AR Indoor Navigation for SKKU Natural Science Campus Benzene-ring Building*

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Abstract. As indoor spaces become larger and more complex due to the development of technology, solutions for efficient guidance are needed indoors. However, traditional navigation using GPS is not suitable for indoor use. AR navigation enables intuitive navigates and is useful to specify the user's indoor location with information obtained through the camera. The subject of this paper is the completion of practical AR indoor navigation available on campus. The navigation target is a structure in which five buildings are connected in a complex manner. Considering the spatial characteristics of the campus, the initial position of the user was specified using the door plate as an AR marker, and the position error during navigation guidance was corrected using a static object as an AR anchor. For 160 tests, 146 (91 percents) succeeded in guiding to the actual destination, and 52 cases were guided to the destination for 53 cases where positional correction occurred through Anchor.

Keywords: Artificial Reality · Indoor Navigation · AR marker · Indoor Positioning

1 Introduction

With the advancement in technology, not only are the buildings becoming bigger, but they are becoming more complex. This had lead the users of the building confused and losing their bearing in the building. Such results are either one or both fruition of bad architectural design category; over-complexity and over-similarity. Therefore, the need for indoor navigation is increasing, but existing GPS cannot be used indoors because the satellite's signal is blocked by a wall.

The latter category of over-similarity architectural design is the infamous "Benzene-ring" buildings, that named because 5 buildings are connected in the form of benzene rings, situated in SungKyunKwanUniversity(SKKU) Natural Science Campus(Fig: 1). These buildings have a structure that rotates and repeats, making it difficult for users to find directions indoors. We would like to create an indoor AR navigation system that can be used practically on these buildings.

* Supported by Prof. Kevin Koo

Fig. 1. Benzene-ring Building

2 Objective and Motivation

AR navigation is an area that large companies such as Apple/Google/Naver are continuously researching because it can provide intuitive guidance and apply various source technologies such as AR and AI. AR navigation allows users to see the front view at the same time as guidance in an indoor space where people or objects are more dense than outdoors, ensuring safer walking for users compared to the map method of alternating eye view with the device screen. In addition, navigation image is displayed in the vision of reality, so it is suitable as a solution for indoor navigation because it provides intuitive guidance to the user. But so far, the 'core and huge' space is a priority because it takes a lot of resources to map indoor spaces accurately and process data obtained through sensors. Google's service is difficult to introduce in Korea due to security reasons, and Naver's service is also in the process of testing in a space with a large floating population such as COEX department store(Fig: 2). For this

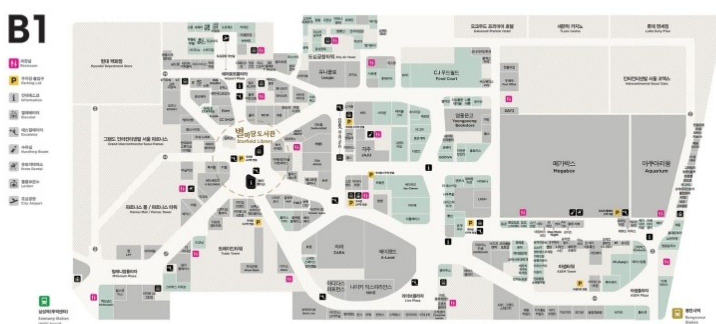

Fig. 2. COEX Building Indoor Map

reason, it is impossible to expect corporate services for campus in the near future. However, there are many buildings on campus that are prone to get lost due to repetitive structures, and due to the nature of the space called the school, there are new students and visitors every year who encounter the building for the first time. Therefore, in this project, we aim to analyze existing indoor navigation-related technologies and provide a compact and practical “Artificial Reality(AR) Navigation” service suitable for SungKyunKwan Natural Science campus. The goal of this project was to create an indoor navigation application for SungKyunKwan University(specifically benzene-ring building), allowing the user to navigate from one any one of the set locations to another set location.

We developed in 'Unity game engine' as an AR platform. We created 3d map data based on the blueprint of the campus for navigation and used the door plate that exists in all rooms of the campus as an AR marker. Estimate the user's initial position by scanning the room number of the door plate by Google Cloud Vision OCR through camera vision and comparing it with map data. The navigation path was constructed with each intersection of the campus as vertex, and the location error was corrected by recognizing the Google Cloud Anchor created by scanning the static object of the campus during navigation guidance. For the Artificial Reality Navigation, we have decided to use recording from the user's camera for the background. With icon markers to indicate the current position of the user and the destination placement, and navigation icon to indicate where to go.

