INDOOR NAVIGATION USING AUGMENTED REALITY

[1]R. Reni Hena Helan, [2] S. J. Vivekanandan, [3] Ayitha Deepak, [4] Syed Imran, [5] Thummala Hemanth.
[1,2]Assistant Professor, Dhanalakshmi College of Engineering, Chennai
[3,4,5] Students, Dhanalakshmi College of Engineering

***Abstract* - Most current competitive business navigation programs are based on GPS-based navigating technology. However, its performance when applied for indoor navigation is weaker to that in an outdoor environment. A lot of the research and development done on indoor navigational systems involves installing extra added equipment, that typically has a high setup fee. Identifying the top indoor localization, pathfinding, and path navigation systems methods for an indoor navigation approach, study and comparisons were conducted. The objective of this project is to demonstrate a user-friendly and cost-effective indoor navigation system. The recommended solution combines AR technology with the in-built sensors that are currently available in the majority of mobile devices to establish the user's location and provide users with an immersive navigating experience. In this project, a smartphone app for indoor navigation was built and tested. AR Core will make use of the estimated route to display AR guidance. Surveys were conducted to determine the effectiveness of the methodology and to get participant feedback. The method's architecture and an example and its uses are described.**

Keywords: Indoor Navigation, Indoor Localization, Path navigation, Augmented Reality;

1.INTRODUCTION

According to its high precision, GPS-based outdoor navigation systems on smartphones have become very popular recently. While less frequent than outdoor navigation because GPS signals cannot be received inside intricate multi-story buildings, outdoor navigation is required. In contrast to outside navigation, commercial interior navigation systems have undergone relatively less progress.

The real-time interior navigation technique proposed in this study uses augmented reality (AR) technology in conjunction with mobile devices' built-in sensors to be both effective and affordable. "The user's current position is determined using the magnetic field, Wi-Fi signals, and inertial sensor of mobile devices, and the route to the destination is calculated using the ACO algorithm to give navigation direction"[23]. This approach does not require the installation of additional hardware. The standard map is replaced by augmented reality technology, which offers a virtual navigation experience that is immersive. In this project, a prototype for a mobile application that will provide campus navigation for Dhanalakshmi College Of Engineering was created.

Spatial information use in the mobile environment has increased since smartphones with a Global Positioning System (GPS) receiver, a digital compass, and accelerometers become standard. In order to acquire continuous spatial information that cover the user's full journey, Most mobile AR applications now available that utilize POI data only display location information as a point in their AR view, forcing the user to convert from an AR view to a basic 2-dimensional view. In this work, we describe a scenario-based method for creating a mobile augmented reality system that makes use of geographical data, particularly route information for pedestrian use.

2. LITERATURE SURVEY

Three essential components make up an indoor navigation system: localization, pathfinding, and path navigation system. While navigation focuses on establishing a path from the user's position to a certain destination, positioning refers to determining the user's current position. The navigational instructions that show the path are known as route guidance.

A. Indoor Positioning Techniques:

The most common positioning methods,"including GPS, Wi-Fi-based positioning, BLE beacon-based positioning, magnetic field-based positioning, and vision-based positioning, are explained in order to decide which method is best."[23]

When walls and roofs block the straight line of sight between the GPS receivers and the satellite, the signal may be weakened [1]. In addition, it is very challenging to identify the floor's level [2]. As a result, especially in multilevel structures , GPS signals are extremely low to deliver accurate tracking information within.

Using Wi-Fi for locating is highly available and has a cheap hardware installation cost because Wi-Fi is now widely installed inside of buildings [3]. The procedure is time-consuming, though, because it collects Wi-Fi signals and links the signals to location using a fingerprinting technique. Building barriers may also result in multipath effects, which reduce precision [4].

The BLE beacon uses less electricity and is compact, affordable, and simple to set up [5]. Besides that, Bluetooth is a more cost-effective wireless transmission than others in terms of battery consumption [6]. The fingerprinting procedure takes time, just like with Wi-Fi-based positioning, and BLE positioning is even more susceptible to multipath effects than Wi-Fi-based positioning [5].

