INDOOR NAVIGATION SYSTEM USING AUGMENTED REALITY

Sandra C J[1], Sandra Dileep[2], Sithara C S[3], Leya Elizabeth Sunny[4]

[1,2,3]Student, Department of Computer Science and Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India
[4]Assistant Professor, Department of Computer Science and Technology, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

---***---

Abstract - *GPS satellite signals are inaccurately trackable for indoor navigation systems. The project's purpose is to design and build an augmented reality-based system for indoor navigation application. The primary purpose is to navigate through various locations within large buildings such as airports, hospitals, shopping malls, and so on, where GPS satellite signals are precisely trackable for navigation applications.The Augmented Reality-based navigation system helps people to align themselves and navigate within large buildings. The technology used is SLAM: Simultaneous Localization and Mapping. The project has four modules: ARCore localisation, QR-code repositioning, Unity Navmesh navigation, and AR path showing. The admin uploads the map and has the ability to place the game objects in Unity.The user scans the QR code using the mobile app and, by selecting the desired destination, the app displays the path to traverse using augmented reality objects (arrows). The app navigates the user through the shortest path using the AStar pathfinding algorithm.*

Key Words: **Augmented Reality, SLAM, ARCore, NavMesh, Indoor Positioning System, Indoor Navigation, A* Pathfinding Algorithm**

1.INTRODUCTION

With the rise of underground retail malls and large-scale commercial facilities in recent years, the demand for indoor navigation systems has grown.

Existing methods for indoor positioning and navigation include using radio wave strength and Bluetooth, magnetic repositioning, position based on visual markers, radio frequency identification (RFID) tags and dead reckoning. However, these methods have huge installation costs and accuracy problems.

Although the present Global Positioning System (GPS) is typically effective for outside navigation, it is ineffective for inside navigation due to the satellite's low radio wave acceptance. Therefore, it is necessary to use a positioning method other than GPS for indoor navigation.

2. PROPOSED SYSTEM

The overall architecture diagram of the proposed system is given in Fig. 1. The development environment selected for the project is Unity because of the NavMesh components and its advantages. The proposed indoor navigation system is mainly divided into four basic modules, namely the AR Core based localisation, the QR-code repositioning, the unity navmesh navigation, and finally the AR path showing.

QR-codes are placed at different destinations inside the building. The user can scan the QR code at a specific location and choose the location he or she wants to visit. The path to get to the destination is shown as a line-render inside the minimap, which is placed at the bottom.

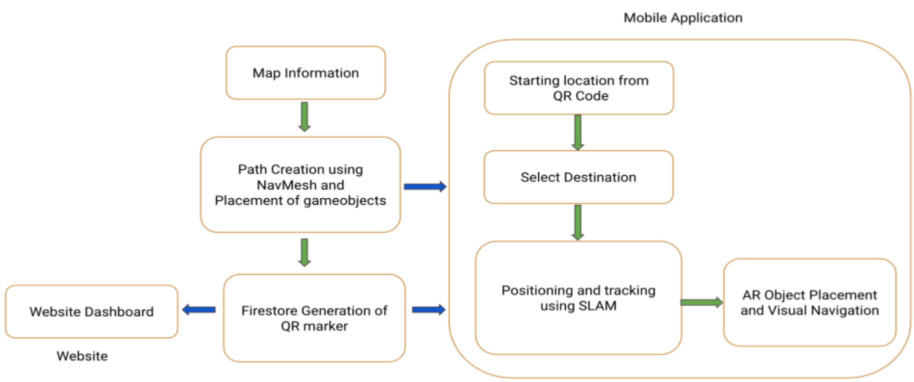

Fig -1: Architecture

Once the destination is selected, augmented reality objects (arrows) are shown on the camera frame and the user can navigate to the destination. Also, users have the provision to switch views on the minimap.

