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Development of Android-Based 3D Building Augmented Reality Application at Jogja Student Islamic Boarding School 2

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Abstract: Islamic boarding schools are pivotal in providing religious education for Muslims in Indonesia. Despite their widespread presence, detailed knowledge about these institutions, particularly their architectural design, remains limited. Prospective students and the public often rely on internet images for information, leading to a partial understanding of the physical structure of these schools. This study introduces an innovative solution through the development of an Augmented Reality (AR) mobile application specifically designed for the Jogja 2 Islamic Boarding School. Augmented Reality technology effectively integrates 2D and 3D virtual objects into a real-world environment, offering an immersive, real-time experience. By utilizing the waterfall methodology in its development, this application aims to provide an in-depth, three-dimensional exploration of the Jogja 2 boarding school's infrastructure. This tool is intended to assist potential students and interested individuals in gaining a comprehensive understanding of the school's architectural layout and design in a dynamic and interactive manner.

Keywords: Islamic Boarding Schools; Augmented Reality; Waterfall; Android.

1. Introduction

Indonesia, recognized globally for its majority Muslim population, stands as a country where nearly 87% of its inhabitants follow Islam [1]. This demographic landscape has led to the widespread establishment of Islamic boarding schools, known as 'pondok pesantren', which serve as pivotal centers for Islamic learning and education [2]. These pondok pesantren play a vital role in imparting Islamic teachings and values. One such prominent institution in the Jogja region is the Pondok Pesantren Mahasiswa Jogja 2. However, there exists a notable gap in accessible, detailed information about the structure and individual room dimensions of these institutions. Prospective students and the local community often rely on second-hand information from acquaintances or limited visual representations found on the internet, resulting in an incomplete understanding of the boarding school's physical layout [3].

In this era of technological advancement, the ease of accessing information through various media forms has significantly increased. A common and increasingly popular medium in today's world is multimedia, especially in the form of Augmented Reality (AR) [4]. AR technology integrates virtual objects into the real world, either in two or three dimensions, in real-time. This immersive technology requires the use of markers, which are two-dimensional objects with specific dot patterns that are identified through a camera. These markers function as triggers to display three-dimensional objects within an augmented reality environment [5]. Typically, these markers are designed as black and white squares with a distinctive black pattern in the center and thick black borders [6][7].

The goal of this research is to develop a three-dimensional application for the Pondok Pesantren Mahasiswa Jogja 2 using mobile-based augmented reality. This application aims to facilitate a comprehensive understanding of the boarding school's layout and room sizes for potential students and the community. By utilizing AR technology, the application intends to provide an engaging and easily accessible way for users to explore and familiarize themselves with the structure

and amenities of the Pondok Pesantren Mahasiswa Jogja 2 [8]. Through this innovative approach, the research seeks to bridge the information gap and enhance the overall experience of learning about these vital educational institutions.

2. Research Method

2.1. Marker Based Tracking:

Marker-based tracking is a pivotal method in Augmented Reality (AR) where a camera is utilized to scan a designated area or object marked with specific markers. These markers are then analyzed based on their distances, and the results of these analyses are meticulously recorded. This data is subsequently evaluated to draw conclusive insights into the functionality and efficacy of the markers within the AR environment [9].

2.2. Waterfall

The software development for this project employs the Waterfall methodology, a structured and sequential approach encompassing various stages of software development. The Waterfall method is methodical, commencing with planning and progressing through to management and maintenance. It comprises six distinct phases: Requirement Analysis, Design, Implementation and Unit Testing, Integration and System Testing, and Maintenance [10]. These stages are visually represented in Figure 1.

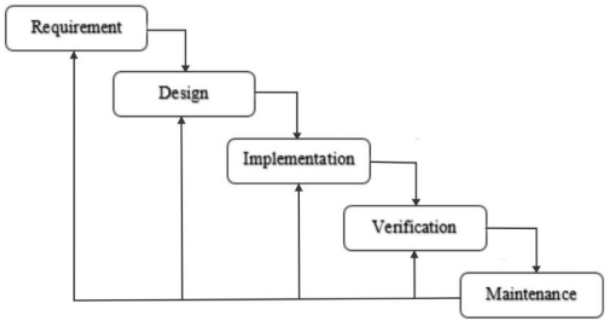


Figure 1. Stages of Software Development in the Waterfall Method

In software development, six stages are used, namely:

1) Requirement Analysis: This stage involves detailed observation and interviews with the leaders of Pondok Pesantren Mahasiswa Jogja 2. The aim is to gather direct data about the institution, focusing on its specific needs and requirements.
2) Design: Based on the data acquired, this phase entails designing the application layout, specifically for the main menu of the AR application for Pondok Pesantren Mahasiswa Jogja 2.
3) Implementation and Unit Testing: This stage involves the development of the application using C# programming language, utilizing tools like Unity and Vuforia. It also includes unit testing to verify the application's functionalities.
4) Integration and System Testing: Comprehensive system testing is conducted in this phase, ensuring the application's functionality is robust and error-free. This involves trial runs with students to identify any potential failures or bugs.
5) Maintenance: The final stage focuses on the ongoing maintenance and upkeep of the application to ensure its smooth operation.

2.3. Research Framework

The research framework starts from the initial condition, where prospective students or the community lack detailed knowledge about the building and room layouts of the boarding school. They typically seek information through internet media. The proposed model involves creating a mobile augmented reality application for Pondok Pesantren Mahasiswa Jogja 2. The application allows users to view the boarding school's building in three dimensions by scanning provided markers. The goal is to enable easy visualization of the building and room layouts in 3D. The research framework is depicted in Figure 2.

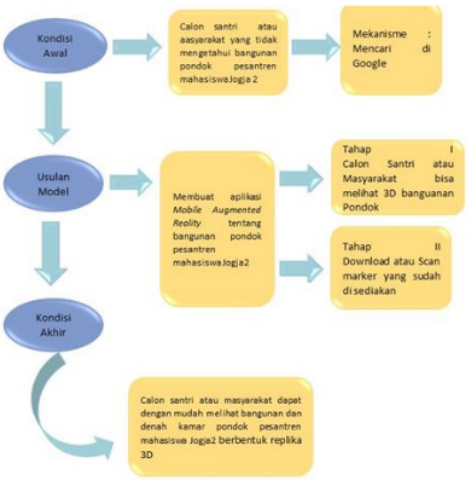


Figure 2. Research Framework

2.4. Illustration of Augmented Reality Application Usage

The proposed AR application is designed to provide detailed information about the Pondok Pesantren Mahasiswa Jogja 2 building. It operates by scanning markers with a smartphone camera. Upon successful marker detection, the application displays the relevant data in augmented reality on the smartphone screen, offering an immersive experience. An illustration of the application usage is shown in Figure 3.

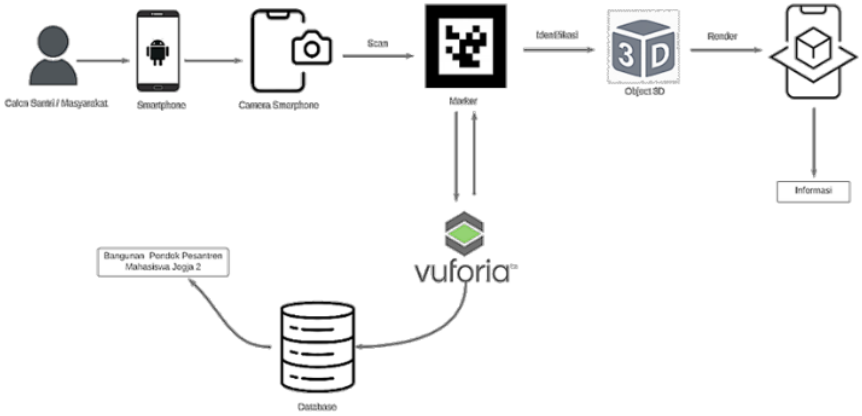


Figure 3. Illustration of Using Augmented Reality Applications.

3. Result and Discussion

3.1 Results

3.1.1 App View

The results of the research that has been carried out are producing an application that includes a main menu, the main menu consists of an AR scan menu, application guide menu, information menu, exit button to exit the application and a music sound button. For more details on the appearance of the menu page in the application, see Figure 4 below:

(a) Splash Screen (b) Main Menu

(c) AR Scan Page (d) Application Guide Page

(e) Information Page

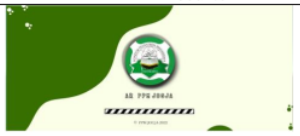
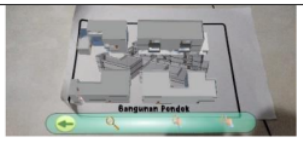
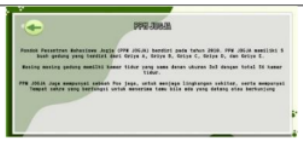
Figure 4. App View

