

# Designing Android-Based Augmented Reality Application on Three Dimension Space Geometry

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**Abstract.** Augmented reality (AR) technology is a visual technology that combines virtual world objects into real world views in real time. By utilizing augmented reality technology on an android smartphone, a geometry object of space can be visualized concretely through three-dimension virtual modeling that is similar to the original object. This research incorporates AR technology into 3dimension space geometry objects and then it is implemented in three dimension objects lectures for cadets of Ship Machinery Study Program. The purpose of this research is to find out: how the cadets response in using the AR application. This application is an application that runs on the android mobile platform, where the AR application requires video streaming taken from a smartphone camera as an input source, then this application will detect markers using a tracking system, after the markers have been detected, the object model in the geometry of the space will appear above the marker as if the object model is real. The methods or stages in designing this application use the Prototype Model, whereas the implementation of the application uses a one-group pretest-posttest design pattern. The results showed that the use of the AR application on the Android platform was able to get a positive response from cadets in lecturing the Concept of Geometry Course, especially three-dimension objects.

## 1. Introduction

Technological progress is currently developing very rapidly. This technological progress diffuses to the world of education ranging from elementary schools to higher education, this is evidenced by many innovations for the development of education [1,2]. In the world of education, technology is created and developed to help educators and students in the learning process to be more effective, efficient and enjoyable [3]. One of the technology implementations in the world of education is the Augmented Reality technology. Augmented Reality ({AR}) is a technology that replaces two or three-dimensional virtual objects and projects virtual objects in real-time [4, 5, 6] in addition, AR is one technology that dramatically changes the time and location of education[7, 8]. This technology uses a system that is integrated into an android smartphone to perceive it in the real world [9, 10, 11].

In Indonesia, smartphone users in Indonesia are increasing and ranked fourth as smartphone users in the world [12, 13]. This improvement can be used to integrate AR technology into android, especially AR application media in the world of education. In direct observation at Yogyakarta Maritime College, especially the Study Program of Ship Machinery, lecturers still rarely use android-based media [14, 15, 16]. The researcher tried to combine applied mathematics courses especially in the geometry chapter



with AR. This is because Geometry is very difficult for some cadets to understand. Geometry is an important field of mathematics to be studied. By learning geometry, students might be able to identify shapes and spaces around them. Understanding of the geometry model and its properties can improve spatial skill [17]. The spatial skill has a significant role in developing science, technology, engineering and mathematics skills [18]. In geometry lectures, most cadets face difficulties in visualizing objects in 3-dimensional geometry [19,20].

Therefore, this study aimed to 1) Develop an application that can display 3D Geometry objects in augmented reality technology based on Android. 2) Know the response of cadets to the use of applications in applied mathematics especially 3D geometry material?

## 2. Method

The method or stages in designing this application used the Prototype Model where this system can later be developed again. Prototype stages are started from Listen to Customer, Build/Revise, Customer Test-Drives Mock-Up [21]. Prototype stages can see in figure 1.

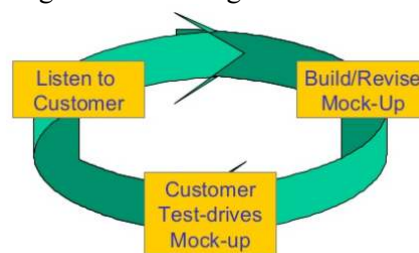


Figure 1. Prototype stages

### 2.1. Listen to Customer

Listen to Customer is the initial stage in prototype modelling where developers and customers will meet, application developers in this study were research teams who are also lecturers while customers in the research were cadets from the Study Program of Ship Machinery, Yogyakarta Maritime College. Developers and customers meet to plan goals, needs. Data collection methods used were observation and interview. The observation was performed directly related to the curriculum review, semester learning plans, the media used, as well as lecture materials related to 3D geometry for third-year cadets, while for the Interview was performed unstructured and directly with cadets especially those who take applied mathematics courses.

