

Development of a Location-Based Augmented Reality Application for Navigation

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Abstract

Universitas Klabat (UNKLAB) is one of the private higher education institutions directly affiliated with the Seventh-day Adventist Church (SDA), located in North Minahasa, North Sulawesi. UNKLAB has approximately 3,500 students and boasts many buildings and facilities, including lecture halls, dormitories, sports fields, and more. Given the vast campus and numerous buildings, navigation is essential to help individuals find their way to specific buildings or locations. With the advancement of technology, the author identified an opportunity to implement Augmented Reality (AR) technology as a navigation aid at Universitas Klabat, utilizing iOS as the chosen platform. In this application, users can search for various locations, such as buildings, facilities, or faculty residences. The Research and Design (R&D) method was employed for this study, wherein the researcher conducted investigations and subsequently developed this application. During the application's development, one of the models within the Software Development Life Cycle (SDLC), namely the Prototyping model, was utilized. The researcher successfully created a location-based Augmented Reality application for navigating UNKLAB's campus, and it functions effectively on iOS mobile devices.

Keywords— UNKLAB, Navigation, Augmented Reality, iOS

1. INTRODUCTION

Universitas Klabat (UNKLAB) is one of the private higher education institutions directly under the administration of the Seventh-day Adventist Church (GMAHK) in North Minahasa, North Sulawesi. Universitas Klabat accommodates approximately 3,500 students and hosts numerous visitors [1]. Currently, Universitas Klabat has three lecture buildings, Pioneer Chapel (PC), Cafeteria, three male dormitories, three female dormitories, faculty apartments, Universitas Klabat High School, Universitas Klabat Junior High School, Universitas Klabat Elementary School, Universitas Klabat Kindergarten, Sports Hall, East Hall, Health Unit, Soccer Field, Tennis Court, Study Garden, Administration Building, Prayer Garden, as well as 64 faculty houses [2].

Universitas Klabat boasts a vast campus area, complemented by various campus buildings and facilities. Beyond lecture buildings, Universitas Klabat also features dormitory buildings to accommodate students who choose to reside independently within the campus. Given the extensive campus size and the multitude of buildings, especially for first-time visitors, identifying Universitas Klabat and locating specific buildings or faculty residences can prove challenging.

Navigation technology in today's era proves to be highly beneficial for determining the direction to a destination [3]. Navigation technology is a versatile tool, one application of which is within the campus environment. The use of the Universitas Klabat campus navigation application can assist new arrivals in navigating towards their intended destinations. For instance, the Administration Building is frequently visited by guests, especially students who are

registering at Universitas Klabat. However, navigation tools commonly remain two-dimensional (2D), and in certain situations, the entire area may not be fully accessible using a 2D map [3].

In line with the evolution of time, numerous technologies have emerged, and one with promising advancements is Augmented Reality (AR) technology [4]. The application of Augmented Reality technology has been underway since 1968 [4]. Augmented Reality (AR) is a technology that combines digital objects with real-world objects virtually to enhance user interaction with their surrounding environment [3]. This technology enables us to view digital objects directly using hardware such as cameras. Augmented Reality operates through several mechanisms, including Sensor-Based Mechanisms, Vision-Based Mechanisms, and Hybrid Tracking Mechanisms. Each method within the Augmented Reality mechanism has its advantages and disadvantages, depending on specific requirements [5]. Devices that can be used to display AR include mobile devices such as smartphones, tablets, and iPads, which use cameras and sensors to overlay digital objects in the real world. In addition to mobile devices, there are other examples of devices that can be used to display AR, such as glasses like Google Glass, and AR headsets like Microsoft Hololens, and one that is currently under further development is AR contact lenses being developed by a startup named Mojo Vision. [6] With the advancement of time, the implementation of AR has greatly assisted in various fields such as sports, gaming, advertising, education, navigation, maintenance, medical, military, and many others. [7]

With the ongoing advancement of AR technology in today's era, the author envisions an opportunity to implement Augmented Reality as a real-time navigation tool at Universitas Klabat for both students and visitors. Real-time can be defined as something that happens instantly [8]. This means that navigation information is delivered or processed immediately after it occurs, without delay, as it is continuously updated every second. The primary advantage of adopting AR technology lies in its visually engaging display, presenting three-dimensional objects in the real environment, complete with animations. In other words, it transforms the real world into a user interface [9].

