International Journal of Computer Techniques -– Volume 7 Issue 2, April 2020

# INDOOR NAVIGATION SYSTEM USING AUGMENTED REALITY

AAIMON QURESHI
*INFORMATION TECHNOLOGY*
*M.H Saboo Siddik College of Engineering*
Mumbai, Maharashta
aaimonqureshi@gmail.com

SUFYAAN WAGLE
*INFORMATION TECHNOLOGY*
*M.H Saboo Siddik College of Engineering*
Mumbai, Maharashta
sufyaanwagle@gmail.com

DR. RIYAZODDIN SIDDIQUI
*INFORMATION TECHNOLOGY*
*M.H Saboo Siddik College of Engineering*
Mumbai, Maharashta
sriyazoddin4@gmail.com

***Abstract—*** Web-Based Indoor Navigation System refers to engaging different types of clients to begin partnership with EZYPATH and enjoy seamless indoor navigation within their organization's premises. Our web based system aims to encourage the client to build for themselves a place in our android application which will allow visitors of their organization an ease of navigating in their premises by simply providing us with their organization's map layouts and floor details. The system categorizes the website users as clients and admin. The users that will register themselves and provide us with the organization's infrastructural detailing are the clients, while the users that are able to access the client's information and process the map layouts are the admins. The admin of the system can access the details of a client in the system through the software. After the processing is completed and admin approves the output of processing, the admin then updates the database. The database then channels the information of the new client to the android based indoor navigation application system. The system integrates the use of graphs and nodes that will be applied on the map layouts so that the admins can mark the nodes on a 1D graph. The nodes then can be used to find the shortest path between the source and the destination and provide with the shortest path possible for navigation. The system uses A* (aystar) algorithm for finding the shortest path between two consecutives nodes and uses the distance formula for finding the estimated distance between nodes that lie on X & Y plane. The android part of the system works on the established connection between the mobile device and the web server. As the new institutes enroll into our website, the same institutes are reflected in the android application for navigation purpose. The android application is integrated with orientation sensor for guiding the user in a 1D overview of the building. It works on collecting two inputs from the user (source & destination) for presenting the shortest path on the mobile screen. The users of the android app are defined as visitors. Once the android application is updated with the new client's insttute, any visitors to the client can easily use the EZYPATH Android Application. The visitors can simply input their source and destination location and the server will return a map layout with the path the visitor needs to follow. Along with the map layout, the estimated steps to the destination will also be provided. Once the user reaches the destination he/she will be notified that destination has been reached and the app will take the visitor back to homepage. On the basis of registration and happy clients, this system generates a report weekly and monthly. It also shows the statistics of clients enrolling. This paper is a proposal for introducing augmented reality module in our existing system.

## I. INTRODUCTION

### A. *Personal Perception*

We all have been inside an unknown building and not known how to reach the destination place at some point. For e.g., Tried to find a particular store in a mall without any help except that of a static map. Especially when you are pressed for time and don't know the building well. For instance, you are late for an interview. Or more importantly, you have to evacuate the building in an emergency situation. Also in highly congested cities keeping track of places is difficult. Usually these places can be a local neighborhood, mall, hospital, or some big place. People not familiar with the place may need local guidance.

Existing navigation systems can be broadly classified into two major categories, indoor and outdoor. Most outdoor navigation techniques use satellite based navigation systems such as GPS, GLONASS, etc. to locate an object in any outdoor area. Such techniques work well in open spaces with a clear line of sight to the satellites, but may not perform well in an indoor environment, as the signals get scattered and attenuated by physical objects.

***Keywords: indoor navigation, augmented reality, map layout, source, destination, A*, graph***

### B. *Technologies to be used*

As we know that gathering location based information at places malls or any indoor environment is unreliable via satellite communication the main focus is to build the desired maps and integrate it with Augmented Reality to track the user and trace the destination. The tools that are used in the project are:-

**1. Unity Hub**
The Unity Hub is a game and graphics development platform that helps in integration of our work to achieve maximum performance. The Unity s/w can be used to develop AR applications integrating them with Map layouts and Android Studio to create an interface.

**2. Mapbox**
Mapbox is a tool that can be integrated with Unity that helps in creating map layouts with precision and can be used to perform 2D or 3D map developments.

**3. Wikitude SDK**
It is a tool that we can integrate with Unity to build AR related applications.

**4. Android Studio**
It is used to develop Android related applications to work on mobile platforms. It can be used to create a interface between users and the AR applications to achieve ease of use.

**5. Bootstrap**
Bootstrap is a free and open-source CSS framework directed at responsive, mobile-first front-end web development. It contains CSS- and JavaScript-based design templates for typography, forms, buttons, navigation, and other interface components

### *C. Drawbacks in previous systems*

1.The previous applications worked for a specific institutions or a specific building.
2. Different places like malls, hospitals, schools and other monuments were not included under the same application.
3. As network availability is an issue, the previous applications required on demand internet access inside buildings to load the specific map.
4. Live tour i.e. AR based navigation supported a specific institution.

### *D. Problem Statement*

To develop and implement an indoor navigation system comprising of a web application for general clients participation and a smartphone based augmented reality android application for visitor's indoor navigation by searching and navigating through the places of interests.

