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Analysis and Implementation of Augmented Reality Using Markerless and A-Star Algorithm (Case Study: Gedung Kuliah Umum ITERA)

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ABSTRACT

Institut Teknologi Sumatera is a public university in the province of Lampung. Institut Teknologi Sumatera (ITERA) has many buildings, including Gedung Kuliah Umum (GKU). GKU is the largest and widest lecture building in ITERA. GKU has four floors, where each floor has many rooms in it with different functions in each room. As the largest building in ITERA, GKU is often used for various events, including CPNS exams, new student admissions, or for visits from other campuses. Due to the size of this building, this allows visitors from outside ITERA to GKU to experience problems in terms of time to ask questions and difficulty finding various spaces in the GKU Building. This research uses Augmented Reality technology to help make it easier for visitors from outside ITERA to find space quickly and precisely. In its development using several tools, including the ARWaKit SDK. This framework is used on devices with the IoS operating system. In its implementation, it requires a camera on a smartphone to capture existing images and convert them into cyberspace. In the ARWayKit framework, Azure Spatial Anchors have been used which can be used to carry out the mapping process as a markerless method and to optimize the distance from the user's position to the destination location, the a-star algorithm is used. The results obtained from the Variation-2 test were 91.6%.

Keywords: A-Star, ARWayKit, Augmented Reality, Markerless, GKU

1. INTRODUCTION

Institut Teknologi Sumatera is a state university in the city of South Lampung. ITERA was founded in 2012 and inaugurated in 2014. Until now ITERA development continues, various infrastructure developments from year to year are always increasing. Along with the increasing number of students, adequate facilities are also needed so that they can provide better quality of student learning facilities and infrastructure. The addition of the building and the different building areas will make it difficult for new visitors to find the space they want to go to. Not all buildings on campus locations already have a floor plan for each room, one of which is the GKU building.

The GKU building is one of the largest buildings on the ITERA campus, consisting of four floors, and has many rooms and different functions. The GKU building has always been used as the center for implementing campus events, so it is often possible to find new visitors from outside the campus. With the large size of the GKU building, it is possible that visitors will spend a lot of time asking question

in finding the location of the space they are looking for.

Collecting data using a questionnaire, a questionnaire is needed as an initial stage to determine what problems are currently being experienced [1]. From collecting data using a questionnaire, 112 respondents got data that stated that the GKU building was often used as a campus event activity with the highest total of 66.1%, then new visitors would have difficulty when looking for a GKU room with respondents supporting 61.6%, and respondents who support this application will be useful for new visitors as much as 61.6%. Then the next thing is the results of observation data carried out based on the researcher's own sources getting data on the capacity of the existing room in the GKU building as many as 2520 and in building F having a capacity of 1260. From this capacity it can be seen that the GKU Building is the largest building and all events in the ITERA environment are held in the GKU Building, therefore it is necessary to approach efforts in the form of technology to assist new visitors in obtaining information related to the location of the space in the GKU Building [2].

Based on the description of the previous needs and problems, using augmented reality technology to combine the dimensions of the real world with the dimensions of the virtual world which is displayed in real time as a navigation pointer for finding the location of the room [3]. In making augmented reality, a markerless method is needed to track objects contained in the real environment without using a marker which is commonly called a marker [4]. Another research conducted by Yohanes [5], shows the results that the percentage of success of the markerless algorithm is better than the marker algorithm, because from a total of 25 trials there were 4 failures with marker based and 0 failures using markerless.

Based on the results of the comparison of the closest distance search algorithm that has been carried out by Handy Permana et.al. [6] that the comparison between the A-Star, Dijkstra, and Breadth First Search algorithms shows that the A-Star algorithm is the best algorithm in finding the closest distance, especially in the game/grid maze. Augmented Reality capability can be a solution to the problem of building space search navigation (indoor) with the markerless method as an object tracker and the A-Star algorithm as the closest distance search [7][8]. The implementation of augmented reality will be embedded in mobile-based applications. This mobile-based application is used to help make it easier for users to get real-time information and be more portable [9].

