IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Low Cost Indoor Navigation System using Augmented Reality

[1]Rahulsingh Goud, [2]Nitesha Paatil, [3]Mayank Patil, [4]Hrishikesh Khadakar, [5]Shweta Koparde

[1-4]Student, [5]Professor,

[1]Computer Engineering,

[1]Pimpri Chinchwad College of Engineering and Research, Pune, India

Abstract: In today's world, outdoor navigation applications are present in lion's share, but there are hardly any that can pinpoint a user's location inside a large infrastructure. Indoor Navigation is a challenging task, especially in large structures like malls, airports, museums, factories, etc. Present solutions and technologies are not cost-effective as well as complicated but have a lot of room for improvement. Hence, we are proposing a cost-effective model that uses Augmented Reality to place virtual markers across a structure, so a person can navigate from one location to another with the help of these markers along with live feeds to process the information and provide real time localisation. The proposed model is quite different as it doesn't make use of high-level use technologies like satellite based GPS,Complex Machine Learning, and Artificial Intelligence but here, the markers placed are pervasive and persistent within the closed walls for smooth navigation. Once staged, these virtual anchors persist at a designated location and can be used at any time by anyone through our app. This system can be extended for the general public in any indoor space and also can be improvised by gamification for better user interaction and retention. This model can also be extended to collaborate with the Aarogya Setu app, which can help us identify potential victims and routes through which covid positive patients have passed which in turn helps us avoid those routes in real-time navigation.

Index Terms **- Indoor Navigation, Augmented Reality, Unity 3D, SLAM, Image Recognition, A* Algorithm**

I. Introduction

The present invention relates to an Indoor Navigation System used for assisting general public or specially abled people to identify routes in large structures like malls, airports, hospitals, etc using augmented reality based software. Moreover, it is capable of obtaining live feed from a standard smartphone to capture the environment for efficient location tracking. The importance of indoor navigation in modern times cannot be overstated. For navigating inside modern buildings, standard maps are used, which are well relayed but can still be confusing for the general public to gather all the details on the maps in a short amount of time, in addition to not being able to recall the required directions in one sitting. Moreover, visually challenged would have no access to this information and must depend on others not visually challenged. The present invention helps overcome these challenges through augmented reality indoor navigation by enabling user to scan the area without any external help and even prompts the users about the diversions to be taken. Hence, at times where pandemic or endemics can cause social construct to waver, smart solutions like these can help overcome difficult situations. This application uses technologies like AR SDKs, Simultaneous Localization and Mapping(SLAM), A* shortest path algorithm, image recognition, Convoluted Neural Networks(CNN), etc to provide an easy navigation. Nowadays, almost everyone has a smartphone. AR is heavily used in our application so that users only need a smartphone to access it and pay no additional amounts. Few challenges that come across navigating indoors using GPS is to locate the user's exact location. In this case, using GPS indoors require direct line of sight communication with the satellites which is not possible indoors. Hence, we cannot use GPS to locate the user's exact location in any indoor structure. Here, augmented reality comes into play where it locates on the basis of the user's surroundings instead of longitudes and latitudes.

II. Literature Survey

[1] The corresponding composition provides an introductory point-of-view to its audience in a manner where an application is a complete navigation system consisting of GPS technology and augmented reality for outdoor navigation where the line of sight for satellite communication persists. As for indoor navigation it proposes use of various technologies such as Apple's IBeacon, Wi-Fi, etc in addition to augmented reality for localization purposes. It also emphasises opportunities and challenges that may be associated with such a system. In addition to this, it provides the audience with necessary terminologies that are crucial in developing the system as a whole.

[2] The major focus of the corresponding composition is to provide a simple but effective navigation system in low network areas. Navmesh, a tool provided by Unity, is used to detect the shortest path and make movements accordingly, as the user selects the targeted location. Third- person navigation is done for testing on a Pie-based Android device. Two modules are used in the above composition: firstly, Interior Modelling is done using Unity 3d and secondly, navigation is done using Navmesh by baking. Baking is the process in which a Navmesh is created that collects the rendered meshes and terrains of the game objects. This system is to be considered as the fastest, platform independent and a low cost indoor navigation system. As it is a gamified model, users will be able to enjoy the experience to reach their destination location.