### *E. Paper organization contents*

Section 1: Provides the project background, the idea and the techniques to be used that overcome the drawbacks of the previously developed solutions.

Section 2: Provides in depth knowledge about the literature reviews and the study about the previously developed technologies.

Section 3: Provides the overall architecture of the system to be developed and the methodology that is to be followed including the analytics and the functionalities.

Section 4: Provides the overall outcome of the proposed solution.

## II. LITERATURE SURVEY

The existing applications and research papers suggests that augmented reality and map layouts have never been integrated in the same application previously. In order to achieve this integration, detailed study of individual components has been completed as seen below:

The shortest path or the route that will take the least time to reach the destination should be selected ideally in navigation. To achieve this , An application of Dijkstra's Algorithm to shortest route problem [11] is used to addresses the problem of Dominion Paints Nig. Ltd in transporting their products from their production plant to stores of sales by presenting analysis where multiple routes with their distances is deduced and according to Dijkstra's algorithm the shortest path is traced . 1-3-5-6-7 is the shortest path according to the software.It was concluded that the best paths found from the analysis will save the company less distance in transporting the paints and minimize time and cost of fueling their vehicles. A TORA software (version 2006) was used in the analysis.

The Traveler's Sidekick [7] is a mobile GPS application with a built in Shortest Path Finder for travelers visiting multiple locations. In order to find a good route in a reasonable time, a new algorithm, named Two Stage Divide and Conquer (TSDC) algorithm, was developed based on divide and conquer method. The divide and conquer (D&C) is an algorithm design paradigm based on multi-branched recursion

To increase the efficiency in the emergency room, the research has implemented a mobile-based indoor positioning system using mobile applications (APP) with the iBeacon solution [2] based on the Bluetooth Low Energy (BLE) technology. To estimate the patient's location the Received Signal Strength (RSS) based localization method is used. Their positioning algorithm achieves 97.22% (95% Confidence Interval = 95.90% ─ 98.55%) accuracy of classification.Nevertheless, these solutions require massive deployment of iBeacons as seen in fig 1.1, Wi-Fi AP's or RFID tags in the environment. It is very troublesome and costly. Also, proper deployment is necessary to gain high accuracy on user localization .

Android based application of integrated Augmented Reality and Location Based Service is implemented to provide the android mobile user to search tourist attractions, culinary places, map view and route of those places in Phnom Penh city, Cambodia. This application called Camtour [4] is conducted by using Wikitude SDK 5.2.0 and Google Maps API. According to system testing, the result indicates that the application usability assessment is achieved with a high rate 91.72. Another android application INSAR, Indoor Navigation System Using Augmented Reality [8], which utilizes WiFi fingerprinting technique as a positioning system and displays the information to the user using augmented reality AR technology determines the direction toward the destination on the fly using the smart compass of the mobile device. INSAR was tested on different Android mobile devices, smart phones and tablets, with different Android operating system versions. While INSAR uses wifi fingerprinting the Smartphone Based Indoor Navigation System uses on-device sensors for Dead-reckoning and is supported by a web based architecture, for easily creating indoor maps and providing an indoor location's information for navigation and localization.The solution uses a two phase approach : Map Generation phase and Localization and Navigation phase .
The Map Generation phase is a onetime process and is performed first for each indoor location. The Localization and Navigation phase will use the map generated in the first phase for user navigation. In the Map Generation phase, a user, the map-creator, captures multiple 360◦ panoramic images of the indoor environment. The user must ensure that these images are captured from each intersection of the pathways of the given indoor environment. These intersections are called Points of Interest(PoIs). Once these images are captured, the user can generate a map by uploading the images to our online web based editor, the Map-Maker.
The Map-Maker allows us to create and maintain maps for any number of indoor locations. The user can then use the Map-Maker to define tags in each of these images. A tag is a quadrilateral area defined in the panoramic image. When a user selects an indoor location in our proposed navigation system, we request this map data from the web server to generate a visual representation of the indoor area.

It is well-known that GPS performs too poorly inside buildings to provide usable indoor positioning it is for that reason that indoor navigation systems are considered much more challenging than outdoor navigation systems .The QR Code-based Indoor Navigation System Using Augmented Reality [9] constructed two scenarios that use QR codes to give indoor positioning data to navigation systems that have an AR interface. In cases where high-accuracy positioning is not required, QR codes could be the cheapest and easiest positioning method for an indoor navigation system. An AR navigation system can be efficiently implemented within defined areas such as university campuses, shopping centres, museums, and so on.

A Smartphone Based Indoor Navigation System[5],this proposed method uses on-device sensors for Dead-reckoning and is supported by a web based architecture, for easily creating indoor maps and providing an indoor location's information for navigation and localization.The solution uses a two phase approach : Map Generation phase and Localization and Navigation phase.The Map Generation phase is a one time process and is performed first for each indoor location. The Localization and Navigation phase will use the map generated in the first phase for user navigation.
In the Map Generation phase, a user, the map-creator, captures multiple 360◦ panoramic images of the indoor environment. The user must ensure that these images are captured from each intersection of the pathways of the given indoor environment. These intersections are called Points of Interest(PoIs). Once these images are captured, the user can generate a map by uploading the images to our online web based editor, the Map-Maker. The Map-Maker allows us to create and maintain maps for any number of indoor locations.

