

DEVELOPMENT OF AUGMENTED REALITY APPLICATION AS AN EDUCATIONAL MEDIA FOR VISITORS TO MUSEUM PUSAKA KERATON KASEPUHAN CIREBON USING OBJECT TRACKING METHOD AND FAST CORNER DETECTION ALGORITHM BASED ON ANDROID

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Abstract

Augmented Reality is a technology that combines two-dimensional or three-dimensional virtual objects and projects these virtual objects in real time. One implementation of Augmented Reality in the tourism sector is to educate museum visitors. Museum Pusaka Keraton Kasepuhan Cirebon does not yet have a touch of technology to attract visitors, and the public paradigm is that visiting the museum only sees heirloom objects, nothing interesting or unique. The aim of the research carried out by the author is to apply Augmented Reality with the Object Tracking method and the FAST Corner Detection algorithm to educate museum visitors, so that it can attract visitors' attention. By utilizing these methods and algorithms, it can be easier for visitors to explore heirloom objects to obtain the desired information. So the results obtained from the research conducted by the author are that the response time for objects appearing using the Tracking Object method and the FAST Corner Detection algorithm in environments that use glass is an average of 1.52 seconds to 2.40 seconds and that does not use glass, namely 2.84 seconds to 4.71 seconds with a level of confidence at the 95% level.

Keywords : augmented reality, tracking object, FAST corner detection, museum

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INTRODUCTION

The very rapid development of technology in the current era of globalization has provided many benefits in progress in various social aspects, including providing ease of communication, providing accurate knowledge of information sources, complete data management, and facilitating business opportunities for companies and governments in various parts of the world [1]. The development of information and communication technology itself has grown rapidly in all fields, one of which is Augmented Reality (AR) which is used in the gaming, entertainment, tourism and medical industries. Meanwhile, in the tourism sector, there is still little use of Augmented Reality technology. Augmented Reality (AR) is a technology that combines two-dimensional or three-dimensional virtual objects and then projects these virtual objects in real time [2].

One implementation of Augmented Reality (AR) in the tourism sector is to educate museum

visitors. According to Dinas Pariwisata dan Kebudayaan West Java Province, the level of visits by the general public to museums is relatively low. The percentage of museum visitors, elementary to middle school students, reaches 50% while high school student is 30%. Meanwhile, the general public and foreigners only make up 20% [3]. One of the factors causing low visits to museums is that visitor activities in museums tend to be passive, that is, they only look at objects in the museum. And people think that museums are just exhibition halls that are used to store historical and ancient objects.

The following is a summary of visitor data for one of the museums in West Java, namely Museum Pusaka Keraton Kasepuhan Cirebon. Judging from the data in Figure 1, there was an increase visitors in November because there was the Prophet's Birthday event, the rest of the visits to the museum were up and down. Keraton Kasepuhan Cirebon, West Java, continues to

develop to increase the number of tourist visits, one of which is by operating Museum Pusaka with a "more modern" atmosphere. So far, the museum has been synonymous with a dark and ancient atmosphere. "Young people now love going to shopping centers. That's why we created a Museum Pusaka atmosphere that is like a neat, clean and cool shopping center," said the King of Kasultanan Kasepuhan Cirebon [4].

During an interview with the General Manager of Museum Pusaka Kertaon Kasepuhan Cirebon, the museum did not have a touch of contemporary technology aimed at educating visitors [5]. It is hoped that the museum can become a creative educational medium. Even though heirloom objects look ancient, the museum is also expected to use contemporary technology and attract visitors, especially young people [6]. For this reason, we need technology that can be a creative educational medium and attract tourists to visit museums. Therefore, the author wants to utilize Augmented Reality (AR) technology at Museum Pusaka Keraton Kasepuhan Cirebon in the hope that more tourists will visit Cirebon tourism and eliminate people's thinking that activities in the museum are not just looking at objects. Apart from that, Augmented Reality (AR) can be the right moment to make visitors miss their interest in exploring heritage objects through Augmented Reality (AR).

At Museum Pusaka Keraton Kasepuhan Cirebon, there are several obstacles in exploring heirloom objects, namely the lack of getting historical information on each heirloom object if you don't have a guide. Also, historical information on the heirloom objects is not yet

available with explanations about the objects in English. To explain information about these objects, only a few guides can explain the information to foreign tourists. Therefore, Augmented Reality (AR) has an important role in helping visitors to see heritage objects from various angles. Helps visitors take photos with objects in 3D form. As well as helping to obtain detailed information about the history of heirloom objects in Indonesian and English.

So starting from the problems that have been explained, the author will provide solutions to these problems. The author will provide innovation by combining conventional 2D images which will be combined with 3D Augmented Reality (AR) technology which is packaged in an Android-based application that is more interesting and imaginative so that it can be used as a more interactive and interesting educational or learning media for visitors to Museum Pusaka Keraton Kasepuhan Cirebon.

