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A Survey- Indoor Navigation Using Inertial Mobile Phone Sensors

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ABSTRACT: GPS is in fact the only solution for outdoor positioning, no clear solution has as yet emerged for indoor positioning despite the commercial significance. Therefore, the main aim is to develop real time indoor tracking system and using mobile phone sensors to provide reliable and accurate indoor localization. Indoor navigation is an important enabling technology for application such as finding a conference room in an office building, safety exit during an emergency or targeted retail advertisement in a shopping mall. Using this idea, an application can be made and by means of that application we are tackling indoor navigation using real time navigation. The android application provides: awareness, ease to find your way, advertisement and simplicity. To provide reliable indoor navigation for commercial buildings like malls, industries, colleges, hospitals, hotels. The indoor localisation system is comprised of several modules, the step detector, step length estimator and a personalisation module for adapting a step model to an individual user. Accelerometer and gyroscope data can be used by Motion mode Recognition to distinguish between different modes of movement Orientation Tracking which uses accelerometer and gyroscope data to estimate the device orientation.

KEYWORDS: Indoor Navigation, Pedestrian Navigation, GPS, Inertial Phone Sensors, QR codes.

GENERAL TERMS: Wi-Fi, Bluetooth, Smart Phones.

I. INTRODUCTION

There are various technologies that can be used for indoor localization and positioning. Ultrasound, Radio Frequency ID (RFID), Infrared Beacons, Bluetooth, Global System for Mobile communication (GSM), Wireless Local Area Network (Wi-Fi), and these are some of the few. One option will be better than anotherdepending on location and need. For instance, using Wi-Fi based methods can be dangerous as the Wi-Fi signals could interfere with hospital equipment radio frequency signals in a hospital environment. On the other hand, in most urban settings densely placed Wi-Fi AP will provide best range. Additionally with the number of Wi-Fi capable devices in the market and because of the currently existing Wi-Fi infrastructure, Wi-Fi has become a logical and best choice to use for tracking to general public. GPS Navigation Devices have become a necessity and guide for users whenever they want to find their way with ease. An essential feature of many industrial/commercial applications is that a radio node needs to be aware of its geographical locations. Each node is able to acquire the location information with the help of global navigation satellite systems (GNSS).But GPS navigation systems rely on satellites which are useless when required to track a user's movements inside a building. So basically the problem of navigation inside complex structures like: Malls, Railway Stations, Airports, Hotels can only be addressed using indoor navigation systems. The various approaches for indoor navigation have been adopted like: using Wi-Fi beacons, QR code scanning, using Bluetooth devices etc. But these approaches use hardware units which are costly and requirement installation and maintenance efforts. So, the idea concentrates on providing indoor navigation using inbuilt inertial mobile phone sensors. Sensors like accelerometer and gyroscope can be used for providing indoor navigation. Basically, there will be a desktop application operated by admin. The admin can add locations, link the location points and export the map image to server. The user will download the android application and with the app he/she can load maps that are uploaded by the admin. User will provide his current location and destination and he'll get directions to the destination. The user will get on-going offers and events. User will also have the option to get back to parked vehicle and he will get directions for the nearest exit.

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II. RELATED WORK

2.1. Navigation Using Bluetooth[1]**:**
Bluetooth positioning technology requires Bluetooth access point to be installed in the room. The user holds a mobile device with Bluetooth integrated in it, then turns on Bluetooth function and estimates the distance and angle between the terminal and a Bluetooth transmitter which is installed in the indoor positioning system to locate the user's current location. Bluetooth positioning technology devices are compact in size, very easy to integrate in a mobile terminal, and the technology impact from sight propagation, and therefore straightforward and effective to popularize. However, due to the noise signal interference, Bluetooth provides poor stability. Bluetooth positioning system is used in complex indoor environments. Based on RFID, infrared, ultrasonic, Bluetooth positioning technologies are also called perceptual positioning technology. Sensors have to be deployed in the interior, which can determine its position, when the object enters the sensor to be positioned within the detection range. Perceived positioning technologies require extra hardware which increases the system costs and results in poor scalability. Ultrasonic, infrared susceptible to obstructions are not suitable for long-distance transmission, and to limit the range and accuracy of the positioning.

2.1.1 Range-Free Indoor Positioning System Using Smartphone device with Bluetooth:
It shows a range-free [2][3] positioning system in smart mobile devices with Bluetooth technology to implement the range-free localization for finding indoor position. In the range-free localization system, each device is capable of discovering nearby Bluetooth [4] enabled devices and it sends the results to the common localization server. The localization server gathers the scanned output results, information and identifies their positions using range-free algorithm. A monitoring unit supervises the range-free localization system. On tested in a real environment, the test results showed that 5 m accuracy can be achieved with range-free localization. Range-free localization makes use of network connectivity details to find distances between two nodes or locations.