The application successfully navigated 141 cases in 160 tests to the vicinity of the destination, and 52 cases out of 53 cases that recognized AR anchor successfully navigated to the vicinity of the destination to prove the location error correction function through AR anchor.

3 Design for proposed Service

The overall architecture is implemented into a 'Unity game engine' and is generally divided into two phases, standby mode, and navigation mode. During the standby mode, the program awaits the user's destination setting input. After the destination has been inputted, the program will start to scan for the current user location; this is done by the user using the built-in scanner which recognizes the number to scan the nearest room plate as AR Marker. When the scanner acquires camera vision information of the device, it processes it as 'Open CV' and sends the processed image to the Google cloud vision application server to obtain the classroom name information on the doorplate as a string through optical character recognition. Compare this with the information stored in map data to determine which room the user is in front of and set the initial location. With current location and destination location inputted, the program goes into navigation mode. The user's movement is detected by the acceleration sensor of the device and reflected in the user's position data. As explained in (Fig: 4), by using the implemented navigation algorithm, the program will search for the next destination the user is to move next to. When encountering the stair, the user will be asked to click the popup icon, once the user has finished using the staircase. If that there is an 'AR anchor' detected around the data during navigation, send a resolve request to Google cloud anchor api based on the identifier

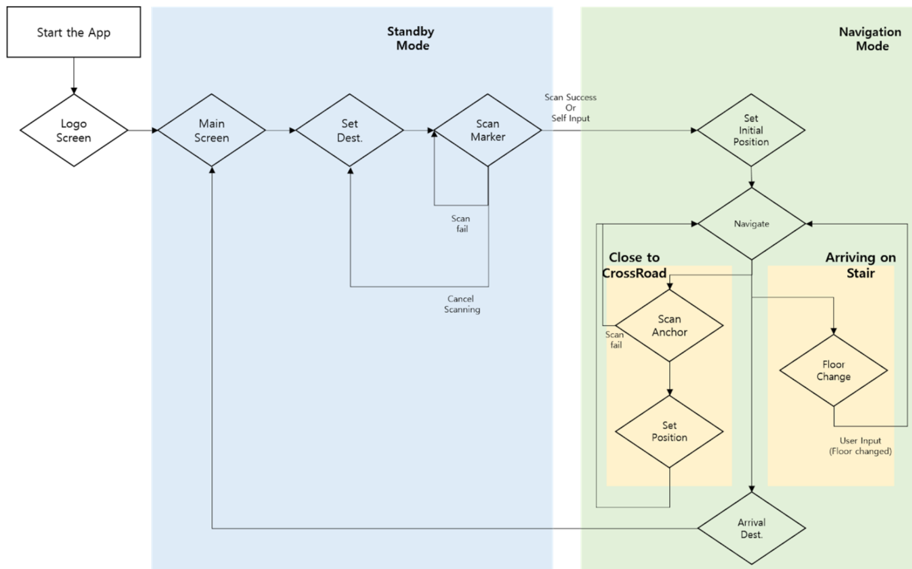

Fig. 3. App flow of Application

id of the anchor, read the anchor feature from the camera of the device, and compare it with the feature stored in the cloud anchor server. If the correct feature is found in the vision of the device, resolve the anchor and correct the error in the user location data based on the location information of the anchor and device. Once the user has reached the destination, the program will notify the user about it. Then, the program will ask the user to shut off the navigation mode, in order to revert back to standby mode.

Our Challenge is focused on studying indoor AR navigation methods suitable for the actual Campus environment. Unlike store signboards and artificially produced QR codes, every room on campus has a doorplate containing information about the room, which is used as an AR marker to read the information on the doorplate and compare it with mapped data to estimate the user's initial location. Space or objects with static and easy-to-identify features on campus, mainly emergency lights, columns, and corridors, served as the main AR anchors, and scanned them to store anchor data and resolve them during navigation guidance to correct location errors. Considering the campus environment where the classroom is mainly located in the straight corridor, the navigation was optimized by using a graph centered on an intersection rather than a vertex in all rooms and corridors, and finding an intersection adjacent to the origin and destination through Algorithm. Finally, the Arrow Guide method was adopted to provide intuitive guidance without being affected by the lighting environment or walking speed by exploring AR navigation methods suitable for campus environment of campus environment.