METHOD

The Extreme Programming method is a method that uses an Object-Oriented approach, whose approach is included in the agile method, namely an active and continuous development method, between developers and customers who must always collaborate and communicate well, which was introduced by Kent Back [8]. According to the definition, Extreme Programming is a software development method that is fast, efficient, low risk, flexible, predictable and fun. The stages of this method are planning, design, coding, and test. In Figure 2 you can see the workflow stages of this method.



Figure 1. Number of Visitors Museum Pusaka Keraton Kasepuhan Cirebon in 2022 [5]

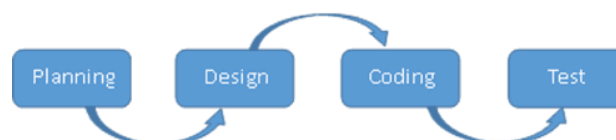


Figure 2. The Stages of Extreme Programming Method

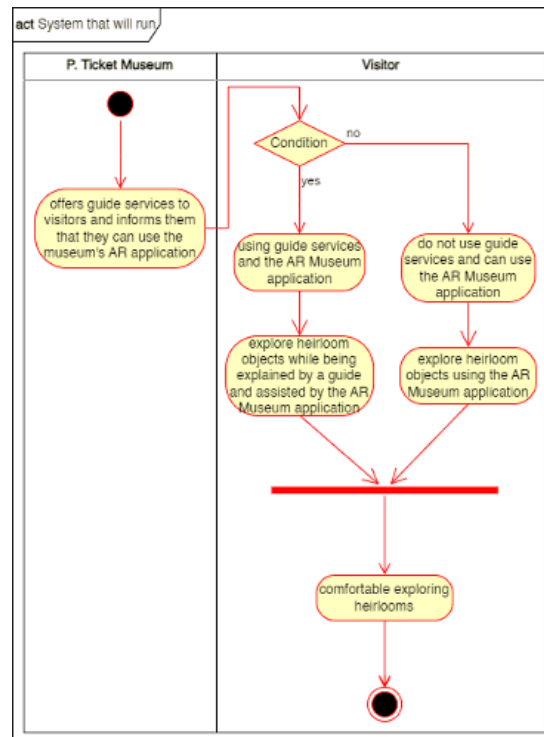


Figure 3. System That Will Run

Planning

The first step is planning, namely planning what kind of system will be built, what data will be needed, and how long it will take to build the system. The following is a depiction of the activity diagram for the system that will run, which can be seen in Figure 3.

Initialization: At this stage, markers are determined that will be used as input sources for the 3D objects that will be used. In this initialization section, the 3D object is initialized

first because the creation of a 3D object takes quite a long time. The 3D model to be displayed requires a configuration file to determine the 3D object that will be loaded according to the detected marker pattern. The process of creating an object consists of 3 steps, namely Adjusting 3D objects with shapes that will be created according to real objects. For example, you can see in Figure 4 the process of creating a 3D object along with the results of the 3D object from Singa Barong.

