© July 2021| IJIRT | Volume 8 Issue 2 | ISSN: 2349-6002

# Indoor Navigation System

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***Abstract* - Our aim is to provide a comprehensive summary of the evolution of indoor navigation technologies. Indoor navigation is a system that is used to locate the exact locations inside a campus both. This system does not use the GPS (Global Positioning System) and any other Internet technologies. The challenge is to create an app that would show a navigation path in the real world on your mobile device screen. This is beneficial to everyday citizens because it allows one to accurately navigate to a specific location in a building they have never been to before, such as government offices, an airport, a classroom on the mall campus / grocery store to show customers what they want to buy etc. To developed system should provide, in real-time, useful navigation information that enables a user to make suitable and timely decisions on which route to follow in an indoor space.**

## 1.INTRODUCTION

Reaching to specific locations in indoor environments is a challenging task. Especially in complex and large buildings, such as airports, hospitals, or other public buildings, people find it difficult to locate their desired place. They often have to go through different paths in order to reach their individual goals. Global GPS system is attractive outside but does not work reliably in-houseofces. Therefore, it is important to tailor a navigation system to cater the needs of a visiting person and the specific task that has to be fulfilled. Nowadays, several indoor navigation technologies and systems have already been published [2] proving a reasonable tracking technique in indoor environments with an accuracy of a few meters down to a few centimeters in certain regions. These technologies, usually based on Bluetooth or other radio frequency (RF) technologies, only operate at a short distance and need a complex infrastructure. Positioning and navigation via Wi-Fi requires a dense network of access points, which leads to high maintenance costs, but only provides positional accuracy of 1–3 m. Technologies which are using signal strength triangulation methods allow us at least to estimate a rough position. Other technologies such as vision-based methods [1] provide high accuracy in subsequent tracking and simulate device configuration in real time. However, there are still limitations concerning the localization and reliability over time because most of the vision-based systems depend on the lighting conditions to give coveted results.
Vision-based systems are very popular these days. It has two subtypes, marker-based AR and marker-less-based AR [3]. Without any doubt marker-based AR is more mature, but also it needs more computation and memory. AR is being used to superimpose directional signage on a real time environment which is seen through the smartphone's camera.

## 2. LITERATURE SURVEY

Thomas J. Gallagher[4], proposed an approach "A sector-based campus-wide indoor positioning system" The system that relies on the Wi-Fi fingerprinting technique when used indoors and can provide users with useful location information of the indoors, even when relying on a simple database that is very quick to build. A more advanced positioning algorithm on the server-side can increase the accuracy by up to 15%.
R.Abhilash , P.Asha[7], proposed an approach "Indoor Navigation System" The system makes navigation simple by designing it to work in offline mode and street view makes the user to know the buildings inside the campus as it is in reality as it offers 2D and 3D navigation systems.
Hao Xue, Lin Ma [3], has proposed an approach "A Fast Visual Map Building Method Using Video Stream for Visual-Based Indoor Localization" This paper presents ways of video stream and visual maps for indoor localization. Users can interact and navigate easily. It used the concept of image where GPS signals are often not available.
Dhanashree Dhawan, Megha Anpat, Clita D'Souza, Prof. R.V.Shahabade[5] as proposed "University campus event navigation guidance and updated event

information alert system" It will work on GPS based android mobile colleges organizing various events but students/people not getting information about it. Many times students are unaware of the events going around them and are unable to explore themselves, by their proposed system users can access the details regarding a particular event through an android application on his/her smartphone along with the location of the event and the route to reach to that location with the help of GPS.

Vidhyavani.A, StephinStanly, Ankit Kumar Pandey, Shivam Choudhury[6], proposed an approach "Combination Of Real And Virtual World For Indoor Navigation using Mobile Application" A system for indoor navigation based on augmented reality which is supported on the android platform. The complex scenarios can be found in various indoor environments where one cannot find a real-world object which acts as a feature for the navigation hence we have introduced the QR code based feature for that.

Yadav, R., Chugh, H., Jain, V., & Baneriee, P[3], proposed an approach "System Using Visual Positioning System with Augmented Reality" The accuracy of the AR toolkit in detecting a marker depends on lighting conditions. It is required to maintain the same lighting condition for the marker to provide users with precise navigation with the help of the marker. In the future, there can be various modifications made to the navigation system, such as using an audio module for helping in navigating, and also, the processing and camera rating can be improved. AR tools can be trained to find colored markers as well.

## 3. INFERENCES

Among the different navigation techniques surveyed, Wi-Fi fingerprinting, RFID etc. have an external hardware requirement such as Wi-Fi access points or beacons. Vision-based navigation and VPS, on the other hand, can be achieved without these external hardware resources, though using them jointly will definitely increase the accuracy of computer vision. The various augmented reality types and implementation approaches studied show the various possible implementations of this technology. AR can be implemented with head-mounted displays as well as handheld devices like smartphones. Marker-based AR is the easiest to implement but it limits the experience to areas where markers are available. To make the user interaction more immersive, we can best try to implement marker less AR which is more difficult to implement than marker-based but more flexible as required for navigation.