2. METHODS

In this study, there are two types of users who will use augmented reality applications, namely ordinary users, and admins. Where related activity diagrams from users to applications and admins to applications can be seen in Figure 1 and Figure 2.

The Activity Diagram in Figure 1 is a process flow that occurs on the user/user's side when searching for the closest space to the destination by displaying AR objects. When the user opens the Play AR menu, it will display a menu for the navigation function with the first process being tracking markerless based on anchor points that have been set on the ARwayKit web service.

In Figure 2 is a diagram of the activities carried out on the admin system when the admin wants to create additional routes that will be stored in the application

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database. The data that has been created by the admin is used for users using the navigation route that has been created by the admin

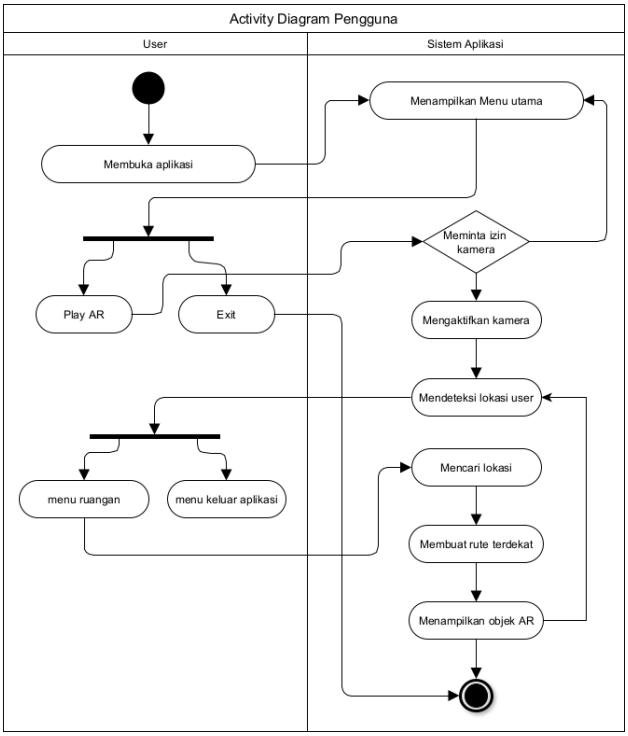

FIGURE 1. User Activity Diagram for AR Applications