The application 3D Augmented Reality Mobile Navigation System Supporting Indoor Positioning Function [10] took "Oxford College" as an example to develop a 3D augmented reality mobile navigation system that supports the function of indoor positioning. This system collected the historical data to develop the 3D models according to the ratio of actual objectives, and constructed the 3D external and internal structures of Oxford College of the past.Moreover, this system combined RFID positioning function with the technology of markerless augmented reality to actively detect the location of visitors and to further instantaneously present 3D and multimedia navigation information on mobile devices.

## III. METHODOLOGY

### *A. Architecture*

1**.**GUI development - The graphical user interface mainly focuses on the ease and development of the app towards naïve users. Designing it using visual basics and SDK will make it more interactive and user-friendly.
2**.** Search the place, current and destination location – Using machine learning algorithms to make it more preference based rather than having to insert the location over and over again the main focus is to make the application more responsive.
3. Load the map – All the layout of the map and the location of the building will be pre-stored and pre-configured in the database. Using low cost or free database to help store the maps is the main motive. Using SQLite or MongoDB for easier access and less storage handling is very efficient.

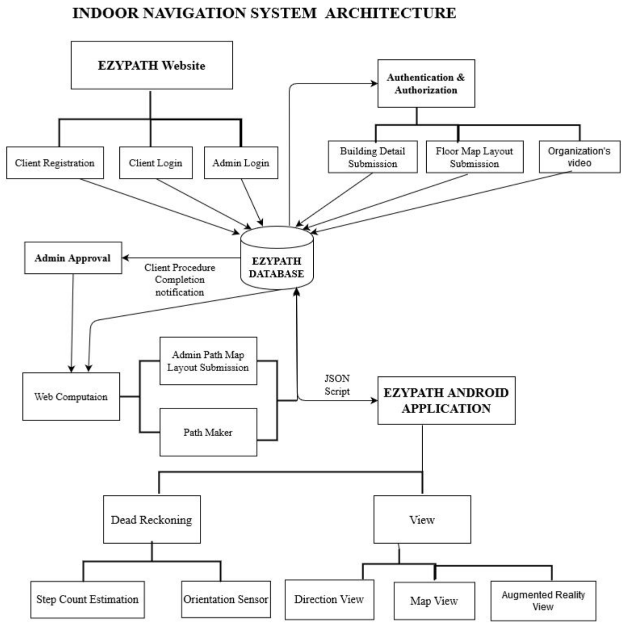



**Fig 1: Architecture of proposed solution**

4. Trace the path – Using technologies like GPS or Google Map Engine and APIs it becomes possible to trace and track the path the user inserted.
5. Predict steps and distance - Using Accelerometer and Gyroscope it becomes possible to estimate the steps and distance to make it easier for the naïve users to easily reach the destination.

### *B. FUNCTIONALITIES*

1. **Precision and Accuracy**
When user selects 'from' and 'to' location the precision with which the application marks the path and unmarks the area covered by the user when he/she begins to walk by following the directions which needs to be perfectly exact. The step estimation and time required to reach the destination are the calculations that should also be accurate whose failure may affect the functionality of the application.
2. **Path Marking**
After feeding to and from location the path marker is responsible to mark the path on the map that user is required to follow in order to reach the destination. A* algorithm used in the processing to mark the path under idle scenarios marks the path correctly but validation of path marked every time a search proceeds is a tedious job.

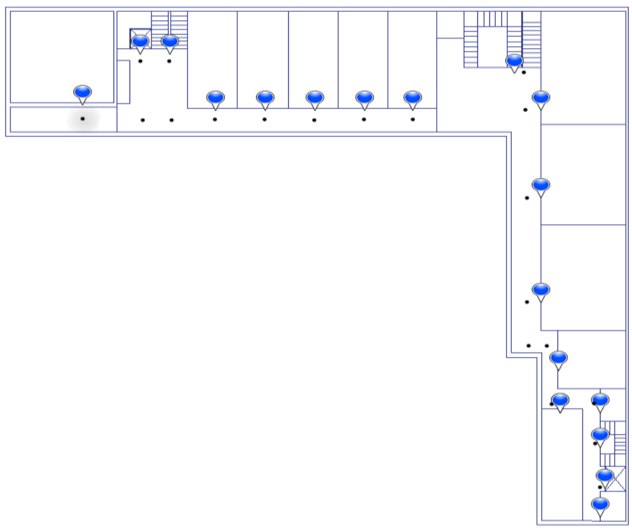


**Fig 2: Map Marked with Nodes**

The system integrates the use of graphs and nodes that will be applied on the map layouts so that the admins can mark the nodes on a 1D graph. The nodes then can be used to find the shortest path between the source and the destination and provide with the shortest path possible for navigation. The system uses A* (aystar) algorithm for finding the shortest path between two consecutives nodes and uses the distance formula for finding the estimated distance between nodes that lie on X & Y plane.