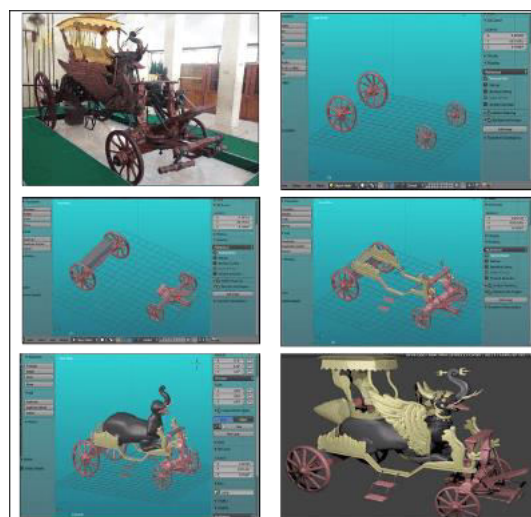


Figure 4. 3D Object Modelling



Figure 5. Marker Used

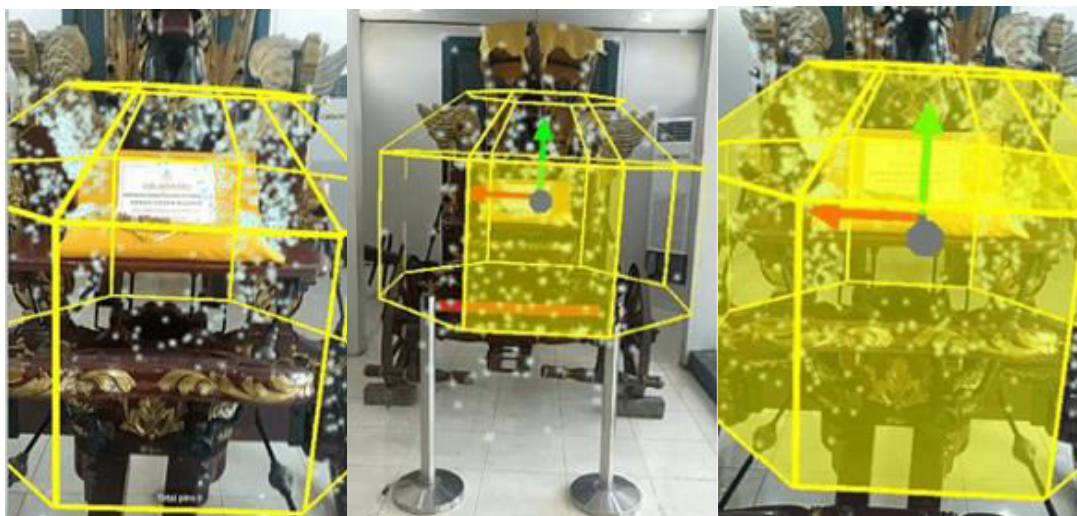


Figure 6. Object Recognition, Adjusting Size and Position, Scanning

The markers used to display 3D objects are the original objects and the target objects already exist in the Cirebon Kasepuhan Palace Heritage Museum, the markers used can be seen in Figure 5.

Tracking objects is the ability to detect objects and calculate the object's position using a standard camera. The position information obtained will be used to place the 3D object in the object's position. The process of making tracking objects into target objects is carried out using an additional application from MAXST, namely Visual SMAL Tools, by scanning the objects that have been provided. There are 3 steps for scanning this object, which can be seen in Figure 6.

After the scanning process, museum visitors can immediately display 3D objects into the camera without having to use images or

barcodes, simply by scanning the original object, the 3D object will immediately appear in the visitor's camera and can display information in the form of audio and text.

Non-Functional Requirements: non-functional requirements are requirements outside the system that are needed to run the application being built. The non-functional requirements for the Augmented Reality-based Tumiris Kota Pusaka Keraton Kasepuhan Cirebon application include hardware requirements, software requirements and system users who will use the application. Hardware requirements are one of the important things because without hardware that meets the requirements, the application that will be created will not run. The following hardware specifications that can be used to create this application can be seen in Table 1. The following are the minimum

specifications that can be used by users when using the Tumis Kota application, which can be

seen in Table 2.

Table 1. Developer Hardware Requirements

No	Hardware Name	Laptop	Android
		Specification	Specification
1	Processor	Intel Core i5 2.50 GHz	Snapdragon 636 Octa-core
2	Screen	14 inch	5.99 inch
3	RAM	4 GB	4 GB
4	Harddisk/ROM	250 GB	64 GB
5	Camera	0.9 MP	12 MP + 5 MP

Table 2. Minimum Device Specification

No	Hardware Name	Android Specification	
		Minimum	Recommended
1	Processor	Snapdragon 400 Quad-core	Snapdragon 636 Octa-core
2	Screen	4.7 inch	5.99 inch
3	RAM/ROM	1 GB/8 GB	4 GB/64 GB
4	Oper	Android Jelly Bean 4.3	Android Pie 9.0
5	Camera	8 MP	12 MP + 5 MP

Table 3. Developer Software Requirements

No	Software Name	Laptop	Android
		Specification	Specification
1	Operating System	Windows 10	Android Pie 9.0
2	Developing Tools	Unity 2018.3.8	Visual SMAL Tools
3	Design Tools	Blender	-
4	SDK	MAXST, Android	-
5	Programming Language	C#	-

Software is the most important thing to support the performance of a system. The software used by the author in making this application for hardware consists of commands that can interact with each other. The software can be seen in Table 3.

Functional Requirements: functional requirements are functionality or services that must be provided by the system, how the system reacts to certain inputs and how the system behaves in certain situations. In supporting the performance of the application system, analysis of functionality requirements is very necessary, whether the application system created is appropriate to what is required by the user. The following are the functional requirements of the

application system being created. The system can display the application created, the system can display a map of the Heritage Museum and the user can use the map to go to that location and the user can see the atmosphere inside the Heritage Museum in a 360 degree camera, the system is able to scan heritage objects and display information in the form of text or audio, the system can display heirlooms that can be scanned, and the system is able to display guidance about scanning on the AR system.