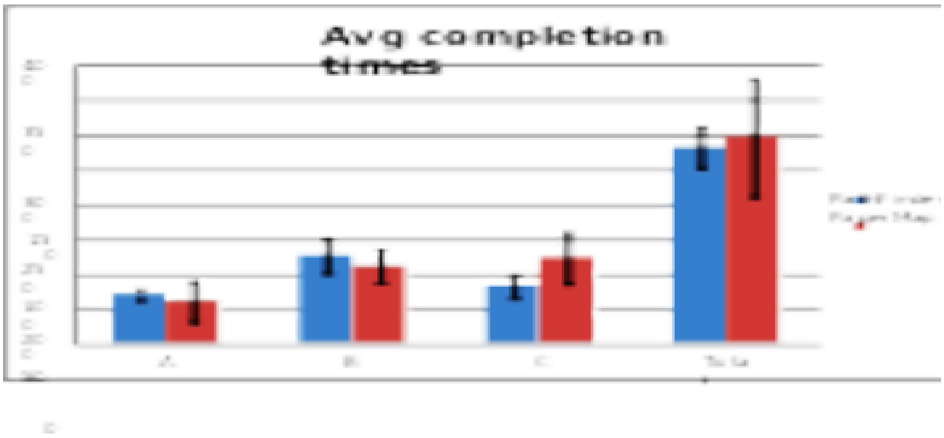
[3] A comparative analytic study, is what can be asserted through this literature with a handheld smartphone device and google glass on weighing scale and states its findings based on multiple technical assessments. The technical assessments and the respective observations are briefly noted in the following table which were done across nine different locations and aggregate results were calculated.

[3] Table II: Comparative analysis of technical performance assessments conducted on google glass and an android cell phone using the same AR-based navigation technology.

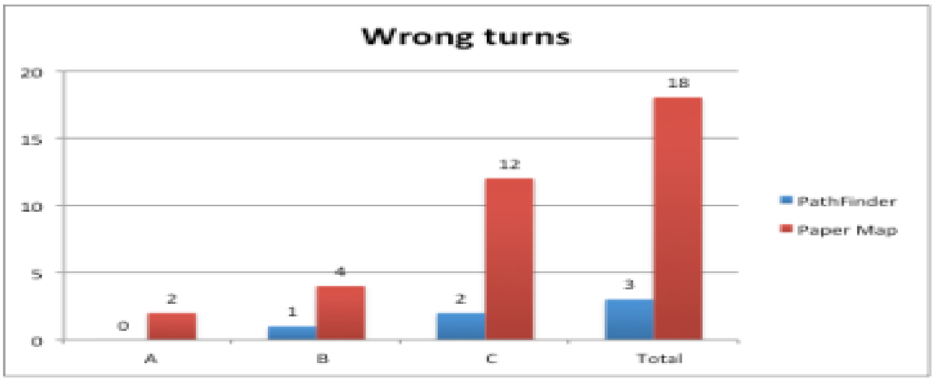
Specifications	Google Glass	Samsung Galaxy S4
Minimum percentage of features needed to initiate AR overlay processing	45.0% on average for the nine locations (respectively 34%, 37%, 34%, 49%, 53%, 35%, 46%, 67%, 50%) with the speed between 6.4 km/h to 7.6 km/h	42.7% on average for the nine locations (respectively 31%, 32%, 22%, 36%, 47%, 33%, 46%, 72%, 66%)with the speed between 6.0 km/h to 7.9 km/h
Percentage of features detected at a fast walking pace	50.6% on average for the nine locations (respectively 57%, 45%, 44%, 53%, 40%, 42%, 50%, 47%, 77%)with an average speed of 6.4 km/h and minimum speed of 5.5 km/h	44.3% on average for the nine locations (respectively 36%, 38%, 40%, 24%, 55%, 63%, 48%, 41%, 54%)with an average speed of 6.5 km/h and minimum speed of 5.3 km/h
Time taken to detect 95% of features	95% of features detected under 1 s for all nine areas (respectively 0.81 s, 0.93 s, 0.92 s, 0.84 s, 1.07 s, 0.96 s, 0.88 s, 0.89 s, 0.74 s) with an average speed of around 4.3 km/h	95% of features detected under 1 s for all nine areas (respectively 0.76 s, 0.74 s, 1.01 s, 0.85 s, 0.92 s, 0.99 s, 0.93 s, 0.9 s, 0.82 s) with an average speed of around 3.9 km/h
Time needed to generate each type of navigational information	0.18 s on average for all nine locations (respectively 0.17 s, 0.25 s, 0.2 s, 0.19 s, 0.13 s, 0.14 s, 0.2 s, 0.19 s, 0.16 s) to generate audio augmentation; 0.14 s on average for all nine locations (respectively 0.12 s, 0.11 s, 0.15 s, 0.19 s, 0.17 s, 0.15 s, 0.12 s, 0.1 s, 0.15 s) to generate visual direction arrows and texts	0.22 s on average for all nine locations (respectively 0.2 s, 0.27 s, 0.18 s, 0.23 s, 0.15 s, 0.24 s, 0.23 s, 0.26 s, 0.24 s) to generate audio augmentation; 0.13 s on average for all nine locations (respectively 0.09 s, 0.16 s, 0.13 s, 0.11 s, 0.1 s, 0.12 s, 0.1 s, 0.2 s, 0.17 s) to generate visual direction arrows and texts
Framerate	About 12-18 fps	About 14-23 fps