The building's floor plan is provided by the administrator and he can define the walkable and non-walkable paths using the gameobjects of the NavMesh component in Unity. Also, different destinations can be defined using the same. The admin also has the provision to delete the map. The SLAM technology keeps track of the user's position on the map. Users are directed along the path using the AStar pathfinding algorithm. Since the introduction of Apple's ARKit and Google's ARCore, SLAM has been present on all new touch phones.

3. IMPLEMENTATION

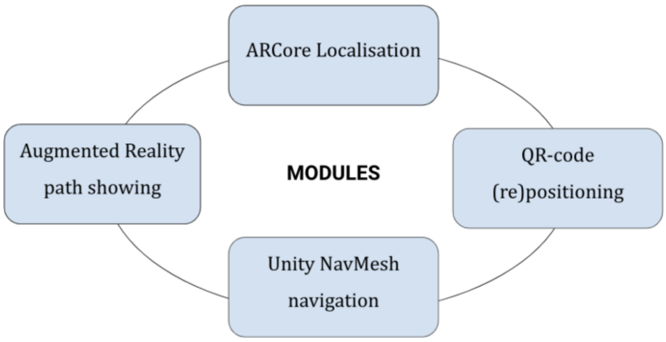

Fig -2: System modules

3.1. Creating Main Application

The development environment chosen for the project is Unity. This is because of the NavMesh components and their advantages. The proposed indoor navigation system is mainly divided into four basic modules, namely the AR Core based localisation, the QR-code repositioning, the unity navmesh navigation, and finally the AR path showing. Implementation of different functionalities is discussed in detail below.

3.2 Indoor Positioning System

An indoor positioning system (IPS)[1] is actually a collection of networked devices which can be used to find and locate objects or people inside buildings. Due to the scattering and attenuation of satellite signals, GPS and other satellite technologies can not be used. It lacks precision or accuracy since there is no line of sight for satellites inside buildings.

Hence, there is actually no accurate and perfect indoor positioning system in order to apply it to indoor navigation. Indoor navigation employs technologies such as Wifi, Bluetooth, visual lights, magnetic positioning, and visual marker positioning[4].But all these require additional hardware devices.

We used ARCore based indoor positioning and localisation since it is provided by Google with all Android devices 8.1 and later. Thus, no additional costs or installation are required for the implementation.

3.2.1 ARCore based Indoor Localisation

SLAM is the Simultaneous Localisation and Mapping that means, it is the job of creating an internal map of an unknown region while also keeping track of its location inside that space.

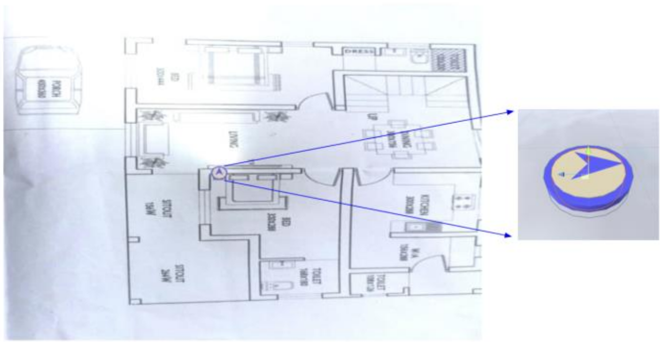

Fig -3: Blue dot indicator showing position on the map

The technologies using Wifi, Bluetooth and beacons can be implemented with the aid of transmitters and other hardwares in order to get the signal strength. Calculating these signal strength, the technology can pinpoint a user's precise location within a structure. But these additional hardwares and devices make it more complicated. But SLAM uses no additional hardware and it is available with all devices having ARCore. Thus no need for preparation for using SLAM technology.

SLAM technology uses a camera feed to get feature points. They are separate geographical locations obtained by comparing all of the surroundings. Different corners, edge segments, interest points, and also regions are taken as feature points. ARCore's SLAM algorithm uses different sensors, like accelerometers. This is to get corresponding spatial information.