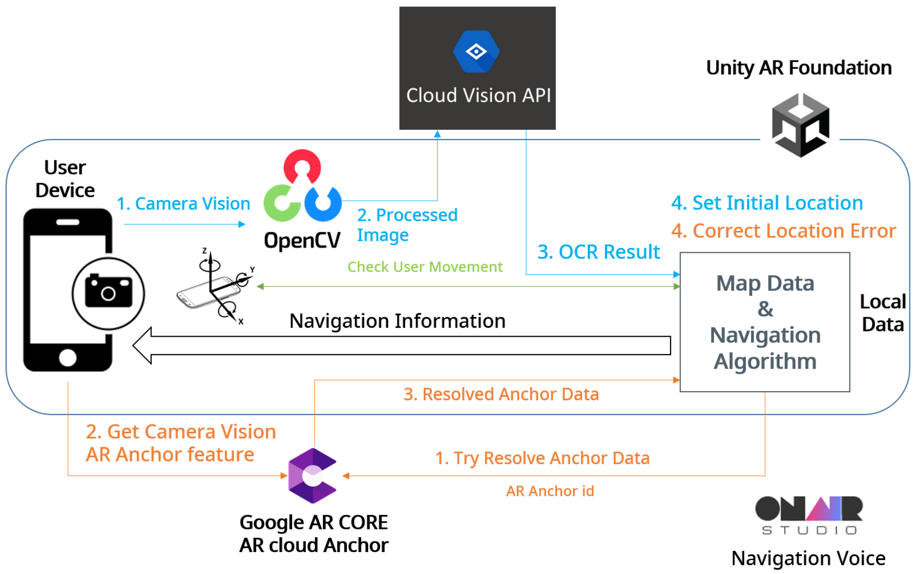

Fig. 4. Overall Architecture of Application. Blue Color: AR Marker Scan, Green Color: Acceleration Sensor, Orange Color: AR Anchor Resolve

4 Implementation

Map Data and AR Platform The Team developed in 'Unity Game Engine(2020.3.12f1 LTS)' as a platform and created 3d mapping data of Benzene-Gori-Kwan building through floor plan of campus building and actual field survey. The mapping data created in this way has location coordinates for each building's rooms and also contains location information for the anchor or navigation vertex required for navigation guidance.(Fig: 5) The 3d mapping data created in the Unity environment is easy to visually check the data, and the user's avatar can be created to simulate the navigation function and check simple functions without going to the campus.

AR Marker In estimating the user's starting position, a method called AR-marker that recognizes a specific image in which location information is stored through a camera is widely used[3][4]. We identified the user's initial location using a doorplate that is common to all rooms on campus and allows them to distinguish between rooms. Process the image obtained by the camera of the device through 'Open CV' and read the text string of the doorplate using the 'Google cloud vision api'. Compare the read string with map data and set the user's initial position according to the location and angle stored in the data, if any. Specifying the area to scan through the UI has the effect of removing

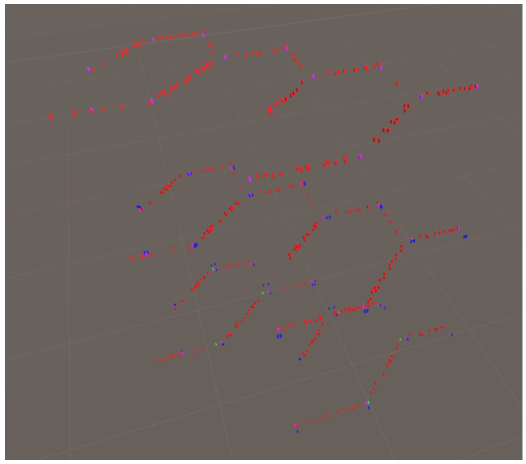

Fig. 5. 3D map data of buildings. Red: Room, Blue: Stair, Sky Blue: AR Anchor, Pink: Navigation Vertex

unnecessary parts in the image process and reducing the overall image size, which plays a major role in improving accuracy and speed.(Fig: 6) Due to lighting and other reasons, the Scan Result may not match the Map data, which allows the user to retry the scan or enter the current location directly.(Fig: 7)

Navigation Each intersection in the campus space was vertex, and the route from origin to destination was created through Dijkstra's graph algorithm, and the vertex on the next path was guided by the AR arrow pointing the direction from the user's current location. In addition, if the user attempts to move in a different direction than the direction indicated by the arrow, the user will be notified by voice that the user has left the path. The AI voice of 'Onair Studio' was used for the navigation voice. In the case of stair movement, when floor change is required on the path, the stair movement guide UI is displayed near the stair and the application is informed that the user completes the stair movement through UI interaction.

