

Utilization of Augmented Reality as a Media Introduction to Pests in Rice Plants Using the Marker Base Method

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ABSTRACT

Indonesia is an agrarian country where rice is a major commodity and a primary food source for the Indonesian population. To encourage the interest and knowledge of the younger generation as farmers, innovation is needed as a basic learning medium about agriculture, specifically rice. This research aims to develop a mobile application based on Marker-Based Augmented Reality (AR) to enhance the effectiveness of pest identification in rice plants. The application is designed to provide visual and interactive information to farmers about the types of pests that frequently attack rice plants, along with their characteristics. Data on rice pests are collected through literature reviews and interviews with several rice farmers. The application utilizes markers that can be recognized by the mobile device's camera to display 3D models and information about the pests. Testing results show that the application works well as expected, and the 3D object information regarding rice pests, along with their characteristics, can be displayed. Additionally, this application is expected to contribute to reducing crop losses due to pest attacks by improving farmers' quick and accurate responses, and it can serve as an effective and innovative tool in the field of agriculture, particularly in pest identification in rice plants.

Keywords: Agriculture Application, Augmented Reality, Rice Pest, Marker Based, Pest Recognition

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INTRODUCTION

In an agrarian country like Indonesia, agriculture is a vital sector in supporting food security, particularly rice as a major commodity. However, there are significant challenges in rice cultivation, one of which is pest attacks that can reduce productivity and even cause crop failure (Sarumaha M, 2020).

Early identification of pests and diseases in rice plants is crucial to take immediate action before the spread becomes widespread. However, many farmers do not have access to adequate information or visual aids to recognize various types of pests and diseases in rice plants.

In the current digital era, technological and informational developments can be utilized to help farmers recognize and increase their knowledge about pests. One such

technology is Augmented Reality (AR), an innovative technology that combines the real world with virtual objects in real-time (Syahrizal Syaifullah et al., 2020). In this research, Augmented Reality is used to depict the form of each pest attacking rice plants in a virtual manner.

This research employs the Marker-Based Tracking method to display virtual objects representing pests that attack rice plants. This method uses a black-and-white image or marker with a black border and white background or unique pattern (Putra et al., 2023). This marker is used by the application to display virtual objects according to the database specified during application development. With this technology, it is expected that farmers can more easily recognize pest types and their descriptions in a visual and interactive way.

The application was developed using Unity 3D as the main game engine and Vuforia SDK for implementing marker-based Augmented Reality technology. Unity 3D was chosen for its flexibility in building interactive interfaces and supporting multiplatform, including Android. This makes it easier to develop responsive and user-friendly 3D applications. Meanwhile, Vuforia SDK is software that helps developers in developing Augmented Reality. Vuforia uses computer vision to detect markers stably and accurately, allowing the application to recognize markers and display visual information in real-time (Rahmat & Noviyanti, 2021). The combination of Unity 3D and Vuforia SDK allows the creation of interactive and effective Augmented Reality applications as educational media for farmers in recognizing and identifying diseases in rice plants.

The development of this Augmented Reality-based application was carried out using the Mobile Application Development Life Cycle (MADLC) framework. MADLC is a structured and systematic software development method for mobile applications, from planning to testing phases (Sandhika Jaya et al., 2024). Using MADLC, the development of Augmented Reality applications can be conducted systematically, ensuring that the resulting application functions well. Through this application, farmers can quickly and easily recognize various types of pests and diseases, which is expected to increase awareness and accuracy in pest and disease control in rice plants.

By utilizing Augmented Reality technology, it is hoped that this practical solution will not only make it easier for farmers to recognize pests but also increase accuracy in pest management, thereby maintaining rice crop productivity. This research aims to design and implement a pest identification system in rice plants using marker-based Augmented Reality technology.