ARCore gives all these abilities in order to use as SDK. ARCore handles motion tracking and environmental understanding so that they can be used more conveniently.Along with all those features, ARCore can create a better augmented reality navigation system which will be accurate and efficient.

3.3 QR Code (Re)positioning

QR codes are used in the system in order to get location data from the user. QR codes will be pasted in all necessary locations throughout the building to obtain the information needed for the proposed system.The mobile application scans the QR codes to give accurate indoor navigation to the user. This is the QR code positioning method.

The user can scan the QR code and can start moving inside the building.By setting the destination, the system will get the start and end points for the required path. Hence, navigation will be easier.

While moving inside the building, the image frames are taken every second in order to work with SLAM. Thus, there will be occasions for encountering QR codes in between the start and the destination. This will provide the system with more convenience in getting the user's present location inside the building while moving. Then the person's indicator will be re-positioned according to that indicator. The actual camera pixels provided by the ARCore SDK are used to find the QR code. This will make the system more accurate.

3.4 Navigation

The purpose of an interior navigation system is to direct a user through enormous buildings by creating a path in real time from the user's current location to their destined location. For navigation inside large buildings, from among the multiple paths, we have to select the shortest path. There exist several algorithms for finding the shortest path, like Dijkstra's algorithm, the best first search algorithm, the Astar pathfinding algorithm, etc. Among these, a star path finding algorithm gives a more optimal and accurate path in a short time. As a result, for indoor navigation, we used the A * path finding algorithm. .The heuristic function which is the function that determines whether or not something is true is the euclidean distance between the initial position where the user starts navigation and the desired final location of the user. The total time complexity of finding a path using this algorithm is O (n log n).

3.4.1 Unity NavMesh Navigation

Unity has so many built-in functionalities which provide ease of use and many more advantages. The NavMesh components are one of the functionalities.This can be used to generate a strong mesh and can be used for pathfinding inside buildings. These NavMesh components are open source. The navigation system will generate augmented reality characters that can be easily placed and moved within the game world using navigation meshes.These navigation meshes are created from scene geometry automatically. As the user moves through the building, there is a chance that he or she will run into obstacles or hindrances in the way of the actual path.So the NavMesh properties will help to identify these obstacles and can provide an alternate path to the runtime by changing the position of these augmented reality objects, like directing arrows.

3.4.2 A* Path Finding Algorithm

One of the finest path-finding algorithms is A* and it is the most efficient path finding methods.Actually, there are numerous algorithms for finding the shortest path between two nodes, like Dijkstra's best first search. However, the A * is the result of combining these two algorithms.This will improve A *'s efficiency and accuracy.It is efficient and complete. Thus, it can be used in so many fields of computer science.