AR Anchor AR anchor was used to correct the error between the user's current position and the data of the app's recognized position because the acceleration sensor reflects the user's approximate movement fairly well but not 100percents accurately. We scanned static and characteristic spaces or objects on campus and hosted them as AR anchors, and recorded the location where they were hosted in map data. The 'Google Cloud anchor api' was used for the anchor's host and resolve. If the user's location data is adjacent to AR Anchor data during the navigation operation, an attempt is made to resolve the Anchor based on the ID of the corresponding data. By resolving AR anchor, we can obtain position information between the user device and the AR anchor[5]. This corrects the

Fig. 6. Door Plate Scan UI, Reads only the area inside the yellow rectangle validly.

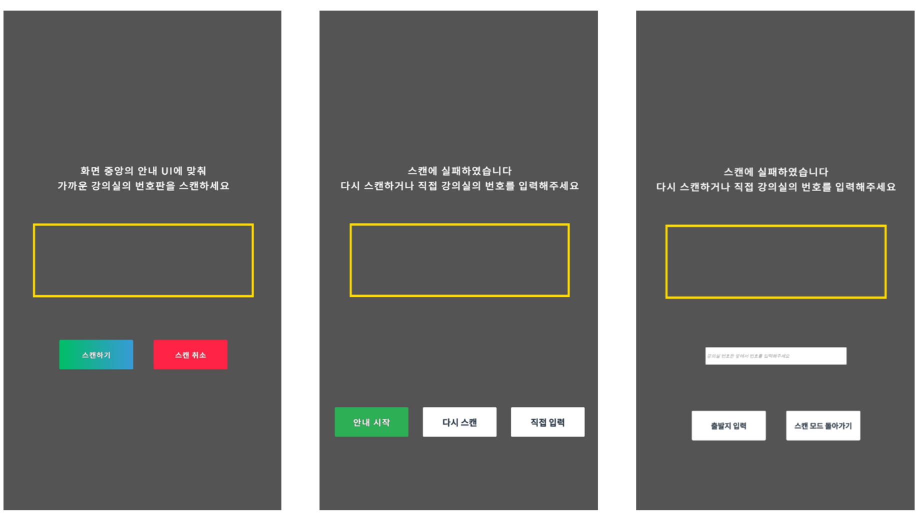

Fig. 7. Door Plate Scan UI in exceptional situations

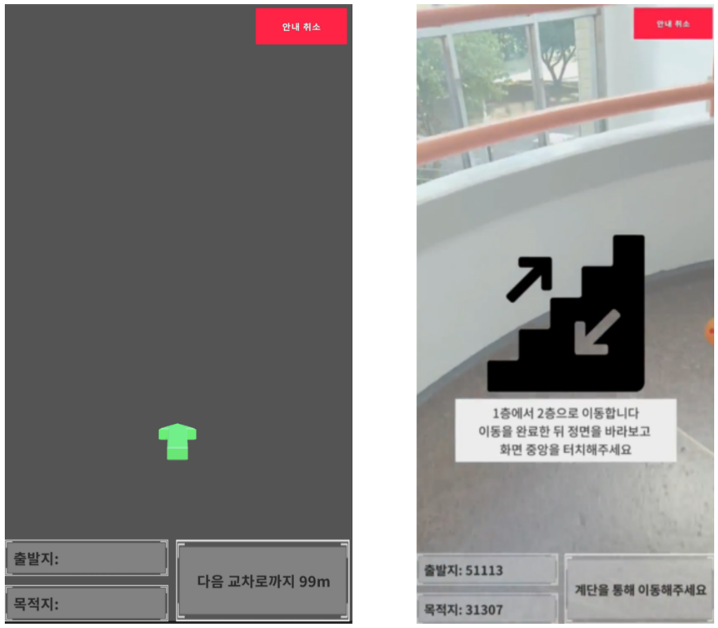

Fig. 8. (Left: Navigation UI, Right: Floor Change UI

error by reflecting this position difference in the user's current position data based on the anchor's position data in map data.