METHOD

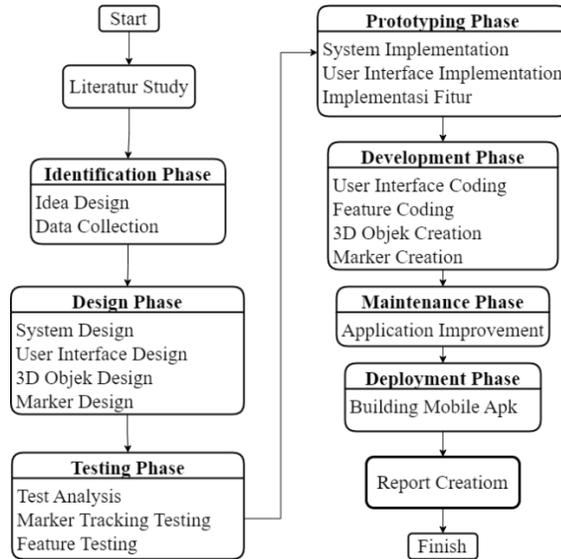


Figure 1. Research Framework

The research framework consists of several stages, including literature study, identification phase involving idea design and data collection, design phase consisting of system design, user interface, 3D objects, and markers, testing phase involving test analysis, marker tracking testing, and application feature testing, prototyping phase involving system implementation, user interface implementation, and feature implementation, development phase involving user interface coding, feature coding, 3D object creation, and marker creation, maintenance phase involving application improvements, deployment phase involving building the mobile APK, and documentation report creation related to application development.

The system designed in this research is an Augmented Reality application using marker base tracking method that runs on the Mobile Android platform. The collected data includes pests that frequently attack rice plants, which will be implemented and displayed as virtual objects within the application.

The result of this research is an Augmented Reality application that can display three-dimensional (3D) objects representing pests found on rice plants. These objects are accompanied by brief explanations of each pest's characteristics. This application is developed to help farmers obtain valid information about the types and names of pests that often attack rice plants, allowing farmers to anticipate better before pest attacks.

Mobile Application Development Life Cycle

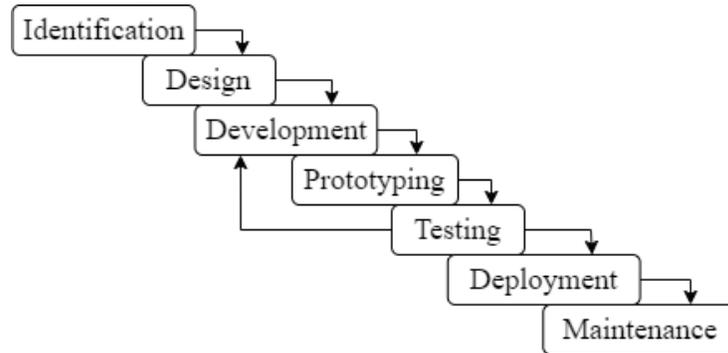


Figure 2. Stage of Mobile Application Development Life Cycle

Mobile Application Development Life Cycle (MADLC) is a systematic framework for planning, designing, developing, and managing the lifecycle of mobile applications. The MADLC process includes various stages to ensure effective, efficient, and customized application development. The MADLC method consists of 7 (seven) stages, namely Identification phase, Design phase, Development phase, Prototyping phase, Testing phase, Deployment phase, and Maintenance phase (Januarita R et al., 2015).

System Design

System design is a stage in software or application development that aims to design the framework and the main components that will make up the application. This stage involves creating architectural designs, databases, and interaction schemes between components to ensure the application works according to predetermined specifications.

Primary Data Sources

Primary data sources are data obtained directly from the main source. Researchers use literature study techniques from previous journals to find valid and accountable material. The journal in question is a journal that discusses pests that often attack rice plants.

Secondary Data Sources

Secondary data sources are data obtained by researchers directly from the location through interviews. In taking this data source, researchers use interview techniques to cultivators or farmers, to obtain data in the form of pests that often attack rice plants which will be used as virtual objects in the application later.