FAST (Features From Accelerated Segment Test), is an algorithm for identifying high-speed intrigued focuses based on the thought of pixels in a circular range around the intrigued point. Intrigued point discovery is an

approach utilized in computer vision frameworks and the division prepare to require numerous points from an image and induce the substance of an image. Point discovery is frequently utilized in movement discovery, image coordinating, following, 3D modeling and object acknowledgment. A point is characterized as the crossing point of two lines. A point can too be characterized as a point that has two prevailing sides and distinctive bearings from that point. A point of interest could be a point contained in an image that's well situated and can be recognized appropriately. This implies that a point of interest can be a corner point but moreover an genuine point of interest. Quick corner location works on an image on Figure 7. Discover a point p on the image with the starting position (x_p, y_p) . Discover the four focuses. The primary point ($n = 1$) lies on the arrangement $(x_p, y_p + 2)$, the moment point ($n = 2$) is found at the facilitates $(x_p + 2, y_p)$ the third point is found at the facilitates ($n = 3$) lies on the facilitates $(x_p, y_p - 2)$, the fourth point ($n = 4$) is found at the

facilitates $(x_p - 2, y_p)$. Compare the escalated of the center point p with the four encompassing focuses. If there are at slightest 3 focuses that meet the taking after conditions, at that point the center p is the vertex. Repeat the method until all focuses on the image have been compared in escalated. Find the p point on the image with an initial position (x_p, y_p) according to Figure 7.

Determine the four points, the primary point ($n = 1$) lies at the facilitates $(x_p, y_p + 3)$, the moment point ($n = 2$) lies at the arrangements $(x_p + 3, y_p)$, the third point is found at the arrangements ($n = 3$) lies at the arrangements $(x_p, y_p - 3)$, the fourth point ($n = 4$) which is found underneath as can be seen in Figure 8.

Compare the escalated of the center point p with the four encompassing focuses. On the off chance that there are at slightest 3 focuses that meet the taking after conditions, at that point the center p is the vertex. Repeat the method until all focuses on the image have been compared in escalated as can be seen in Figure 9.

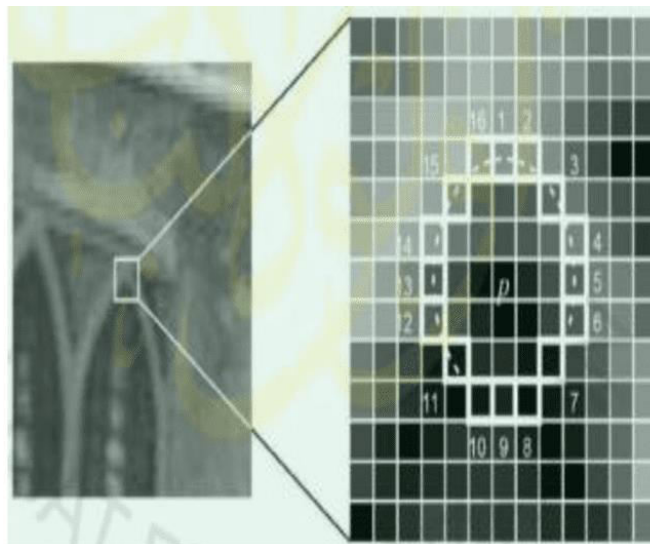


Figure 7. Starting Point Test of FAST Corner Detection [18]

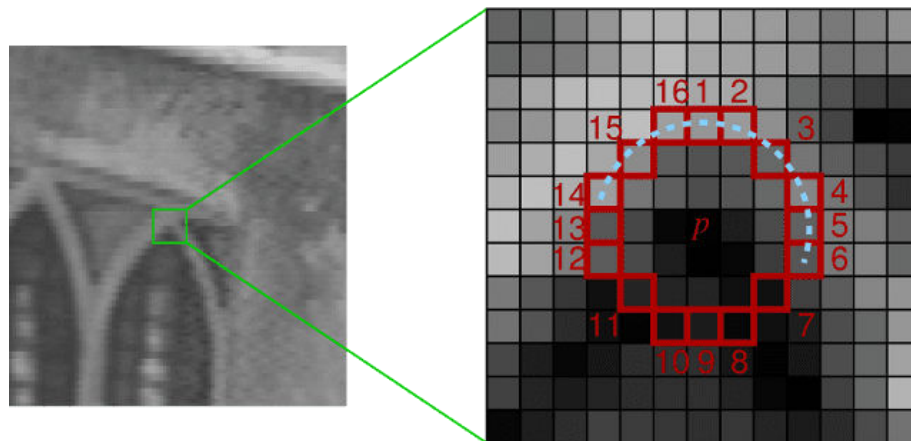


Figure 8. Four Coordinates Points [18]

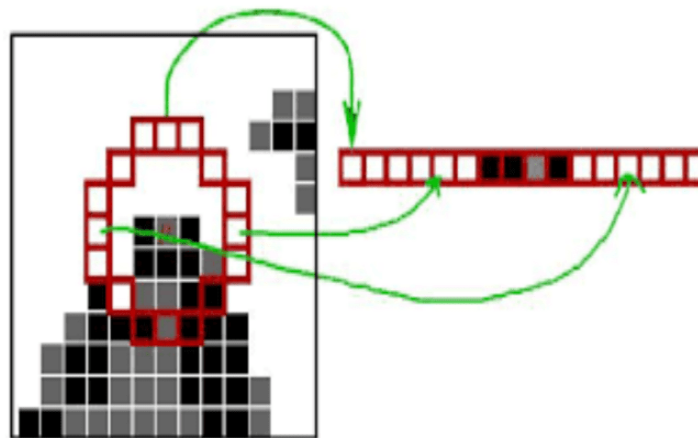


Figure 9. Three Points of FAST Corner Detection Algorithm [18]

Design

In designing this application system the author used object-oriented modeling. This software is modeled using UML (Unified Modeling Language), namely Use Case, Activity Diagram and Class Diagram, which describes the requirements of the system that will run.