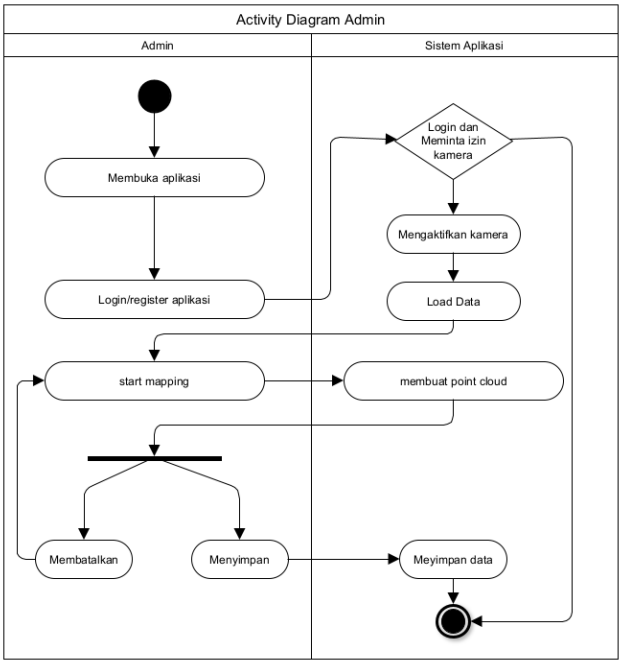

FIGURE 2. Admin Activity Diagram for AR Application

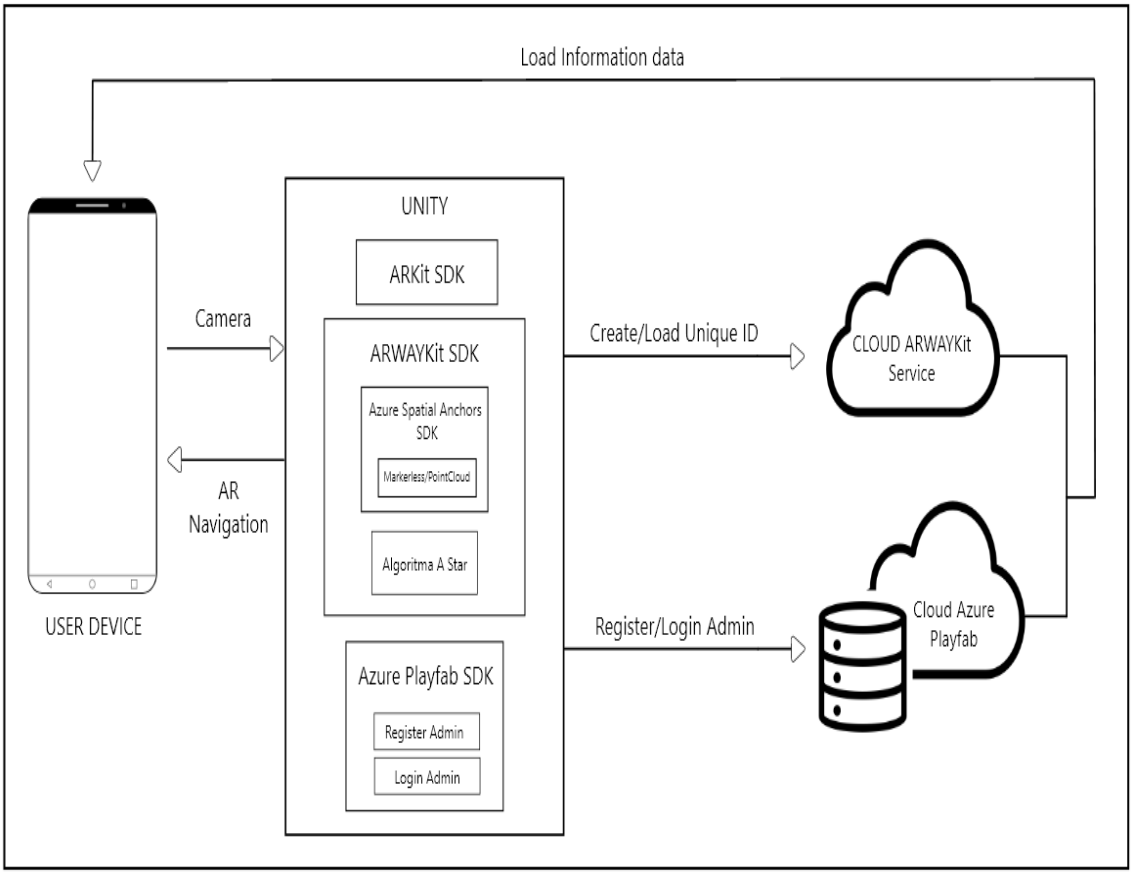

FIGURE 3. System Overview

In Figure 3, the main process carried out by the smartphone first loads data from Azure PlayFab to create the mapping needed on the system when entering the AR play menu or when successfully logging in to admin. When it is done, the application scans the user's environment as the initial initiation of the user's position.

You can see the direction of the arrow on the smartphone pointing to the box containing the Unity3D Game Engine for programming application development [10], then there is ARKit in a wrapped position or in a bundle as the intention that processing on an iOS smartphone requires a special AR framework on the OS device that will be created/used. While the ARWAYKit SDK is the main function of research that is integrated with Azure Spatial Anchors' services which will be used as a mapping function for markerless materials and a navigation system to perform room searches using the A-Star algorithm [11].