The data obtained were then grouped by type. Researchers separated the types of pests into 3 groups, namely weeds, insects, and diseases. Pest grouping can be seen in table 1 below.

Table 1. Pest Grouping Table

NO	Pest Name	Pest Type
1	Ageratum Conyzoides (Rosanti, 2016)	Weeds
2	Digitaria Longiflora (Rosanti, 2016)	Weeds
3	Ischaemum Timorensis (Rosanti, 2016)	Weeds
4	Eleusine Indica (Rosanti, 2016)	Weeds
5	Cyperus Difformis (Mokoginta A et al., 2021)	Weeds
6	Ludwigia Hyssopifolia (Mokoginta A et al., 2021)	Weeds
7	Monochoria Vaginalis (Sarifin M et al., 2017)	Weeds
8	Scirpophaga Sp or Pengerek Batang (Puspitasari et al., 2021)	Insects
9	Leptocorisa Oratorius or Walang Sangit (Puspitasari et al., 2021)	Insects
10	Caseworm or Hama Putih (Puspitasari et al., 2021)	Insects
11	Hydrellia Sp or Lalat Daun (Puspitasari et al., 2021)	Insects
12	Scotinophara Coarctata or Kepinding Tanah (Puspitasari et al., 2021)	Insects
13	Armyworm or Ulat Grayak (Puspitasari et al., 2021)	Insects
14	Rattus Argentiventer or Tikus Sawah (Puspitasari et al., 2021)	Insects
15	Nilaparvata Lugen or Wereng Coklat (Manueke et al., 2017)	Insects
16	Grylotalpa Hirsuta or Orong-orong (Lydia Rosmaretta Gayatri et al., 2021)	Insects
17	Rhizoctinia Solani or Hawar Pelepah (Ramadhan et al., 2023)	Disease
18	Pyricularia Oryzae or Blast (Ramadhan et al., 2023)	Disease
19	Cercospora Oryzae or Bercak Daun (Murniyasih E & Suryani L, 2020)	Disease

Weeds are wild plants that grow in agricultural areas and compete with the main crop, in this case the rice plant, for nutrients, water, light and space to grow. Growing requirements that are almost the same as rice plants will result in rice plants not being able to grow optimally (Sarifin M et al., 2017).

Insects are small animals with segmented bodies that can damage rice plants directly through eating or laying eggs on plants. Insects also attack rice plants by eating plant parts such as leaves, stems, or roots. Some insects such as brown planthoppers and stem borers can cause major damage and reduced yields. Insects also have the potential to spread diseases that can worsen plant conditions.

Plant diseases are caused by pathogenic microorganisms such as fungi, bacteria, or viruses that infect rice plants. Diseases cause physiological changes in plants, which can result in discoloration, abnormal growth, wilting, and plant death. Diseases in rice plants often cause huge losses because they can spread quickly in rice fields.

Model Architecture

Architecture Model describes the flow of the system in the application of pest recognition in Augmented Reality-based rice plants that will be made. This stage identifies what components are in the system so that the application can run smoothly.