5 Evaluation

We set eight cases according to distance and number of floors to evaluate the function of the app, and collected three results: 'Guidance Success', 'Destination Approximate Radius', and 'AR Anchor Use' for a total of 160 tests. When the navigation reaches within 3m of the destination on the data, the guidance is terminated. When the guidance is terminated, 131 cases are within 3m of the actual destination, and 146 cases when include within 4m of actual destination(91 percent) are included. There was no significant difference in the success rate depending on the distance or number of floors. We expect because that the overall success rate is high, and in the case of the case with a lot of moving distance, the location error was more often corrected when moving anchors or stairs. For 53 cases recognized the anchor, 52 cases are within 4m of the actual destination, so the location correction using anchor was found to be helpful for correct guidance. For 7 cases where navigation failed, 2 cases were completely failed to move along the arrow and 5 cases were guided to the destination with an error of 5m or more. As a result of analyzing the cause of the error through mini-map and debug text for these 7 cases, there were incorrect anchor recognition, initial use

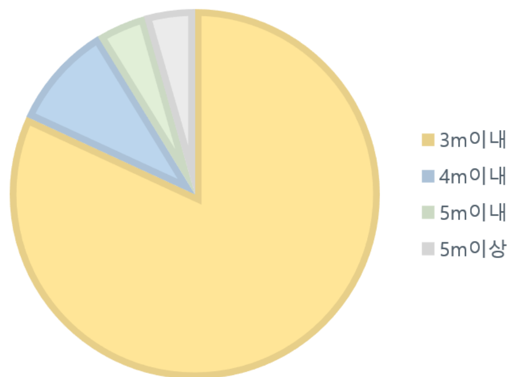

Fig. 9. (Result of Navigation evaluation test. within 3m(Yellow): 131, within 4m(Blue): 15, within 5m(Green): 7, over 5m or fail(Gray): 7

angle error, location error of origin data itself, and angle error by acceleration sensor during use.

6 Limitations and Discussions

Due to the limitations of capital and technology, there are several limitations to the application we have completed. We discusses these limitations and suggests ways to improve them.

Mapping and scanning manually Since all mapping and scanning were done manually by humans, it took a lot of time, and there was a limitation that perfect matching location data could not be created. This leads to a location error when navigation is guided. This can be overcome by attaching sensors that scan space on self-driving robots. Although the price of related equipment is still expensive, it is expected that accessibility to accurate space scans will increase in the future[1].

User's angle recognition error The problem that still exists in common navigation, which leads to errors in location as the user's angle is incorrectly recognized, is also limitation. In our project, we correct the position error through Anchor, but we cannot correct the angle of the fundamentally misrecognized user. The quick solution would be to put all the information about the corridor into the data, similar to car navigation, so that the user's location data does not deviate from the corridor. With the development of computer vision research, this problem can be overcome if technology that can obtain angle information through images is optimized to operate in real time on mobile devices. [6].

AR Anchor The Google Cloud Anchor API performs well on anchor hosts and resolve, but is not persistent because it has a maximum storage period of 365 days. In addition, scanning and resolving Anchor's 3d feature point has a limitation that it is difficult to use in places where the lighting environment changes due to the influence of the lighting situation.

7 Related Work

Yael Landau presented a framework for developing indoor navigation on mobile devices.[9]. Varelas' research demonstrates that AR anchor can obtain location information between the device and anchor[5]. Rusnida Romli and Jang's researches suggest that the AR marker can be used for navigation in indoor environment[7][8]. Oliver Sheibert's work suggests the indoor positioning technique available for AR navigation and how to overcome the uncured tracking that can occur in each environment[2].

8 Conclusion

We confirmed that the initial positioning of the user with the door plate as an AR marker and navigation guidance using the device's acceleration sensor guide to the destination with a high probability in the campus environment. In addition, by setting the appropriate space or object to AR Anchor, significant results were obtained in correcting the position error that occurs during navigation path guidance. The problem caused by the user's angle error is expected to be solved through the development of the technology to read the angle from a dynamic image.

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