin used to develop Augmented Reality applications, especially for use in Unity 3D applications. Using this platform, developers can easily insert advanced computer vision capabilities into applications, enabling them to recognize images and objects and interact with real-world environments [17].

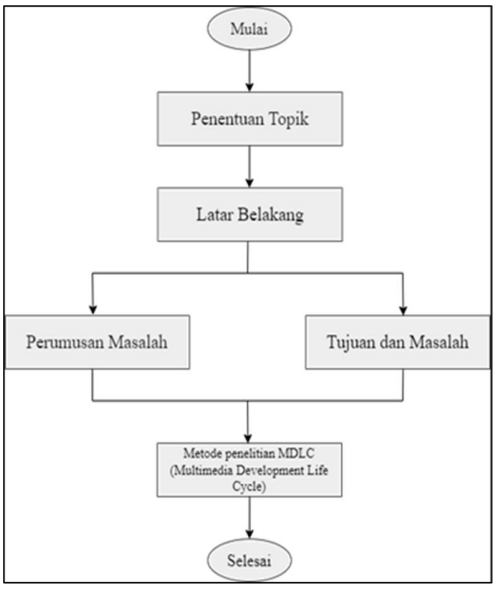


Figure 1. Framework of thinking

J. Unity3D

Unity 3D is a game engine that is used to simplify the development process for various types of games and applications, such as those including 2D, 3D, VR and AR. This game engine is equipped with a graphical user interface (GUI) that makes it easy to create, edit, and script to create 3D games. Unity 3D supports multiple platforms, so games or applications created using this game engine can be run on various devices, including PC (Windows, Mac, Linux), Android, iOS, Windows Phone, Tizen, web, game consoles (PS, Xbox , Nintendo Wii), even smart TVs. Programming in Unity 3D is very easy to learn and quite simple, with support for three programming languages, namely JavaScript, C#, and Boo. [18].

K. Blender3D

Blender3D is an Open Source based 3D computer graphics software. This software is used for creating animated films, visual effects, creating 3D printed models, developing interactive 3D applications, and creating video games. Blender has a number of features that include 3D modeling, texture creation, bitmap image editing, machining, fluid and smoke simulation, particle simulation, animation creation, video editing, digital sculpting, and rendering. One of the very special advantages of Blender3D is its ability to create games [19].

L. Multimedia Development Life Cycle

The method used is the Multimedia development life cycle (MDLC) which consists of six stages, namely Concept, Design, Material Collecting, Assembly, Testing, and Distribution[7].

M. UML (Unifed Modeling Language)

UML (Unified Modeling Language) is a language that uses visual representations or images to describe, clarify, design and document software development systems based on object-oriented (OO) programming.

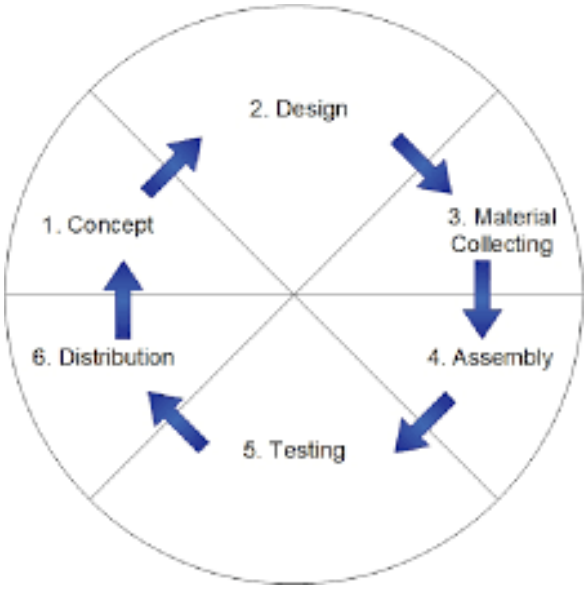


Figure 2. *Multimedia development life cycle*

UML also provides standards for creating system sketches or blueprints, which include aspects such as business processes, explanations of classes in specific programming languages, database schema design, as well as components required in system software [20].