**The Distance formula for multiple nodes on a graph in 1 Dimension:**

Consider a graph with multiple nodes on a 1D graph each having a unique x & y coordinate. Every two nodes on the graph share a distance. This distance is the time taken to reach from one node to another. So, considering that a graph which has a 4 node path to be traversed is from n1-n4 with nodes n1,n2,n3 and n4, we first calculated the distance between nodes n1 and n2… similarly n2 and n3 then add then add the distance between these three node and the n3 and n4. Next n1 and n3…. And so on. Now select the shortest distance between the nodes, eg: distance from n1-n2-n3-n4 is 23 and distance between n1-n4 directly is 11… so we can directly traverse the path from n1-n4

So the distance formula for traversing the paths between multiple nodes is:

THE DISTANCE FORMULA

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Where d= Distance between two nodes
X1= x coordinates of the node 1; Y1= y coordinate of the node 1
X2= x coordinates of the node 2; Y2= y coordinate of the node 2

The android part of the system works on the established connection between the mobile device and the web server. As the new institutes enroll into our website with ne institutes, the same institutes are reflected in the android application for navigation purpose. The android application is integrated with orientation sensor for guiding the user in a 1D overview of the building. It works on collecting two inputs from the user (source & destination) for presenting the shortest path on the mobile screen.

3. **Dead Reckoning**

Dead reckoning is an important technique used for finding the position of user and estimation of time and foot step. It involves step detection, accelerometer sensing and orientation sensing techniques to achieve its complete functioning.

3.1 Step Detection

A step motion can be defined when the foot start lifting and touch the ground with a measurable movement range to make a change from the outset to the posterior position. Another parameter is a time gap between each step. So as soon as user begins to walk depending upon his/her initial footsteps the accelerometer and magnetometer is used to estimate the time and steps required by the user to reach a particular destination.

3.2 Accelerometer Sensing

To achieve accelerometer sensing 'A human Movement Detection Algorithm Using 3-Axis Accelerometer Sensor' will utilize low-power management scheme that uses baseband processor installed in a portable communication device to limit electric power consumed by device,along with a human movement detection algorithm that records and predicts the movement of the mobile user in a low-power mode. It will use 3-axis accelerometer sensors on an Android platform and calculates the amount of human movement from the sensor output which is another basic requirement of this application.

3.3 Orientation Sensing

Kalman filter algorithm will help gyroscope's output of orientation change to be utilized by the path marker to trace the turns, left and right taken by the user and guide him/her accordingly. Failing to sense the motion correctly application will end up confusing the user and will result into wastage of time.

4. **Augmented Reality Preview**

SLAM (Simultaneous Localization and Mapping) is the most effective way to render virtual images over real-world objects. SLAM simultaneously localizes sensors with respect to their surroundings, while at the same time mapping the structure of the environment.

SLAM is an approach to solve complex AR simulation problems and is not any specific algorithm or software. The SLAM system is, in fact, a set of algorithms aimed at solving simultaneous localization and mapping problem. This can be done in multiple ways and now every augmented reality development kit has it upon to providing SLAM functionality.

Augmented reality preview when triggered by the user will invoke the functioning of SLAM and will deliver the expected results which is the augmented reality of the environment.

5. **Direction View**

In augmented reality view the most important component is the view that directs the user to his/her destination by pointing arrows towards the right direction. This view uses embedded compass in smartphones to give correct direction towards destination. Direction view is only invoked after user has selected augmented reality preview.

6. **Path View**

After the entire map is displayed and user has already selected its initial and final location then the path that will take the user from source to the destination is zoomed in and only specific section of required map will be displayed which is known as path view.

7. **Map View**

Maps fed into system will be displayed by the application when users will select 'Map View' of a particular institution/building/railway station. This map view integrated with dead reckoning will implement guiding the user to his/her destination. However, usage of 3D map layouts requires the use and integration of Unity software.

### *C. Analysis/ Comparative Study*

Table 1: Comparative study

| **Proposed System** | **Sensor/ Positioning Technology** | **Supporting Software/ Technology (s)** | **Comm. / Transmission** | **Purpose/ Target** |
|---|---|---|---|---|
| Kushleyev A. et al [21] | Vicon Cameras | MatLab | Radio Freq. (900 MHz), Zigbee (2.4 GHz) | Agility, Tight formation, Precise control. |
| Gageik et al [22] | Optical Flow Sensor (ADNS-3080) | Ultrasonic Sensor, Qt ControlSoftware | NA | Autonomous Flight with six DOF, Position Hold |
| Zingg et al [23] | Optical Flow based fisheye camera | MATLAB Simulink , IMU data | ZigBee Wireless communication at 20 Hz | Obstacle avoidance using depth mapping |
| Shaima et al [24] | 12 Vicon Cameras | Matlab, Simulink, Calibration Wand, Sync Box | NA | Compare the results received from On-board sensors and Vicon system |
| Hui et al [25] | Ultrasonic sensor | optical flow sensor, 9-DOF | 40 Hz for the highlevel, 400 | Position control, |

| | | | | |
|---|---|---|---|---|
| | | IMU | Hz for low level stabilization | autonomous trajectory tracking with 6 DOF |
| Pravitra et al [18] | Hokuyo URG-04LX laser range scanner | sonar range finder to altitude, IMU | Laser scanner works at 10 Hz | Unknown indoor exploration |
| Yang et al [26] | Infrared camera | Infrared laser lamp | Data update rate 200 HZ | UAV automatic landing in real time in GPS denied environment |

### D. *Improvement*

The existing systems for any indoor environment focused on a particular building or an institute but our system focuses on any general indoor place/buildings. Many applications were dependent on Google API for location specifications which involved dependencies but our system focuses on layouts and videos provided by clients irrespective of any outdoor area thus excluding any dependency. Each existing application focused on either map layout and tracing or Augmented Reality but our system aims to provide both the tracing and AR experience for the end users based on ones need 3D map layouts designed can provide interactive look of the institute which enhances user experience.