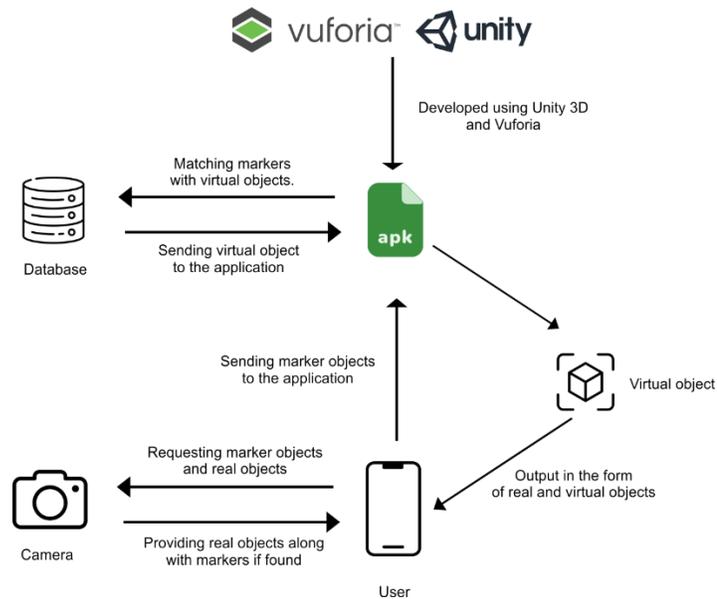


Figure 3. Model Architecture Design

The system architecture in this model describes the flow of Augmented Reality-based mobile application development using Unity 3D and Vuforia SDK for the Android platform. The process starts with Unity 3D and Vuforia SDK as the main software for designing and developing marker-based Augmented Reality applications. Unity 3D acts as a game engine that provides an interface development environment, while Vuforia SDK serves to detect markers and manage Augmented Reality features.

After the development process is completed in Unity 3D, the project is compiled into an APK file, which is an Android application format. This APK file is then installed on an Android device that supports the Augmented Reality feature. In the final stage, users can open the application on their Android device and point the camera at the marker to trigger the application to display information or 3D objects according to the application design.

This architecture shows the process flow from design to implementation on the user's device, with Vuforia SDK as the key element to identify markers and Unity 3D as the main development environment that produces ready-to-use Augmented Reality-based applications.

Unified Modeling Language

The design phase in this research is UML (Unified Modeling Language) design. UML is used to describe, define, design, model, and document aspects of a system to be built. This stage is done to provide an overview of the Augmented Reality-based pest learning system on rice plants that will be made so that it can function properly as needed. In this design consists of use case diagrams, class diagrams and sequence diagrams.

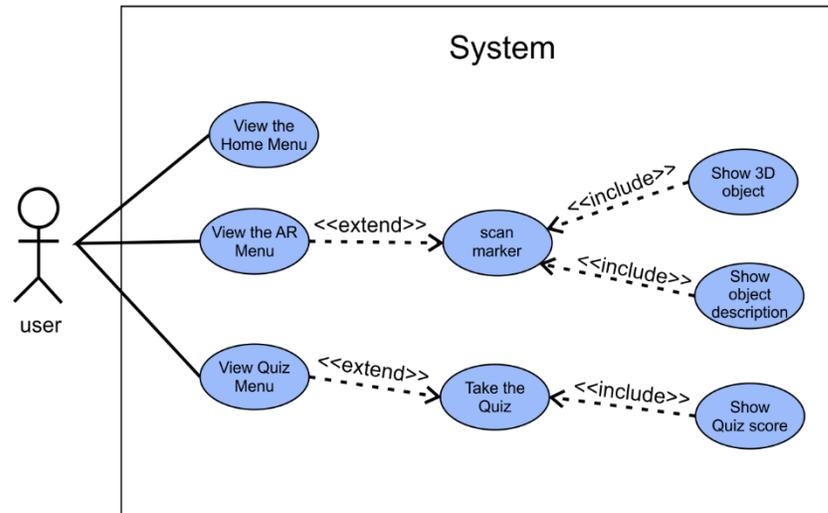


Figure 4. Use Case Diagram

This use case diagram describes the interaction between users and the Augmented Reality application system for pest recognition in rice plants. There are three main actors that interact with the system, namely User, AR Application, and Quiz Application. Users have access to several functions in the application, including viewing the Home menu, opening the AR menu to start the Augmented Reality feature, and accessing the quiz menu which aims to test their understanding of pests on rice plants. In the AR Menu, the system displays 3D objects and descriptions related to pests when the User scans the Marker. After the Marker is detected, the application displays a 3D model of the relevant pest and provides a description of the identified pest. Meanwhile, in the Quiz Menu, users can take quizzes as part of the evaluation of understanding and view quiz scores to get feedback. This diagram shows that the application not only presents educational information through Augmented Reality technology, but also tests user understanding with an interactive quiz feature.