Then in the Azure PlayFab SDK bundle it is used as a function to signup/sign an admin account so that you can enter the mapping feature in the application. The unity bundle leads to the ARwayKit service cloud section to generate/get a unique id to be used as markerless by storing data on the ARwayKit service, this process can only be done by the admin. The user process only processes the load information data that has been created by the admin to search for room locations that have used the A-Star algorithm.

The application testing method uses Alpha testing using black box testing. Blackbox testing will focus on the output functionality section to identify the success and failure of the application functions generated during system checks [12].

Then for the next test method is the method of testing the percentage of accuracy

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based on the results of making variations of map content. Variations in the content of the map are divided into two parts to find out the best results. Tests of location search navigation in buildings were carried out three times and always starts from the starting point on the 1st floor of the spot wifi corner towards the end point to the 1st floor of the women's toilet, the 2nd floor of room 210, the 3rd floor of room 308, and the 4th floor of the hall room.

TABLE 1.
Application Testing Plan

No.	Test Cases	Test Scenarios	Expected Results
1.	Displays the results of Mapping data that has been carried out on the environment in the GKU Building	1. The smartphone is connected to an internet connection. 2. Login Admin first to be able to use the Mapping feature 3. Enable GPS service and allow camera use 4. Perform Start Mapping and point the camera at the environment 5. Mapping is done by comparing the data of all objects in the building, one floor, the left, the middle, and the right.	Object visualization of data generated from markerless mapping, and obtain latitude and longitude data
2	Showing room search navigation in GKU Building	1. Smartphone is connected to internet connection 2. Enable GPS service and allow camera use. 3. Do environmental tracking at the GKU Building. 4. The contents of the map creation are varied to perform a location search. 5. Test the accuracy of the location search from the starting point to the destination point.	Location search navigation can be displayed, find out the difference to variations in the content of the created map, and test the level of accuracy obtained from variations in map creation.
3	Showing the closest distance location search using Unity	1. PC/Laptop is connected to the internet connection. 2. Play Unity 3. Open the Navigation Menu. 4. Conducting a location search experiment.	Location search can be displayed in Unity and can run.

The A-Star algorithm is one of the pathfinding algorithms that can be used for location searches with the results of selecting the shortest distance from the starting point to the destination point by taking into account the distance g(n) between nodes that can be traversed, and adding the calculation to the heuristic value of h(n) as an estimate of the cost weight value to get to the destination point in order to produce a node evaluation value f(n) as a consideration of the path to be traversed to reach the destination point/node [13][14]. The researcher will try to describe the workings of the a-star algorithm using a simple GKU plan with the condition that if a path is made that can only be passed on the 1st floor to the 2nd floor or vice versa, and the

starting point (node S) is on the 1st floor and the destination/target point (node T) is on the 2nd floor, the illustration can be seen in figure 4.