Figure 2.1 : Google Glass VS Samsung Galaxy S4 technical performance

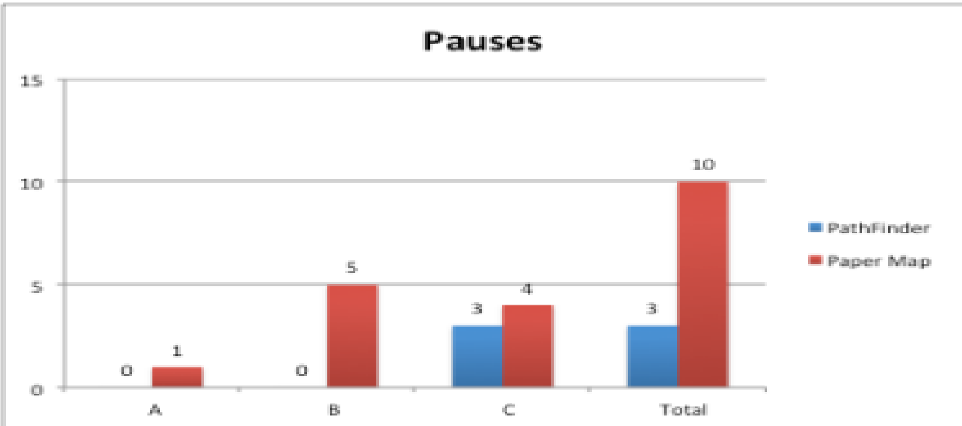
[4] People have always been exposed to 2D maps for navigation but not AR navigation systems. The fundamental focus of this literature is to provide statistical evidence why AR navigation systems are much better than 2D maps. Here a specially developed AR system is used to conduct experiments and gather evidence to prove the subject in focus. It is stated that in general for indoor navigation some directives are always provided. Taking advantage of this fact, the system uses Vuforia SDK to implement a recognition model that captures images and determines patterns in captured images from converting it to grayscale and generating feature-points that contribute to the localization process. Once localization is done, the path to destination is found using Dijkstra's algorithm and an AR pointer is embedded onto the screen of the mobile device. As for the field work, volunteers were given the task to navigate through unknown buildings and pause performance, wrong turn performance were calculated in addition to average completion time.



[4] figure - 1



[4] figure - 2



[4] figure - 3

Figure 2.2 : Comparative analysis of Handheld map VS PathFinder

[4] figure-2.2 shows the difference between the number of wrong turns taken when either of the systems were being used. [4] figure-2.2-3 shows the amount of pauses taken. [4] figure-2.2-1 shows the amount of time taken to complete the task on average. Even though the average time taken using maps seems better we can see the errors occurring while navigation which certainly proves that with a certain amount of adjusting time, AR navigation systems will be much more efficient.

[5] Reviewing the literature, it is understood that instead of using maps or sign boards for navigating indoors, an augmented reality based indoor navigation system is proposed. The above literature majorly uses ARCore SDK to convert the real world objects into logical features, based on machine learning. Motion tracking is done using the movement and orientation of the mobile phone. The powerful advantage of the literature used is that the user input will be taken in the form of video feed and will be analysed. It is also proposed that if new objects are present in the environment, then it will be added to the database. In the complex scenarios, if the real world objects are not detected in the indoor environments, QR Code feature will be helpful in such scenarios.