## IV. DESIGNS

### 1. USE CASE DIAGRAM:

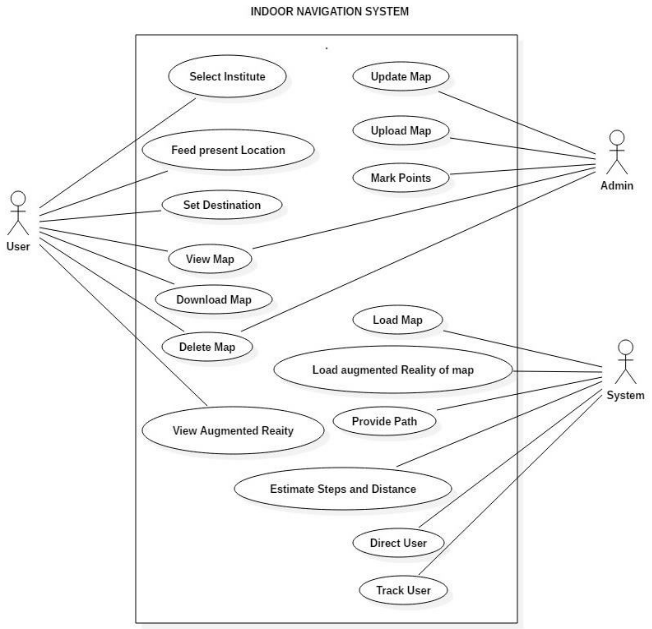



**Fig 2: Use Case diagram for indoor navigation system**

**Use Cases:**

1. Select Institute: It is the module that allows the users to select from different types of institute like college, hospital, railway station, etc.
2. Feed present location: This module allows users to give the input for their current location in a particular institute.
3. Set destination: This module gives the users the choice to choose the destination from a list of predefined locations present in the selected institute.
4. View Map: This module helps the user to view the map layout of the selected institute depending upon the destination displayed by the system and allows user to understand the institute layout better.
5. Download Map: Users can easily download the map of the institute due to this module.
6. Delete Map: This module allows users to delete the previously downloaded map.
7. View augmented Reality: This module allows user to view the augmented reality of the map of selected institute.
8. Update Map: The admin has the authority to correct/add/delete elements of the map from the database on the basis of changes in the institute using this module.
9. Upload Map: The admin can correct/add/delete elements of the map from the database on the basis of changes in the institute and upload the same on the android application using this module.
10. Mark Points: Using this module admin can mark calibration points on the map in cases where new destination has been updated in the map and without marking the calibration point destination cannot be reached.
11. Load Map: The system can display the layout of the map of selected institute using this module.
12. Load Augmented Reality of Map: The system displays the augmented reality of the selected map and makes it available for the users to view.
13. Provide Path: The path from source to destination is highlighted by the system in cases of map layout and in case of augmented reality, directions are provided using this module.
14. Estimate Steps and Distance: The system will calculate the step estimates and distance depending upon the accelerometer and gyroscope readings that are already embedded in the smart-phone motherboard and gives user a general idea of how far the destination is and how much time it will take to reach the destination.
15. Direct User: This module will show the correct directions to the user and indicate whether user is following the right route or not.
16. Track User: User will be tracked by the system depending upon the calibration points in cases of augmented reality and estimates steps and distance in case map layout is being used by the users.

### 2. SEQUENCE DIAGRAM:

**Classes Roles:** Class roles describe the way an object will behave in context. The classes that are used in this application are as follows:-

**Database:** The database stores map layouts and videos of various institutes and depending upon the user request that particular information is retrieved and displayed.

**User Interface:** Allows users to interact with the application and displays various screens and views depending upon the user request.

**Path Marker:** Depending upon the source and destination the path marker will highlight the route on the map and will also display the path covered by the user and path to be covered.

