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Augmented Reality (AR) Solar System Objects Based on Marker-Based 3D

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ABSTRACT

This research implements Augmented Reality (AR) technology in solar system learning using a marker-based 3D object recognition method. The aim of this research is to create an interactive and immersive experience for users to learn about the solar system through an Android smartphone. The research development method follows the waterfall approach, which includes requirements analysis, system and software design, implementation, integration, testing, and maintenance. This AR application utilizes marker-based 3D object recognition technology on an Android smartphone. The test results demonstrate the success of the application in displaying 3D objects during the scanning process using marker cards. Distance testing indicates that the optimal range for recognizing solar system objects is 20-30 cm. Meanwhile, light intensity testing reveals that outdoor daylight conditions with an intensity of 90-120 Lux provide optimal results. In conclusion, this research successfully develops an application for recognizing solar system objects using AR technology. The application offers an interactive learning experience for the solar system. The utilization of the waterfall method and the positive test results are the strengths of this research. For future development, the consideration of employing the scrum method can accelerate the application development and testing processes.

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1. INTRODUCTION

Incorporating Augmented Reality (AR) technology to combine the physical environment with digital components, resulting in immersive and interactive encounters. The implementation of AR technology in solar system exploration enables an immersive and educational experience for users to investigate and gain knowledge about planets, stars, and other celestial bodies. Utilizing 3D world camera technology on mobile devices, users can enhance their understanding of the universe by visually exploring the solar system.

AR is a cutting-edge technology that can be used as an effective learning method for students in various educational domains. Previous studies have utilized AR technology in various fields, including medical studies [1-3], animal studies [4-8], recognizing hijaiyah letters [9-10], and general subjects such as MIPA [11-13]. In addition, cultural learning such as traditional music and related objects in Indonesia have also been explored using AR [14-15]. AR has been utilized for educational purposes in the field of astronomy, especially in the study of the solar system [16-25].

The main emphasis of this research is to maximize the use of Augmented Reality (AR) technology for educational purposes, especially in the realm of understanding celestial bodies in the solar system through the application of 3D base markers. There is a research gap in the utilization of augmented reality (AR) technology for educational purposes related to the study of celestial bodies in the solar system, particularly in the context of using 3D ground markers. This research aims to address such a gap by investigating the capacity of augmented reality (AR) technology to produce interactive, comprehensive, and effective educational encounters that enhance understanding and knowledge acquisition related to the solar system.

2. METHOD

The research method is used to describe the ongoing research process. The following are the methods used in this research:

A. Waterfall Method

The first stage needs analysis and definition. In this stage, a thorough analysis is conducted to determine the needs of the application and the features to be implemented[26]. This analysis includes user needs, learning content, and appropriate technology for AR application development.

Based on the results of the analysis, the architecture and structure of the AR application are designed. This design includes the whole system, such as workflow, user interface, and database, as well as program code and algorithms that will be used in the application.

The design results from the previous stage are implemented in program form. Each program unit is tested to ensure that the specifications have been met.

The modules and program units are integrated into a complete AR application. Then, system testing is carried out to ensure that all features work well and in accordance with the needs.

After the AR application has been developed, the process of installing and applying the application to users is carried out. Review and assessment are also carried out to ensure and restore failures that may occur. Input from users is used as feedback for further application development, such as adding new features and functions.

B. Unity 3D

Augmented Reality (AR) is a tool that blends two- or three-dimensional virtual objects into the real world, creating a combined space that unites the two and produces Mixed Reality. AR projects virtual elements in real-time, merging them with the surrounding environment. This technology combines the interaction between the real world and the virtual world. The principles of AR are similar to virtual reality in terms of interactivity, depth of experience, real-time response, and virtual objects having three dimensions. However, AR blends virtual objects with the real environment. One of the main advantages of AR is its ease of development and more affordable cost compared to virtual reality [27-28].

C. Marker Based Tracking

In the field of Augmented Reality (AR), virtual information is combined with the real world to enhance the user's view of the surrounding environment. The illusory quality of AR relies heavily on good registration between the virtual and real worlds. Many applications, for example in medical environments, require highly accurate registration where real and virtual objects are well aligned. One of the main sources of registration errors is errors in the tracking system used. Therefore, it is very important to know as accurately as possible the results of the system for a given tracking situation [29].