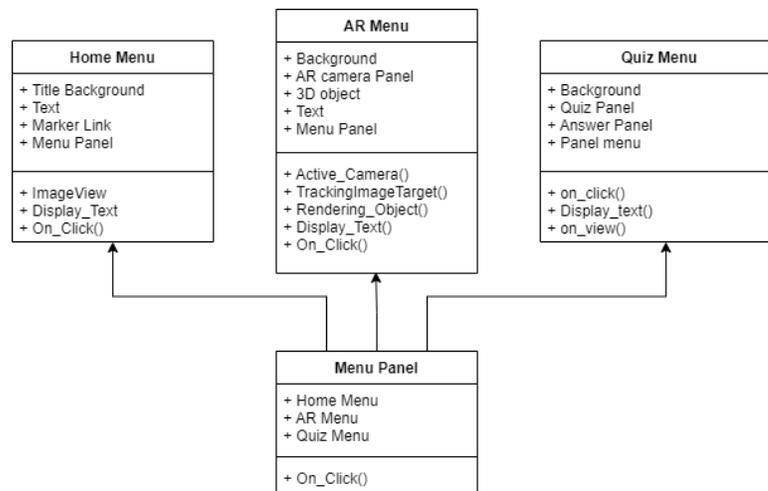


Figure 5. Class Diagram

This Class Diagram illustrates the structure of the components in the Augmented Reality application for pest recognition in rice plants, which consists of four main classes: Home Menu, AR Menu, Quiz Menu, and Menu Panel.

The Menu Panel class functions as the main navigation panel, which contains the Home Menu, AR Menu, and Quiz Menu attributes. This class has an On_Click() method to direct the user to the selected menu.

The Home Menu class has attributes such as Background Title, Text, Link Marker, and Menu Panel, as well as ImageView, Display_Text(), and On_Click() methods to display the main information and switch to another menu.

The AR Menu class serves to display the Augmented Reality feature, equipped with attributes such as Background, AR camera panel, 3D Object, Text, and Menu Panel. This class has Active_Camera() method to activate the camera, TrackingImageTarget() to detect markers, Rendering_Object() to display 3D objects, Display_Text() to display information, and On_Click() for interaction.

The Quiz Menu class is used to display the quiz which consists of Background attributes, Question panel, Answer panel, and Menu panel. Methods in this class include on_click() for interaction on answer choices, Display_text() to display questions and answers, and on_view() for navigation between menus.

This diagram shows the relationships between classes that help build the logical structure of the application, where each class functions specifically to display content and features that support the Augmented Reality-based educational experience in this application.

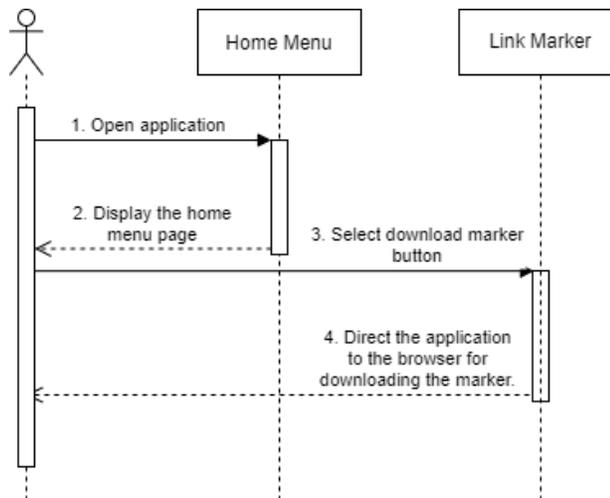


Figure 6. Home Menu Sequence Diagram

This Sequence Diagram illustrates the flow of interaction between the user, home menu, and marker links in the application. The process starts when the user opens the application, which then triggers the system to display the home menu page as a response. After the home menu page is displayed, the user has the option to select the marker download button. When the button is pressed, the app will redirect the user to the browser or Google Drive to download the markers required for the Augmented Reality feature of the app. This diagram shows the sequence of activities and simple interactions that occur in the marker access process from the home menu to the browser.

