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Augmented Reality Peripheral Performance: Light Intensity, Distance, Occlusion and Marker Testing

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Abstract. Augmented Reality peripherals (ARP) that use marker detection objects have developed rapidly and are implemented in various forms to support the activities of everyday human life. The challenge that is currently being faced is the increasingly widespread application of ARP technology to the reliability of software product performance in detecting objects. This research has developed and implemented ARP in the academic space. The application development method uses the Multimedia Development Life Cycle (MDLC) approach, developed based on the Android operating system, using the Unity 3D Engine and Vuforia SDK. 3D object modelling with Sweet Home 3D. Whereas for testing the reliability of ARP performance in object detection using testing of light intensity, distance, occlusion and marker with each scenario. The research produces augmented reality technology products that are able to offer visualization in the form of interactive 2D and 3D objects in academic rooms that provide information to users about the peripheral layout and division of academic spatial layouts and the good reliability performance.

1. Introduction

The development of Augmented Reality peripherals (ARP) which uses marker detection objects is very rapid and is implemented in various forms to support the activities of everyday human life. In research, Jose Manuel Andújar et al building AR for the Improvement of Remote Laboratories[1]. Kyle N Plunkett's latest research is applied to Augmented Reality into the Classroom and Laboratory[2]. AR for Office and Basic Programming Laboratory Peripheral[3], AR in the Classroom[4], Designing augmented reality for the classroom[5]. analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum[6], AR Applied to Geometry Education[7], etc. Today's challenge relates to the rapid development of ARP technology on how ARP products are capable of being used in the detection of abnormal objects under certain conditions. A product created by ARP that is reliable in object detection is the hope for every developer for the satisfaction of ARP product users as a tool to support their daily activities.

This study builds ARP that focuses on the reliability performance of ARP products using object marker detection. The work item measures the accuracy of ARP performance, providing various manipulation markers for abnormal conditions. There are three tests that are the focus for assessing the reliability performance of ARP, ie Light intensity test, marker distance test, and marker occlusion test. This work applies to the ARP case in the academic room of the Informatics undergraduate program at Mulawarman University, apart from being an experimental object, the application of ARP in this space is also used to be able to provide information to users (stakeholders). about device layout and academic



facility information. Augmented reality technology that is able to offer visualization of interactive 2D and 3D objects.

2. Methodology

A brief overview of the designing, developing and testing room ARP process shown in Figure 1.

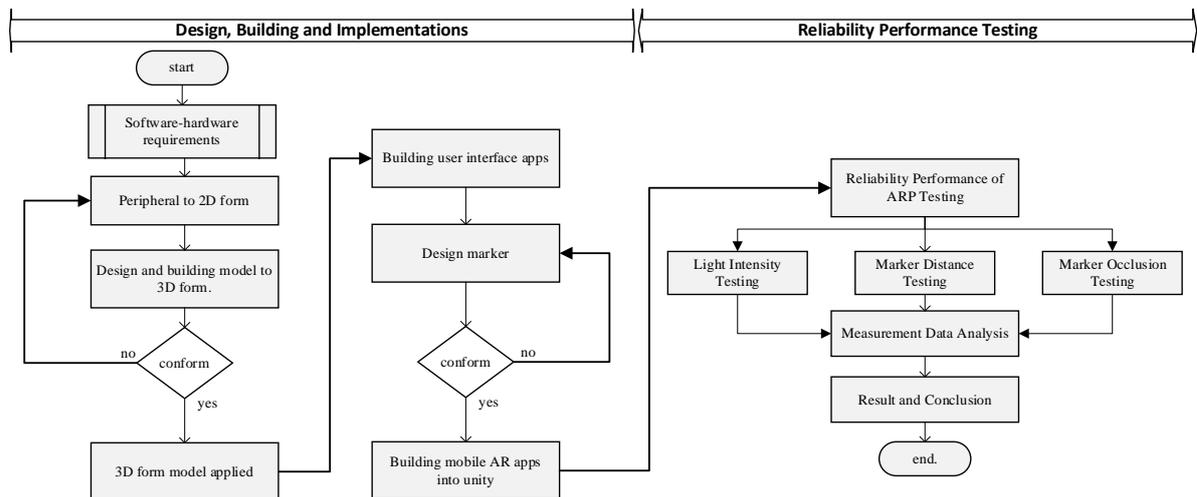


Figure 1. The designing, developing and testing academic room ARP process.

