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Development of Mobile Durian Farming Application Using Augmented Reality (AR)

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Abstract: As technology advances, an internet platform is being utilized to gather information regarding durian agriculture, from planting through harvesting. Using a smartphone application, farmers can manage their durian farms using the benefits of information technology. Mobile agriculture applications may be the finest option for enhancing agricultural production in the country. Therefore, the goal of this project is to create MyDurianLand, an Augmented Reality (AR)-based mobile application for durian farming that employs Android technology.MyDurianLand will provide augmented reality (AR) features of the various types of durians, the cultivation steps for durian plants, and tips for growing durian plants. The software should display a 3D model of different types of durians as well as show the user how to cultivate durian plants using 2D animations. Multimedia Development Life Cycle (MDLC) is the development approach for this project, which involves six stages: conceptualization, design, material collection, assembly, testing, and distribution.

Keywords: Durian Agriculture, Augmented Reality (AR), Multimedia SDevelopment Life Cycle (MDLC)

1. Introduction

Augmented Reality has been successfully used in domains including education, military, medicine, and entertainment [1]. However, despite its importance, agriculture is one of the least investigated fields of augmented reality, according to a recent report. It is recommended that this AR technology can be used to promote agriculture in a more effective and advanced manner. It is suitable to use AR technology in durian cultivation because in terms of fruit production, durian is Malaysia's most important crop, with a large domestic and export market in ASEAN countries. Furthermore, as technology advances, an internet platform, mainly mobile application should be utilized to gather information regarding durian agriculture.

However, due to the lack of mobile applications in the agriculture field, durian planting especially has become one of the factors to develop this project. There is still a lack of an application neither helps the gardener keep data of preservation of some durian species nor helps the gardener manage the durian market [2]. Besides, the interface design of the application plays an important role in implementing technologies in the agriculture field. Some farmers are aged, lack skills and resources. The need for

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user-friendly features with interactive elements can guide users to access the application. Hence, to overcome this, a mobile durian farming application is proposed.

The project's objectives are to (1) to design a mobile durian farming application using an Augmented Reality (AR) approach, (2) to develop an interactive application using multimedia elements, and (3) to conduct alpha and beta performance testing on the target user. The case study location is located at one of the local farm at Sg Ayam, Senggarang, Batu Pahat, Johor. Encik Khusairi Safuan, who owns a durian farm, became the Subject Matter Expert (SME) for this project. This application primarily consisted of two modules: Augmented Reality (AR) of durian type and cultivation information. Markerless augmented reality technology is used to display a 3D model of durian varieties. The target user of the developed application are new or local farmers who cultivate durian. The application is developed in Malay because the intended audience is local.

2. Related Work

Relevant works are essential when conducting research on a particular topic. In this section, two sub-sections, Augmented Reality (AR) and Mobile Technology, will show some project-related examples.

2.1 Augmented Reality (AR)

Augmented Reality (AR) is a real-time direct or indirect view of a physical real-world environment that has been enhanced or augmented by adding virtual computer-generated information to it [3]. Augmented Reality (AR) is one compelling technology which removes the barrier between Physical and virtual environments [4]. With augmented reality, the digital world is brought to life inside the field of view captured by the tablet or phone camera. The term "mobile augmented reality" was used to describe the application of technology with mobile devices such as smartphones and tablets [5]. For its importance, AR should be used in agriculture to develop the industry in a more efficient and modern manner. In general, there are two forms of augmented reality (AR): marker-based AR and markerless AR. This study describes a markerless AR-based mobile application for displaying 3D models of several type of durians. By utilizing three-dimensional (3D) image modelling, mobile devices can incorporate 3D models of durians. Using the EasyAR engine, the markerless AR-based mobile application is implemented. EasyAR SDK is an Augmented Reality Engine and a cross-platform augmented reality software development kit (SDK) for Android, iOS, UWP, Windows, Mac, and the Unity editor.

2.2 Mobile Technology

Mobile technology is a type of technology that is predominantly used in cellular communication and other communication-related areas. Mobile technology includes portable electronic devices that use a liquid crystal display to project digital images and are manipulated by touching the screen using a stylus, or by the entry of characters from a digital keypad [6]. Mobile technology has had a significant impact on our daily lives due to its widespread availability and fewer communication costs than other modes of communication. There are applications for it in practically every field, including the agricultural sector. In this project, Android technology is chosen to develop an interactive application since the Android operating system is a free and open-source operating system created by GOOGLE and the Open Handset Alliance [7].

2.3 Comparison Between Reviewed Applications and Proposed Application

In this section, the project will examine three existing applications that are comparable and can be used for comparative analysis. MARDI myAgriManager, Musang King, and Durian: IOI Musang King, are reviewed based on several features. The table below provides a summary of each application, as well as a comparison between three existing applications and the proposed application.

Table 1: Similar existing application comparison

Application	MARDI myAgriManager	Musang King	Durian: IOI Musang King	MyDurianLand
Platform	Android and IOS	Android and IOS	Android	Android
Content Focus	Listing the activity schedule for each planting	Detection and differentiation of Musang King durian and other types using image identification.	Provide information on the durian and location of sales centre	Provide AR of 3D model of durian types and information of durian cultivation
Tutorial Guidance	Not available	Provide tutorial on how to use the application	Not available	Provide tutorial on how to cultivate durian step by step by 2D animation.
Augmented Reality	No Augmented Reality (AR) is provided.			Markerless AR is provided
Language	Malay language	English language	Malay Language	Malay Language
Multimedia Element	Text, Graphic	Text, Graphic, Image Identification	Text, Graphic	Text, Graphic, Animation, Audio

3. Methodology

The Multimedia Development Life Cycle (MDLC) frameworks were used in this project to create an instructional multimedia product. In the development of multimedia, MDLC is commonly applied. Multimedia has been used in various fields, such as business, education, entertainment, as well as various other public interests [8]. The MDLC model was chosen for this project because it is simple to implement and may be developed cyclically. This model is common with all multimedia products. It can facilitate the delivery of materials in images, videos, and sounds to guide farmers that are interested in developing their own durian crop, as opposed to the traditional method. Figure 1 shows the basic phases for the development of multimedia applications such as conceptualizing, designing, material collecting, assembly, testing, and distribution [9].