Use Case Diagram: use case diagram are used to model or describe system boundaries and its main functions. Use Case Diagram work by describing typical interactions between users of a system and the system itself. In the system there are users/visitors, namely users of this application. The roles of existing actors can be seen in Figure 10.

Activity Diagram: activity diagram describe the various activity flows in the designed system, how each flow begins, the decisions that may occur and how they end. Activity diagram model events that occur in a Use Case Diagram and are used to model dynamic aspects of the system. The AR English activity diagram menu is a menu for running the AR camera in English with the Open AR Camera button. Apart from that, this menu also has an object gallery menu and an AR camera manual. For an overview of the activity diagram, see Figure 11.

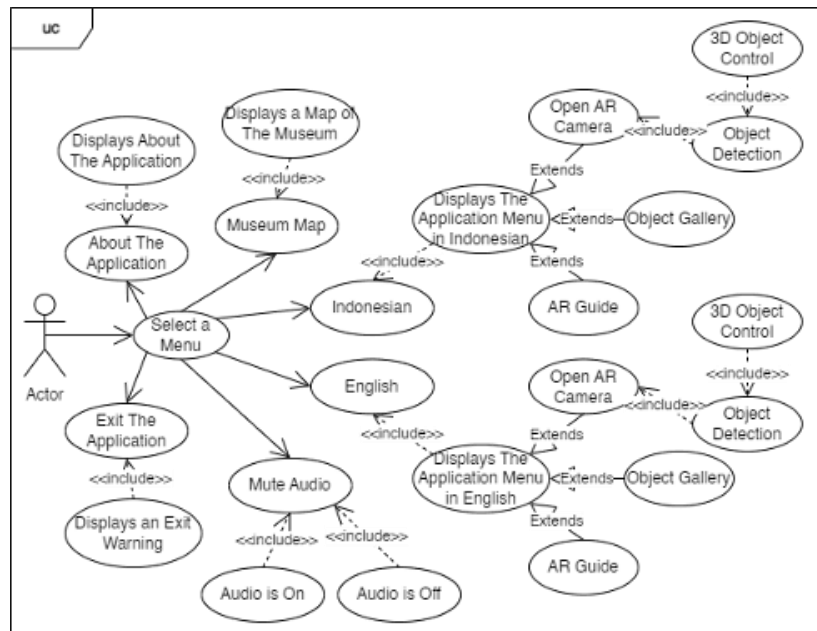


Figure 10. Use Case Diagram of The Application

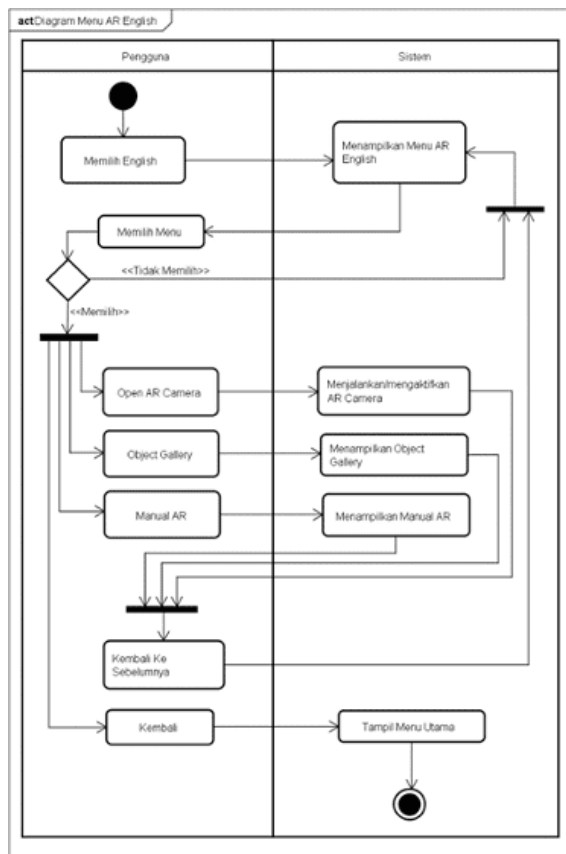


Figure 11. Activity Diagram of The Application

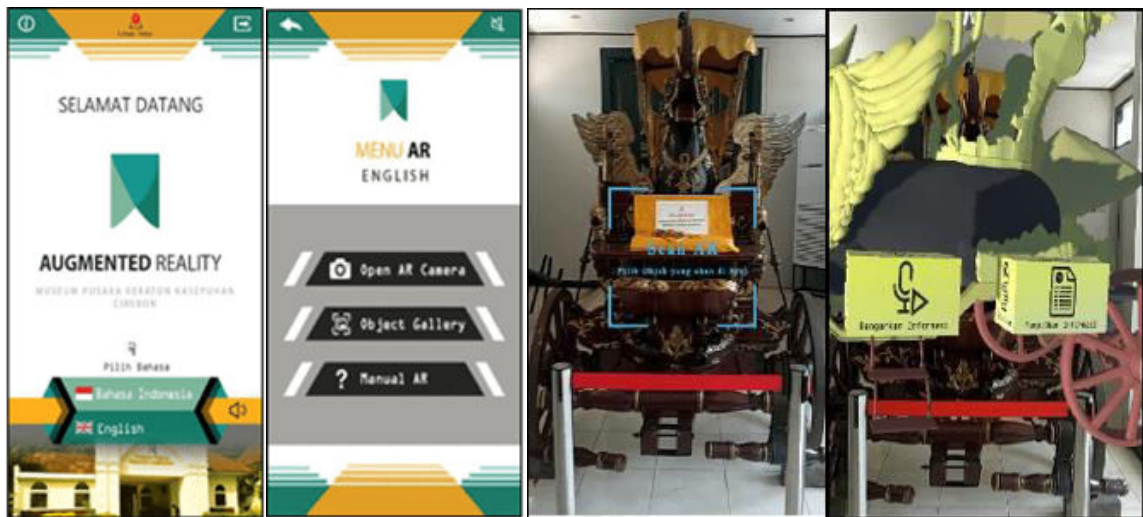


Figure 12. Application Display

Interface Design: After designing new procedures and systems, the author will describe the interface design of the Tumis Kota application and the menu structure. Where the application interface is the design of the software interface that will be built, while the menu structure is a tiered list of instruction items that can be selected by the user to run the system next.

Coding

Program code implementation is the presentation of the results of the core program code for each stage in accordance with the algorithm flow and methods used. One example of the main program code for displaying 3D objects can be seen in Figure 13.

```

121 void Update()
122 {
123     UpdateAllTrackables();
124
125     TrackingState state = TrackerManager.GetInstance().UpdateTrackingState();
126
127     CameraBackgroundBehaviour.UpdateCameraBackgroundImage(state);
128     TrackingResult = state.GetTrackingResult();
129
130     if (trackingResult.GetCount() > 0)
131     {
132         Debug.Log("text");
133         for (int i = 0; i < trackingResult.GetCount(); i++)
134         {
135             Trackable trackable = trackingResult.GetTrackable(i);
136             scene.gameObject.SetActive(false);
