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Development of a Solar System Learning Application Using Markerless Augmented Reality Based on Android

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Abstract

The use of technology in learning has opened up new opportunities to create more interesting and effective learning applications. In learning solar system material, especially at elementary school level, the teaching method still uses books, 2D pictures and teaching aids. However, the limitations of teaching aids which can only be used in class and do not allow them to be taken home can create obstacles in the learning process. To overcome these obstacles, innovation is needed in the development of learning media. One solution that can be used is to apply augmented reality technology. In this research, a solar system object learning application was created that applies markerless augmented reality technology. This application can be used as an alternative to using teaching aids in studying solar system objects. The methodology used in this research is the Multimedia Development Life Cycle (MDLC). The development of this augmented reality application was developed using tools Android Studio by implementing ARCore SDK and Sceneform in implementing markerless augmented reality. The results of this research are in the form of an Android-based learning application that applies markerless augmented reality technology and based on field testing, the effectiveness of the application in delivering solar system materials through the quiz feature is 75%, while 85% of users feel satisfied with the visual and ease of use of the application.

Keywords: Solar Systems, Markerless Augmented Reality, ARCore SDK

1. Introduction

The solar system is a group of astronomical objects that orbit the sun as their central point (Nuqisari & Sudarmilah, 2019). In every elementary school, the solar system is taught as part of the natural sciences curriculum. Currently, the material about the solar system, such as the introduction of its objects, is still presented through books, 2D images, or even teaching aids (Qosid Ilahy et al., 2022). In the learning process, teaching aids play a crucial role as they help students understand the concepts being taught (Unaenah et al., 2023). Although schools provide various types of teaching aids, unfortunately, these tools can only be used by students at specific times and cannot be taken home, making them less practical and effective (Husna, 2022). To overcome these challenges, innovation is needed in the development of instructional media by transforming conventional teaching aids into a more modern form through the utilization of technology (Bayu et al., 2022). And one technology that can be utilized is Augmented Reality (Widodo & Utomo, 2021).

Augmented Reality is a technology that combines 2D and 3D virtual objects and projects them into the real world (Kanti et al., 2022). And 3D objects play a crucial role in Augmented Reality (Hendriyani et al., 2019). This is because the presence of 3D objects can enhance the realistic impression of the displayed objects, making them appear more lifelike (Gumilang & Qoiriah, 2023). Augmented Reality is now available on iOS and Android devices, both of which are popular among the public for their ease of use, particularly on Android devices (Harahap et al., 2018). Currently, there is a developing method in Augmented Reality known as markerless Augmented Reality. This method allows users to display virtual 2D or 3D objects in real-time without the need for a marker (Suhandra et al., 2018).

Unified Modeling Language (UML) is a language used for software design. UML enables a developer to visualize, specify, construct, and document complex software systems. The primary goal of UML is to visualize the design of a system, providing an easily understandable visual representation of the system (Roger S Pressman & Bruce R. Maxim, 2015).

Based on previous research, the application of markerless augmented reality for fruit name education on Android (Agil & Sitio, 2022) and the implementation of augmented reality-based learning media for Sunnah prayers on Android (Br Siregar & Aliyah, 2023), both studies concluded that augmented reality is highly effective as an educational medium and as a supportive tool in enhancing the learning process.

This research aims to develop an Android-based learning application for the solar system that incorporates markerless Augmented Reality technology. This application is designed to facilitate easier and more effective learning of solar system materials for students, even without the use of physical solar system models.

2. Research Methods

2.1 Development Method

The development method used in this research is the Multimedia Development Life Cycle (MDLC). MDLC is a widely used method for developing multimedia products, including in the process of creating multimedia applications. This methodology is crucial as it ensures systematic development of products, thereby enabling more effective completion of the final outcomes (Benawan et al., 2023). The method involves six stages: concept, design, material collecting, assembly, testing, and distribution.

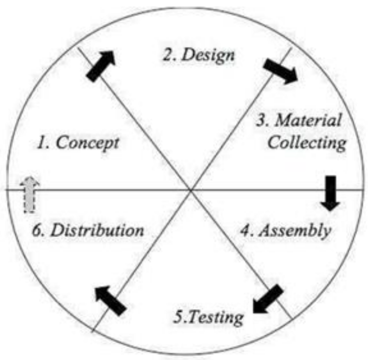

Figure 1. MDLC Stages

This research method involves six stages:

1. Concept
   This stage defines the purpose of the application and its target users. The goal is to facilitate easier and more interactive learning of solar system materials and objects through Augmented Reality technology. The application targets students from 6th grade upwards. It also outlines the main functions, including displaying solar system materials, showcasing Augmented Reality objects, and other functionalities.
2. Design
   This stage involves designing the system flow using UML diagrams, creating application storyboards to visualize the interface, and designing 3D objects using Blender software.
3. Material Collecting
   Here, necessary materials for the application are gathered. This includes collecting solar system material from e-books and 2D images of solar system objects from various online sources. A total of 11 materials are collected, categorized into 1 star, 8 planets, and 2 satellites.
4. Assembly
   The designs from previous stages are implemented to create the application. Using gathered materials, the application is developed into an APK format. The Augmented Reality app is developed using Android Studio, programmed in Java, utilizing ARCore SDK and Sceneform for markerless AR implementation.
5. *Testing*
   This stage involves testing the completed application to ensure its functionality through black-box testing. Field testing with target users is also conducted to assess usability.
6. *Distribution*
   After testing successful, the application is deployed. The built APK is distributed to users via cloud storage, specifically Google Drive in this study.

2.2 Quantitative Measurement

This research utilizes quantitative measurements to assess the effectiveness and user satisfaction of an application. Effectiveness is evaluated by assessing users' comprehension of solar system materials presented via a quiz feature with multiple-choice questions. Meanwhile, user satisfaction is gauged through their feedback on the application's visual quality and usability. The quantitative data gathered from these assessments will be used to evaluate the application's performance and support the analysis in the research findings.

3. Results and Discussion

3.1 Concept

Besides determining the goals and user targets for the application being developed, this stage also defines the system architecture. The system architecture encompasses how data and information flow within the application. This application adopts a client-server model, where the client actively sends and requests data from services provided by the server as the service provider. The architecture results are illustrated in Figure 2.

3.2 Design

One of the outcomes of this design stage is a depiction of the system flow using UML diagrams. The specific UML diagram used is the use case diagram, which illustrates interactions between actors and the system under development. The designed use case diagram is shown in Figure 3.

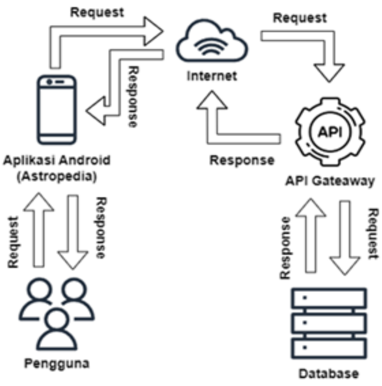

Figure 2. System Architecture

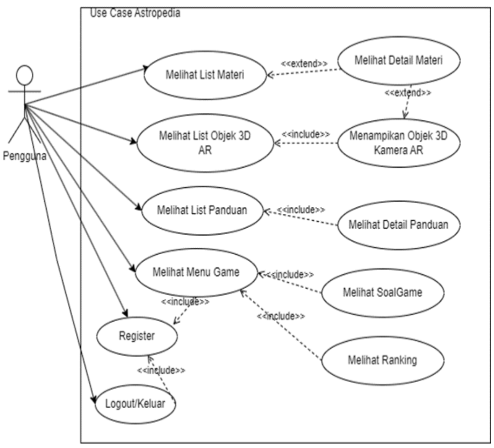

Figure 3. Use Case Diagram

3.3 *Assembly*

The following presents the results of several screenshots and explanations regarding the interface of a solar system object learning application using markerless augmented reality technology, successfully developed and installed on Android devices.

In Figure 4, the main page of the application is displayed, featuring four primary buttons leading to the AR camera page, a list of materials, a game menu page, and a guide list page. Additionally, this page provides information explaining the concept of the solar system and the importance of studying this material.

In Figure 5 shows the AR 3D object list page, which appears after users press the AR camera button on the main menu page. On this page, users can select 3D objects they wish to display on the AR camera. There are three categories of solar system objects to choose from: Planets, Stars, and Satellites.

Figure 4. Main Menu Page

Figure 5. AR 3D Object List Page

Figure 6. AR Camera Page

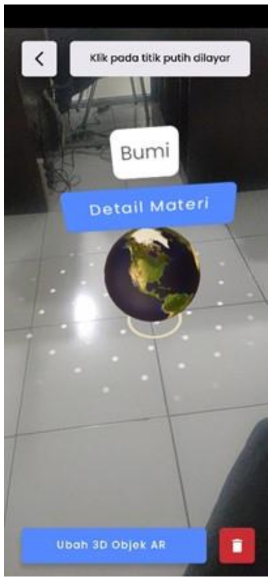

Figure 7. AR Camera Page - 2

In Figure 6, the AR camera page displays a user guide that appears after selecting a 3D object from the 3D object list page. This guide explains how to display planes on detected flat surfaces. In ARCore, planes are flat surfaces successfully detected by the camera, represented as white dots above the detected flat surface.