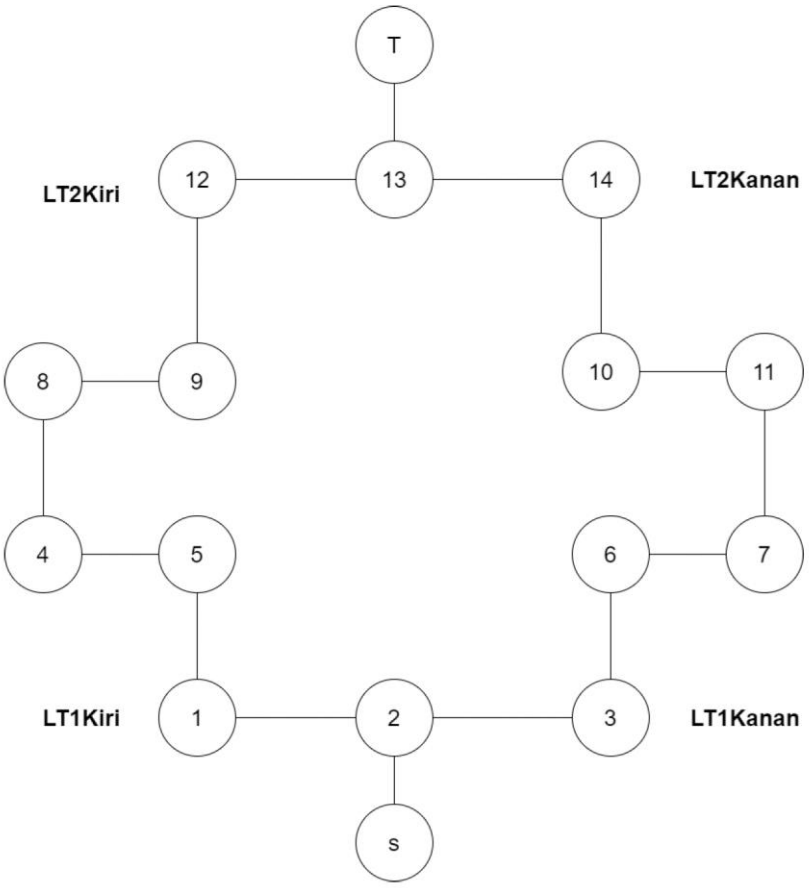

FIGURE 4. GKU Graph Chart

To determine the distance between nodes and the next one can be calculated point n Cartesian coordinates xyz with the formula Distance Formula in formula 2.1:

$$d(P_1, P_2) = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2 + (Z_2 - Z_1)^2} \quad (1)$$

d = distance
p = point

3. RESULT AND ANALYSIS

This application was made in the Windows OS environment by researchers for the needs of making applications as well as demo/testing the desktop and the Mac OS environment is used only to build/install applications to iOS smartphones. On Windows OS using Game Engine Unity3D (version 2019.4.28f1) as application development, application demo/testing, debugging, and build output in XCode

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format (version 12). Then the XCode format is built in the XCode IDE to be installed on an iOS smartphone.

Based on the needs of the application created, this application is designed using the ARKit framework to run on iOS smartphones, then the system requirements used require the Azure Playfab SDK Software Development Kit (SDK) and the ARWAYKit SDK which have been integrated with Azure Spatial Anchors. Implementation of the application using an iOS smartphone, namely iPhone XS which has fulfilled the application requirements, namely: [15]:

1. IOS Version 15
2. Has a camera sensor
3. Has a GPS sensor
4. Has a Metal API graphic standard

Requirements related to SDK implementation can be seen in table 2.

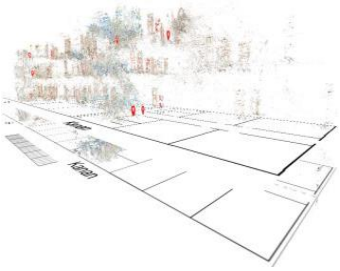
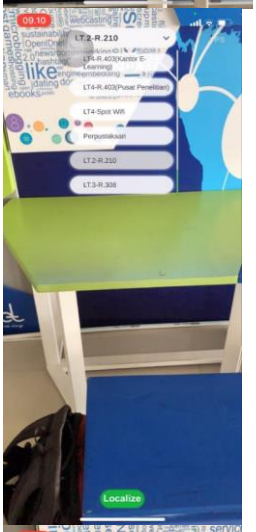
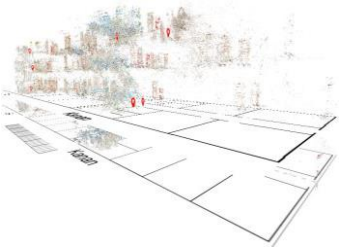
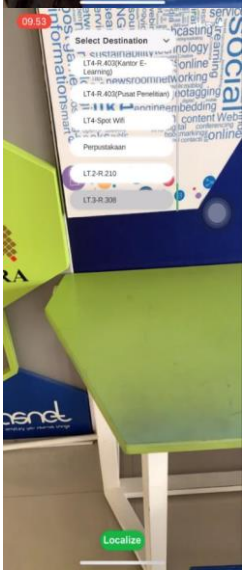
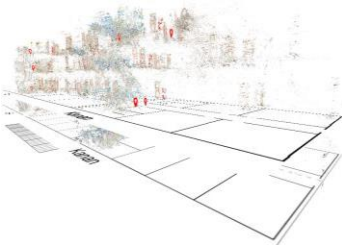
TABLE 2.
SDK Implementation