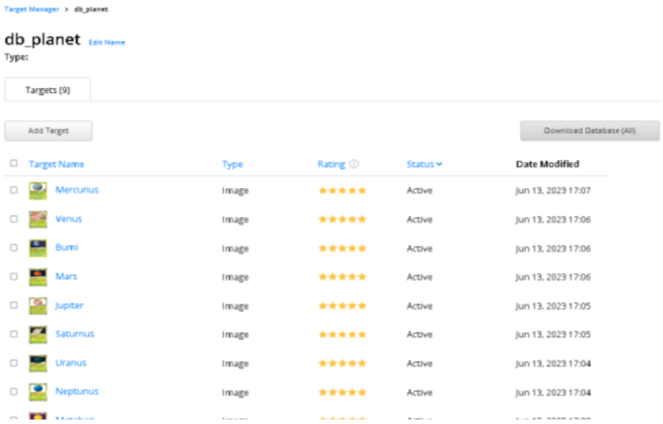
D. Vuforia

Vuforia is a Software Development Kit (SDK) for Augmented Reality (AR) that facilitates the development and creation of AR applications on mobile devices. The Vuforia software development kit (SDK) is offered by Qualcomm with the aim of facilitating the creation and advancement of augmented reality applications on mobile devices. In addition, Vuforia provides a wide array of functions and capabilities that allow software developers to actualize their concepts without constraints. Vuforia uses the smartphone camera as an input mechanism with the ability to scan and identify specific markers. This allows the smartphone display screen to show a direct merging of the physical environment and the three-dimensional world [30].

3. RESULTS AND DISCUSSION

3.1. Discussion result

For marker creation, it can be done online through the developer.vuforia.com platform. In this case, the target manager is used to upload markers into the application on Unity3D. Information about the marker upload process in Vuforia can be found in Figure 1.



Target Manager > db_planet

db_planet Edit Name

Type:

Targets (9)

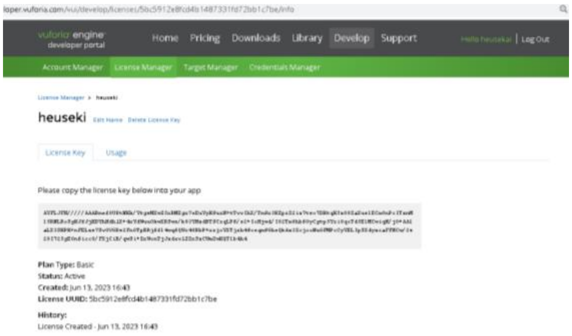
Add Target

Download Database (All)

☐	Target Name	Type	Rating	Status	Date Modified
☐	Mercurius	Image	★★★★★	Active	Jun 13, 2023 17:07
☐	Venus	Image	★★★★★	Active	Jun 13, 2023 17:06
☐	Bumi	Image	★★★★★	Active	Jun 13, 2023 17:06
☐	Mars	Image	★★★★★	Active	Jun 13, 2023 17:06
☐	Jupiter	Image	★★★★★	Active	Jun 13, 2023 17:05
☐	Saturnus	Image	★★★★★	Active	Jun 13, 2023 17:05
☐	Uranus	Image	★★★★★	Active	Jun 13, 2023 17:04
☐	Neptunus	Image	★★★★★	Active	Jun 13, 2023 17:04

.Figure 1. Upload vuforia app marker

To connect markers to Vuforia in Unity3D, a Vuforia key license is required. The Vuforia key license view can be seen in Figure 2.



heuseki

Please copy the license key below into your app

Plan Type: Basic
Status: Active
Created: Jun 13, 2023 16:43
License UUID: 5bc5912e8fcd4b1487331fd72bb1c7be

History:
License Created - Jun 13, 2023 16:43

.Figure 2. Vuforia key license

In this process, the planet is created in Blender software. Where starting from the shape to giving textures so that the planetary objects are ready to use for Augmented Reality everything is done in the software.

In data design, the data required is a marker image that will be used as a target image to display 3D objects. Marker: Solar System, which can be seen in Figure 3. Markers that have been made are uploaded or uploaded to the UFORIA database so that they can be recognized by the camera of the Android Smartphone.

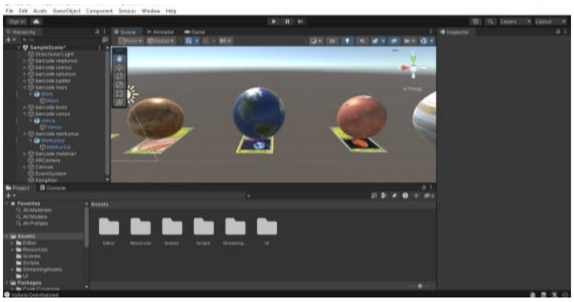


Figure 3. Target image implementation

Computer components consisting of 3D objects are imported into Unity, while markers that have been downloaded from the Vuforia Database are also imported into Unity by setting the scale according to the markers to be displayed, as can be seen in Figure 4.