In Figure 7 shows the AR camera page successfully displaying an AR object achieved by tapping on the detected plane. A 3D object, along with other virtual AR objects (such as material detail buttons and object names), will be displayed above the plane through a node. In ARCore, nodes serve as tools for displaying markerless virtual augmented reality objects.

Figure 8. List Learning Materials Page

Figure 9. Detail Learning Materials Page

In Figure 8, the page displays a list of learning materials that appears after the user presses the learning materials button on the main menu page. This page lists materials about solar system objects. The list of learning materials is determined by the user through filters based on material categories, such as planets, stars, and satellites.

In Figure 9 shows the detailed learning material page that appears after the user presses a material on the materials list page or the material detail button on the AR camera page.

Figure 10. Game Menu Page

Figure 11. Quiz Page

In Figure 10, the game menu page is shown after the user presses the game button on the main menu page. This page displays user data such as a photo, name, and highest score obtained in the quiz game. Additionally, there are two buttons with their respective functions: the start game button and view player rankings.

In Figure 11 displays the quiz game page that appears after the user presses the start game button on the game menu page. This quiz game follows rules where correct answers increase the score by 10 points. However, incorrect answers result in a deduction of 5 points, with the note that points cannot go below 0. A total of 10 quiz questions are presented in the game, and always randomized from a total of 30 questions available.

Figure 12. Guide List Page

Figure 13. *Detail* Guide Page

In Figure 12, the guide list page is displayed after the user presses the guide button on the main menu page. This page lists guides on how to use the application.

In Figure 13 shows the detailed content page displayed after the user selects a guide from the guide list page. This page features videos and text explaining how to use a specific application feature according to the selected guide.

3.4 *Testing*

The testing in this study is divided into two parts: testing the application through black-box testing method and field testing. The results of the application testing phase are presented in Table 1, while the field testing results are shown in Figure 14.

Table 1. Results of Black-box Testing

Action	Response	Result
Pressing the "AR Camera" button	Displays the list of 3D objects page	Successful
Pressing the "Learning Materials" button	Displays the list of learning materials page	Successful
Pressing the "Game" button	Displays the game menu page	Successful
Pressing the "Guide" button	Displays the list of guides page	Successful
Selecting a 3D object from the 3D objects list page	Displays the camera on the AR camera page	Successful
Pressing the plane (white dots) on the AR camera page	Displays the selected 3D object and other AR objects on the detected plane	Successful
Pressing the "Start Game" button on the game menu page	Starts and displays the game quiz	Successful
Selecting a material from the materials list page	Displays the material details page according to the selected material	Successful
Selecting a guide from the guides list page	Displays the guide details page according to the selected guide	Successful

In Figure 14 shows the target users using the application. The test results indicate that the target users can use the application effectively.

3.5 Distribution

The result of the distribution stage is an APK file of the application, which is uploaded to cloud storage. In this research, Google Drive is used for cloud storage. Distribution shown in Figure 15.

Figure 14. Field Testing

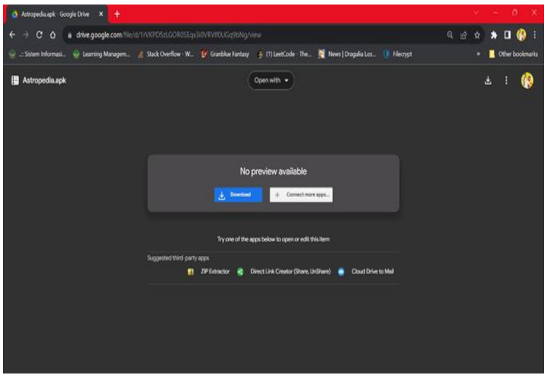

Figure 15. Distribution via Google Drive

3.6 Measurement Results

Based on field testing, the effectiveness of the application in delivering solar system material, determined by the scores obtained by users from the quiz feature in the application, is 75%. Additionally, 85% of users reported satisfaction with the visuals and ease of use of the application.

4. Conclusion

The Android-based solar system learning application, which employs markerless augmented reality technology, has been successfully developed and is well-received by the target users. The application can also serve as an alternative to conventional media such as textbooks and solar system teaching aids. The development and research of this application followed the Multimedia Development Life Cycle (MDLC) and was tested using black-box testing, which showed that all application features functioned as expected. According to field testing results, the application's effectiveness in delivering solar system material through the quiz feature is 75%, and 85% of users are satisfied with the application's visuals and ease of use.

A recommendation for future research is to develop an iOS version of this solar system learning application.

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