[6] The fundamental focus of this literature is on augmented reality and 2-D visual markers. The arrow marks or directions are displayed with the use of augmented reality and the user can directly scan multiple visual markers using a smartphone as nowadays, cameras with better capabilities are available in smartphones. After scanning, users will be directed to the preferred location with the help of arrows displayed on the screen. The following development kits are used for developing software: Unity and Vuforia. Unity 3D is a powerful platform, where virtual and real world environments can be combined to create a gamified environment. Vuforia SDK is used to create AR applications for mobile devices. Use of position markers is done, when scanned the user is

directed to the preferred destination location. Firebase database is used to store the data collected from the user while registering such as emails, passwords. This data is used for authentication and then stored to the cloud for easier access. Above model can be used within a large indoor structure and users will be provided with accurate virtual assistance just by using a smartphone. The most important advantage of the above model is that the user will have the ability to choose and change their destination location in between

[7] This particular literature puts emphasis on vision-based localization compared to other methods of localization available that make use of technologies in which dedicated systems are put to use. Diving further, it provides an interrogative approach towards the risks faced during vision-based localization. Emphasising on vision-based localization, it provides advantages along with challenges that may be confronted during the development cycle of any project where this particular localization may be used. Furthermore, it presents a set of questions that are investigated through experiments and answered with statistical analysis over the findings of the experiment. To complement this study, a preferential and situational analysis over AR and VR was conducted, analysed and presented. The following table shows the accuracy of the said system with observed values and standard deviations. It suggests that AR systems are better but not considerably, with each having its own benefits and drawbacks.

Perceived Accuracy of Virtual Reality and Augmented Reality Views								
	No error		Orientation error		Location error		Loc + Ori. error	
	Response	STD. DEV	Response	STD. DEV	Response	STD. DEV	Response	STD. DEV
The system seemed to know my location well.	2.5	0.9	0.8	2.0	1.7	1.5	0.6	2.0
	1.7	1.6	1.4	1.8	1.4	1.8	1.0	1.7
The system seemed to know my orientation well	2.4	1.0	0.2	2.1	1.2	1.8	0.4	2.1
	1.7	1.5	1.1	1.8	1.3	1.7	0.9	1.8
I perceived the navigation instructions as correct	2.3	1.0	-0.2	2.0	0.4	1.9	-0.5	1.9
	1.8	1.4	1.4	1.6	1.4	1.7	0.9	1.8

Figure 2.3 : VR VS AR perceived accuracy

The whole study conclusively proposes a situational use of AR and VR. This can be illustrated where a particular location lacks enough features for AR to work effectively and to overcome the fact that VR localisation and navigation is used with respect to the most recent localization data available. When features available for AR rendering are above the threshold, AR-based localization will be resumed. [8] The proposed model in the literature introduces a web based Indoor Navigation System comprising a general client for visitors. The web-based system allows clients to add infrastructural details of their particular institute and build a place within their application and also allows visitors to navigate easily by providing their map layouts and floor details through their mobile application. A* algorithm is used for detecting the shortest path between the nodes and the distance formula to find an estimate between source and destination on the x and y plane. In the above system, the user has to input the preferred destination and the server will return a map layout which comprises a path to the destination. It is also stated that it will estimate the steps to reach the destination location based on average human stepping distance and also can generate weekly and monthly data of happy clients through the feedback from the clients. Technologies used in this particular literature are Unity Hub, which is used for creating an AR environment and an interface that can be created by integrating map layout in association with Android Studio. Secondly, Mapbox is used as a tool to develop map layouts with precision and 2D or 3D map developments. Next tool is the wikitude SDK which was integrated with Unity to create AR related applications Bootstrap and Android studio were also used to build the project. The functionalities mentioned are path marking controlled through GUI by the admin, dead reckoning is done in steps as step detection, accelerometer sensing and orientation sensing which would help in estimating the number of steps and time of arrival, augmented reality preview with SLAM(Simultaneous Localization and Mapping), map view, direction view and path view. Use case and sequence diagrams are used to convey the working flow of the application.