Natural resources like magnetic field signals mean that no extra infrastructure is required. Additionally, it won't be impacted by barriers like walls or ceilings [7]. However, the precision may be impacted by the hard-iron and soft-iron effects caused by metal elements [8]. The process of fingerprinting takes a long period.

Marker less “tracking and visible marker-based tracking are two subcategories of vision-based location [9]. No extra infrastructure is required because marker less vision recognition uses the natural features of the environment, such as corners and textures, to provide positioning information [10]. However, because the system must continuously scan and compare the world with a large-scale database, high computational and memory resources are needed”[23] [11]. If used in a dynamic environment with constant change, this method is also unreliable [7].

Any image-based identifier, like a QR code, is considered a visible marker [12]. The marker will be positioned in a specific area to provide location data when it is read. The markers around the structure must be placed using a more expensive method. In addition, the user will need to continue locating and scanning the marker in order to update their location. Both vision-based positioning techniques can follow objects reasonably accurately in small spaces, making them ideal for indoor positioning [13].

However, factors like light and temperature will have an impact on both [7]. For instance, neither method will function during a blackout.

GPS signals aren't strong enough to provide indoor positioning, as was previously stated. Building obstacles may interfere with “Wi-Fi and BLE beacon signals, and light sources may interfere with vision-based positioning. A technology fusion positioning system, which combines various technologies to complement one another, would therefore be the ideal option. According to [14], the median accuracy of the fusion method, which combines Wi-Fi and magnetic field signals, is 1.20 metres, which is better than using only Wi-Fi. Additionally, the method suggested in [15]”[23] that integrates Wi-Fi and magnetic fields can dependably reach a precision of 0.836 metres in the experimental setting. Additionally, since Wi-Fi is already installed in the majority of buildings and magnetic fields are a natural resource, extra infrastructure costs can be kept to a minimum. TABLE 1 provides a comparison of the indoor positioning approaches.

B. Path Navigation Techniques:

“Dijkstra's algorithm, A* algorithm, and ACO algorithm are three common pathfinding methods [18]. Dijkstra's algorithm is an existing method for finding the shortest path between two nodes, whereas the A* algorithm is a development of it that combines the advantages of uniform-cost search with pure heuristic search to discover the best path [19]. Yet, the Ant Colony Optimization (ACO) algorithm imitates how ants might move along a graph. ACO algorithm uses the same strategy to choose the path as ants use, which is to follow the trail with more pheromones [16]”[23].

TABLE 1: Comparisons of indoor positioning techniques

Positioning Technology	Indoor Positioning Accuracy Range
GPS	>40m
Wi-Fi	30 – 40m
BLE Beacon	10 – 20m
Magnetic Field	2 – 6m
Visible Marker	Unreliable
Marker less Vision Recognition	Unreliable
Fusion (Wi-Fi + Magnetic Field)	1.2m

“A* algorithm is more effective than Dijkstra's algorithm, claims [18]. However, as demonstrated by the test results in [16], ACO algorithm has greater accuracy and requires less time to explore a route than A* algorithm. The calculation cost of the A* algorithm will be significantly higher than the ACO method in the case of an indoor environment.”[23] When compared to ACO algorithm, the path that is explored using the A* method is occasionally a little bit shorter, but it takes 8 times as long. ACO algorithm is hence effective for pathfinding in indoor environments, according to [16].

C. Route Guidance Techniques:

Indoor navigation is frequently provided using digital maps. Yet, research has shown that computer graphics fall short in their ability to accurately display the real environment, “making it challenging for users to compare the map to the real world. Users will need to contrast the actual landmark and direction with those on the map,”[23] which adds to the confusion [20].