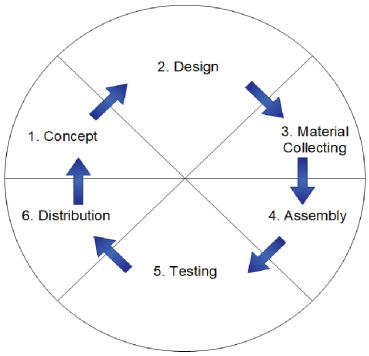


Figure 1: Multimedia Development Life Cycle (MDLC) [9]

The workflow in system development for the project is outlined in this section, and it is listed in Table 2 below. The table describes each phase, as well as the actions carried out throughout each phase and the result of each phase.

3.1 Conceptualizing Phase

In the conceptualizing phase, the project is discussed through the meeting with the supervisor to determine the project title and determine the requirements and plan for the upcoming phase of the cycle. Through this phase, the process is clearly identified as to what will need to execute in the development of a mobile durian farming application for newbie farmers using Augmented Reality (AR).

3.2 Designing Phase

Following the conceptualizing phase, the designing step is the following phase to complete. A storyboard, software requirements, and hardware requirements are all determined during the designing phase of the project. According to the findings of the research, the software that is suitable for developing the application is Unity and Blender. During this phase, the complete storyboard is created to be able to visualize the entire program's features. The detailed storyboard for the MyDurianLand application is present in Appendix A. Hence, the functional and non-functional requirements outlined in Appendix B were also identified at this phase. Figure 2 depicts a navigational structure that provides an overview of the navigational structure, followed by the flowchart depicted in Figure 3.