Mobile devices have become the ideal platform for implementing AR technology due to their portability, allowing for quick access anytime and anywhere [10]. The chosen operating system for this endeavor is iOS. iOS (iPhone Operating System) is a mobile operating system developed by Apple Inc. and runs on Apple devices such as the iPhone and iPad. Initially, iOS was developed to support the operation of Apple's mobile phone product, the iPhone, and was specifically designed for three Apple devices: the iPhone, iPad, and iPod Touch [11]. Furthermore, iOS provides a built-in platform called ARKit, which aids developers in creating AR experiences on iPhones and iPads [12].

The objective of this research is to develop an application for navigating the buildings and facilities at Universitas Klabat using Location-Based Augmented Reality technology. The aim is to assist students and guests in real-time navigation around Universitas Klabat. This research is expected to provide a solution for individuals who wish to visit Universitas Klabat, making it easier for them to familiarize themselves with the campus. The application is also anticipated to fulfill the needs of visitors and students at Universitas Klabat, such as providing information about buildings, specific building locations, details about UNKLAB's buildings and facilities, as well as guiding directions within the campus area to prevent visitors from getting lost. Every year, new high school graduates come to Universitas Klabat to enroll as students. Therefore, this application is expected to be highly beneficial for new students at Universitas Klabat by aiding in their introduction to the campus environment and facilitating a quick familiarity with the campus surroundings.

Several relevant previous studies to this research include the study titled "Design of Augmented Reality Application as Information and Navigation at PGRI Kanjuruhan University Malang Based on Android" by Heni Dwi Nurazizah, Danang Aditya Nugraha, and Alexius Endy Budianto. This research was conducted at PGRI Kanjuruhan University Malang with a focus on developing an Augmented Reality application for campus navigation. Utilizing the Research and Development (R&D) method, the study involves four main stages: needs analysis, design,

development, and testing. The resulting application can be used by users at PGRI Kanjuruhan University Malang to navigate rooms and buildings. Blackbox testing results indicate that the application functions effectively. Similarities with previous research conducted by the same researchers include the focus on developing AR applications for campus navigation and the use of the R&D method with four similar stages, involving needs analysis, design, development, and testing [13].

The second study, titled "Mobile Campus Tour Augmented Reality Engineering at Bogor Agricultural University," by Auzi Asfarian and Firman Ardiansyah, resulted in the development of a prototype Augmented Reality (AR) application for campus tours at Bogor Agricultural University based on the Android platform. The research method encompassed stages such as system needs analysis, hardware acquisition, data acquisition, software implementation, and testing. The study utilized mobile devices with the Android operating system equipped with an accelerometer, magnetometer, GPS, and camera. The resulting application, named IPB Reality Browser, enables simple navigation within the IPB Dramaga campus environment. Similar to our research, the focus is on developing AR applications for campus navigation using mobile devices as a platform, but this study specifically chose the Android operating system [14].

The third research, titled "Development of Augmented Reality Mobile Navigation at the University of Jember with Scenario Approach," conducted by Ahmad Syafiq Kamil, involves the development of an Augmented Reality (AR) application to assist navigation at the University of Jember, which covers an area of 1,120,508.5 m². This application is based on the Android operating system with GPS features. The research is qualitative and descriptive, employing a scenario approach for needs analysis and using a prototyping model in the Software Development Life Cycle (SDLC) for application development. The development stages include system needs analysis, prototype design, user evaluation, system coding, testing, and evaluation. Testing encompasses white box testing to measure system performance, black box testing to examine application functions, and a scenario approach using test cases. After completing these stages, the application is ready for use. Similarities with other research lie in the focus on developing AR applications for campus navigation and utilizing the prototyping model in SDLC [15].

2. RESEARCH METHODS

This section details the methodology used in the research, including the conceptual framework, research design, and research methods employed.

2.1. Conceptual Framework

Figure 1 below, illustrates the working mechanism of the augmented reality navigation application developed by the researcher for Universitas Klabat. The flow of the image is as follows: users utilize their smartphones to open the Augmented Reality Navigation Application for Klabat University. Subsequently, the application requests permission to access the camera and location on the user's smartphone.