### 2.2. Build/revise mock-up

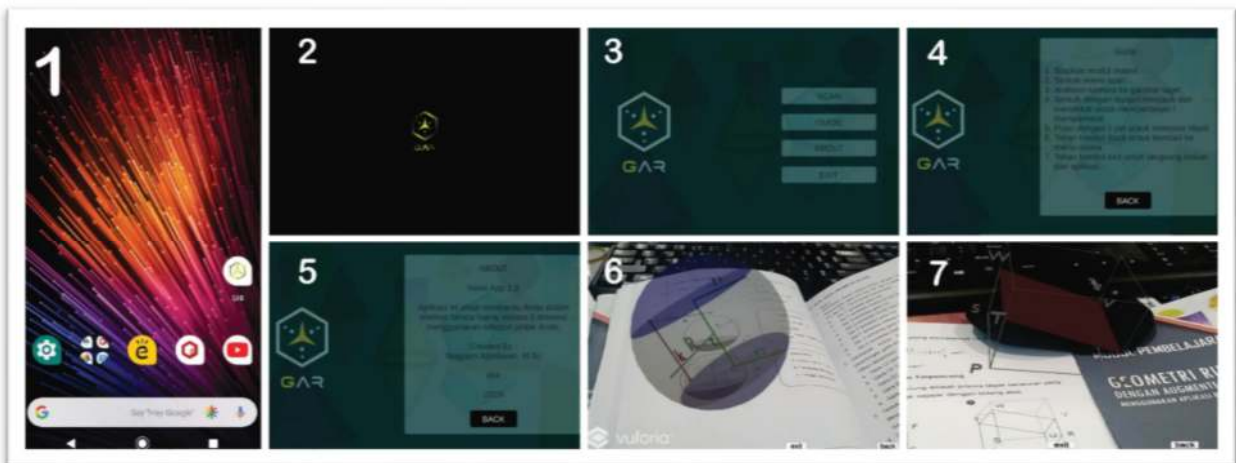
The design was performed quickly, and the design represents all known aspects of the software and this design is the basis of making a prototype. After knowing the needs of cadets about the purpose to be made at the listen to the customer stage, the next step was to build applications quickly. The design of making this application was still in the prototype stage where the initial stage was carried out by making the design of building space into a 3-dimensional shape using Blender software. After the design of the 3-dimensional object was complete, then it would be exported to the tool to create an AR application, unity.

### 2.3. Customer test-drives mock-up

At this stage, a prototype was developed and used to clarify software requirements. After the application was complete, the final step was the customer test, where the application would be tested by a cadet. In the application test, used a one-group pretest-posttest design. After the application was tested, various defects in the application can be seen, whether the application was in accordance with the customer's initial requirements or not. If it was not appropriate, the developer/researcher would repeat steps one and so on.

### 3. Result and Discussion

The application was developed as a tool for displaying images of objects in 3-dimension, where these 3D objects were displayed on a marker or geometry images. There were 22 images of 3D objects, including Points, lines and shapes; Cube; Cuboid; Triangular Prism; Pentagon Prism; Prism with Surface and Base; Hexagon Prism; Triangular Pyramid; Hexagon Pyramid; Square Pyramid; Cylinder; Cone; Sphere; Sliced Triangular Prism, Sliced Square Prism; Sliced Triangular Prism; Sliced Triangular Pyramid; Sliced Square Pyramid; Sliced Cylinder; Sliced Cone; Sliced Sphere in Segment and Radius. This application was developed using Unity software and the Android SDK. For developing 3-dimensional images blender software was used. In addition, this application used the Vuforia library as a tool to create Augmented Reality applications which are then named GAR which stands for Geometry Augmented Reality. The mechanism of the augmented reality application process begins with the provision of geometry-image markers. Then the object is displayed in front of the smartphone camera, the camera will read and the application will detect the marker with a marker that has been previously detected that is stored on the smartphone. Detection of markers stored on an Android smartphone uses the Natural Feature Tracking and Rating algorithm from the basic Fast Corner Detection algorithm developed by Vuforia, markers will detect contrast differences between pixels, more contrast markers will have better detection values. If the marker does not match the marker in android smartphone, the process will be repeated continuously, and if the marker matches the application will render the 3D object and then display the intended image. Figure 2 is a display of the GAR application which stands for Geometry Augmented Reality.



**Figure 2.** GAR application

In figure 2 above, box number 1 is the display of the GAR application installed on the Android platform. Box number 2 is the splash screen of the GAR application. Box number 3 is the home view of the GAR application which consists of "scan", "guide", "about" and "exit" menus. Box number 4 is the "guide" menu display containing the application usage procedures. Box number 5 is the "about" menu display containing the application version, developer name, and application function. Boxes number 6 and 7 are the scan button where when a marker or object geometry of space is captured by a smartphone camera a 3D object will appear corresponding to the geometry image highlighted along with the points and lines, in this menu, there is an "exit" and "back" menu. The "exit" menu exits the application while the "back" menu returns to the main application menu. Box number 6 is the result of a scan of the sliced sphere object with a sphere segment and sphere radius while box number 7 is a scan result of the sliced square prism. The test used 3 different smartphone devices, which are explained in table 1.