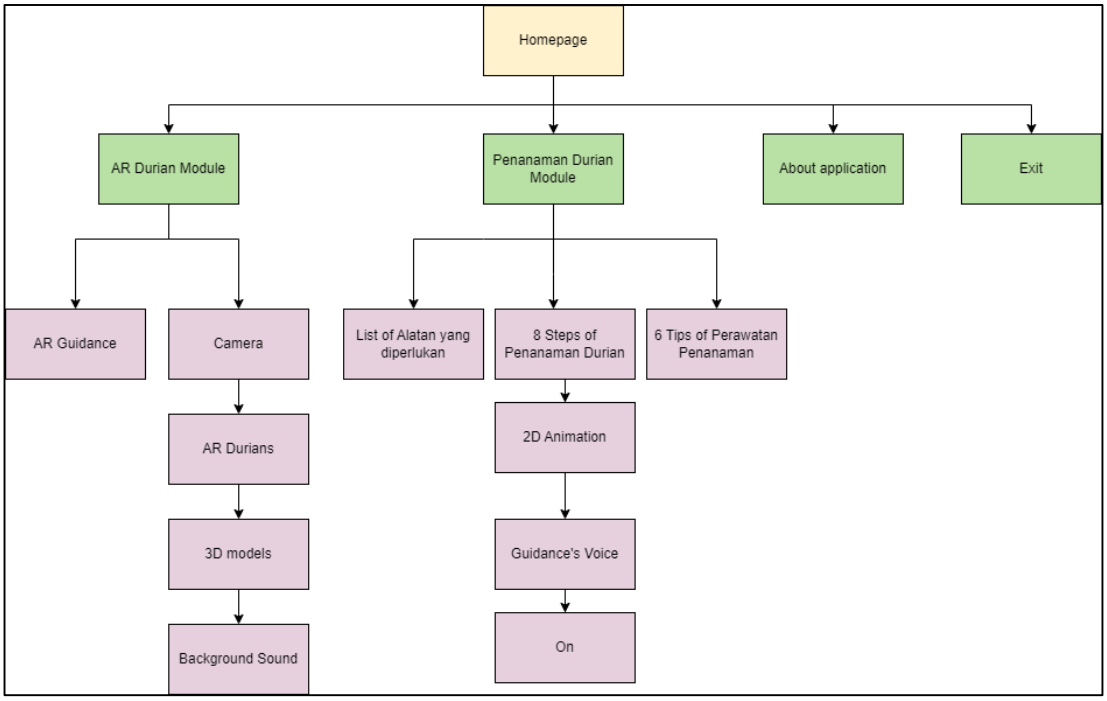


Figure 2: Navigational Structure

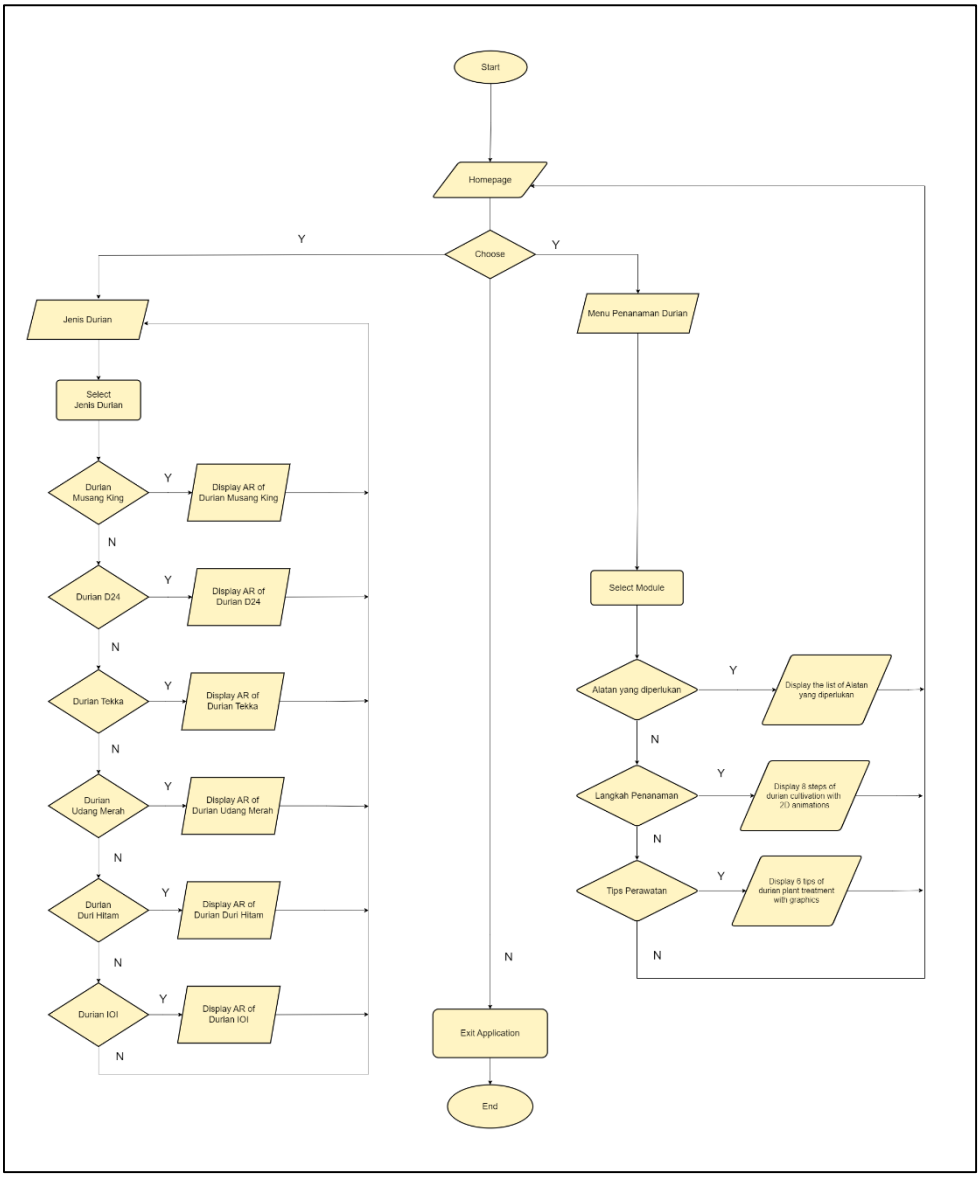


Figure 3: Flowchart

3.3 Material Collecting Phase

After the designing phase, the material collecting phase is about collecting the images, videos, information and sounds as learning materials which later are integrated into the application. The materials are obtained and edited using several tools such as Canva, Unity and Blender. All of the buttons in Table 2 were created using Canva, an online design application.

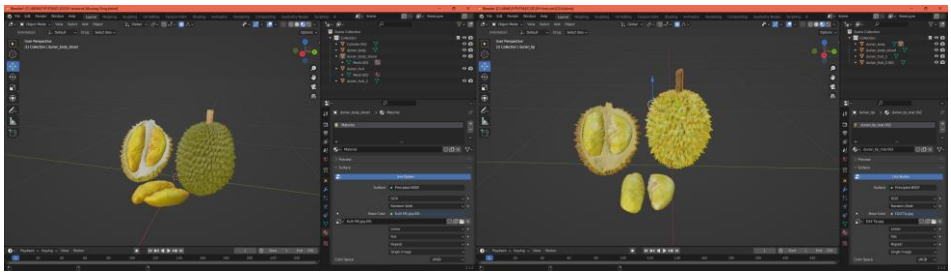
Table 2: List of The Button Design of The Application

Button Design	Detail
AR Durian	• AR Durian button. • Navigates the user to the AR module.
Penanaman Durian	• Penanaman Durian button. • Navigates the user to the Penanaman Durian module.

Button Design	Detail
Alatan yang diperlukan	• Alatan button. • Shows the list of tools needed in durian cultivation.
Langkah Penanaman	• Langkah Penanaman button. • Navigates the user to the steps of durian cultivation interfaces using 2D animation.
Tips Perawatan	• Tips Perawatan button. • Navigates the user to the tips of growing durian interfaces.
Seterusnya	• Next button in Penanaman Durian module. • Navigates the user to the next page of the interface.
Selesai	• Complete button in Penanaman Durian module. • This button is displayed when the user completes the step of durian cultivation in Langkah Penanaman module.
Kembali	• Back button in Penanaman Durian module. • Navigates the user to the previous page of the interface.
Kembali ke Menu	• Back to Menu button in Penanaman Durian module. • Navigates the user to the main menu of Penanaman Durian module.
	• Exit Button symbol. • The user can click on this button to exit from the application.
	• Home button symbol. • Navigates the user to the homepage of the application.
	• Info button symbol. • Navigates the user to the information of the application.
	• Back button symbol. • Navigates the user to the previous page of the interface.

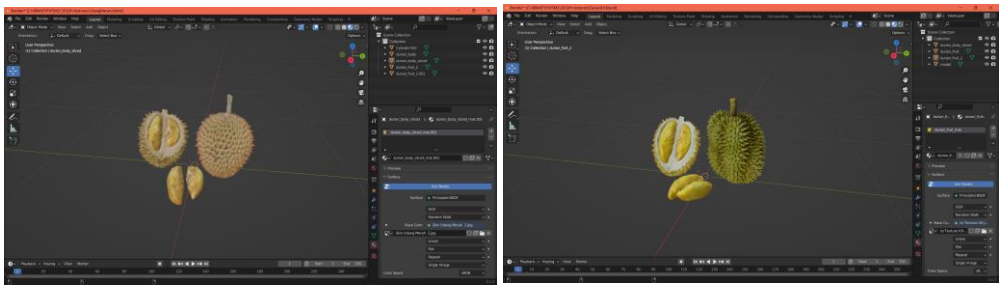
Button Design	Detail
	• AR Info button symbol. • Navigates the user to the AR tutorial guide.
	• Sound On button symbol. • Enables the sound of guidance's voice in Langkah Penanaman module.