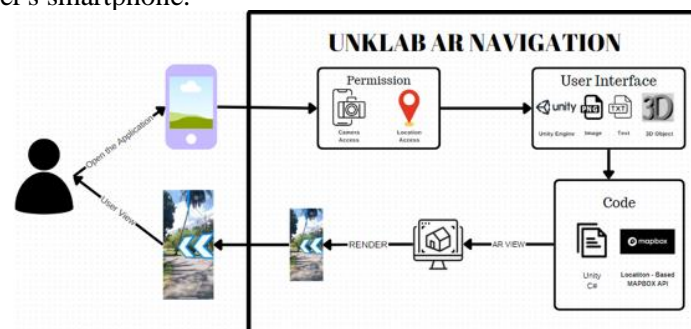


Figure 1. Conceptual Framework

The AR navigation app integrates the GPS location sensor on the smartphone to acquire information about the user's location. The application accesses maps and necessary location data to determine the user's position and destination. The augmented reality components within the app use location data to present an expanded reality view through the smartphone camera. This expanded reality view involves the incorporation of three-dimensional objects into the real environment via the user's smartphone camera. Additionally, it includes the overlay of location-based information such as directional indicators, destinations, and other relevant details.

Users perceive a representation of digital objects in their real surroundings through their smartphone screens, displaying navigation information visually. By employing augmented reality mechanisms and location data, users can easily follow visually displayed navigation instructions within the expanded reality view, featuring three-dimensional objects, ultimately facilitating their journey to the intended destination.

2.2. Research Design

The research method to be employed in this study is the Research and Development (R&D) method. Research and Development (R&D) is the research methodology that combines two approaches such as research and development to create an innovative curriculum and learning [16].

The Research and Development (R&D) research method consists of the following stages:

1. Requirement Analysis

The needs analysis involves collecting necessary data, which is then processed to identify user needs and required features. Data collection methods include reading scientific journals, conducting interviews, surveys, consulting books, or other sources.

2. Design

In this stage, the design is created to provide an overview of the application to be developed. This includes architectural design, software design, and application interface design.

3. Development

During this stage, the researcher translates the existing design into code. The application is developed using various tools such as Visual Studio, Unity, and others. The development process follows one of the Software Development Life Cycle (SDLC) models, namely Prototyping.

4. Testing

The final stage is the testing phase, where the developed application is evaluated to ensure it runs smoothly and aligns with the specified needs and objectives.

2.3. Prototyping Model

In the application development process, the researcher employs one of the models in the Software Development Life Cycle, namely the Prototyping model. This model enables users to have an initial understanding of the software under development, and users can conduct testing before the application is fully released.

The stages of application development using the prototyping model are as follows:

1. Requirement Analysis

In this stage, the researcher analyzes to outlines the requirements of the application. The researcher's requirements analysis can be carried out by collecting data from online sources such as journals, books, and websites to determine what is needed and utilized in the augmented reality navigation application. The analysis conducted by the researcher is based on the first Prototyping theory, which involves visiting and observing places such as classroom buildings, campus facilities, as well as faculty

houses within Universitas Klabat. The researcher captures points from MapBox, which is one of the largest custom map providers [17], within Universitas Klabat, records the areas within Universitas Klabat intending to provide the researcher with an understanding of where to place digital objects within Universitas Klabat. Finally, the researcher compiled a list of places within Universitas Klabat, such as lecture buildings, administrative buildings, study gardens, prayer gardens, pioneer chapel, and others.

2. Design

In this stage, the researcher creates the user interface design of the application based on the required features derived from the conceptual framework, which outlines the essential needs that must be addressed. The design is crafted to provide an overview of the developed application and assists the researcher in evaluating the application's appearance. In this era, the User Interface/User Experience (UI/UX) of an application holds paramount importance.

3. Prototyping

The next stage is prototyping, this method involves producing an early, inexpensive, and scaled-down version of the product to reveal any problems with the current design. [18] During this stage, users can observe the input and output provided by the application. Building a prototype involves creating a model or a simplified flow of the system to be developed.