The application that emerged from the study is equipped with a user-friendly interface, beginning with Figure 4.a, the splash screen, which greets users as they launch the application. Proceeding to Figure 4.b, the main menu serves as the navigational hub, offering access to all other pages within the app. This includes three main features: the AR Scan for immersive interaction with the boarding school's structures, the Application Guide which provides instructions for use, and the Information menu which offers detailed insights into the institution. Specifically, Figure 4.c showcases the AR Scan page, equipped with functional buttons for returning to the previous screen, accessing detailed views, and zooming in and out of the 3D models. This feature allows users to delve into the details of the boarding school's buildings and room layouts, presenting them in a three-dimensional space. Meanwhile, Figure 4.d displays the Application Guide page, a resource that details the functionality of the app and simplifies the user experience with the inclusion of a return button and an application exit option. Lastly, Figure 4.e, the Information page, acts as an informative segment within the application, where users can find comprehensive data about Pondok Pesantren, all while offering straightforward navigation back to the main menu or exit the application. Each page is designed to provide a seamless transition and a cohesive user experience, underlining the application's ease of use and informative nature.

3.1.2 Black Box Testing

Black box testing is an essential validation technique in software development, focusing on the analysis of software functionality without peering into its internal structures or coding. The primary aim of this testing method is to confirm that the software's inputs and outputs operate in strict accordance with the predefined requirements and specifications. By abstracting the complexity of the code, this form of testing can be conducted without any knowledge of the internal workings of the software, ensuring an unbiased assessment of its external behavior. Table 1 illustrates the results of the black box testing conducted on the Augmented Reality Jogja Student Islamic Boarding School 2 application, detailing its operational performance against the expected outcomes.

Table 1. Black Box Testing

No.	Testing	Information	Results	Conclusion
1	Splash Screen Page	This is the initial page displayed upon opening the application. The test confirmed that the splash screen functions as intended		Succeed
2	Main Menu Page	The test validated that the main menu successfully displays options for the AR scan, application guide, information menu, and an exit button		Succeed
3	AR Scan Menu Page	The functionality of displaying 3D objects, along with the detail and return buttons, was tested, and found to be successful		Succeed
4	Detail Page in AR Scan Menu	The test ensured that detailed information about each building is displayed in text format, with a return button available. The feature operated correctly		Succeed
5	Return Button	When the return button on the AR Scan Menu Page was engaged, it appropriately navigated back to the main menu	Will return to the main menu page	Succeed
6.	Zoom In/Out Button	The zoom in/out feature on the AR Scan Menu Page was tested, confirming that 3D building objects could be zoomed in and out effectively	3D Building objects will zoom in/out	Succeed
7	Application Guide Menu Page	The page displayed general instructions on how to use the application, with return and exit buttons functioning correctly		Succeed
8	Return Button	Clicking the return button on the Application Guide Page redirected back to the main menu as expected	Will return to the main menu page	Succeed

No.	Testing	Information	Results	Conclusion
9	Exit Button	When the exit button on the Application Guide Page was used, it closed the application, confirming its functionality	Will exit the application	Succeed
10	Information Menu Page	This page displayed information about the boarding school, with both return and exit buttons operational		Succeed
11	Return Button	Engaging the return button on the Information Page took the user back to the main menu, confirming its successful implementation	Will return to the main menu page	Succeed

3.1.3 Android Device Test Results

Device testing is a process used to identify accuracy, compatibility, and good performance on various devices that may be used by users in an application implemented in a system. This testing involves testing various types of different smartphone specifications. The goal is to ensure that the application functions correctly across devices and to identify any issues or limitations that may occur on a particular device. The list of Android devices used to test AR applications at the Jogja 2 student Islamic boarding school is presented in Table 2.

Table 2. Android Device Testing

No.	Device	Device Specifications	Results	
			Status	Information
1	Realme 7i	Android 11, 8GB RAM, 64 MP rear camera, resolution 1600 x 720 pixels.	Succeed	Smooth, move from splash screen page to main menu page 4 seconds, move to AR Scan page 2 seconds, move to application guide and information page 2 seconds.
2	Redmi Note 10S	Android 11, 8GB RAM, 64 MP rear camera, resolution 1080 x 2400 pixels.	Succeed	Smooth, move from splash screen page to main menu page 4 seconds, move to AR Scan page 1 second, move to application guide and information page 1 second.
3	Xiaomi Pocophone F1	Android 10, 6GB RAM, 12 MP rear camera, resolution 1080 x 2246 pixels.	Succeed	Smooth, move from splash screen page to main menu page 4 seconds, move to AR Scan page 1 second