II. METHODS

Research and application testing was carried out at the Waruga Cultural Reserve in Sawangan, Airmadidi District, North Minahasa Regency. This research will take place from January 2023 to June 2023.

In preparing this research, it has a framework structure as in Figure 1 which was created to describe the design or flow.

A. Software development methods

This research was designed using the Multimedia development life cycle (MDLC) method as in Figure 2 which has 6 stages, namely concept, design, material collecting, assembly, testing, and distribution.

1) *Concept*

At this stage, conceptualization of the application is carried out, such as the general specifications of the application, namely the application platform, namely Android, the application title, multimedia content in image and video formats. Then the purpose of the application is to introduce the Waruga cultural heritage. And the target users of the application are all groups. At this stage, direct observation is also carried out to identify application needs as well as collect primary data.

2) *Design*

Next, the design stage is the design stage for describing the application that will be created and to guide the flow of the application, namely by creating UML diagrams such as Use Case and Activity diagrams. As for planning*interface* application interface design.

3) *Material Collecting*

At this stage the researcher will collect the assets needed to create the application. In this research, images were collected that would become markers by taking pictures directly at the cultural heritage site for each object needed. Then design the background, typography and buttons.

4) *Assembly*

At this stage, researchers will start making 3D objects, namely 13 objects designed in a blender with 2 stages, namely modeling and texturing. The next stage is making markers which are made using the Vuforia engine website and assembling applications designed using Unity software.

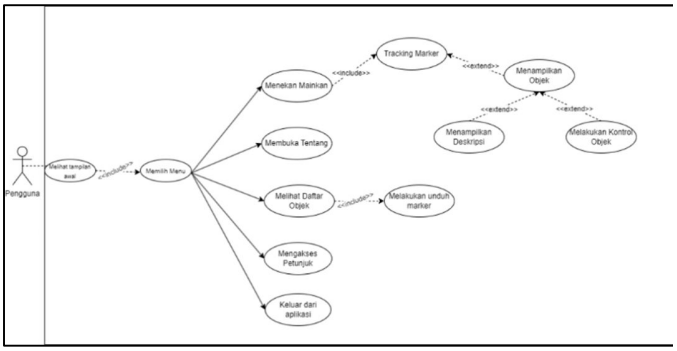


Figure 3. Use case diagram

5) *Testing*

At this stage, the application that has been assembled from the previous stage will be tested, using the alpha testing method to ensure that the functions and features of the application run well and according to design and beta testing, namely by testing the application directly on users.

6) *Distribution*

If the testing stage has been completed where the application has run well, it will enter this stage, namely the application will be distributed to the public and visitors to the Waruga cultural heritage.

III. RESULT AND DISCUSSION

A. Concept

This stage is the first stage in the MDLC cycle, which begins with identifying the purpose of creating the application and determining the application users.

In conceptualizing there are several stages that need to be considered, namely:

Aims and Benefits of Introduction Media

To introduce the Waruga cultural heritage by applying Augmented Reality technology.

User

The application will be made with an appearance that is easy to run and has sufficient features to be used by all groups.

Description and specifications

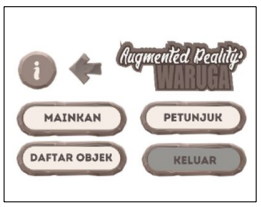
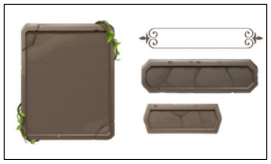
The Waruga tourist attraction recognition application uses augmented reality technology where users can scan objects directly. This application also runs on the Android operating system.

Also at this stage, the researcher made direct observations at the waruga cultural heritage to identify application needs as well as collect primary data. During observations, it was found that there were several warugas that could still be identified regarding their details, namely there were 12 warugas and there was also a North Sulawesi traditional house which was used as an ancient museum, so from the observations an interview was conducted with the tour guide with questions regarding the details of the 12 warugas and the ancient museum.