[9] This literature simply proposes a system that can be effectively used for indoor navigation with QR code repositioning but also uses SLAM (Simultaneous Localization And Mapping) to locate the user with minimal deviations. The approach uses four basic modules of QR code repositioning to determine user's location statically, ARCore localization for dynamic positioning, Augmented reality to provide directions and NavMesh with A* pathfinding algorithm to generate and track path between source and destination. The first mentioned module of QR code is used to create a distinct QR code for each significant location which when scanned gives the user its precise location and the source is automatically known. This set also hosts a QR code for the admin dashboard to

maintain the credibility of each marker and manage them, hosted as a website. The next module of ARCore localization is based on SLAM technology. It uses no additional hardware but rather uses the accelerometer and gyroscope of the handheld device to get spatial information along with camera feed to get feature points(separate geographical locations procured by analysing surroundings for corners, edges, interest points,etc). The AR core handles all the motion tracking and environmental understanding. The next part of navigation is handled by the use of heuristic search A* algorithm and Unity's NavMesh. NavMesh will generate augmented reality entities that can be easily staged and moved within the game world using navigation meshes.These navigation meshes are created from scene geometry automatically. The last module of AR path illustration is handled using an AR object manipulated from within the NavMesh indicating directions to the user. Moreover, a technology comparison table is also presented showcasing the variation values.

[9] Table -1: Technology Comparison

Waypoint v/s Technology	GPS	Markers	AR SLAM
Waypoint 1: 0 m	0 m	0 m	0 m
Waypoint 2: 0.75 m	0.1 m	0.1m	0.025 m
Waypoint 3: 1.5 m	0.1 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	0.85 m	0.5 m	0.08 m

Figure 2.4 : Variation comparison between GPS, Augmented markers and AR SLAM

The above table is generated based on six different locations starting from the living room and ending in the kitchen. It indicates that SLAM is most efficient since its variation is 0.08.

[10] Following the current trends, this literature aims at achieving indoor navigation with the use of bluetooth beacons placed inside the infrastructure as an extension to the Internet of Things. The justification to the use of beacons is given as using explicit markers and feature recognition techniques are time consuming and tuning is required. Also there is a possibility that there are features that are quite similar and that cause problems in its recognition. It also throws light on related approaches using marker-based methods, 2D image recognition and 3D space recognition methods. These were discarded on the basis of user's ability and knowledge of marker recognition and device alignment to capture the markers, the degradation of 2D images used along with angle of view and accuracy, costly 3D model construction and recognition where crowds can also prove a big hindrance. In order to overcome these challenges, the use of bluetooth beacons was chosen. ARBIN consists of four models : route planning, indoor positioning, motion tracking and AR 3D model placement. Indoor positioning is accomplished with the use of beacons as waypoints and the user's location is identified based on the signals received from the beacons and the user is then directed to the next waypoint. To improve its accuracy an RSSI (received signal strength indicator) model was generated and UUID was given to each beacon and they were categorised into four types to determine the distance between the beacon and the mobile device. Route planning was achieved using Dijkstra's algorithm and the orientation of the mobile device. The orientation of the mobile device was determined using the IMU of the mobile device. If the orientation was improper then a popup message was displayed to reorient the device. Motion tracking was done with the help of magnetic sensors and accelerometer along with transformation of coordinates because coordinate systems are different for earth and mobile devices. Lastly, the AR placement model places an object onto the screen when the pitch and orientation of the device meets the requirements.

III. PROPOSED SYSTEM AND APPROACH

Navigation has been quite a required skill since the beginning of time, but this comes with experience and a good knowledge of the environment. Hence in order to overcome these factors people have always been interested in developing devices, technologies and applications such as maps, compasses, sextants, etc and yet people always find it difficult to navigate in novel destinations. In modern times, there are various technologies available like GPS, that are capable of getting a user to a required location but fail indoors due to its requirements for a clear line of sight with earth-orbiting satellites for precise positioning. To overcome this problem, an AR based indoor navigation system is being developed. The proposed system aims to limit the use of high end technologies like Machine learning, Artificial Intelligence and Global Positioning System and focuses on the use of Augmented Reality. The model also makes sure to consider minimum possible requirements for the user. Therefore, smartphones with AR capabilities are the only user requirement. It comprises three basic elements: user, mobile application and database. The user interacts with the mobile application and the application interacts with the database. Virtual anchors are stored in the database. The user interaction flow is explained in the following ways:

1. The user has to start the application and scan the environment using a smartphone.
2. This live feed is used to identify the location of the user.
3. After the user's location is recognized, the user has to give the preferred required destination as an input and based on that a path will be generated.
4. The user is then prompted with the AR pointer to follow the particular path to his destination.
5. When the user reaches the destination, it will be prompted to the user.