Blender has been implemented to model the 3D models of various durian types. Durian Musang King, Durian D24, Durian Tekka, Durian IOI, Durian Duri Hitam, and Durian Udang Merah are the six varieties of durians modeled. Figure 4 exhibits the modeling process of durians in Blender during this phase.



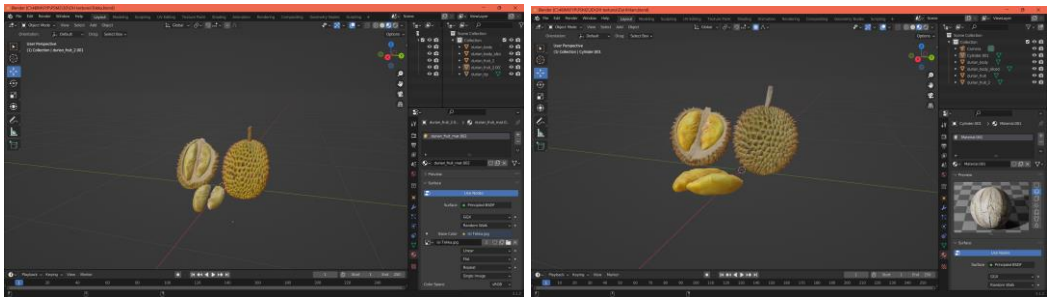
(a) **(b)**

Figure 4(a): Model Musang King in Blender, Figure 4(b): Model D24 in Blender



(c) **(d)**

Figure 4(c): Model Udang Merah in Blender, Figure 4(d): Model IOI in Blender



(e) **(f)**

Figure 4(e): Model Tekka in Blender, Figure 4(f) :Model Duri Hitam in Blender

3.4 Assembly Phase

Parallel to the collecting of materials phase, the assembly phase, also known as the preparation and making phase, can be completed in the same time frame. In this phase, the software tools that is mainly used is Unity. Unity is utilised to construct, merge, and integrate all essential assets for the scripting process.During this phase, the 3D models are imported into Unity using FBX file format for the AR development in the application. Moreover, EasyAR is implemented in Unity to allow in creating AR and offers multiple AR features including planar image tracking, surface tracking and also 3D object tracking [10].

During this phase, the process of designing and building a interface is developed in Unity. The total of 28 scenes as shown in Figure 5 are developed consistently including AR module and durian cultivation module.

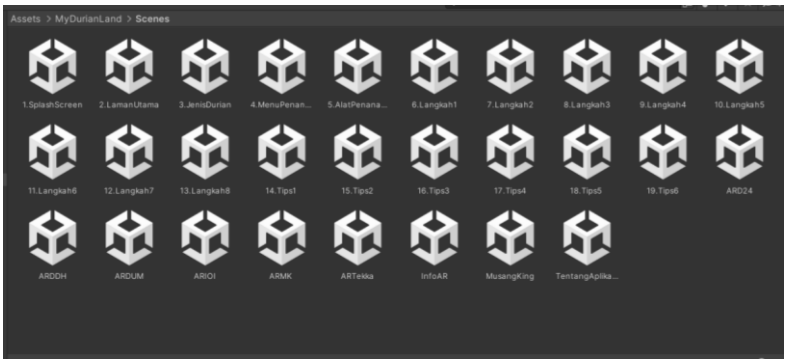


Figure 5: The total scenes developed in Unity

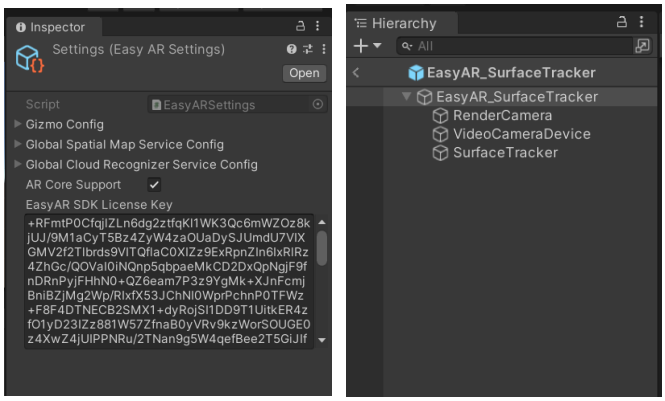
C# is the programming language used to develop the functionality of the Unity software. In Figure 6 (a) and Figure 6 (b), it shows the C# language that utilizes UnityEngine.SceneManagement that enables to write a single function prototype. SceneManager.LoadScene() is implemented in the code to load a scene from one scene to another. For instance, SceneManager.LoadScene(3.JenisDurian) indicates that when the user clicks the ARDurian button, the Jenis Durian scene will be loaded, and the user will be navigated to the Jenis Durian interface.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class MainMenu : MonoBehaviour
{
    public void ExitButton()
    {
        Application.Quit();
        Debug.Log("App Closed");

    }
    public void TentangAplikasi()
    {
        SceneManager.LoadScene("TentangAplikasi");
    }

    public void ARDurian()
    {
        SceneManager.LoadScene("3.JenisDurian");
    }

    public void PenanamanDurian()
    {
        SceneManager.LoadScene("4.MenuPenanaman");
    }
}
```

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class PenanamanDurian : MonoBehaviour
{
    public void MainMenu()
    {
        SceneManager.LoadScene("2.LamanUtama");
    }

    public void Alat()
    {
        SceneManager.LoadScene("5.AlatPenanaman");
    }

    public void Langkah()
    {
        SceneManager.LoadScene("6.Langkah1");
    }

    public void Tips()
    {
        SceneManager.LoadScene("14.Tips1");
    }
}
```

(a) **(b)**

Figure 6(a): C# script for Main Menu page, Figure 6(b): C# script for Menu Penanaman Durian page



(a) **(b)**

Figure 7(a): License Key (EasyAR), Figure 7(b): EasyAR Surface Tracker

This project's augmented reality session is implemented using the EasyAR engine, which is a Unity package. This engine offers the interactive capabilities of resizing, moving, and rotating 3D models. Figure 7 (a) portrays the licence key copied from the EasyAR Developer Portal and pasted into the App License Key field of the EasyAR Settings file in Unity. The developer can therefore use the EasyAR SurfaceTracker, as depicted in Figure 7(b), to detect 3D models on the camera and develop markerless augmented reality.