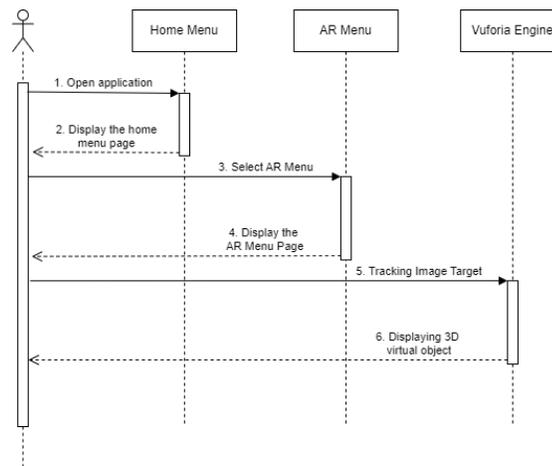


Figure 7. AR Menu Sequence Diagram

This Sequence Diagram describes the flow of user interaction with the Augmented Reality application system using Vuforia Engine. The process starts when the user opens the application, which then the system will display the main menu page. After that, the user selects the AR menu, so the application displays the AR menu page. At this

stage, the system starts the image target tracking process using Vuforia Engine to detect a specific target. After the target is successfully recognized, the system displays a 3D virtual object on the user's device screen. This diagram shows the sequence of interactions between the user and the application system

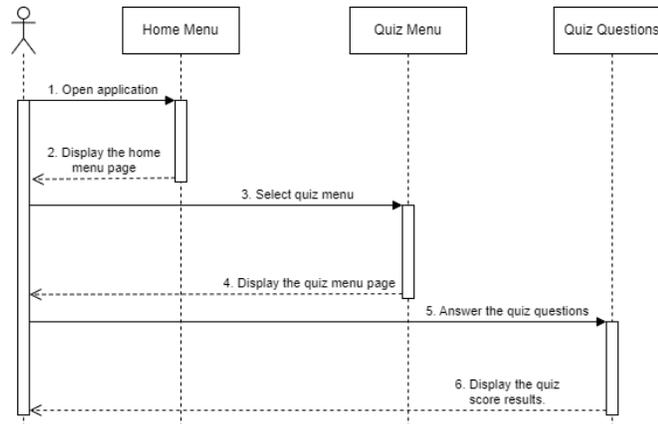


Figure 8. Quiz Menu Sequence Diagram

This Sequence Diagram illustrates the flow of user interaction with the application system in the quiz feature. The process starts when the user opens the application, which then causes the application to display the main menu page. Next, the user selects the Quiz menu, and the system responds by displaying the quiz menu page. On that page, the user starts answering quiz questions. After the user completes the quiz questions, the system displays the quiz score results obtained by the user. This diagram shows the sequence of communication between the user, the menu component, and the quiz question module sequentially in the application.

After understanding the basic concepts and analyzing the requirement data, the designed system will be implemented. This implementation includes 3D object design using Blender, User Interface implementation, writing program code for marker tracking on Unity Engine, and creating a database that matches the existing design using Vuforia SDK. In the final stage, the software that has been developed will be tested to assess its feasibility. This system test will use the blackbox method, which is a test that does not involve examining or testing the program source code.