The Object detection algorithms' will be used to integrate to avoid collision, improvement can be done through gamification and extra animations making it more user friendly, warnings for distinct indoor infrastructures such as stairs, escalators and elevators will be prompted, integration with other applications will be done to avoid spread of Covid-19 are the possible fields of improvement.

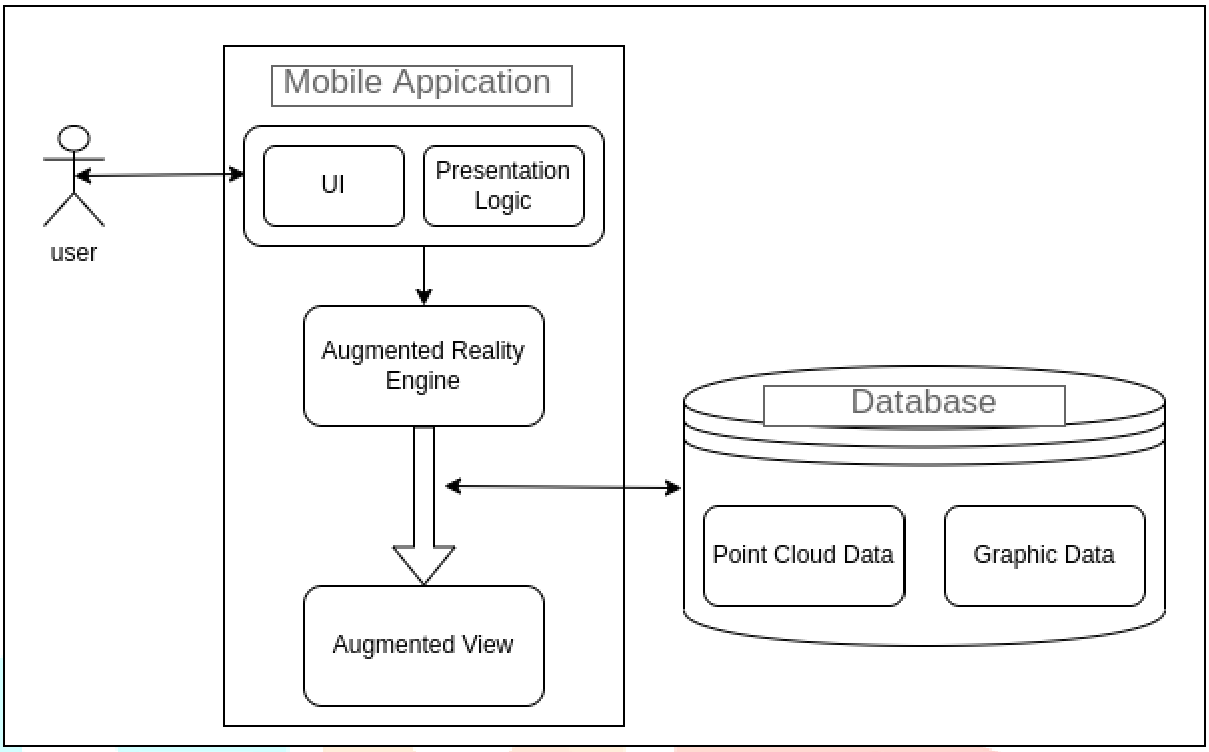


Figure 3.1 : Architecture diagram

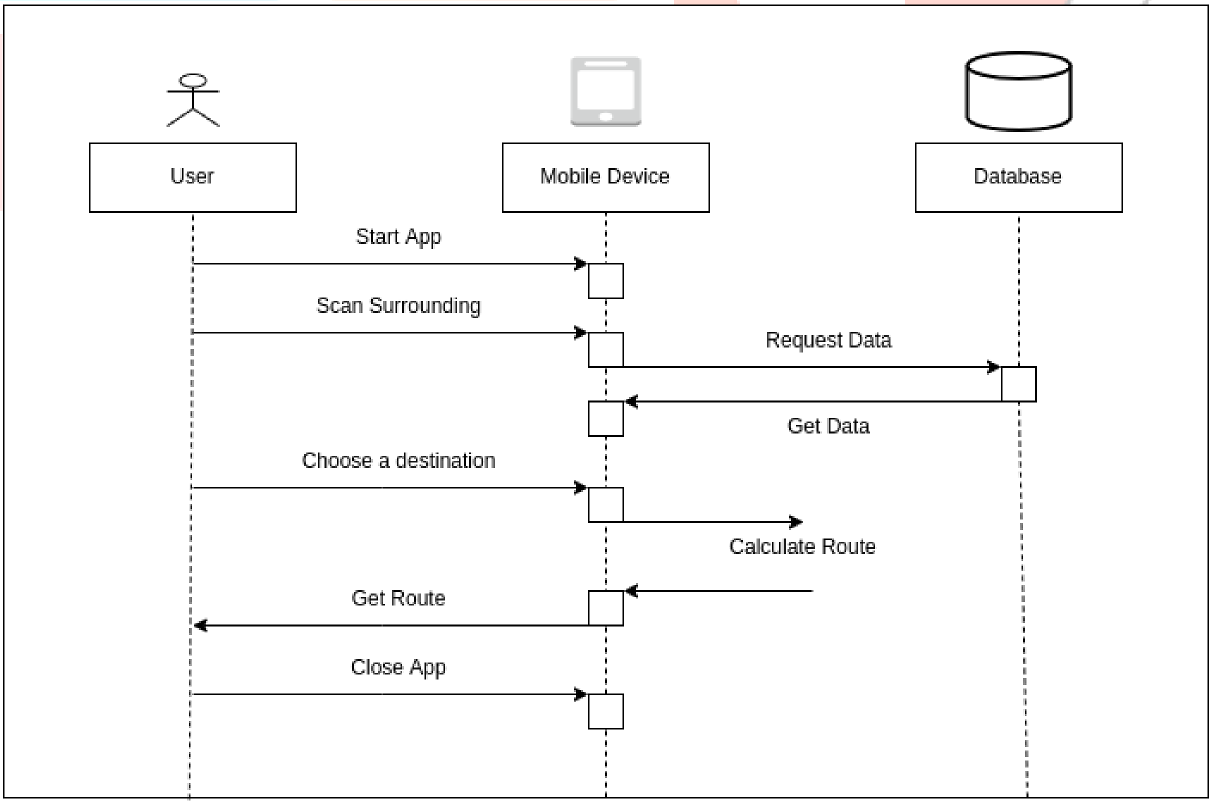


Figure 3.2 : Sequence diagram

IV. RESULTS

Figure 4.1 : Localisation

Figure 4.2 : Navigation

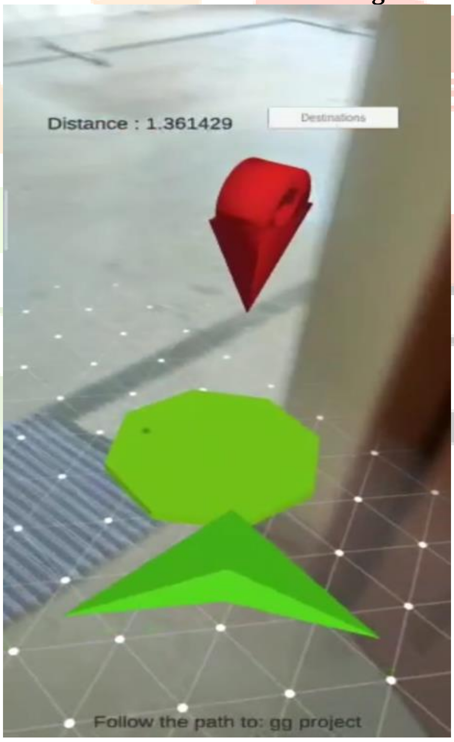


Figure 4.3 : Destination Reached

V. CONCLUSION

Augmented reality is relatively new and growing technology with lots more to discover, invent, reinvent, and reengineer. This will make AR a vibrant field to research and let its roots grow deeper into other disciplines too. One root of AR that is rapidly making its way to be researched by many is indoor navigation. Indoor navigation has become quite popular in the advent that people generally prefer going to large infrastructures as a mode of entertainment, but the frequency is not quite enough to remember details of navigating from the past. Moreover, 2D maps being helpful are also too vague. This is where indoor navigation using augmented reality comes into picture. A simple handheld device with AR capabilities could prove a very cost-effective and efficient way to handle navigation problems indoors. Various experiments have been done and completed successfully that also provide insights to better design these systems, directly indicating the need and scope of improvement. Comparing the findings, there are encounters with research studies and experimentations that have profound ways of approaching the problems and acquiring relationships between various factors that may influence the outcome while