Figure 4. Activity diagram AR Camera

Figure 5. Initial menu display

TABLE I
MATERIAL COLLECTION

No.	Material	Information
1.		Image name: marker waruga mandagi.jpg Format file : JPG Source: Meilani, 19 February 2023, Waruga Sawangan Complex. Image for waruga dotu mandagi marker
2.		Image name: guiformenu.png Format file : PNG Images for menu buttons, back and menu title.
3.		Image name: guipapan.png Format file : PNG Images for title, name, frame and information boards
4.		Video name : videowaruga.mp4 Format file : MP4 Duration: 05.20 minutes Source: Fancy Walkers, April 22 2023 Sawangan waruga profile video

B. Design

At this stage, an analysis of all activities that occur in the overall system architecture is carried out by designing*use case, activity diagram* and the initial appearance of the application.

Use case designed to show how actors or users perform actions or interact with the system in the application as in Figure 3.

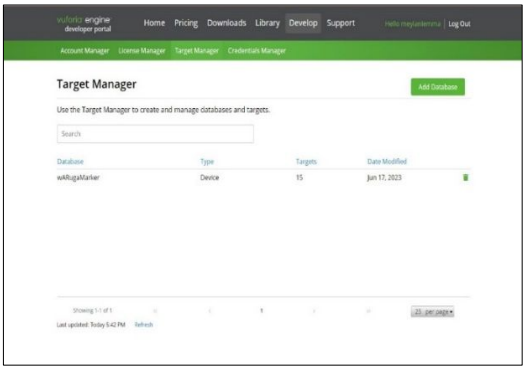


Figure 6. *Database marker*

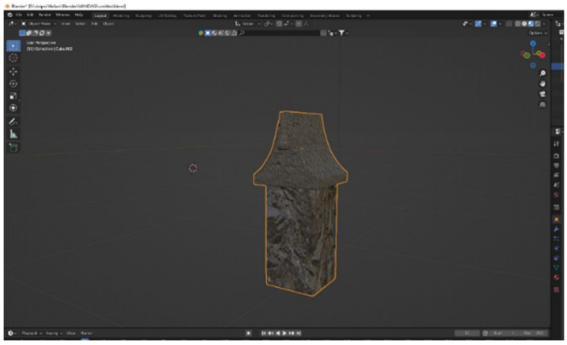


Figure 7. Mandagi 3D Object

Figure 8. Import UI

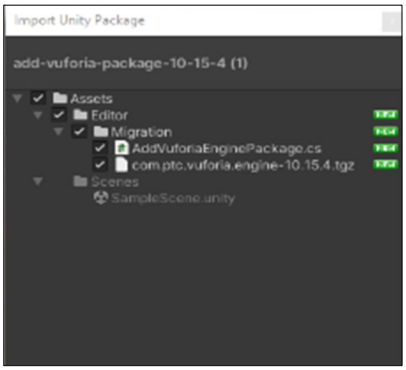


Figure 9. *Import Vuforia*

Activity diagram will show the sequence of user and application activities as in Figure 4.

The initial appearance of the application is an initial overview of the appearance of the application that will be designed each*scene* and features in the application as in Figure 5.

C. Material collecting

After the design stage is complete, we enter the next stage, namely collecting materials. At this stage the researcher will collect materials in accordance with the system design