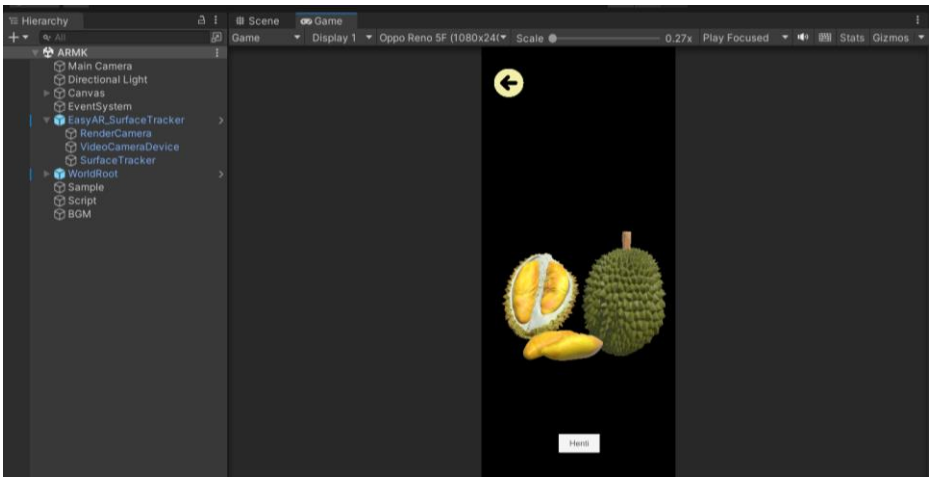


Figure 8: Durian model implemented in AR Scene

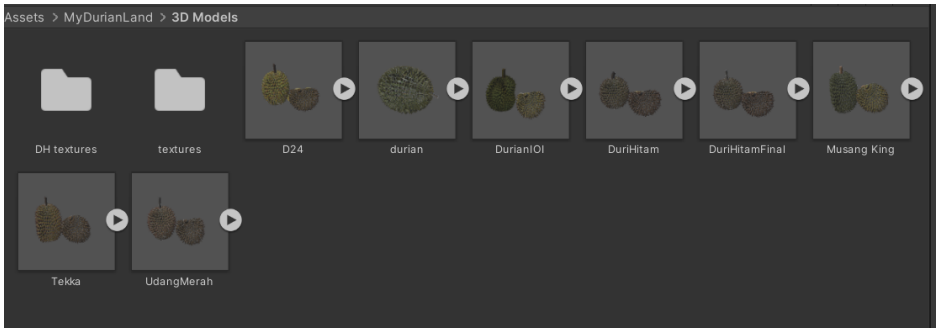


Figure 9: 3D models of AR durian

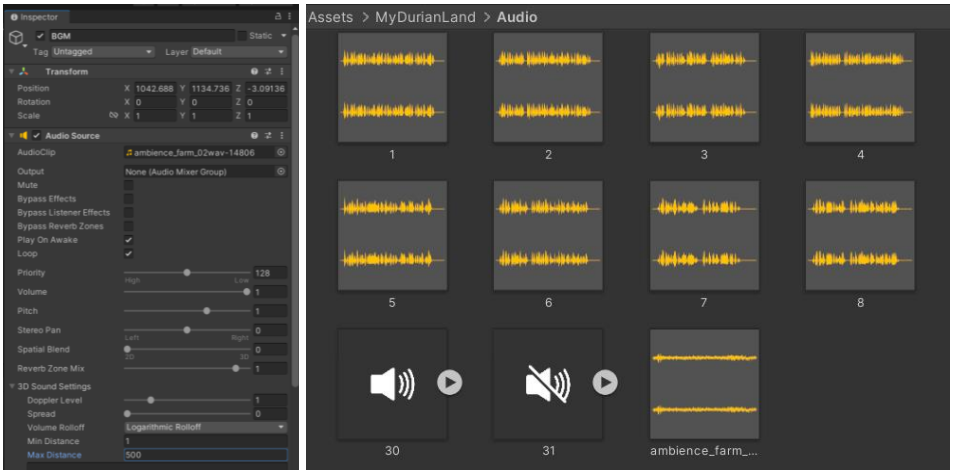


Figure 10: Audio files

After placing the 3D model in the WorldRoot as shown in Figure 8, the camera can track the model without a marker, resulting in an augmented reality feature. There are a total of six different durian models integrated into each AR scene. Figure 9 displays the 3D models of durian. In addition, this application includes an audio feature that allows users to experience the real environment of a durian farm through farm sounds. In addition, the Penanaman Durian module includes a voice that guides the user and makes this application more interactive. Figure 10 shows the audio files inserted in the application.

3.5 Testing Phase

The testing stage involves putting the multi-media system through its paces to discover if there are any elements that are not functioning properly before releasing them to the public. Alpha testing is the term used to describe this type of testing. It will be possible to identify and uncover any errors that may exist in the developed application because of the testing that has been carried out, and if any errors are discovered, an improvement programme will be implemented. It is also known as functional testing, in which the developer verifies and tests the functionality of all application buttons before releasing it to the intended audience. Tables 3, 4, and 5 below show the results of functional testing for each module; Home page, AR Durian and Penanaman Durian.