Figure 4. Display of markers and 3D objects

This marker-based implementation is made in the implementation of marker-based methods, and can be seen in Figure 5, the goal is to display 3D objects on smartphones using markers as a reference. solar system.

Bumi adalah planet tempat kita tinggal. Ukuran Bumi memiliki diameter sekitar 12.742 kilometer. Ini adalah satu-satunya planet yang diketahui memiliki kehidupan. Bumi memiliki atmosfer yang mendukung kehidupan dan memiliki cairan air di permukaannya.

Figure 5. Implementation of Augmented Reality (AR) with Marker Based

3.2. Application Testing

After the development process, the AR application for Solar System learning is tested to measure its performance. These tests include application functionality testing, ideal distance testing, and light intensity testing. The tests were conducted on three Android devices with various specifications to ensure app compatibility.

Application functionality testing focuses on the application's ability to display 3D objects using marker cards during the scanning process. Testing is done by scanning the marker through the application that has been built. The test results show that the application successfully displays all 3D objects without problems, as shown in Table 2.

Table 1. Testing

Testing Activity	**Expected realization**	**Result**
Sun	Will display the image of the Sun according to the marker of the Sun	As expected
Mercury	Will display the image of Mercury according to the marker of Mercury	As expected
Venus	Will display the image of Venus according to the marker of Venus	As expected
Earth	Will display the image of the Earth according to the marker of the Earth	As expected
Mars	Will display the image of Mars according to the marker of Mars	As expected
Jupiter	Will display the image of the Jupiter according to the marker of the Jupiter	As expected

Testing Activity	**Expected realization**	**Result**
Saturn	Will display the image of the Saturn according to the marker of the Saturn	As expected
Uranus	Will display the image of the Uranus according to the marker of the Uranus	As expected
Neptune	Will display the image of the Neptune according to the marker of the Neptune	As expected

Ideal distance testing is conducted to determine the optimal distance at which the application can recognize Solar System objects properly. The test was conducted by varying the distance between the device and the marker card in various conditions. The test results show that the ideal distance for 3D object recognition is between 10 cm and 50 cm in Table 2.

Table 2

Distance	**Result**
Close (10 cm-15 cm)	Successful, Fast
Medium (20 cm-30 cm)	Successful, Fast
Far (30 cm-50 cm)	Successful, Fast

In the distance test, the results of the process can be observed in a form that has been adjusted and can be seen in the final display. table 2, When scanning the marker using Close Range (10-15cm), scanning is done with a fast process, and 3D objects are captured but all objects are not displayed because some objects are quite large if using a Medium distance (20-30 cm), scanning is fast and 3D objects are displayed correctly and comfortably, but when using a Far distance (30-50cm), scanning the marker is fast but the 3D objects displayed are not straight or symmetrical.

Light intensity testing is conducted to determine the effect of light intensity on application performance. Tests were conducted under various lighting conditions, from a bright room to a dark room. The test results show that the application can work well under various lighting conditions, although the application performance decreases slightly in a very dark room. Table 3 describes the results of the Light intensity test.

Table 3. Light intensity testing

Light (Lux)	**Result**
Daylight (indoor, no lights), 15-20 Lux	Successful, Slow
Daylight (outdoor, no lights), 90-120 Lux	Successful, Fast
Nighttime (indoor, with lights), 40-50 Lux	Successful, Fast
Nighttime (outdoor, with lights), 20-30 Lux	Successful, Slow

The results of the light intensity test can be seen in Table 3. The first test was carried out in a daytime situation (indoor, without lights) with a light intensity of 15-20 Lux getting the results of the scanning process running slowly but the 3D object was successfully displayed on the marker card. The next test was carried out with conditions or in daytime conditions outdoors without lights, the light intensity that occurred was around 90-120 Lux. obtaining the results of the scanning process on the marker card can be done quickly, in the night situation indoors with lights, the light intensity that occurs is around 40-50 Lux. obtained results when performing the scanning process runs quickly and smoothly, in the last situation at night (outdoors, with lights) with a light intensity of 20-30 Lux getting delayed results in scanning the marker card even though the 3D object is successfully displayed.

4. CONCLUSION

This research aims to develop an Android application using Augmented Reality technology as a learning medium for the Solar System. The method used is marker-based Tracking, and the development of this application involves testing distance, light intensity, and other tests to achieve optimal results and provide a comfortable experience for users. The results of testing the "Solar System object recognition" application system show that the ideal and optimal use of the application can be done by maintaining a distance between 20-30 cm between the marker card and the device. In addition, the use of this application is also recommended in daytime situations outdoors with a light intensity of around 90-120 Lux, or at night situations indoors with a light intensity of around 40-50 Lux. Based on the research that has been carried out, the development and testing methods can be improved using the scrum method to shorten the duration of application development and testing.

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