137
138             if (!objectTrackablesMap.ContainsKey(trackable.GetName()))
139             {
140                 return;
141             }
142
143             objectTrackablesMap[trackable.GetName()].OnTrackSuccess(trackable.GetId(), trackable.GetName(),
144                 trackable.GetPose());
145         }
146     }
147     else
148     {
149         scene.gameObject.SetActive(true);
150         PanelA.gameObject.SetActive(false);
151         PanelB.gameObject.SetActive(false);
152         audioSourceA.Stop();
153         audioSourceB.Stop();
154     }
155 }

```

Figure 13. Program Code for Scanning Target Objects and Displaying 3D Objects

Figure 13 explains that if a target object is detected, the object appears. Then this program code is also used to provide functions to 3D objects so that they can be pressed or tapped and carry out each function. The Object Tracker Sample program code is a script from the MAXST SDK library, the function of this program code is to detect target objects so that the scanned target can appear on the user's camera. The author developed the library by adding scene functions, panel A, panel B, Audio

Source A, and Audio Source B. Scene shows that when the user opens the AR camera it says AR scene (Select object to be scanned). Panel A and Panel B are target object description panels which show that when the display information button is clicked it will display a description of the 3D object. Audio Sources A and B are explanatory audio descriptions of the target object which shows that when the listen to information button will display an audio description of the 3D object.

Test

Testing is the most important thing that aims to find errors or deficiencies in the software to be tested. This test aims to determine whether the software created meets the criteria in accordance with the design objectives or not. This test uses the object tracking method and FAST Corner Detection in one of the SDKs, namely Maxst. Based on the tests that have been carried out, test result data is obtained from each tracking on these objects. Objects are grouped into 2 parts. The data is presented in table form, each table still has readings only from the front, because for the bottom, top, right side,

left side and back the test results were not successful.