Table 3: Results of functional testing on Home page

Element Testing	Expected Result	Actual Result
AR Durian Button	Navigates to the Jenis Durian scene.	Works well as expected
Penanaman Durian Button	Navigates to the Menu Penanaman scene.	Works well as expected
Exit Button	Exit from the application.	Works well as expected
Info Application Button	Displays the information of application page.	Works well as expected
Close Button	Navigates to the Home page.	Works well as expected

Table 4: Results of functional testing on AR Module

Element Testing	Expected Result	Actual Result
AR Guidance Button	Displays the guide on how to use the AR.	Works well as expected
Durian Musang King AR Button	Displays the camera with 3D model of Durian Musang King.	Works well as expected

Element Testing	Expected Result	Actual Result
Durian D24 AR Button	Displays the camera with 3D model of Durian D24.	Works well as expected
Durian Tekka AR Button	Displays the camera with 3D model of Durian Tekka.	Works well as expected
Durian Udang Merah AR Button	Displays the camera with 3D model of Durian Udang Merah.	Works well as expected
Durian Duri Hitam AR Button	Displays the camera with 3D model of Durian Duri Hitam.	Works well as expected
Durian IOI AR Button	Displays the camera with 3D model of Durian IOI.	Works well as expected
Movement of 3D model	Can be scaled, rotated and moved.	Works well as expected
Mula AR Button	Start the AR tracking of 3D model.	Works well as expected
Henti AR Button	Stop the AR tracking of 3D model.	Works well as expected
Back Button	Navigates to the Jenis Durian scene.	Works well as expected

Table 5: Results of functional testing on *Penanaman* Module

Element Testing	Expected Result	Actual Result
Home Button	Navigates to the Home page.	Works well as expected
Alatan yang diperlukan Button	Displays the list of equipment needed for durian cultivation.	Works well as expected
Langkah Penanaman Button	Displays the 8 steps of durian cultivation with 2D animation.	Works well as expected
Sound Button	Enable the sound of guidance's voice.	Works well as expected
Tips Perawatan Button	Displays the 6 tips of durian cultivation.	Works well as expected
Seterusnya Button	Navigates to the next page of the module.	Works well as expected
Kembali Button	Navigates to the previous page of the module.	Works well as expected
Selesai Button	Navigates Main Menu of *Penanaman* Module.	Works well as expected

After alpha testing is carried out, beta testing is also performed by real users in a real environment. The application is demonstrated and the feedback from the user is collected using Google Form. The results and discussion section below gives details about beta testing.

3.6 Distribution Phase

Following the conclusion of the testing phase, the application is ready for distribution to the targeted audiences. The application has been compiled in .apk file and is prepared for installation on Android smartphones. The .apk file is distributed by sharing the QR code generated by an online QR code generator. Therefore, users can access the application after installing it using the QR code.

4. Results and Discussion

The beta testing is conducted after all the functionality of the application is successfully worked during the alpha testing by developer. In this beta testing, about 12 respondents have given their feedback regarding the mobile farming application. To conduct this test, a Google Form is distributed to the target audience. The Google Form consists of three sections: the functionality of the application, the user interface design, and the overall rating of the application. Each question is measured using a 5-point Likert scale ranging from 1 - "Very Poor" to 5 - "Very Good." Each question is analysed and depicted in Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15.

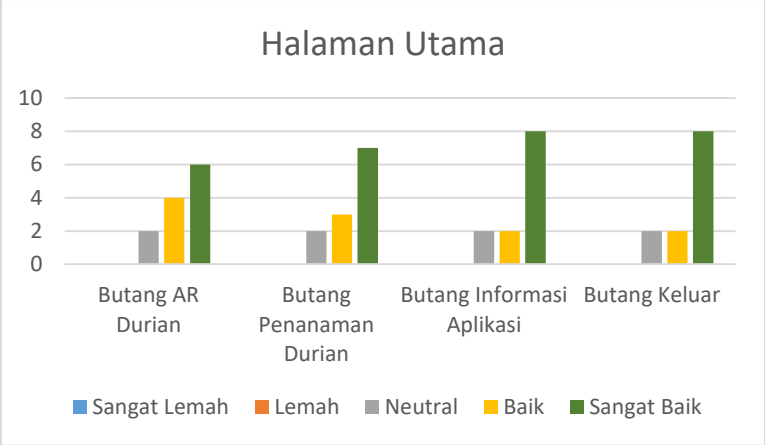


Figure 11: Analysis of Home page functionality

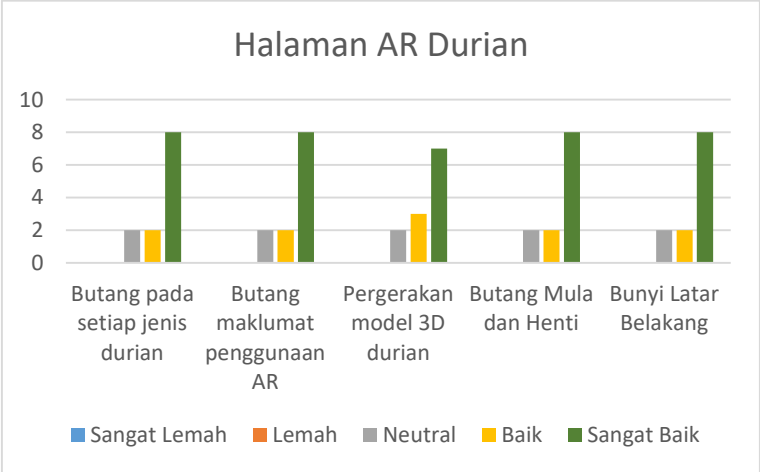


Figure 12: Analysis of AR Durian module functionality

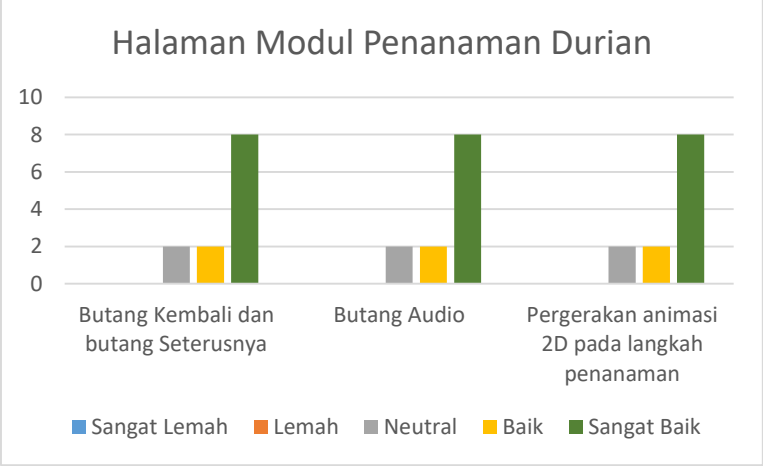


Figure 13: Analysis of Penanaman module functionality

Based on Figure 11, 12 and 13, the respondent was required to answer questions about the functionality of the application. Three modules were evaluated, including the Homepage, the AR Durian Module, and the Penanaman Durian Module. According to the results of the respondents' testing, most of the buttons have full function.