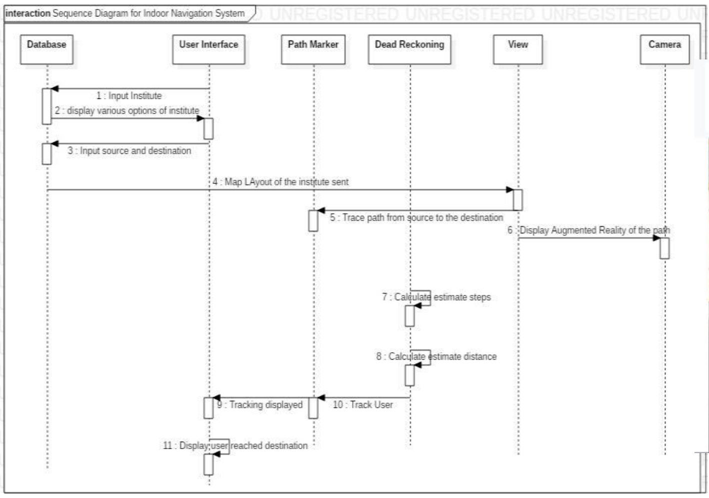



**Fig 3: Sequence diagram for indoor navigation system**

**Dead Reckoning:** Helps to mark calibration points and gives users a rough idea about how far the destination is and allows

**View :** It allows user to view map layout and track themselves

**Camera:**The allows to activate the augmented reality of the map and directs the user.

## COMMUNICATION DIAGRAM:

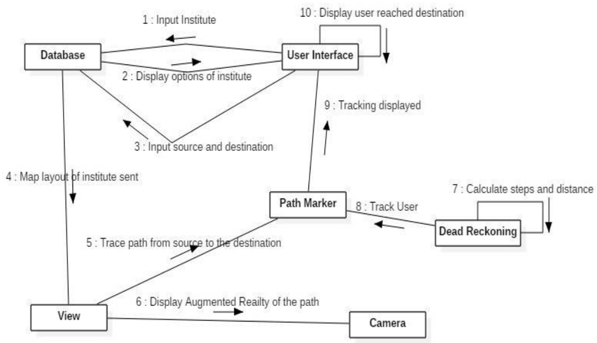



**Fig 4: Communication diagram for indoor navigation system**

## Objects:

Communication diagram consists of multiple objects that communicate with each other to ensure smooth running of application. Various objects used in this application are as follows:-

**Database:** The database stores map layouts and videos of various institutes and depending upon the user request that particular information is retrieved and displayed.

**User Interface:** Allows users to interact with the application and displays various screens and views depending upon the user request.

**Path Marker:** Depending upon the source and destination the path marker will highlight the route on the map and will also display the path covered by the user and path to be covered.

**Dead Reckoning:** Helps to mark calibration points and gives users a rough idea about how far the destination is and allows

**View :** It allows user to view map layout and track themselves

**Camera:**The allows to activate the augmented reality of the map and directs the user.

# V. RESULTS

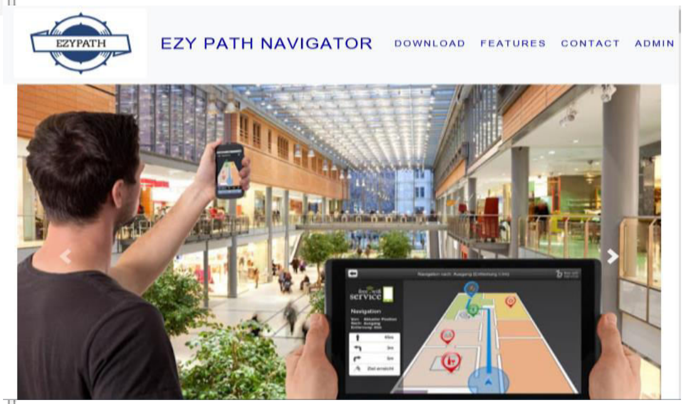



**Fig 5: EZYPATH Homepage**

The EZYPATH website allows general client participation and allows web users to register themselves. Once registered the clients can then log into the system and start providing us with their company's infrastructural details as seen in fig 6 & fig7.

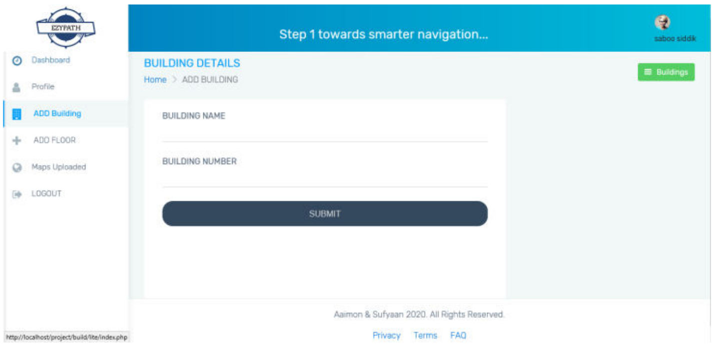



**Fig 6: Add Building Page**

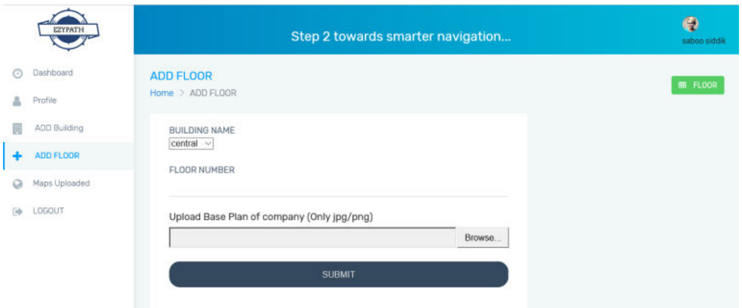



**Fig 7: Add Floor page**

After submitting all details the new organization's details will be reflected in the android application after a few days.