No.	Name	Version	Reason
1.	ARwayKit SDK	0.2.0	• Provide Augmented Reality services. • Provides Mapping and Navigation. • Integrated with Azure Spatial Anchors (version 2.8.1). • Can use a free account.
2.	Azure PlayFab SDK	2.114.210913	• Provides account data storage. • Can use a free account for Student.

Tables 4 and 5 are divided into 2 variations, namely ID-Scenario VARS1 and ID-Scenario VARS2. In Scenario ID, VARS1 uses all content object data that has been generated from mapping. As for the VARS2 Scenario ID, only 1 content object is used. The test was carried out on 4 floors of the GKU Building with each floor being searched for 1 room with 3 experiments carried out to find a comparison of the level of accuracy. Navigation testing related to finding locations in the GKU Building can be seen in table 3.

To know the difference in accuracy of the two variations of the map, data collection is determined starting from the starting point being on the 1st floor of the wifi corner spot to the end point to the 1st floor of the women's restroom, the 2nd floor of room 210, the 3rd floor of room 308, and 4th floor hall hall [16]. The results of the data obtained are as follows can be seen in tables 4 and 5.

TABLE 3.
Location Search Navigation Tests

ID-Scenario	Starting Point	Endpoint	Content At Web Service	Status
VARS 1-1				Success
VARS 1-2				Success
VARS 1-3				Success

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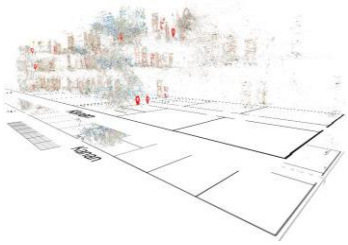
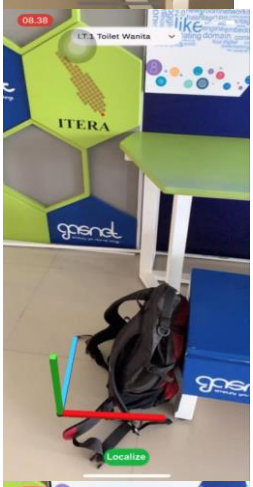
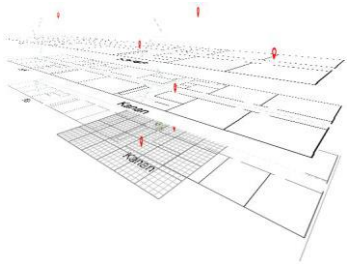
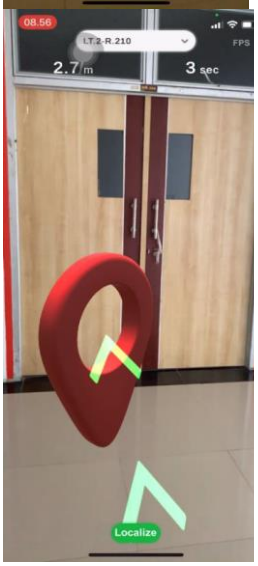
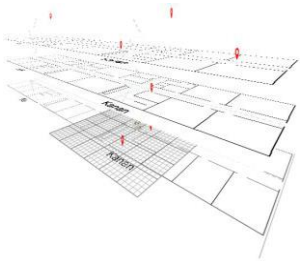
ID-Scenario	Starting Point	Endpoint	Content At Web Service	Status
VARS 1-4				Success
VARS 2-5				Success
VARS 2-6				Success