## 4.BASIC REQUIREMENT OF SYSTEM

DATABASES:

1. Central Database Server: To store access point SSID and geo-location central database server will be used for it. When a system specific unique SSID will be selected then it will be assigned to an access point and further using the public web API it will be crowdsourced to the database.
2. Local Application database: This will actually contain a database for particular buildings, and we can call it a subset of the central database. Using the web API this database will be synchronized with the central database.

WEB SERVICE: To transact the data between a database and our web application the system will contain a web service. A RESTful public web API can be used to receive and respond to the user with valid arguments.

INDOOR MAPPING: Creating indoor maps of buildings (colleges, hospitals, malls, etc.) is not as simple as maps of the outdoor environment. As we do not have GPS signals indoors and robots walking through such places can be risky. Also, such buildings often have many levels or floors, so basically an ideal solution would require 3D maps and/or models. It is said that there are few indoor mapping initiatives that are working on the challenge in commercial as well as public domains.

Internal position like GPS for indoor ips refers to technology that helps find people and objects inside. For instance, IPS technologies enable a number of location-based indoor tracking solutions, including real-time location systems (RTLS), wayfinding, inventory management, and first responder location systems. Home storage solutions based on standard consumer standards Wi-Fi or Bluetooth energyble but also solutions based on ultra-wideband uwb or passive RFID

NAVIGATING ALGORITHM: The algorithms have been divided into indoor positioning and shortest path algorithms using different technologies. It can be seen that most of the previous studies have focused on indoor positioning algorithms while few studies have explored the shortest path algorithms. As illustrated in Fig 1

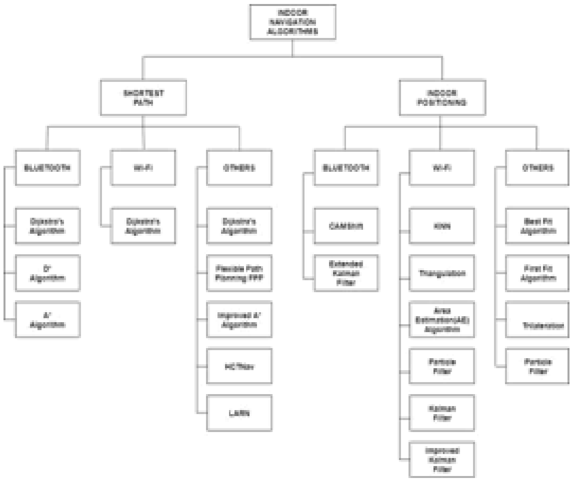


Figure 1: Indoor Navigation Algorithms for Shortest Path and Indoor Positioning

## 5.TAXONOMY OF INDOOR NAVIGATION SYSTEM

Having an indoor map is not enough to get the correct path inside a building since GPS signals are not available there. There has been some technology and techniques used for the indoor navigation system.

### 5.1 Proximity-based Systems

This technique uses the tag and beacons as the main component to determine the location of the person. Beacons are attached to the hardware and transfer the unique code data to a nearby hard-wired receiver. It is preferable for small areas. In Figure 2, We described the connectivity between client and the component of the system.

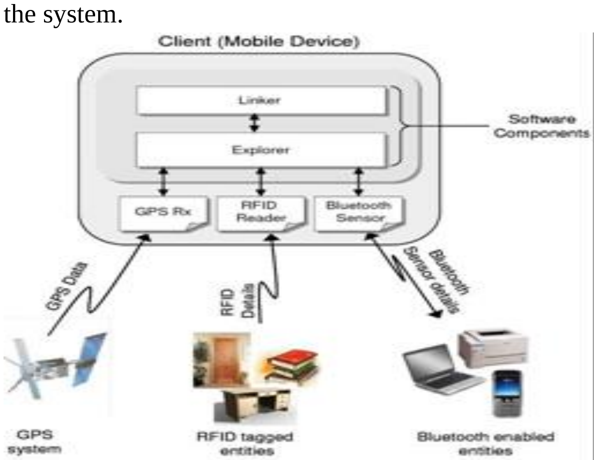


Figure 2: Proximity Architecture [8]

### 5.2 Wi-Fi-based Systems

Wi-Fi Based Positioning System is also an option to get the position of the mobile device inside a building. Here we measured the intensity of Wi-Fi signals and the access points present in the database. But using this technology required a proper installation of wifi routers inside the buildings

Wi-Fi environment and reports the list of Wi-Fi access points and their associated signal strengths. The database from the survey is then used to estimate the tag's likely position. The accuracy depends on the number of nearby access points whose positions have been come into the database.

#### 5.2.1 Access Points

Access points refers to the location or position where we place the networking device to connect with a wifi enabled device to the wired component.

#### 5.2.2 Wi-Fi marker

We are placing routers in rooms to cover the whole place for RSS to be measured. Rooms are divided into smaller areas represented by nodes for referencing. Small portion of a room, we have N number of nodal points.

#### 5.2.3 Triangulation technique

We will receive the signal strength from each access point and use this information to calculate the distance from each access point. This access point will give the location information. It will use all the information to triangulate the Mobile Device's position.