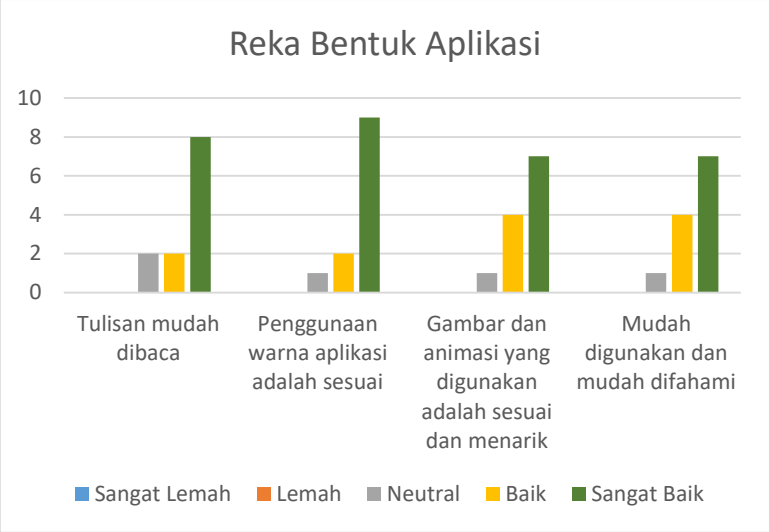


Figure 14: Analysis of User Interface Design

The section then focuses on analysing the respondents' user interface design input. According to Figure 14, approximately 66.7% of respondents agree that the font can be easily read. Therefore, 75% of respondents agreed that the application's colour scheme is appropriate. 58.3 percent of respondents concluded that the application's graphics and animation are appropriate and engaging. The majority of respondents, 58.3 percent, firmly agreed that the application is intuitive and simple to use.

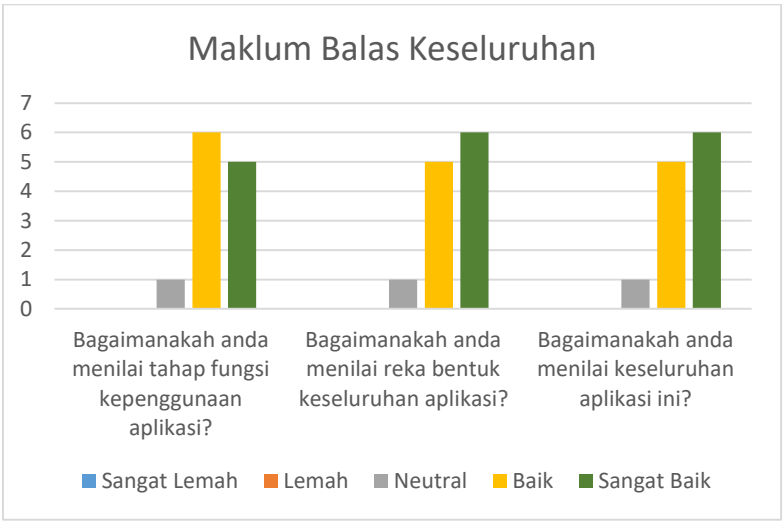


Figure 15: Analysis of feedback from respondents

Finally, responses from survey participants are compiled in Figure 15. Most respondents (50%) agree that the MyDurianLand application has the satisfied functionalities. Fifty percent of respondents rated the performance of the user interface as excellent or very good. Overall, fifty percent of respondents agreed that the application is favourable. According to the findings, the application can be improved in the future by implementing the respondents' comments.

5. Conclusion

MyDurianLand is an android-based mobile application that was successfully developed, and functions as intended. Positive feedback from the testing phase demonstrated that the application is ready for release to its intended users. Consequently, the project's objectives are also fulfilled. The

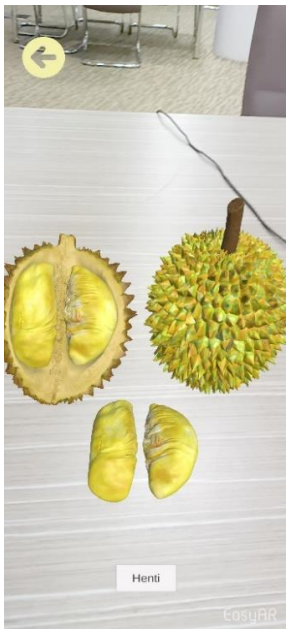
objectives of this project have been subdivided into a total of three objectives. This first objective is reached when the application successfully integrates augmented reality. The second objective is met when the application is interactive and includes text, graphics, 2D animation, and 3D models, among other multimedia elements. The third and final objective is met when the functional test gives a positive result. This application's augmented reality (AR) features that display the various types of durians can provide users with potential advantages. In addition, users can easily follow the durian plant cultivation 2D animation. Consequently, the application also provides tips on cultivating durian plants, allowing users to acquire a deeper understanding of durian cultivation. However, there are disadvantages to this application, including the fact that some Android phones cannot display the AR feature due to incompatibility, and that some buttons require multiple clicks to access the required interface. The enhancements may need to be implemented in future works, such as the use of a suitable font and the addition of durian-specific characteristics so that users can distinguish between durian varieties.