AR has developed to offer more immersive assistance in order to improve user experience. AR is a technology that adds virtual pictures to the camera's view of the actual world. In contrast to digital maps, which show the environment from a third-person perspective, augmented reality (AR) displays a first-person image of the target destination, allowing users to interact with the device accurately [21]. It has also been demonstrated that AR can speed up human wayfinding processes and reduce the effort of recognition [22].

3. PROPOSED METHODOLOGY

Real-time mapping of an indoor area is accomplished by this system using visual simultaneous localization and mapping (SLAM) technology. After then, users can view the map and get navigation instructions to their destination using an AR-capable device.

The following are typical elements of a Visual SLAM system:

Visual sensors: Sensors that acquire visual data about the surroundings include cameras and other forms of visual sensors.

Feature extraction: The feature extraction component pulls out distinguishing characteristics from the visual input, like corners, edges, or blobs.

Feature Tracking: To determine the camera's motion, this component tracks the retrieved features throughout several data frames.

Navigation: This part builds an environment map by merging the tracked features and the predicted camera postures.

Users of Unity could develop 2D and 3D games and experiences, and the engine provides drag-and-drop capabilities in addition to a primary scripting API in C# by using Mono for both the Unity editor and games itself. Prior to C# is the primary language used in this game engine. An effective cross-platform 3D engine and user-friendly programming environment is Unity3D. Everyone who wants to effortlessly create 3D games and applications for mobile, desktop, the web, and consoles should be focused in Unity since it is both simple enough for the rookie and powerful enough for the expert.

4.SYSTEM DESIGN

The system's architectural layout and user interface are presented in this part.

A. Architectural Design

Fig. 1 shows the basic system components and their interactions.

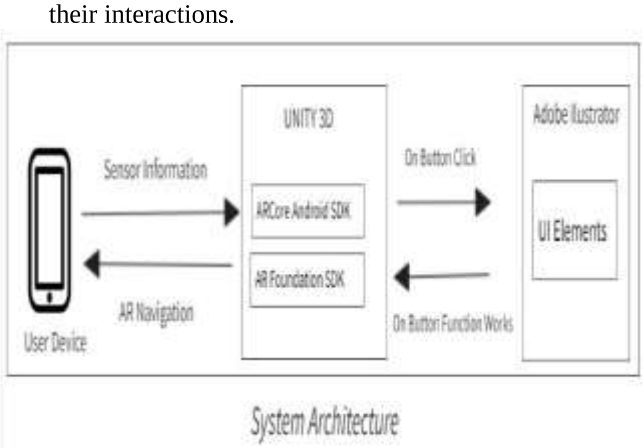

Fig 1. System Architecture

Only with integration of the AR foundation Android SDK and AR Core Android SDK, Utilising Unity 3D, the AR indoor navigation smartphone app was created.

Basic Project Setup:

Initially we need to disable Autographic API and enable Open GLES3 in Graphic API from Android settings. then enable Dynamic Batching. Additionally, prefer android 7.0 Nougat (API Level 24) in Minimum API Level.

For configuration, set IL2CPP in Scripting balanced, choose '.NET framework' in API compatibility level and Enable ARM64 in Target architectures.

Now, we need to switch to android platform in built-in settings. And install AR core from XR plug-in management, install AR foundation in Unity Registry from package manger.

B. User Interface Design

The user interface and navigation path of the mobile AR indoor navigation application are shown in Fig. 2. Via the venue's categories and subcategories, the user can choose their location. Following the user's selection, the path will be calculated and an AR navigation screen with an AR Navigation Path leading to the target destination.