The system integrates the use of graphs and nodes that will be applied on the map layouts so that the admins can mark the nodes on a 1D graph. The admin has the privilege to upload processed maps to database and make the computation process easy. At the time of android app user request the server can simply retrieve the processed map and using A* algorithm mark the path on the map and provide it to user.

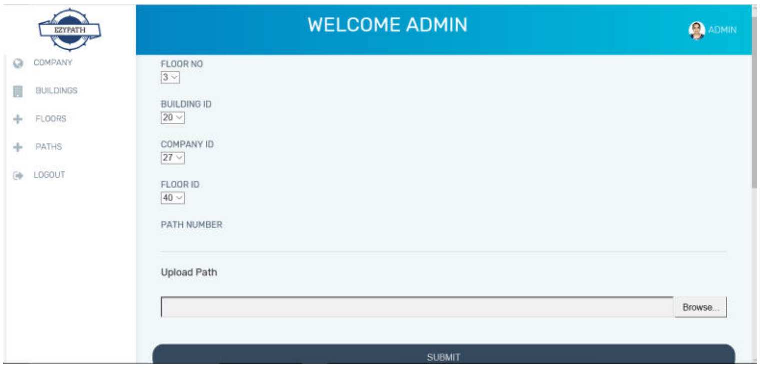
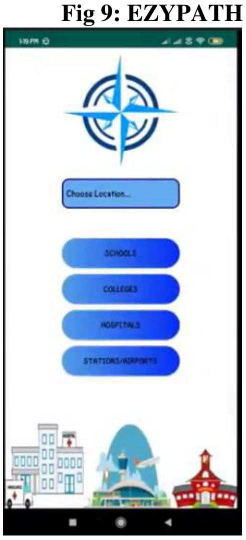



**Fig 8: Add Processed Map Layout Page**


**Fig 9: EZYPATH Android Application**



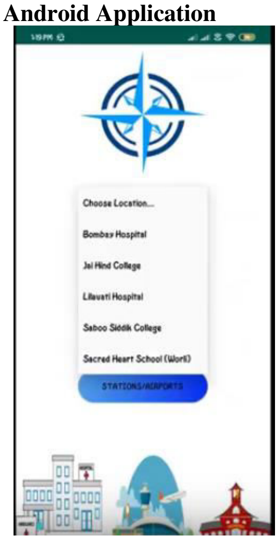




**Fig 10: Homepage** **Fig 11: Input Organization.**

The android user which is the visitor only needs to choose a particular organization/company and then a screen appears which shows the base plan of organization. The screen with base plan also gives two important options to user that are source and destination location. Once user inputs these information, the app begins to guide and track the user and after the user reaches the destination it notifies that the journey has been completed.

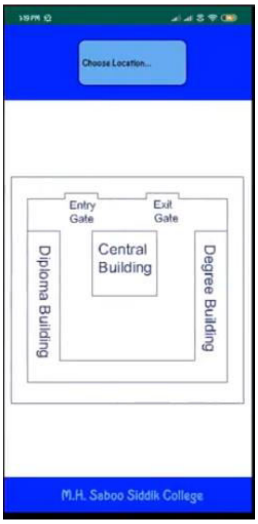



**Fig 12: Base Plan**


**Fig 13: Result 1**


**Fig 13: Result 2**

## VI. CONCLUSION

Multiple technologies and papers have shown the usage of augmented reality being most fruitful in indoor navigation systems. GPS being the key component in navigation systems can however be replaced by accelerometer and gyroscope for navigation purposes. Many papers were referred to understand the working of each module of the proposed solution depicted in the form of architecture diagram. In depth requirement analysis has been done to know the exact functional and non-functional requirements of the application under development. Designs comprised of UML diagrams which were use case, sequence and collaboration diagram. The results can conclude that our existing system works exceptionally well for 2D maps.

## VII. FUTURE SCOPE

Considering our existing system and its results it is very clear that the EZYPATH website and android application works efficiently for indoor navigation. However this system can be modified to comprise an Augmented Reality module as shown in all the UML diagrams and in the proposed solution. The Augmented reality module will help all kinds of people.

## ACKNOWLEDGMENT

We would like to express special thanks of gratitude to our mentor **Associate. Professor Dr. Riyazoddin Siddiqui** as who guided us and gave us this opportunity to do this wonderful project on the topic of **Indoor Navigation System**, which also helped us in doing a lot of research and we came to know about many new things. We would also like to thank our HOD **Er. Zainab Mirza** for providing us with the opportunity to implement our project. We are very thankful to them. Finally we would like to thank our parents and friends who helped us a lot in finalizing this project within the limited time frame.

## REFERENCES

[1] Hsu, H.H., Peng, W.J., Shih, T.K., Pai, T.W. and Man, K.L., 2014, September. Smartphone indoor localization with accelerometer and gyroscope. In *2014 17th International Conference on Network-Based Information Systems* (pp. 465-469). IEEE.

[2] Lin, X.Y., Ho, T.W., Fang, C.C., Yen, Z.S., Yang, B.J. and Lai, F., 2015, August. A mobile indoor positioning system based on iBeacon technology. In *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 4970-4973). IEEE.