Steps to calculate user position with the help of WiFi:

- Get the latitude and longitude
- Position of user's smartphone with respect to each Wi-Fi.
- Calculate the shortest distance.
- Matched the calculated value with the stored database.

#### 5.2.4 Received Signal Strength Indicator

It's used to estimate the state of a dynamic system from a series of incomplete and noisy surroundings.

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Now the Kalman filter is used to convert the RSS value into distance. When we received three valid estimates

from Kalman's filter from any of the access points then we used this to localize the user's position.
To minimize the difference between the expected and actual location. We keep on tracking the output result of our system using EVM.
EVM stands for Error Vector Magnitude is actually Root Mean Square (RMS) of the error vectors calculated and expressed as a percentage of the EVM Normalization Reference.
The below figure shows how EVM metric calculation and how a single error vector is calculated.

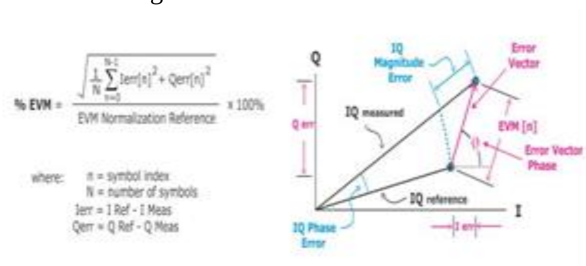


Figure 3: EVM Normalization

To design the Wi-Fi based system we have four main functions.  We have described those functions in Figure 4.


Figure 4: System flow for WiFi

5.3 Ultra-Wide-Band (UWB)

System Ultra-Wide-Band is a wireless technology which can be used for data transmission and positioning. Unlike other common wireless technologies such as ble or Wi-Fi this broad band transmits a low amount of energy distributed across a wide range of frequencies. Nowadays ultra-wideband chips are small enough to put them in any other devices like smartphones. The frequency range of Ultra-wideband is in the range of 3.1 to 10.6 Ghz. Its only drawback is its short range. And uwb is ready to deliver more data from the transmitter to other devices as uwb uses lower power and higher bandwidth.
Ultra-wideband is a wireless communication protocol which uses radio waves as Wi-Fi and bluetooth. Transmitter of the UWB sends an enormous amount of radio pulses across the wide spectrum frequency and further the UWB receiver translates those pulses into data. As the bats use echolocation to understand their surroundings, UWB pulses can be also used to understand distance between two transmitters. Precise distance measurement will be inversely proportional to the duration of the impulse. UWB sends billions of pulses per second and it achieves a real-time accuracy. UWB encodes information by sending pulses in patterns.
Entering a single data code takes 32 to 128 pulses. In latest smart phones UWB is used and whenever they come closer to other UWB devices, they start ranging, or measuring, their exact distance. This ranging is achieved by Time of Flight the time taken by pulse to reach from one point to another.
The next two solutions are based on augmented reality technology.

5.4 AR Cloud with visual world saving

The cloud solution provided by Google allows adding virtual objects to an AR scene. Many users can view and interact with these objects simultaneously from various positions in the shared physical spaceA. The position of the location around which the world is anchored is saved to the cloud. In this case, what is meant by "the world" is images that are taken from the camera view.

AR Cloud also come up with some disadvantages:
Cloud anchors can be resolved within a period of 24 hours after it has been processed. Google is currently developing persistent Cloud Anchors, which can be resolved for much longer time periods.
This solution only works with a stable network connection.

A different identical location can cause negative effects.

5.5 Visual Markers – AR-based indoor navigation
This solution is based on creating visual markers, also known as AR Markers, or AR Reference Image, and then detecting their position. In this case all you need is your camera. Having access to data about the world around your camera field of view, you can process this data and apply any logic you want. That's why we ultimately selected this method.
Visual marker is a visual image of Apple's Kit, AR's Google Core, and other AR SDKs. Visual icons are used to tell the app where to place AR content. If we place a visual marker somewhere in space, on a floor or wall surface for example, then when scanning we will not only be able to see the marker represented in AR but also its exact coordinates in the real world.

## 6.INDOOR MAPPING INITIATIVES

Google Indoor Maps -It allows you to locate our building on Google Map, upload and align our building's floor plan, and submit it for processing. Once processed, the indoor map will be available in Google Maps.

Open Streets Maps (OSM) - The OSM is an open license mapping initiative by people from academia and the general public. Here the aim is to create a free systematic world map, based on the philosophy of Wikipedia i.e. the common people will collect geographical data using manual survey and upload it to the world map.

Micello - It is a one of the commercial products which has a good collection of indoor maps and also provides on-demand indoor maps. It has its own SDK also, by which one can build indoor navigation based mobile applications.

## 7. CONCLUSION

Indoor navigation is unquestionably implementable with smartphones in the present day, and possibly with lesser hassles in a few years. The future of AR is fairly good with the improvement in hardware, sensors and graphics. Both indoor navigation and AR are most likely to be detected all across devices and applications. Using this technology, the power of smartphone cameras and computer vision can be combined with indoor maps to reimagine walking navigation. Thus, the idea of the development of an AR interface on smartphones for indoor navigation has an advantage in the form of a mobile application.

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