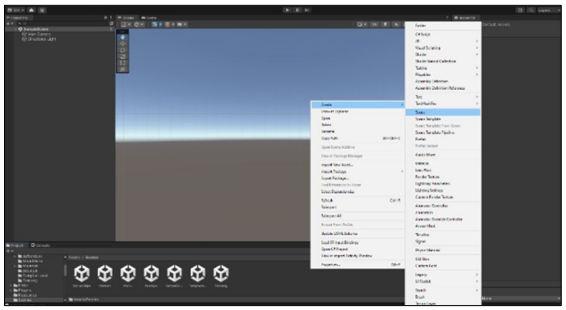


Figure 10. *Create scene*

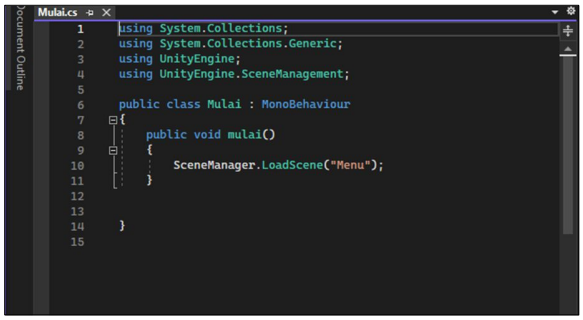


Figure 11. Script for movement scene

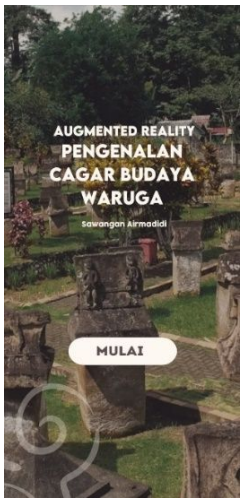


Figure 12. Initial Display

Gambar 13. Menu display

Gambar 14. AR Display

Gambar 15. Display of object rotaion

Previously, these materials were in the form of images, photos, videos, text and 3D objects which can be seen in Table 1.

D.Assembly

At this stage, assembly or application creation will be carried out based on the design that has been previously designed and from the materials that have been collected. Starting from creating marker assets in Vuforia, then creating 3D objects made with Blender software, then finally the application is put together in Unity software.

Asset markers are made from direct photos of objects taken at the Sawangan cultural heritage site. There are 14 markers, namely 12 markers for 12 different warugas, 1 marker for the waruga nameplate and 1 marker for the traditional house museum. Then these photos are processed into markers in Vuforia as in Figure 6 and*export* into a unity package which can be seen in Figure 4.

The creation of 3D objects which included 12 objects was made in Blender software as in Figure 7 and had 2 stages, namely modeling and texturing and exported to .fbx format for input into Unity.

Application design using Unity software version 2022. Starting with creating*new project* on unity and men-*import* all*asset* UI as prepared as in Figure 8 later*import* The downloaded Vuforia

engine and marker package are as shown in Figure 9 and then create each*scene* as in Figure 10 as well*script* required for transfer*scene* as in Figure 11. After all*scene* has been completed, then enter the process*build* application.

E. Testing

At this stage, testing is carried out on the Waruga Cultural Heritage introduction application to evaluate the system in the application and ensure that the system functions correctly.

Alpha testing starting from using the application on*platform android* as in Figure 12 to Figure 15 and several alpha testing tables were also created as in Table 2 to test the success of the button in the application and a marker distance detection testing table as in Table 3.

Beta testing produced responses from 31 users which were submitted via a questionnaire with 4 questions in the first part about satisfaction and 10 questions in the second part about user understanding regarding this waruga cultural heritage. The target respondents for the questionnaire are all age groups. The results of the questionnaire can be seen in Figure 16.

F. Distribution

At this stage, what is being done is distribution to platforms that provide free applications for Android mobiles with the aim that users can download the Waruga cultural heritage introduction application directly on their respective Android mobiles.

IV. CONCLUSIONS AND SUGGESTION

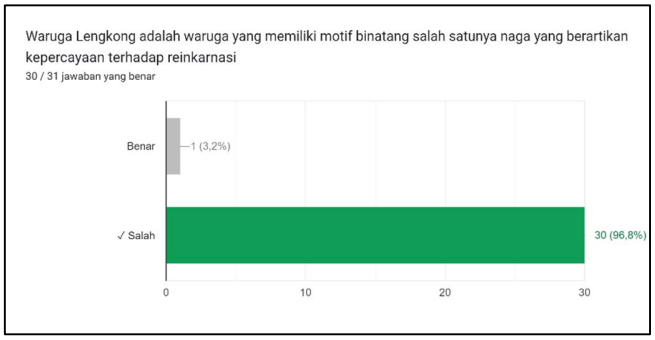
A. Conclusion

Based on the research that has been carried out, it can be concluded that with the application of technology*augmented reality* produced an application for introducing the Waruga cultural heritage which can be an interesting alternative for accessing information about the Waruga cultural heritage because of the ability of augmented reality which can combine the real world with virtual world objects. This research uses a target image tracking method and produces 13 3D waruga objects with different models and motifs

On testing*alpha testing*, all features including 12 buttons and 14 markers were successfully executed. On testing*beta testing,* There were 31 respondents with an age range of 5-50 years, 93.5% responded yes to ease and access to information on the application and in part two of the questionnaire regarding user understanding, the average answer points were obtained, 94.19 out of 100 points with a range of 70- 100 points. So from this data it can be concluded that this application can be a medium for introducing waruga cultural heritage.