[3] Uddin, M.P., Islam, M.Z., Nadim, M. and Afjal, M.I.,2013,November. GPS-based Location Tracking System via Android Device. International Journal of Research in Computer Engineering and Electronics. 1 VOL: 2 ISSUE: 5

[4]SokthayChanphearith, Alb.JokoSantoso, Suyoto, 2016,December. Analysis and Implementation of Location-Based Augmented Reality Mobile Application for Searching Tourist Attractions and Culinary Places in Phnom Penh City, Cambodia. International Journal of Computer Science Trends and Technology (IJCST) – Volume 4 Issue 6.

[5] Kim, S.E., Kim, Y., Yoon, J. and Kim, E.S., 2012, November. Indoor positioning system using geomagnetic anomalies for smartphones. In *2012 International conference on indoor positioning and indoor navigation (IPIN)* (pp. 1-5). IEEE.

[6] La Delfa, G.C. and Catania, V., 2014. Accurate indoor navigation using smartphone, bluetooth low energy and visual tags. In *Proceedings of the 2nd Conference on Mobile and Information Technologies in Medicine*.

[7] Yoo, W.S. and Kloub, L., 2016, July. Mobile web application with shortest path finder. In *2016 SAI Computing Conference (SAI)* (pp. 946-951). IEEE.

[8] Alnabhan, A. and Tomaszewski, B., 2014, November. INSAR: Indoor navigation system using augmented reality. In *Proceedings of the Sixth ACM SIGSPATIAL International Workshop on Indoor Spatial Awareness* (pp. 36-43). ACM.

[9] Jang, S.H., 2012, September. A qr code-based indoor navigation system using augmented reality. In *GIScience–Seventh International Conference on Geographic Information Science, USA*.

[10] Wang, C.S., Chiang, D.J. and Ho, Y.Y., 2012, July. 3D augmented reality mobile navigation system supporting indoor positioning function. In *2012 IEEE International Conference on Computational Intelligence and Cybernetics (CyberneticsCom)*(pp. 64-68). IEEE.

[11] Ojekudo, Nathaniel Akpofure (PhD) 1& Akpan, Nsikan Paul (PhD) 2, 1Department of Mathematics and Computer science, Ignatius Ajuru University of Education,Port Harcourt, Rivers State, Nigeria. 2Department of Mathematics and Statistics, University of Port Harcourt, Nigeria

[12] Barberis, C., Andrea, B., Giovanni, M. and Paolo, M., 2014. Experiencing indoor navigation on mobile devices. *It Professional*, *16*(1), pp.50-57.

[13] Paiva, S., 2013. A Mobile and Web Indoor Navigation System: A Case Study in a University Environment. In *Advances in Information Systems and Technologies* (pp. 959-968). Springer, Berlin, Heidelberg.

[14] Vignesh Vasudevan, Guojun Yang, Jafar Saniie, "Autonomous Indoor Pathfinding Using Neural Network in Complex Scenes", *Electro/Information Technology (EIT) 2018 IEEE International Conference on*, pp. 0323-0327, 2018.

[15] P. Misra and P. Enge, Global Positioning System: Signals, Measurements, and Performance, 2nd ed. Lincoln, MA: Ganga-Jamuna Press 2006

[16] Held M.;Karp,R.M. "The Traveling Salesman Problem and Minimum Spanning Trees" Operations Research 1970.

[17] H. Liu, H.Darabi, P. Banerjee, and J.Liu, "Survey of wireless indoor positioning techniques and systems," IEEE Transactions on Ststems, Man, and Cybernetics ,Part C: Applications and Reviews,vol.37,no.6,pp.1067-1080, Nov.2007.

[18] R.Brunno and F.Delmastro,"Design and analysis of a Bluetooth-based indoor localization system," in Proc.Personal Wireless Communication(PWC), 2003, pp.711-725.

[19] Bellot Arias, S.:Visual tag recognition for indoor positioning (2011).

[20] Bissig,P.,Wattenhofer, R., Welten, S.:A Pocket Guide to Indoor Mapping. In:Workshop on Positioning, Navigation and Communication (WPNC), Dresden, Germany(March 2013).

[21] A Kushleyev, D Mellinger, C Powers, et al. Towards A Swarm of Agile Micro Quadrotors. Auton Robot. 2013; 35: 287.

[22] N Gageik, M Strohmeier, S Montenegro. An Autonomous UAV with an Optical Flow Sensor for Positioning and Navigation. International Journal of Advanced Robotic Systems. 2013; 10(10).

[23] S Zingg, D Scaramuzza, S Weiss, R Siegwart. MAV navigation through indoor corridors using optical flow. 2010 IEEE International Conference on Robotics and Automation. Anchorage, AK. 2010.

[24] SA Habsi, M Shehada, M Abdoon, A Mashood, H Noura. Integration of a Vicon camera system for indoor flight of a Parrot AR Drone. 2015 10th International Symposium on Mechatronics and its Applications (ISMA). Sharjah. 2015.

[25] C Hui, C Yousheng, WW Shing. Trajectory tracking and formation flight of autonomous UAVs in GPS-denied environments using onboard sensing. Proceedings of 2014 IEEE Chinese Guidance, Navigation and Control Conference. Yantai. 2014