2.1. Software and hardware requirements

This process is an initial activity in designing ARP needs which includes the provision of software, and hardware for the development of ARP applications. The list of requirements is seen in Table 1.

Table 1. Software and hardware requirements.

Software	Specifications	Hardware	Specification
Windows OS 64-bit	Windows 10 Pro 64-bit	Processor	Intel® core™i5-9400F CPU 2.90GHz
Unity Engine 3D	Unity Engine 3D 5.6.4f1 64-bit	Installed RAM	8.00 GB
Sweet Home 3D	Sweet Home 3D 5.7	Storage HD-disk	1 TB
Augmented Reality SDK for mobile	Vuforia SDK versi 6.2.10	Graphic Card	NVIDIA GeForce GT 1030 8-bit
Android SDK versi 5.0	Android 5.0 Lollipop SDK 21		

2.2. Development methods

The ARP development method uses the Multimedia Development Life Cycle which is adopted from Al-Jabari et al which consists of 6 stages, namely concept, design, material collection, assembly, testing and distribution.

Concept stage, this stage determines the purpose of the application and its users. The purpose of this application is to visualize 3D models of class, departments room service and laboratory rooms, the model is presented in the form of a floor plan. The plan is made using a 3D model to make it easier to imagine the indoor peripherals and see them in various angles.

Design stage, the design stage is designing the right media to be used in the application, this stage describes the room plan of each academic on paper, from which augmented reality markers and 3D models are made to be used in ARP.

Material collection stage, this stage is the collection of supporting material data in the form of room size data. corridors, classrooms, department rooms, laboratory management rooms, lecturer rooms, seminar rooms, department administration service rooms, laboratory rooms and storage rooms for

devices. Peripheral data contained in the room only includes tables, chairs, whiteboards, air conditioning, computers and printers.

Assembly stage, this stage combines all the data that has been obtained and then assembled and arranged according to the design plan. The assembly stage is carried out by developing augmented reality in the Unity 3D Engine application. Design 3D models and markers required. 3D modelling is made using the Sweet Home 3D app.

3D model design, ARP app development is designed with a 3D model using Sweet Home 3D, an example 3D model of the academic room is seen in Figure 2.

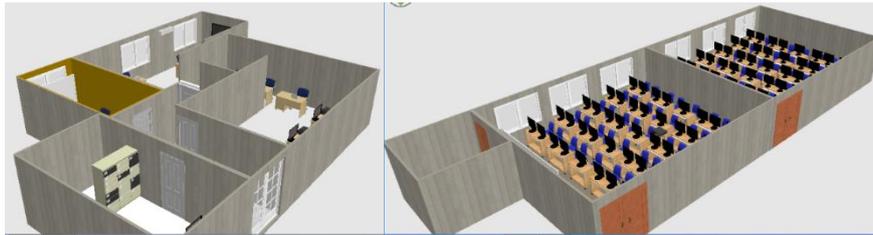


Figure 2. An example 3D model of the academic rooms.

Marker design, the marker designs are created using Adobe Photoshop to design marker images. Vuforia SDK provides a Target Management System converting to unity format, which is then used as a marker on the Unity 3D Engine. An example of the result of the marker design for the academic room is seen in Figure 3.

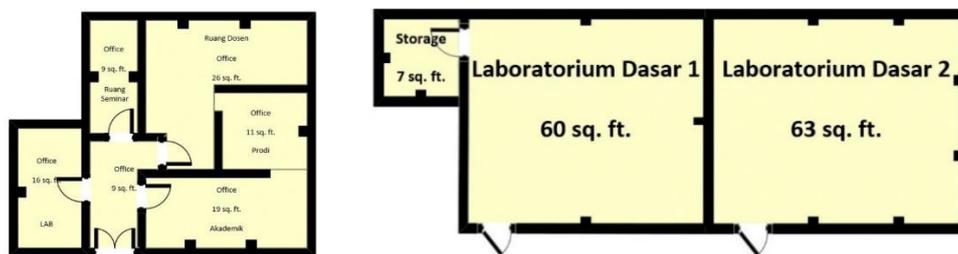


Figure 3. an example 3D model of the academic rooms.