Acknowledgment

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support and encouragement throughout the process of conducting this study.

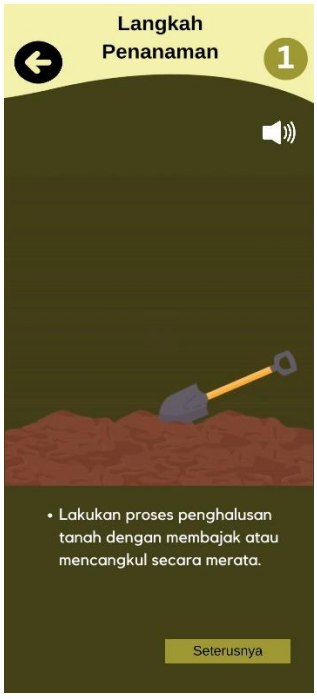
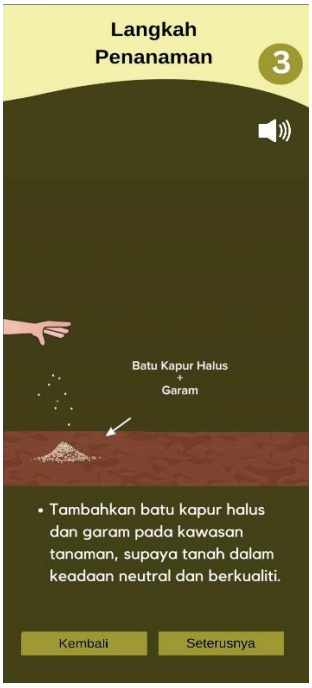
Appendix A

Home Page Interface	App Info Interface	Jenis Durian Interface
		

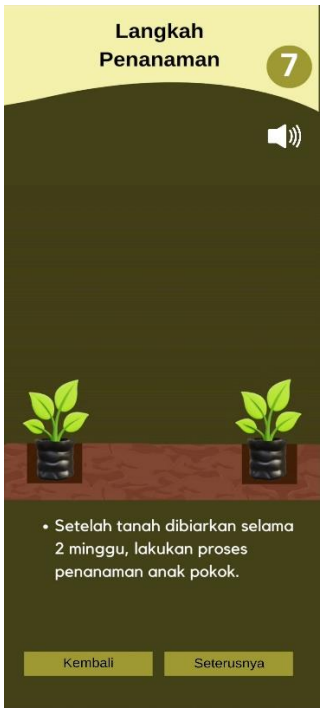
AR Guidance Interface	AR Durian Musang King Interface	AR Durian D24 Interface
		

AR Durian Tekka Interface	AR Durian Udang Merah Interface	AR Durian Duri Hitam Interface
		

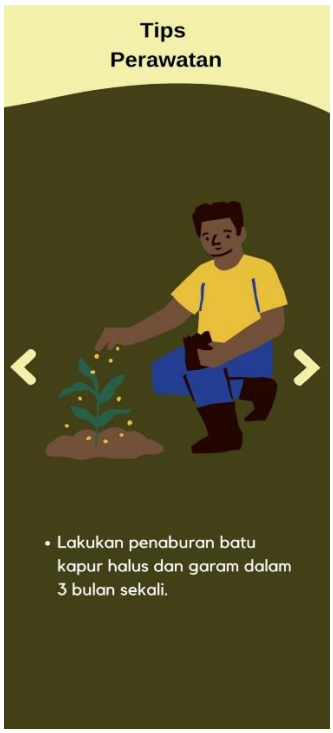
AR Durian IOI Interface	Penanaman Module Menu	List of Equipments Interface
		

First Step of Durian Cultivation Interface	Second Step of Durian Cultivation Interface	Third Step of Durian Cultivation Interface
		

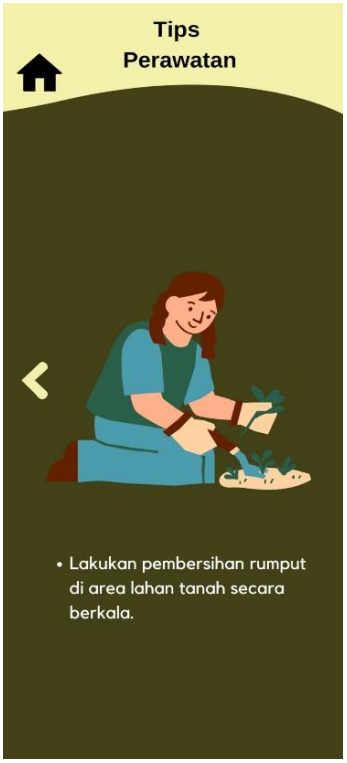
Fourth Step of Durian Cultivation Interface	Fifth Step of Durian Cultivation Interface	Six Step of Durian Cultivation Interface
		

Seven Step of Durian Cultivation Interface	Eight Step of Durian Cultivation Interface	Tips Perawatan Interface
		

Tips Perawatan Interface	Tips Perawatan Interface	Tips Perawatan Interface



Tips Perawatan Interface	Tips Perawatan Interface



Appendix B

Table 6: Functional Requirements Table

Category	Detail
User Interaction	• If the user clicks the button on the screen, the system shall display what they click. • In the Augmented Reality feature of Durian 3D model, users can move, resize and rotate the model. • In the "Langkah Penanaman" page, users can click the audio feature to listen to the audio explanation.
Autonomous system	• After launching the app for the first time, the system will display the Homepage Interface. • In "AR Durian" section, the system shall display of 3D models of durian types by AR technology. • In the durian cultivation module, users can read the information provided along with 2D animation that plays on awake simultaneously.

Table 7: Non-functional Requirements Table

Category	Detail
Usability	• The application is in Malay language. • The application should be able to be used anytime. • The application should be easy to use.
Implementation	• The application shall be able to run using the Android platform.
Performance	• The average response time between click and reaction is less than 0.1 seconds. • The application should be able to load the AR within 3 seconds.

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