4. User Evaluation

Next, when the prototype of the application has been provided to users for use as an initial version, users can conduct evaluations to determine whether the prototype model aligns with their needs and objectives. User evaluations can take the form of feedback, including both criticism and suggestions. It is beneficial to investigate the performance model's strengths and weaknesses. Customer feedback and suggestions are gathered and forwarded to the developer [19]. This feedback serves as valuable input for developers, guiding them in the further development of the application for subsequent versions.

5. Review and Update

This stage involves the researcher, as the application developer, engaging in version maintenance. When certain parts of the application do not meet user needs, the developer conducts a review and updates the application based on the feedback provided by users. The updates made by the researcher are informed by the prototype that has been used by users in the previous stages. This iterative process allows for continuous improvement and refinement of the application to better meet user requirements.

6. Development

If the prototype has undergone evaluation and review, and it successfully meets the fundamental needs of users, including the goals and primary functions of the application, it can be considered accepted. At this point, the prototype can proceed to the development stage, where it will be translated into the appropriate programming language. This marks the transition from the prototype phase to the actual implementation of the application's features and functionalities.

7. Testing

After the application is completed, testing will be conducted to ensure that the developed features and systems can function properly. Prototype testing is the process of testing an early version of a product or feature with real users. The purpose of prototype testing is to validate the design before development starts and identify problems early on, so you can build a product that meets user needs and expectations [20].

8. Maintenance

This stage is where the application undergoes updates and improvements if there are any deficiencies identified by the researcher or by subsequent researchers who aim to enhance the application further.

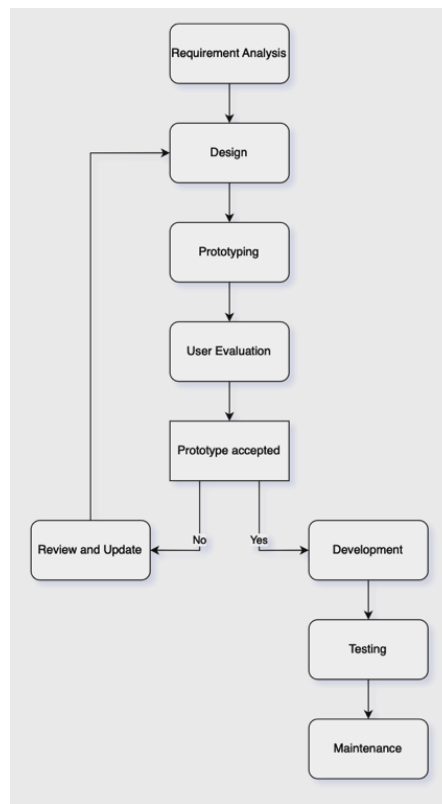


Figure 2. Prototyping Model

3. RESULT AND DISCUSSION

The researcher has developed the Universitas Klabat navigation application using Augmented Reality technology.

3.1. Implementation

This section show the implementation of the application. Figure 3 displays the first page of the application when it is initially activated. This page features the UnkNav logo and a brief description of the application. The interface design was developed using Unity to create a user-friendly experience, with UI elements customized to fit the application's theme. There are two primary buttons: the 'start' button at the bottom, which navigates to the search and location list page (Figure 5), and an 'info' button at the top right, which opens an information page about the application (Figure 4). The design and functionality were implemented following the principles of User Interface (UI) and User Experience (UX) design to ensure intuitive navigation and accessibility.

Figure 4 shows the information page of the application, which includes a description of the application's purpose, its benefits, and information about the developer. This page was developed using Unity's UI system, ensuring that the text is readable and well-organized. The content on this page was designed to provide users with a comprehensive understanding of the application, its intended use, and its development process. This is crucial for transparency and

user engagement, making sure that users are well-informed about the application's capabilities and background.