2.3. ARP testing models

Marker detection testing focuses on the reliability performance of ARP in marker scanning. Marker testing includes testing light intensity, testing the distance between the marker and the camera, testing occlusion.

The light intensity level testing in the range: 0-95 lux, 96-300 lux and > 300 lux using lux-meter.

Marker distance testing is carried out with different distances between the camera and the marker position using a distance meter application with intervals of 0-80 cm.

Marker Occlusion testing, the testing marker occlusion by covering the marker area with an object. Markers were closed at a ratio of 10% up to 60% of the marker.

Marker testing, this scenario is tested on marker paper in an abnormal condition of marker paper, a marker when the marker paper is crumpled, the marker paper is wet and the marker paper is wetly dried. Wet scenario marker paper: 30%, 60% and 100% (all wetted).

3. Result and Discussion

3.1. Results

The 3D image room results of implementing ARP in academic rooms are presented in the Table 2.

Table 2. Example 3D room ARP: department and laboratory.

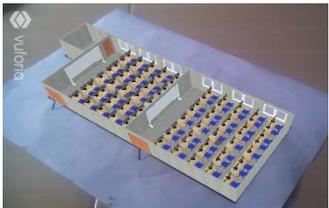
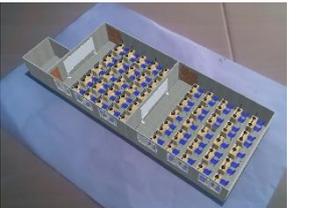
3D rooms	3D image position: Left-front view	3D image position: Right-front view	3D image position: Right-back view
Department room			
Laboratory room			

Table 2 is an example of a 3D interface display of the results of the ARP application when scanning markers from the left-front view, right-front and right-back view.

3.1.1. Marker detection testing. The marker detection test is carried out to determine the things that affect the marker detection process. This marker detection test includes testing the light intensity, testing the distance between the marker and the camera, testing the occlusion and testing the marker paper. Marker detection test results are explained.

**Figure 4.** The Marker detection: 152 lux lighting level.

3.1.2. The light intensity test. Light intensity testing is carried out with different lighting conditions using a light sensor on a device that has been determined using the Lux Light Meter application to measure the light flux per unit area. Figure 3 is an example of marker detection test results in 152 lux lighting conditions, the ARP application can sometimes successfully detect markers, but the camera quickly loses focus on the marker if the device is moved due to lack of lighting on the marker. For other test results scenarios, the lighting level is presented in Table 3.

Table 3. The light intensity test results.

Light intensity level (lux)	Time detection (s)	Status
0-95	-	Fail
96-300	4	Sometimes
> 300	2	Success

The light intensity test results in Table 3 show that the light intensity level of 0-95 lux, the ARP app "failed" to detect markers because the lighting was too dark so that the camera could not detect markers, while 95-300 lux could sometimes detect markers. Light intensity at lighting levels above 300 lux is suitable for use in detecting markers.

3.1.3. Testing marker distance. Marker distance testing is carried out with different distances between the camera and the marker using the Distance Meter application. The marker distance test results shown in Figure 5.

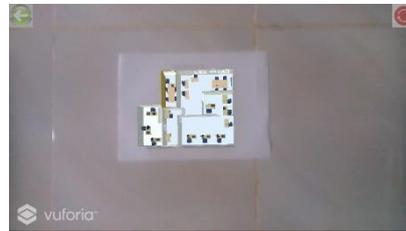


Figure 5. Marker detection a distance of 70 cm.

The marker detection testing result at a distance of 70 cm is that the ARP app sometimes successfully detect markers, but the camera quickly loses focus on the marker if the device is moved. The marker distance testing results are shown in Table 4.

Table 4. Marker distance testing results.