3.2 Discussion

Based on the research results, the application of the three-dimensional augmented reality application in the construction of the Jogja 2 Student Islamic Boarding School using the waterfall method is useful in supporting research. This application makes it easy for prospective students or the public to experience the three-dimensional layout of the buildings and rooms of the Jogja Student Islamic Boarding School 2. So, prospective students or the public do not need to come in person if they want to know the layout of the Jogja Student Islamic Boarding School building 2. When creating a program, the tools used are Unity to create applications, Visual Studio Code to do text editing. The programming language used is C#, the database uses Vuvoria to store image data on the markers. The system has several main menus, especially AR Scan to display three-dimensional details of rooms and buildings. The information menu contains complete information about Islamic boarding schools and the instructions menu contains information on how to use the application. The application of augmented reality has succeeded in providing a solution for prospective students or the public who want to see the Jogja 2 Student Islamic Boarding School building directly without having to visit the location physically or in person.

4. Related Work

Research conducted by Jusrati Attas [12]. This research aims to promote the Nurul Jadid Bua Islamic Boarding School, using brochures that apply Augmented Reality technology. With the implementation of Augmented Reality, it is hoped that it will attract the interest of prospective students or consumers in the products offered. Because it makes it easier for users to understand the specifications of the products offered using only a brochure, which will then display a 3-dimensional visualization when the cellphone camera is pointed at the brochure. In the research, the author used the waterfall model method, which is a very easy method for designing applications. Other research shows that the application of augmented reality technology to information has the benefit of providing more interesting and clear information. Research conducted by Agung Selamat Riadi [13]. This research aims to provide historical knowledge, information, locations, and operating hours of tourist attractions in the form of three-dimensional objects to tourists using augmented reality technology. In terms of data collection techniques, this research supports observation techniques, interviews, literature studies. For application development, this research uses the waterfall model method. When using the application, the user directs the camera at the marker to be scanned, then the camera will track the marker and will render three-dimensional objects above the identified marker. This will make it easier for tourists who visit the Old City of Jakarta to find out about the historical buildings in the tourist area. The aim of research related to augmented reality is to provide interesting information in visual or three-dimensional form. So, this information can be obtained easily, clearly and is very interesting to use as a reference.

5. Conclusion

Considering the findings from this research, the developed application demonstrates proficient functionality on Android platforms, particularly when operated on devices with adequate specifications and necessary support systems like ARCore. This compatibility is crucial for the application's performance, as it heavily relies on the hardware's capacity to handle augmented reality processing. However, the research also underscores certain limitations, indicating areas where the application could benefit from further refinement and testing. This continuous improvement process is vital in software development, especially in the realm of emerging technologies like augmented reality, where user experience and technological capabilities are rapidly evolving. One of the primary recommendations for future development is the enhancement of the application's features. Current functionalities, while effective, could be expanded to include more interactive elements, thereby enriching the user's engagement with the content. This could involve incorporating additional informational layers, interactive simulations, or even gamified learning modules, which could make the exploration of the boarding school's structure and facilities more compelling and informative. Another critical area for improvement is the user interface and experience design. The current application, while straightforward and functional, presents a relatively basic aesthetic that might not fully capture the user's attention or provide an immersive experience. A more sophisticated design, focusing on user-friendly navigation and visually appealing graphics, could significantly enhance the application's appeal. This involves not only aesthetic improvements but also intuitive design elements that make the application accessible and enjoyable for a diverse user base, including those who may not be as technologically adept. Additionally, the realistic rendering of three-dimensional objects is an aspect that deserves particular attention. As the core of an AR experience lies in how convincingly it can merge virtual elements with the real world, enhancing the realism of 3D models can dramatically improve the overall impact of the application. This could involve using higher resolution textures, more accurate lighting effects, and more detailed models to create a more lifelike and engaging virtual environment. In conclusion, while the application successfully demonstrates the potential of augmented reality in educational settings, particularly for institutions like Pondok Pesantren Mahasiswa Jogja 2, there is ample room for advancement. By focusing on enhancing the interactive features, user interface, and the realism of 3D models, the application can evolve into a more powerful educational tool. Such improvements will not only bridge the information gap more effectively but will also set a new standard for the use of augmented reality in educational contexts, offering a model that can be replicated and adapted for similar institutions worldwide.

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