FINDING AND DISCUSSION

Interface Implementation

1. Home Menu Page

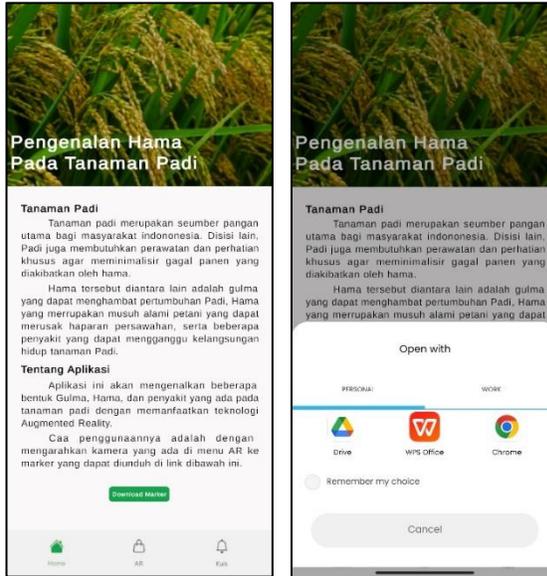


Figure 9. Home page view

The home page of this application is the first page that appears when the application is opened. This page contains a brief explanation of rice plants, information about the application, and a button to download the required marker. This button will direct the application to the marker download page provided via Google Drive.

2. AR Menu Page

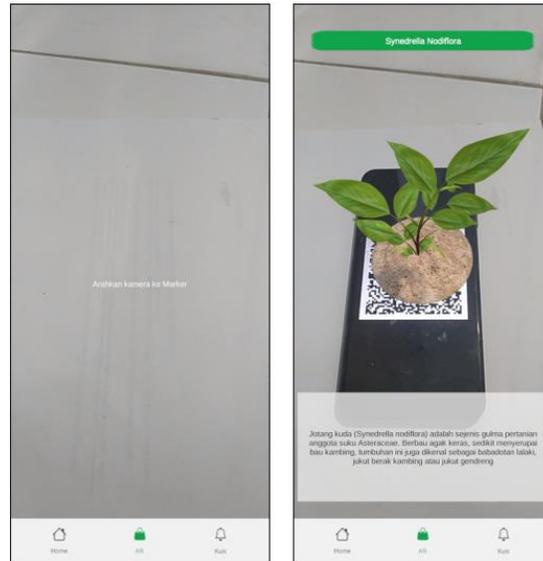


Figure 10. AR menu page view

The AR Menu Page will open when the user taps or selects the AR menu panel located at the bottom of the screen. On this AR page, the application will scan the detected marker and display a three-dimensional (3D) virtual object along with a description of the displayed object. If the camera does not find or detect the marker, a warning saying "Point the Camera at the Marker" will appear.

3. Quiz Menu Page

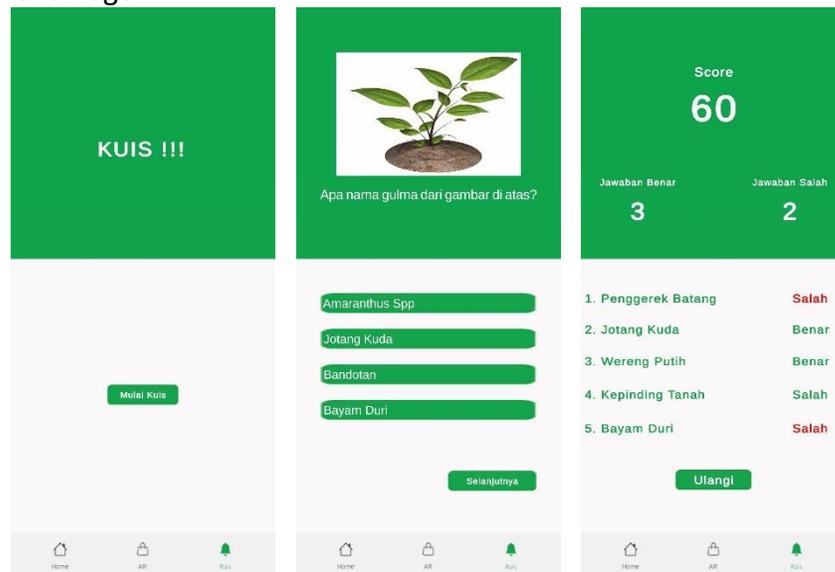


Figure 11. Quiz menu page view

The quiz menu page can be accessed when the user taps or selects the quiz menu on the bottom menu panel. On this quiz page, the application displays the questions that have been provided within the application and the results of the completed quiz

Testing

After the design and development stages of the application, the next stage is the testing phase. The application testing uses the black box testing method, which focuses on the application's functionality without looking at the source code.