**Table 1.** Device Test Application

Specification	Device 1	Device 2	Device 3
	Xiomi Mi A2	Realme 3 Pro	Samsung J7 Prime
OS	Android 8.1 (Oreo)	Android 9.0 (Pie);	Android 6.0.1
CPU	Octa-core (4x2.2 GHz Kryo 260 & 4x1.8 GHz Kryo 260)	Octa-core (2x2.2 GHz Kryo 360 Gold & 6x1.7 GHz Kryo 360 Silver)	Octa-core 1.6 GHz Cortex-A53
Chipset	Qualcomm SDM660 Snapdragon 660 (14 nm)	Qualcomm SDM710 Snapdragon 710 (10 nm)	Exynos 7870 Octa (14 nm)
Internal	128 GB, 6 GB RAM or 32/64 GB, 4 GB RAM	64/128 GB, 6 GB RAM or 64 GB, 4 GB RAM	16/32 GB, 3 GB RAM
GPU	Adreno 512	Adreno 616	Mali-T830 MP1
Camera	20 MP, f/1.8, 1/2.8", 1.0µm, PDAF	16 MP, f/1.7, 1/2.6", 1.22µm, Dual Pixel PDAF	13 MP, f/1.9, 28mm (wide), AF
Resolution	1080 x 2160 pixels, 18:9 ratio (~403 ppi density)	1080 x 2340 pixels, 19.5:9 ratio (~409 ppi density)	1080 x 1920 pixels, 16:9 ratio (~401 ppi density)

The test used a black box testing technique, which evaluates only from the outside appearance. Where at this stage, it would test the functionality of the features provided by the application. In Table 2 is the results of the application functionality test. It can be concluded that functionality run as expected on 3 different smartphone devices.

**Table 2.** GAR Application Functionality Test Results on 3 Devices

Test	Expected Result	Test Result	Conclusion
Install APK (Master)	The installation process and installed on an android smartphone well	According to expectations	Valid
Run the installed application	Runs and applications can open properly	According to expectations	Valid
Detection of predetermined markers	3D objects appear	According to expectations	Valid
Detection of different markers	Cannot exit 3D objects	According to expectations	Valid
The GUIDE menu is pressed	Procedures for using the application appear	According to expectations	Valid
The ABOUT menu is pressed	The application version, developer name and application function appear	According to expectations	Valid
EXIT button is pressed	Exit the Geometry_AR application	According to expectations	Valid

The next test was response time test of the GAR application. Response time test was performed because in this application contains many 3-dimensional objects, where if the application is run on a smartphone device that has different specifications, then the results of the response time will also be different. This test was carried out when loading into a smartphone camera, where this process will determine the difference in response time and also loading the camera in detecting markers. In Table 3 the results of testing the smartphone camera's loading time response. In this test, it can be concluded that the higher the smartphone device specifications the loading of the camera in the application will run faster.

**Table 3.** GAR Application Response Time Test Results

Process	Response Time		
	Device 1	Device 2	Device 3
Loading when opening the application	15.81	9.65	22.45

This geometry application was tested on 24 cadets at Study Program of Ship Machinery, Yogyakarta Maritime College. Cadet responses were collected in stages from the before application use to after application use. The following results are obtained:

**Table 4.** Cadets' Responses Towards the Use of GAR Application

Indicators	Average Pretest	Average Post Test
Application Design	75%	95%
Interaction Usability	72%	96%
Accessibility	72%	94%
Learning Goal Alignment	73%	98%
Motivation	77%	97%

Based on table 4, there are some increase in all indicators. In the aspect of Application Design, the increase is from 75% to 95%, Interaction Usability increases from 72% to 96%, Accessibility goes up from 72% to 94%, the percentage Learning Goal Alignment increases from 73% to 98%, the percentage of Motivation increases from 77% to 97. In averagely, cadets' responses towards the use of geometry learning media based on AR increase along the phases from 73.80% to 96.00%. AR-based geometry objects make it easy for cadets to understand the concept of three-dimensional geometry objects and have a positive response from the cadets.

#### 4. Conclusion

Based on the results, the conclusions are obtained as follows: The design of Android-based Augmented Reality technology in this application run in accordance with the design, which can combine 3D geometry objects that are virtual with the real world and AR-based geometry objects make it easy for cadets to understand the concept of three-dimensional geometry objects and had a positive response from the cadets. Therefore, this media is suitable to be applied in the 3D geometry lecture process.

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