such a navigation system is put to work. Rendering capabilities, hardware limitations such as processing power of standard devices, camera's view angle, space covered, environmental problems like availability, similarity, differentiability of features, human error points such as human parallax, way of use of application, human abiding with capturing capabilities of the camera, network problems such as communication with the server, low signal strength, etc are some of the hindrances discovered. It is clear that AR systems are still under development but have a promising future.

On the other hand, it is also observed that there are working systems that have succeeded in navigating through AR with appreciable efficiency. Many of the systems developed have used various technologies to develop applications such as Android SDK, Vuforia SDK, Placenote SDK, Unity 3D, ARCore, marker-based tracking, markerless tracking, feature-based tracking, QR code based localization, live camera feed based localization, etc. Dijkstra's algorithm and A* algorithms were used for pathfinding. These technologies have been adopted to counter the problems that may arise on site and are effective.

Ultimately, when all the basic problems have been resolved, the goal of such systems would expand to have cross integrations with other applications, use of sophisticated APIs to add functionalities to the existing systems, extending the field of use, adding photorealism (a state where augmented objects would be indistinguishable from the real world objects), and most likely to have telemarketing.

During this survey, the team applied professional methodologies to review literature & understood the importance of ethics, teamwork and communication while doing so, which led the team to attain lifelong learning. The team would also like to thank the anonymous reviewers and contributors of this survey for their valuable insights.