The test was carried out 20 times for each tracking result test, then the average value of the time the speed of the 3D object appeared was taken so that in each table there were 20 time data according to the tests that had been carried out. Below you can see the results in Table 4 for the response time results for objects measuring 0.3 meters to 1.5 meters using glass, then in Table 5 the response times for objects measuring 0.3 meters to 1.5 meters without using glass. Then the test results of less than 0.3 meters and more than 1.5 meters were not successful because the object exceeded the specified maximum limit.

Table 4. Object Response Time Results 0.3 Meters to 1.5 Meters using Glass

No	Test Sequence	Response Time
1	Test 1	2.93 s
2	Test 2	4.43 s
3	Test 3	1.76 s
4	Test 4	1.02 s
5	Test 5	0.61 s
6
7	Test 20	1.01 s
Confidence Interval (95%)		1.96 s ± 0.44 s

Table 5. Object Response Time Results 0.3 Meters to 1.5 Meters without Glass

No	Test Sequence	Response Time
1	Test 1	8.63 s
2	Test 2	6.45 s
3	Test 3	7.76 s
4	Test 4	4.05 s
5	Test 5	4.61 s
6
7	Test 20	1.77 s
Confidence Interval (95%)		3.77 s ± 0.94 s

Based on the test results from Table 4 and Table 5, it can be seen that the average response time for objects appearing using glass is an average of between 1.52 to 2.40 seconds with a confidence level of 95% and the average time for respondents appearing objects those

who do not use glass are average between. 2.84 to 4.71 seconds with a confidence level of 95%. The following is a partial description of the test from Table 4 and Table 5 as well as testing objects more than 1.5 meters can be seen in Figure 14.

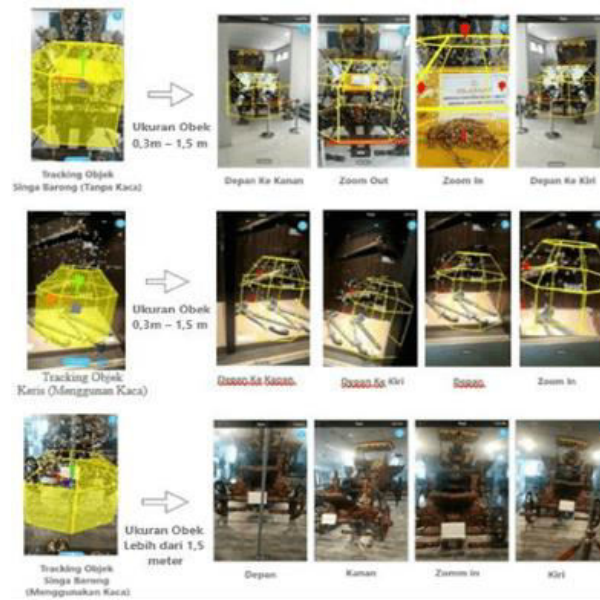


Figure 14. Layout for Feature Extraction using Object Tracking Method and Results of Retrieval FAST Corner Detection Feature

It can be seen in Figure 14 that testing of objects measuring more than 1.5 meters was unsuccessful because when tracking the points on the object they were unstable or did not stay in place, then when mapping to the right and left the points and yellow visual objects followed their position. camera movement. Different from those measuring 0.3 meters to 1.5 meters, when tracking the points on the object are stable and stationary, then when mapping to the right and left the points and yellow visual objects do not follow the camera's movement.

Based on 25 respondents, supporting data can be collected as a method of validating users

directly. It was reported that 21 people or 84% wanted to use augmented reality-based applications to add value to their tourist visits. Of all the respondents who used the application, it was found that 20 people or 95% felt that the application could help increase knowledge during their tourist visits. Apart from that, it is known that of all respondents who want to use the application, there are 16 people or 76% who feel that this application is quite easy to use so that it can have a greater positive impact during their travel experience.

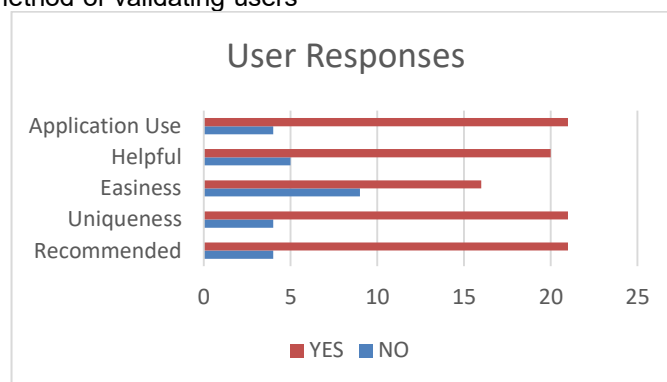


Figure 15. User Responses to The Application

Then, of all the respondents who used it, there were 21 people or 100%, all of whom agreed that the application had a unique value that could be a special attraction when making tourist visits, especially historical tourism, so they agreed to recommend it to other tourists. This can be seen in Figure 15, there are 5

indicators that represent the user's response to this application

RESULT AND DISCUSSION

In the method/algorithm testing section, it can be evaluated that the test results from the object tracking method and FAST Corner