Marker distance (cm)	Status	Marker distance (cm)	Status
0 - 10	Fail	60 - 80	Sometimes
10 - 60	Success	> 80	Fail

The results of the marker distance test in Table 4 show that in the range of 0-10 cm, the ARP app "failed" to detect the marker, while the 10-60 cm distance was considered the most appropriate distance to be used in detecting markers. A distance of 60-80 cm, the camera sometimes fails to detect the marker. For distances greater than 90 cm, the marker failed to detect.

3.1.4. Marker occlusion testing. Marker occlusion testing by covering the marker with an object. Marker occlusion test results when the marker is 20-40% closed, the application is successful in detecting the marker and the 3D model can be displayed, while at 50% occlusion, the application sometimes fails to detect the marker because some patterns on the marker are closed. Markers that have been detected will remain legible until they are completely undetected. So, these markers will still be detected even though the occlusion rate is up to 70%. The occlusion marker test results are presented in Table 5.

Table 5. Marker occlusion testing results.

Marker occlusion	Image view	Marker occlusion	Image view	Status
20%		40%		Success
50%		60%		fail

3.1.5. Testing marker. Testing marker paper on different marker HVS paper conditions. The results of testing marker detection on abnormal paper conditions are presented in Table 6.

Table 6. Marker occlusion testing results.

Marker abnormal	Image view	Status	Marker abnormal	Image view	
Crumpled		Fail	Wet 30%		Fail
Wet-dry		Fail	Wet 60%		Fail
					Fail

The results of the marker detection test on paper soaked in $\pm 30\%$, $\pm 60\%$ water, 100% wet, then dried, the results failed to detect the marker, there were many patterns on the paper that faded after immersion in water.

3.2. Discussion

This work resulted in an Android-based Augmented Reality Peripheral application built with the Unity 3D Engine and Vuforia SDK developer tools, visualizing 3-dimensional models of academic space. To determine the reliability performance of the ARP application, a marker detection test scenario was carried out on the setting of light intensity, marker distance, occlusion and marker objects.

Based on the test results of detection of light intensity setting markers, the reliability of the ARP app of light intensity is good above 300 lux, below 95 lux the ARP application "fails" cannot detect markers, while 95-300 lux can sometimes detect markers. The results of testing the marker distance obtained by the reliability limit up to the normal range of 10-60 cm, above 80 cm can not detect the marker. one thing in distance testing is that a marker that has been detected will remain legible until it is completely undetected. So markers that have been detected will still be detected even though they are moved closer (up to a distance of 5 cm) and farther away to a distance of 80 cm. The occlusion marker test results by covering the marker area obtained an occlusion limit up to $> 40\%$, the application was successful in detecting the marker and the 3D model could be displayed, while at 50% occlusion, the application sometimes failed to detect the marker because some patterns on the marker were closed. Markers that have been detected in normal areas (40%) will remain legible until they are completely undetected. So this marker will still be detected even though the occlusion rate is up to 70%. Testing the marker object in the abnormal marker condition, the paper is crumpled, the marker paper is wetted (30%, 60% to 100% wet) and the marker paper is dried, it was found that the ARP application failed to detect markers due to the many patterns on the paper that faded after being immersed in water.

4. Conclusion

Augmented reality peripheral technology for academic rooms is able to offer visualization in the form of 2D and 3D objects with room plans as a marker. Building VRP applies a multimedia development life cycle methodology approach, the android operation uses the Unity 3D Engine and Vuforia SDK in designing, building and developing ARP mobile app academic rooms. This work has resulted in a

mobile-based AR software product for academic rooms such as; department rooms, laboratory rooms, study classrooms, corridors, student seminar rooms, meeting rooms and administrative service rooms along with peripherals in each room that are displayed in the visualization of 3D objects that provide information to users about the layout of peripherals and the distribution of the layout of each academic rooms.

The results of application reliability performance testing in the light intensity test obtained marker detection limits above > 300 lux (0 up to <300 lux failed). Testing the marker distance obtained good detection results within 60 cm. For occlusion testing, the detection performance was good at 40% occlusion of the marker area. Meanwhile, in marker testing with abnormal scenarios on marker paper, failure was found in the detection of wrinkled, wet and dry markers. The reliability performance test of this work requires scenarios and various other types of tests. Especially in testing abnormal markers, depth of study and experimentation is still needed for future research.

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