B. Suggestion

In the research there are several things that need to be reviewed so that this application can be even better, namely in its implementation, this application can only run on the Android platform so it is hoped that it can be further developed on other platforms and the objects in this research are only 13 so that for its development objects can be upgraded according to needs.



Gambar 16. Questionnaire Result

TABLE II
ALPHA TESTING HOME PAGE

No.	Testing Items	Expected results	Results
1.	Pressing the Start button	The Menu page is displayed	Succeed
2.	Pressing the Play button	The AR camera is displayed	Succeed
3.	Pressing the I (About) button	The About page is displayed	Succeed
4.	Pressing the Object List button	The Object List page is displayed	Succeed
5.	Press the Hint button	The Instructions page is displayed	Succeed
6.	Press the Exit button	Exit the application	Succeed

TABLE III
ALPHA TESTING CAMERA AR

No.	Testing Items	Expected results	Results
1.	Press the Description button	The object description is displayed	Succeed
2.	Press the Sound button	Information in the form of audio is activated	Succeed
3.	Pressing the Rotation button	The 3D object will rotate	Succeed
4.	Push the button *Zoom in*	3D objects will be enlarged	Succeed
5.	Push the button*Zoom out*	3D objects will be scaled down	Succeed
6.	Press the Exit button	The menu page is displayed	Succeed

TABLE IV
TESTING THE CAMERA DETECTION DISTANCE ON THE MARKER

No.	Distance (meters)	Information
1.	3-4 meter	Detected
2.	4-5 meter	Detected
3.	4-6 Meter	Detected
4.	>6 meter	Not detected

V. KUTIPAN

[1] "UU No. 11 Tahun 2010 tentang Cagar Budaya [JDIH BPK RI]." https://peraturan.bpk.go.id/Home/Details/38552/uu-no-11-tahun-2010 (accessed Jan. 07, 2023).

[2] M. Credo, S. Mangolo, I. Putu, G. Sukaatmadja, I. Bagus, and G. Pujaastawa, "'WARUGA' SEBAGAI DAYA TARIK WISATA DI DESA SAWANGAN, KABUPATEN MINAHASA UTARA," 2017.

[3] D. A. Firmansyah, H. Tolle, and A. Pinandito, "Rancang Bangun Aplikasi Informasi Candi berbasis Teknologi Augmented Reality pada Smartphone Android (Studi Kasus : Candi Ngetos , Nganjuk)," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 2, no. 8, pp. 2651–2658, 2018.

[4] A. K. Wahyudi and J. Y. Mambu, "Eksplorasi 3D Photorealistic Situs Warisan Waruga menggunakan Virtual Reality," *Univ. Klabat Airmadidi, Indones.*, no. December, pp. 289–301, 2016.

[5] A. S. Riadi and U. Radiyah, "APLIKASI PENGENALAN OBJEK WISATA SEJARAH KOTA TUA JAKARTA," no. 2, pp. 1035–1039, 2018.

[6] S. P. Bowers, "Predicting success in early childhood teacher education programs," *J. Early Child. Teach. Educ.*, vol. 19, no. 3, pp. 227–233, 1998, doi: 10.1080/0163638980190306.

[7] Y. F. Tielung, V. Tulenan, and Y. D. Y. Rindengan, "Penerapan User Defined Target Pada Augmented Reality Sebagai Media Pengenalan Gereja GMIM Sentrum Manado," *J. Tek. Inform.*, vol. 14, no. 1, pp. 121–128, Mar. 2019, doi: 10.35793/JTI.14.1.2019.23984.