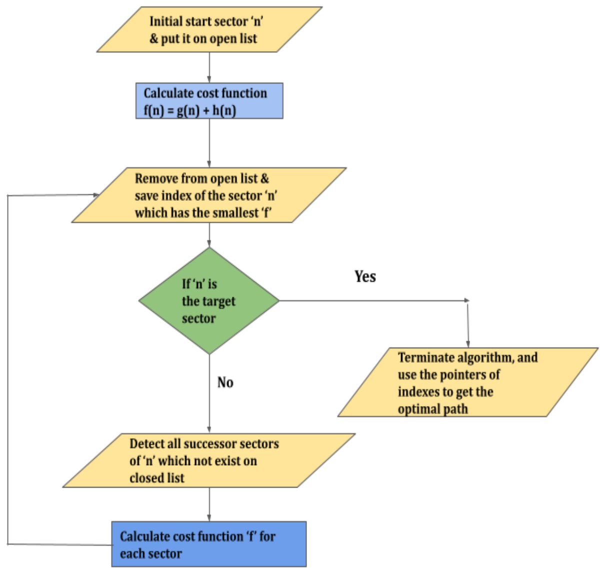

Fig -6: Flowchart of A* Algorithm

3.5 Augmented Reality Path Showing

In the end, our indoor navigation app shows the path to take using augmented reality[2] objects (arrows). When the user needs to place a 3D object in the environment where they can move around, they should select the Tracking Type option for rotation and position. If the position option is selected, then it will get the best localisation. And 3D objects may not be stable in their position. Hence, they can't be clearly visible. The major goal of this part is to produce an arrow in front of the user that guides them in the direction they need to go after a destination is chosen. There exists a defined mesh surrounding the arrow and every time the blue dot exits the mesh, the previous arrow (AR-object) gets removed and a new one comes in before the user appears at the exact angle. The old arrow can not be seen anymore as the user passes by that region.

4. RESULT

4.1 Web App

The purpose of the web application is to deliver information about the proposed system. The admin can login from the website. The QR codes for different locations are generated and will be accessible through the dashboard of the website. The technologies used are HTML, CSS and JS.

Fig -4: Website Dashboard

4.2 Mobile Application

The mobile application is intended for users. The AStar pathfinding algorithm is used by the mobile app to determine the shortest path from point A to point B. The QR codes are placed at different locations inside the building. The user can then scan these codes to identify the location. Then the user will be able to select the room from the given menu. In the real world, AR objects (arrows) are visible and the user can follow the arrows to navigate to the destination. As the destination is reached, an augmented reality object (pin) is displayed.

A mini-map of the floor plan is given in order to show the person's position and path to the destination on the screen. The small blue dot indicates the position of the user. The violet line is the line-renderer which gives the shortest path to the selected destination. Also, there is an option for the user to switch views if they need to navigate with the help of a 2D map.

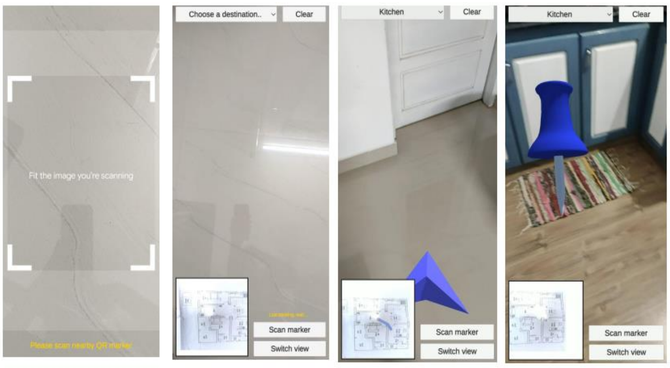

Fig -5: App Interface

5. PERFORMANCE ANALYSIS

The figure below shows the comparison of the travel trails from the living room to the kitchen, considering the six waypoints.

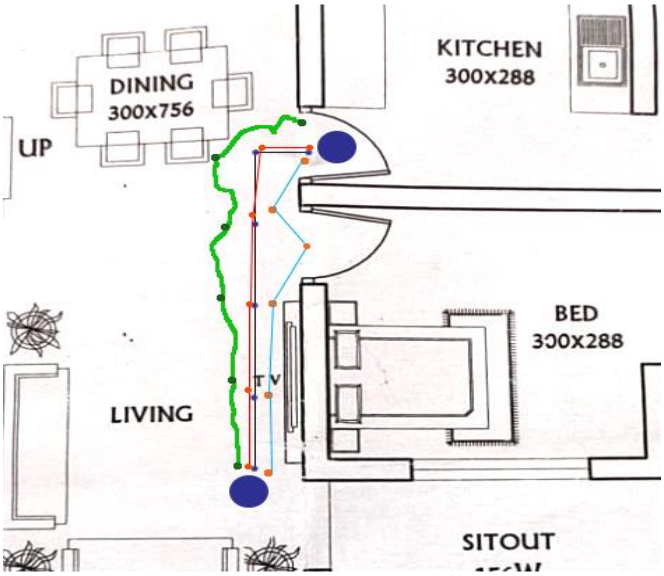

Fig -6: Path from living room to kitchen

According to Fig.6, the start and end points are given as blue-coloured dots. The green line indicates tracking by GPS. The blue line represents indoor navigation using markers. The red line represents tracking by SLAM, which is at the core of our project.