REFERENCES

[1] Munesh Kumar Sharma, Satya Chachaundiya, Vishal, "Augmented Reality Navigation", International Journal of Engineering Research & Technology (IJERT) Vol. 9 Issue 06, June-2020.
[2] Ayush Sharma, Nisarg Gandhewar, Naushad Dhun, Neeraj Nehra, "Indoor Navigation System using Augmented Reality (AR)" Mukt Shabd Journal.
[3] Umair Rehman and Shi Cao, "Augmented Reality-based Indoor Navigation: A Comparative Analysis of Handheld Devices vs. Google Glass", IEEE Transactions on Human-Machine Systems, 47(1), 140–151.
[4] Sebastian Kasprzak, Andreas Komninos, Peter Barrie (2013), "Feature-based Indoor navigation using augmented reality", In Ninth International Conference on Intelligent Environments: Proceedings (pp. 100-107). IEEE.
[5] Dikshant Jopat, Krutarth Makwana, Hardik Dhanmeher,Joyce Lemos, "Indoor Navigation System Using Augmented Reality" IOSR Journal of Engineering (IOSRJEN), Vol. 10, Issue 3, March 2020, ||Series -II|| PP 14-18.
[6] Ashly Martin, John Cheriyan, JJ Ganesh, Joel Sebastian, Jayakrishna V, "Indoor Navigation using Augmented Reality", EAI.EU.
[7] Andreas Möller, Matthias Kranz Robert Huitl, Stefan Diewald, Luis Roalter, "A mobile indoor navigation system interface adapted to vision-based localization, Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia, MUM 2012. 4:1-4:10. 10.1145/2406367.2406372.
[8] Aaimon Quereshi, Sufyaan Wagle, Dr. Riyazoddin Siddiqui, "Indoor Navigation System Using Augmented Reality", International Journal of Computer Techniques -– Volume 7 Issue 2, April 2020.
[9] Sandra C J, Sandra Dileep, Sithara C S, Leya Elizabeth Sunny, "Indoor Navigation System Using Augmented Reality", International Research Journal of Engineering and Technology (IRJET), Volume: 08 Issue: 06 | June 2021
[10] Huang, Bo-Chen, Jiun Hsu, Edward T.-H. Chu, and Hui-Mei Wu. 2020. "ARBIN: Augmented Reality Based Indoor Navigation System", Sensors 20, no. 20: 5890.