The first test is the test of the home page, which appears after the user opens the application. The home page displays several elements such as text, images, and buttons. The button on the home page is the download marker button, which is used to download the required marker. Once the button is pressed, the application will call the Google Drive application if available, or provide other application options to download the marker. The test results can be seen in Table 2 below.

Table 2. Home page testing

Test class	Test scenario	Expected result	Test result
Home menu page	Opening the application	The application can display all text and images according to the design	Successful
	Download marker button	The application can display the download marker link	Successful
	Pressing the download marker button	The application can open and redirect to the download marker page	Successful

The next test is the test of the AR menu page. This testing includes several important scenarios on the AR Menu Page within this application. The testing is carried out to ensure that the application can switch to the AR page when the AR menu is tapped, access the AR camera correctly, and display a warning when the marker is not detected by the camera. Additionally, the testing also verifies that the application can detect the marker and display the corresponding 3D object, as well as accurately display the name and description of the object. Overall, the test results show that each feature operates as expected, ensuring the application functions well in providing the required AR experience. The test results can be seen in Table 3 below.

Table 3. AR menu page testing

Test class	Test scenario	Expected result	Test result
AR Menu Page	Press AR menu	The application can switch to the AR page	Successful
	Access AR camera	The application can access the AR camera feature	Successful
	Marker not detected warning	The application can display a warning when the camera does not detect a marker	Successful
	Direct camera to marker	The camera can detect the marker and display a 3D object according to the detected marker	Successful
	Display object description	The application can display the name and description according to the displayed object	Successful

The next test focuses on the Quiz Menu Page. This testing is conducted to ensure that the application can switch to the quiz page when the quiz menu is tapped, display quiz questions when the start quiz button is pressed, and allow users to select answers. Additionally, the testing ensures that the application can move to the next question when the next button is pressed, and display the final results, including scores and details of correct or incorrect answers after all questions have been answered. Testing is also carried out to ensure whether the application can restart the quiz when the retry button is pressed. The results of all scenarios can be seen in Table 4 below.

Table 4. Quiz menu page testing

Test class	Test scenario	Expected result	Test result
Quiz Menu Page	Press the quiz menu	The application can switch to the Quiz page	Successful
	Press the start quiz button	The application can display the quiz questions	Successful
	Press the answer choice button	The application can select the pressed answer	Successful
	Press the next button	The application can switch to the next question	Successful
	Press the next button after all questions are answered	The application can display results in the form of scores and details of correct and incorrect answers.	Successful
	Press the repeat button	The application can restart the quiz	Successful

CONCLUSION

The conclusion of designing the Augmented Reality application as a medium for introducing pests in rice plants is that the application has been well-designed and has undergone a series of tests that show performance as expected. In this design, the application utilizes Unity 3D as the development platform and Vuforia as the AR SDK, using the Mobile Application Development Life Cycle (MADLC) approach to manage the development stages. The application is designed with several pages, such as the main page as an introduction page to the application and a feature to download the marker, the AR Menu Page to display 3D objects of rice pests using markers, and the Quiz Menu Page to test the user's understanding. The testing shows that each main feature, including marker detection, 3D object display, pest description presentation, and quiz system, operates optimally according to the application's needs.

With test results showing success in each scenario, this application is expected to be an effective and beneficial educational solution in increasing awareness and knowledge about pests in rice plants.

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