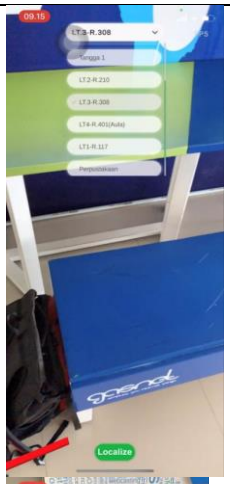
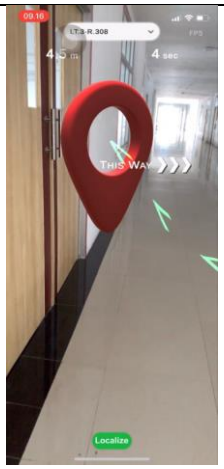
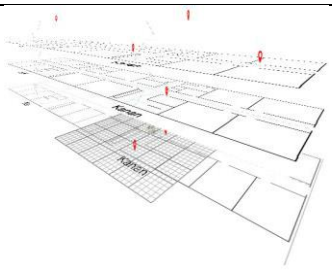
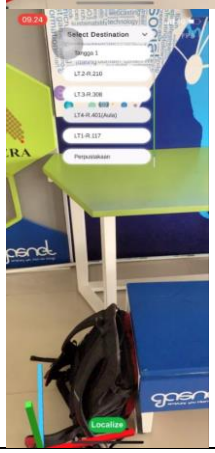
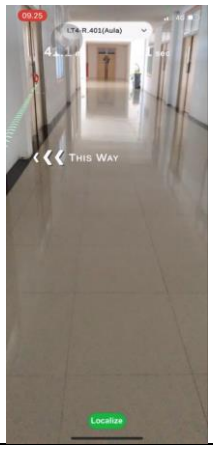
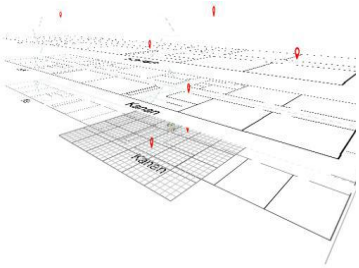
ID-Scenario	Starting Point	Endpoint	Content At Web Service	Status
VARS 2-7				Success
VARS 2-8				Success

TABLE 4.
Data on the results of variation 1

No.	Location Name	Test 1	Test 2	Test 3
1.	1st floor women's toilet	Succeed	Fail	Fail
2.	2nd floor room 210	Fail	Succeed	Fail
3.	3rd floor room 308	Succeed	Fail	Succeed
4.	4th floor hall	Succeed	Succeed	Succeed

$$accuration = \frac{total\ trials - total\ failure}{total\ trials} * 100\ \%$$

$$= \frac{12-5}{12} = 58.3\%$$

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TABLE 5.
Data on the results of variation 2

No.	Location Name	Test 1	Test 2	Test 3
1.	1st floor women's toilet	Succeed	Succeed	Succeed
2.	2nd floor room 210	Succeed	Succeed	Succeed
3.	3rd floor room 308	Succeed	Succeed	Succeed
4.	4th floor hall	Fail	Succeed	Succeed