Detection can be applied to certain target objects, for example solid objects that are not transparent, are not too small or thin, and the size of the target object is not too large. Because the larger the target object being tracked, the more difficult it is to track the object. The size of the target object that can be tracked is 0.3 meters to 1.5 meters, this size is a medium scale to be more accurate in finding the target object in the SLAM Tools visual description, but during testing the author was able to find out that the size of the object was greater than 1.5 meters it is less accurate because when tracking the object you get a lot of points. These points cause inaccuracies, ultimately these points are unstable. Then, when mapping right and left, the dots follow the movement of the camera, in the end the dots disappear and tracking repeats. During the test, the object tracking results did not appear, meaning that the tracking results for those larger than 1.5 meters were not accurate for object tracking.

Meanwhile, for target objects whose size is 0.3 meters to 1.5 meters, when the test for object tracking results is successfully carried out, data is obtained on the results of the response time of the 3D object appearing in the method/algorithm test. So from these data the average result is that objects that use glass are on average between 1.52 to 2.40 seconds with a confidence level of 95% and the average time for respondents to display objects that do not use glass is average. -average between 2.84 to 4.71 seconds with a confidence level of 95%. Where 1.52 and 2.84 are obtained from the average value of the object appearing minus the Confidence Interval (95%), while 2.40 and 4.71 are obtained from the average value of the object appearing plus the Confidence Interval (95%). This object tracking test has a weakness, namely that object tracking can only be supported on smartphones and certain types. In Table 6 you can see various types of smartphones that can be used to utilize the augmented reality feature.

Table 6. Smartphone That Can Support Augmented Reality Features

No	Smartphone Brand	Type
1	Samsung	Galaxy Note 4, Galaxy Note 8, Galaxy S7, Galaxy S7 Edge, Galaxy S8, Galaxy S8+, Galaxy S9, Galaxy S9+
2	Apple	iPad Mini 4, iPad Pro (12.9-inch), iPhone 5s, iPhone 6 Plus, iPhone 6s, iPhone 8, iPhone 8 Plus, iPhone X, iPhone XR, iPhone XS Max
3	Xiaomi	Mi A1, Mi MIX 2, Redmi 5 Plus, Redmi Note 4, Redmi Note 5
4	LG	LG G6, LG G3 (LG-F460K)
5	Etc.	Lenovo PB2-690M, Nexus 6P, Xperia XZ F8331, Xperia Z2

From the results of software testing, it can be evaluated that testing using a black box which tests all the functionality of the software was carried out successfully. However, there is one thing that is not optimal, namely responsiveness, and that is only in the main menu section of the language select menu, when installed on another smartphone, the menu is not in its actual position. This responsive test was carried out on smartphones with screens below 2160x1080 and above 2160x1080.

So that the research that the author makes can be even better Suggestions are needed for development in further research. Some suggestions include the following, with an online database there will of course be more interactive features for displaying heirlooms or other objects. Apart from that, it

can be made not only in two languages, but this application can also be developed into more than 2 languages so that visitors from abroad can use the application. The use of Augmented Reality media is not only for museum tourism, of course it can be developed for other tourist attractions so that it can attract visitors to revisit the tourist attraction. And the use of Maps can be applied to applications by adding an API Key to Google Maps so that it can be called to display maps without having to exit the application to open Google Maps. Then the Augmented Reality media for 3D object control can be further developed to explore objects by adding animation to the 3D object, touch the 3D object to make it more interesting, and object tracking can be applied to objects more than 1.5 meters and less than 0.3 meters.

Based on the respondent data previously presented, it can be seen that with tourist responses tending to be positive, the implementation of this application has been proven to have a real impact on the sustainability of the Kasepuhan Palace Heritage Museum as a historical tourism object which is known to be very monotonous.

CONCLUSION

Based on research from the test results, the author concludes that several conclusions can be drawn including Exploring heirloom objects through Augmented Reality technology can make it easier for museum visitors to get more detailed information, so this research has succeeded in attracting visitors' interest in visiting the Cirebon Kasepuhan Palace Heritage Museum. Through this application, visiting a museum is no longer boring, because there is an interesting technological touch. The average result for objects that use glass is an average of between 1.52 to 2.40 seconds with a confidence level of 95% and the average time for respondents to display objects that do not use glass is an average of between 2.84 to 4.71 seconds with a confidence level of 95%. This multi-language application can also make it easier to explore heirlooms and their explanations for foreign tourists using English. For further research, it can be developed by adding an online database, of course there will be more interactive features to display heirlooms or other objects, then the use of the Tracking Object and FAST Corner Detection methods can be optimized again to make it possible to use with a scan distance of more than 1.5 meters and less than 0.3 meters.

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ensure the success and thoroughness of the research.

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