From Fig 6, it is evident that in navigation by GPS, the path shown by GPS is very inaccurate inside a building due to low signal strength. GPS signals get blocked and they are also reflected by walls.As a result, it was unable to enter the room.Due to this drawback, satellite signals are received incorrectly. So it can not be used to calculate the location of a person or an object inside any building. Some GPS devices can receive satellite signals by being placed near a window.But practically, this can't be done everywhere in the building and, especially, in an indoor environment.

Table -1: **Technology Comparison**

Waypoint v/s Technology	GPS	MARKER	AR SLAM
Waypoint 1: 0 m	0 m	0 m	0 m
Waypoint 2: 0.75 m	0.1 m	0.1 m	0.025 m
Waypoint 3: 1.5 m	0.2 m	0.1 m	0.01 m
Waypoint 4: 2.25 m	0.15 m	0.25 m	0.015 m
Waypoint 5: 3 m	0.3 m	0.3 m	0.02 m
Waypoint 6: 3.75 m	0.1 m	0.05 m	0.01 m

Total Variation	0.085	0.8	0.08

Since all these techniques have drawbacks, we decided to use the QR code only for the initial scanning in order to select the destination. After that, the user will be directed along the path by the way-points created. The technology comparisons for three different technologies, namely GPS, markers, and AR SLAM, are shown in the above table. The comparison is performed at six different locations, starting with the living room and ending with the kitchen.

From the above table, It is obvious that ARCore SLAM is more precise because the total variation is 0.08, whereas for GPS and markers, it is 0.85 and 0.8, respectively.

6. CONCLUSION

We were able to successfully design and develop an efficient and cost-effective method for indoor navigation using ARCore's SLAM process. We faced the challenge of finding alternate paths for navigation in the presence of any obstacle in the way of users. Using the NavMesh components and functionalities, we expect the system to perform well even if there is an unknown obstacle that is not predefined in the floorplan. Our system was discovered to provide a more interactive way of guiding people inside complex buildings. Furthermore, the augmented reality features make it simple and keeps users from interacting with other people in the Covid-19 scenario. Also, the mobile application can easily be installed by the public. The application is free to all users and may be obtained from the most recent Android versions such as Android 8.1 with Google ARCore support. The system is built in such a way that it may simply be scaled to meet the needs of diverse structures.

REFERENCES

[1] C. Perey and T. Miyashita, "Indoor positioning and navigation for mobile AR," 2011 IEEE International Symposium on Mixed and Augmented Reality - Arts, Media, and Humanities, 2011, pp. 1-1, doi: 10.1109/ISMAR-AMH.2011.6093646.
[2] https://www.coursera.org/learn/ar
[3] Infographic: The History of Augmented Reality, [online] Available:http://www.augment.com/blog/infographic-lengthy-history-augmented-reality/.
[4] Marker Based Augmented Reality, [online] Available:https://www.slideshare.net/arshiyasayd/marker-based-augmented-reality.
[5] Difference between Marker Based and Marker less Augmented Reality, [online] Available: https://stackoverflow.com/questions/27229465/difference-between-marker-basedand-markerless-augmented-reality.
[6] Mehdi Mekni and Andre Lemieux, "Augmented reality: Applications challenges and future trends", Applied Computational Science— Proceedings of the 13th International Conference on Applied Computer and Applied Computational Science (ACACOS '14), pp. 205-209, 2014.
[7] What can Augmented Reality do for Manufacturing?, [online]Available:https://www.engineering.com/AdvancedManufacturing/ArticleID/14904/What-CanAugmented-Reality-Do-for-Manufacturing.aspx.