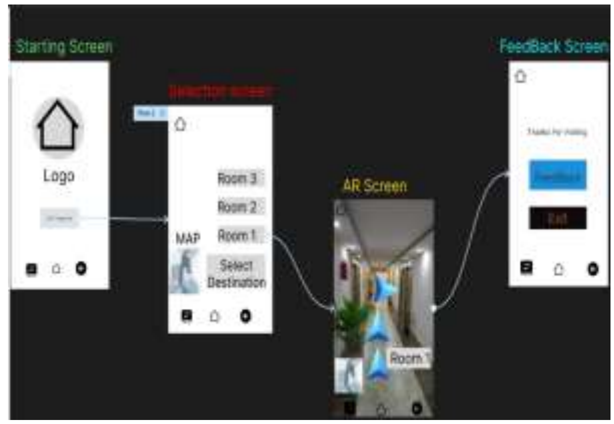

Fig. 2. User Interface and Navigation Path

5. IMPLEMENTATION

The Dhanalakshmi College of Engineering's We gathered venue details and floor plans. as a solution for navigating the campus was being designed.

A. Platform

The implementation of the AR indoor navigation system as a mobile application using Unity 3D, and as a result, the app is usable on the Android operating system. The route was shown to the user as AR images using the AR Core SDK and AR Foundation. Because only the venue information needs to be stored by the application.

B. Activities

Based on the prototype design, a mobile application with a venues menu and a searching function was created at the beginning of the implementation. The database was also used to hold information about the Dhanalakshmi College of Engineering venue, including its name, category.

The Dhanalakshmi College of Engineering's locations and venues were then added as assets to Unity 3D to enable indoor positioning using the AR Foundation SDK. The areas of interest, such as the labs, staff rooms, and classrooms, were added to the top of the floor plan after it had been uploaded, as shown in Fig. 3. The application will be able to specify the locations of all the venues on campus by adding points of interest.

Fig. 3. Integrating Areas of Interest

Then, as seen in Fig. 4, The path from one point to another was determined using the floor plan and the wayfinding system with nodes and edges.

Fig. 4. Adding Wayfinding System

Device Camera was used to perform fingerprinting after the floor plan and wayfinding information had been uploaded, as seen in Fig. 5. To receive location data and get to the right destination, the finger printing process requires physically moving around Dhanalakshmi College of Engineering after calculating the device's sensors.

Fig. 5. Fingerprinting

After importing the floor plan into the Unity project. The whole Path of the plan should be baked with 'Nav Mesh'. With the help of Nav Mesh the wayfinding is easier towards the target destination.

"The user's location will be detected to determine the path to the destination when a venue is chosen as the destination in the mobile application. The Navigation Path will then be displayed on top of the camera view and guide the user to follow its navigation after the route has been successfully computed. In order to direct the user to the destination, the Navigation Path will then move and turn in conformance with the path. The Navigation Path can be rotated and moved to the next node of the route by calculating the difference between the current heading of the device and the heading of the next node. And you are free to explore once you have reached your destination."[23]

The images of the augmented reality navigation process are shown in Fig. 6.

Fig.6. AR navigation process

6. RESULTS AND DISCUSSION

To download and install the mobile application, the user must scan the QR code. After doing so, the user will be directed to the app's home page, as shown in Figure 6, where they must grant the app the required permissions. The user can now continue using the AR view and choose their preferred destination. After that, the user must click the navigation button to begin the navigation, as shown in Figure 6. The user is guided to their destination by the AR Navigation Path. For each place, this process continues. Finally, we also include an additional feature that allows users to provide feedback regarding their AR experiences, allowing us to improve the application's future versions even further.

7. CONCLUSION AND FUTURE ENHANCEMENT

In final analysis, the indoor navigation app provides customers with an immersive navigating experience by utilising augmented reality (AR) technology and the integrated sensors of mobile devices. It was able to pinpoint the user's location and lead them to their desired place by superimposing AR navigation instructions over the actual camera view.

The application was tested on Dhanalakshmi College of Engineering and it is working properly.

This prototype can be developed to provide multi-floor navigation in the future but is only designed for navigation at the same floor level. As the application already supports multi-floor positioning and wayfinding, multi floor navigation could be easily accomplished by changing the AR Navigation path.

Moreover, because the goal of this research is to offer an easy and affordable indoor AR navigation service, the suggested solution might be used in a wide range of locations outside university campuses, such as malls, airports, and hospitals.

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