$$accuration = \frac{total\ trials - total\ failure}{total\ trials} * 100\ \%$$

$$= \frac{12-1}{12} = 91.6\%$$

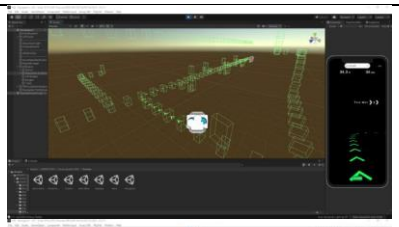
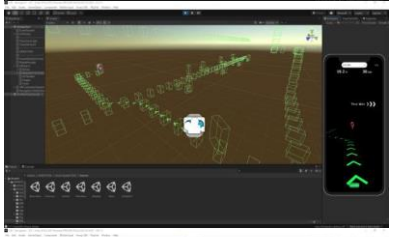
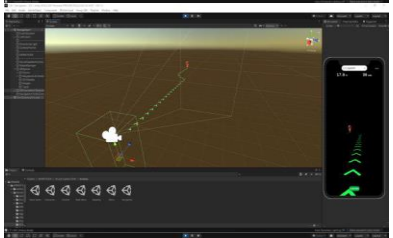
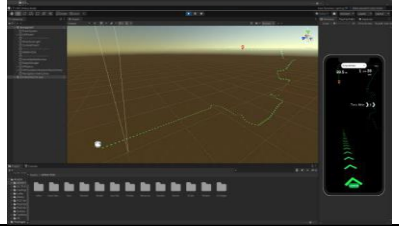
Based on the results of the calculation of the percentage of accuracy, the best performance results between the two variations are on the content of the variation-2 or VARS2 map with an accuracy of 91.6%. Meanwhile for variation-1 or VARS1 with an accuracy of 58.3% due to an error in the map content object compiled on the web service in the form of point cloud placement arrangements that overlap each other, resulting in errors such as table 4.4 in variation-1 or VARS1. Before the field test in the form of finding the location of the space, the map that has been compiled will first be carried out by a test demo that is run on Unity as in table 4.8 successfully run normally, but when the test is carried out in the field the results of the test are very different than had been expected. In table 6, the details of the shift in distance from a predetermined point are based on the success of the variation-2 or VARS2 map content.

TABLE 6.
Details of VARS2 Distance Data

		Variation 2		
No	Location Name	Trial Distance 1	Trial Distance 2	Trial Distance 3
1	1st floor women's restroom	± 80 cm	± 50 cm	± 10 cm
2	2nd floor room 210	± 30 cm	± 25 cm	± 25 cm
3	3rd floor room 308	± 5 cm	± 50 cm	± 5 cm
4	4th floor hall	± 500 cm	± 100 cm	± 100 cm

In table 6 there are data results with measurements of perpendicular distances in number-1 to number-4 experiment-1, and parallel distance measurements are found in number-4 experiment-2 and experiment-3. In the application testing demo section, researchers can test first in unity to see the results of success when making paths/node points and destinations they want to go to when searching for space locations. Table 7 is the result of the visualization of finding the nearest location using the A-Star algorithm which is run/play demo in Unity.

TABLE 7.
Application Demo Testing

No.	Starting Point	Endpoint	Visualization	Result
PDA-1	1st Floor WIFI Spot	Room 122		Succeed
PDA-2	1st Floor WIFI Spot	1st floor WC		Succeed
PDA-3	1st floor WC	1st Floor WIFI Spot		Succeed
PDA-4	1st Floor Middle	library		Succeed

4. CONCLUSION

From the results of research that has been carried out by researchers, it can be concluded that the level of accuracy of the two comparisons of the best map-making variations is in variation-2 or VARS2 with a result of 91.6%. In contrast to making variation-1 or VARS1 with an accuracy rate of 58.3%. This happens because of the placement of point clouds that overlap between other point clouds. The distance between the point clouds should be separated so that they do not accumulate, so that it does not happen as in variation-1 or VARS1. Then the results of the distance shift measurements made on the map with the distance displayed on the application do not exceed the 1.5-meter distance in the normal limit in the opinion of the researcher.

The markerless section in the GKU Building has Limitation in the form of the characteristics of the GKU building environment that it is difficult to get feature points, the mapping environment avoids glass and floor reflections, there are several dynamic lighting spots, and the environment in the GKU Building is white (a drawback of feature points/anchor). So that the creation of a point cloud switches functions that were previously expected to be used flexibly to serve as a reference

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for the placement of room/class location destinations. Based on the known shortcomings based on the research that has been done, the researcher believes that the marker method is more relevant to the current environmental conditions in the GKU Building.

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