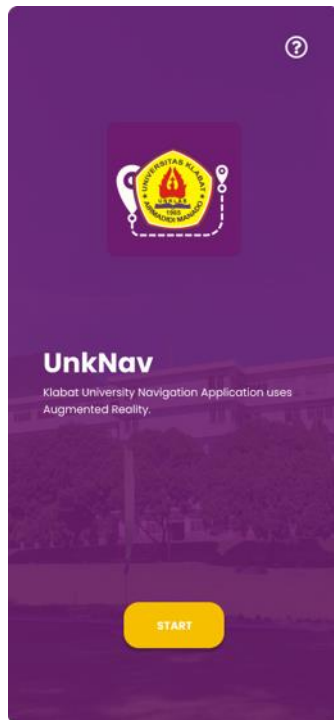


Figure 3. First Page



Figure 4. About Page



Figure 5. Search Page and Location List



Figure 6. Navigation Page

Figure 5 presents the search page and location list within the application. Users can browse and search for various locations available on the campus through this interface. Each location list, represented as a scene in Unity, includes longitude and latitude coordinates. The development of this feature involved integrating the Mapbox API with Unity, enabling real-time location data to be displayed and searchable within the application. The search functionality was implemented using Unity's scripting capabilities to manage user input and dynamically display relevant search results. This page is a critical part of the application, allowing users to easily find and navigate to specific locations on campus.

Figure 6 displays an Augmented Reality (AR) view that provides navigation guidance within the campus. This AR view was developed by integrating the Mapbox API with Unity, using Unity's AR Foundation package to build and deploy AR features. In this figure, users can see virtual navigation instructions overlaid on their real-world surroundings through their device's camera. The AR elements, including 3D models and interaction scripts, were adapted from assets available on the Unity Store to match the campus navigation context. Additionally, there is a question mark icon button that users can tap to view detailed descriptions of the targeted locations, as illustrated in Figure 7.

Figure 7 shows a detailed description of the targeted location within the AR navigation view. When users tap on the question mark icon in the AR view (as seen in Figure 6), it triggers a display of additional information about the selected destination. This feature was implemented using Unity's UI elements to provide an interactive and informative experience. The integration of real-time data from the MapBox API ensures that the descriptions are accurate and relevant to the user's current location and selected destination.

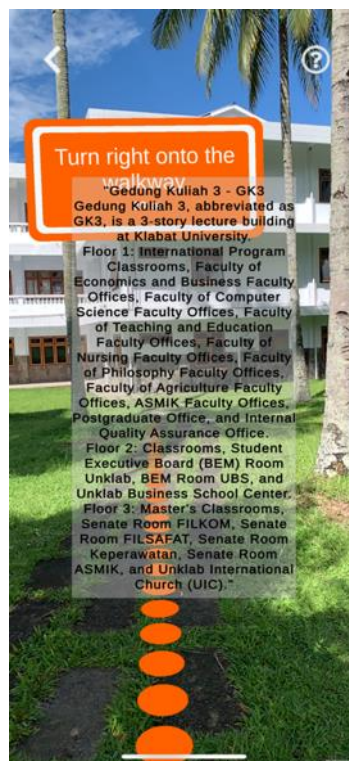


Figure 7. Description of the Targeted Location

3.2. Testing Results

1. Unit Testing: The testing results show that each application component functions according to specifications.

2. System Testing: The application was tested on iOS 15 and iOS 16 devices owned by the authors. The application is stable and compatible with these versions.
3. Latency Testing: The application demonstrated an average response time of 1 second for location searches and 2 seconds for AR navigation.
4. Network Performance Testing: The application was tested on Wi-Fi and 4G networks to evaluate its performance. Results indicated consistent performance across both network types, with minimal lag in AR rendering.

4. CONCLUSION

Based on the results and discussions presented in the previous chapters, the following conclusions can be drawn:

1. The developed application successfully displays navigation with an AR view from the user's location to the user's selected destination available within the application. The navigation and map utilized in this application are sourced from the Mapbox API, while the Augmented Reality technology used is obtained from AR assets available in the Unity Store.
2. The application is installed and functions properly on mobile devices with the iOS operating system.

5. RECOMMENDATIONS

Based on the results of the development of this application, the researcher has identified certain shortcomings that can be improved in the future. Therefore, the researcher suggests the following recommendations for future researchers to make improvements and further developments to the application :

1. Make the application multi-platform to enable its use on the Android operating system as well.
2. Add a bookmark location feature to the application.
3. Integrate an additional user type, namely an Admin, who can perform updates in case there are changes in buildings and facilities within the campus.
4. Incorporate an audio feature for navigation guidance.
5. Adding a 2D map view for navigation.
6. Implementing a feature to change the color of existing 3D objects.

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