[8] M. Nurkhafid and M. Mustagfirin, "Penerapan Augmented Reality Pada Aplikasi 'Pandukawan' (Pengenalan Wayang Pandawa Dan Punakawan)," *J. Inform. dan Rekayasa Perangkat Lunak*, vol. 1, no. 1, pp. 24–30, 2019, doi: 10.36499/jinrpl.v1i1.2763.

[9] Jupriyadi and A. Aziz, "Aplikasi Pengenalan Rumah Adat Sumatera Berbasis Augmented Reality Pada Perangkat Android," *Telefortech*, vol. 1, no. 2, pp. 46–54, 2021.

[10] B. Arifitama and A. Syahputra, "Mobile Augmented Reality Pengenalan Situs Sejarah Kawasan Banten Lama dengan Metode Marker Based Tracking," *JTERA (Jurnal Teknol. Rekayasa)*, vol. 3, no. 2, p. 255, 2018, doi: 10.31544/jtera.v3.i2.2018.255-260.

[11] S. D. Utari and L. Ayundasari, "Perancangan Aplikasi Virtual Reality Cagar Budaya untuk Pembelajaran Sejarah Lokal PURWOSARI MELALUI METODE OUTDOOR LEARNING View project MONOGRAF View project", doi: 10.17509/historia.v4i2.25740.

[12] "Indonesia.go.id - Mengenal Waruga Sawangan, Situs Purbakala Zaman Megalitik." https://www.indonesia.go.id/ragam/budaya/kebudayaan/mengenal-waruga-sawangan-situs-purbakala-zaman-megalitik (accessed Jan. 11, 2023).

[13] B. Prasetyo, *Megalitik Fenomena yang Berkembang di Indonesia*. 2015.

[14] R. T. Azuma, "A Survey of Augmented Reality," *Presence Teleoperators Virtual Environ.*, vol. 6, no. 4, pp. 355–385, Aug. 1997, doi: 10.1162/PRES.1997.6.4.355.

[15] R. M. Alfath and S. Eniyati, "Proceeding SENDIU 2021 IMPLEMENTASI METODE IMAGE TRACKING PADA KATALOG ALAT KESEHATAN (LABORATORIUM) MENGGUNAKAN AUGMENTED REALITY BERBASIS ANDROID," pp. 978–979, 2021.

[16] A. D. Saputra and R. I. Borman, "SISTEM INFORMASI PELAYANAN JASA FOTO BERBASIS ANDROID (STUDI KASUS: ACE PHOTOGRAPHY WAY KANAN)," *J. Teknol. dan Sist. Inf.*, vol. 1, no. 2, pp. 87–94, Dec. 2020, Accessed: Jan. 12, 2023. [Online]. Available: http://jim.teknokrat.ac.id/index.php/sisteminformasi/article/view/420

[17] "Getting Started with Vuforia Engine in Unity | VuforiaLibrary." https://library.vuforia.com/getting-started/getting-started-vuforia-engine-unity#about. (accessed Jan. 12, 2023).

[18] G. I. Amal, "PENGENALAN HEWAN MENGGUNAKAN TEKNOLOGIAUGMENTED REALITY DENGAN METODE USER DEFINEDTARGET BERBASIS ANDROID," Feb. 2021.

[19] R. R. Wijayanti, "IMPLEMENTASI AUGMENTED REALITY SEBAGAI MEDIA PROMOSI INTERAKTIF UNTUK KATALOG FOOD AND BEVERAGE PADA HOKCAFE," *JIKA (Jurnal Inform.*, vol. 2, no. 2, Oct. 2019, Accessed: Jan. 12, 2023. [Online]. Available: https://jurnal.umt.ac.id/index.php/jika/article/view/1519

[20] A. Mubarak, "Rancang Bangun Aplikasi Web Sekolah Menggunakan Uml (Unified Modeling Language) Dan Bahasa Pemrograman Php (Php Hypertext Preprocessor) Berorientasi Objek," *JIKO (Jurnal Inform. dan Komputer)*, vol. 2, no. 1, pp. 19–25, 2019, doi: 10.33387/jiko.v2i1.1052.

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