2.1.2 Architecture:
To find the locations of the points/nodes on the map using the algorithm, following must be possible:
1. To find or discover the existing nearby nodes
2. To communicate, interact with nearby nodes.

The range-free localization system shows use of radio nodes, a localization server, and a monitoring unit, as shown in the system architecture diagram. Radio nodes send the information of periodically scanned nearby location points to the server. The server estimates the locations of the radio nodes with the help of received results from the nodes/points. The monitoring unit examines the server status.

1) Localization Server: The localization server has three functionalities:
   1) To calculate the step counts between nodes.

2) The location of nodes is found by localization algorithm,
3) Localization results are exported to the nodes.

2) Monitoring Unit: A monitoring unit evaluates and supervises the localization system. The monitoring unit displays the positions of all the radio nodes and links between them.

3) Radio Node*:* Radio nodes are devices with Bluetooth ability. Data is transferred to the server with the help of user datagram protocol which reduces the load on the localization server. After receiving the location results/estimates from the server, the device presents the location on the maps.

Currently, Bluetooth beacons are mostly applied in stationary trading. Bluetooth beacons connect the online and offline world and are supposed to increase sales at the point of sale (POS), for example by means of advertisements and coupons. Also, navigation in complex buildings and detailed information about exhibits in museums and at trade fairs are much asked. It is also possible to analyse visitor flows. Based on that information, walking routes can be optimized or products in shops can be arranged perfectly. Customer, visitor, patient, employee or traveller can be provided with relevant information at the right time and at the right place.

Bluetooth navigation system certainly has some advantages. It is cost-effective, it uses unremarkable hardware which results in low energy consumption. It provides flexible integration into the existing infrastructure (battery-powered or power supply with the help of lamps and the domestic electrical system).It also works where some of the other positioning techniques do not receive a signal. It is compatible with iOS and Android and provides high accuracy compared to Wi-Fi (up to 1m).Besides these advantages the system has many disadvantages like: additional hardware is required, app is required for client based solutions and Bluetooth beacons have relatively small range (up to 30m).

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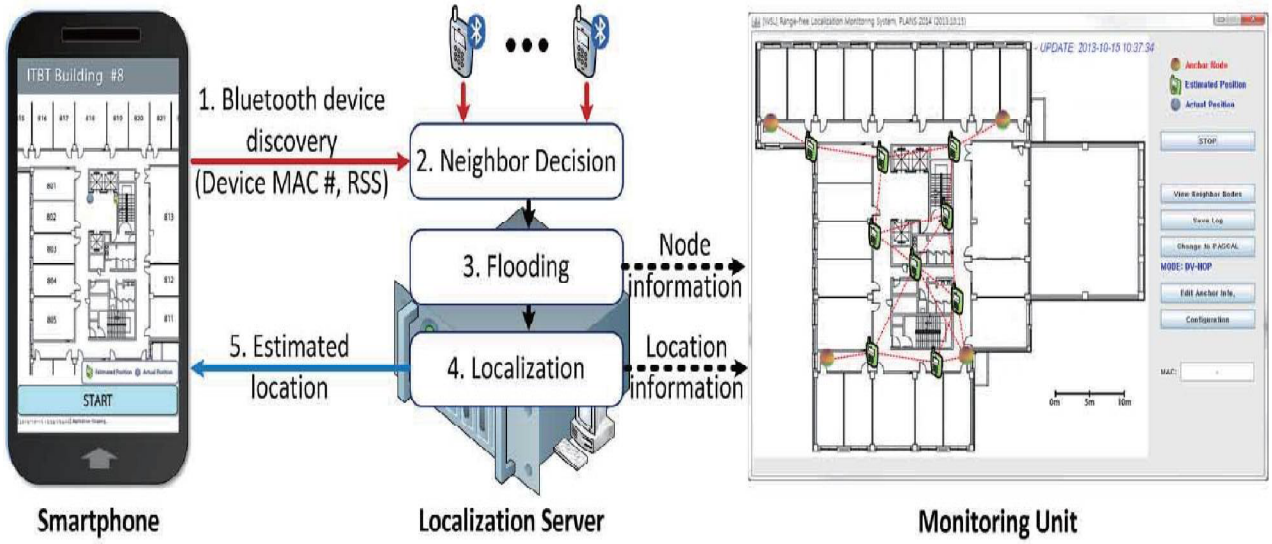

Fig. 1: Range free Indoor Localization System Architecture.[1]

2.2 Navigation Using Wi-Fi [5]:

Wi-Fi based localization system is used where GPS are useless due to various causes including signal blockage. This is most commonly used localization technique used for positioning with wireless access points .The technique measures the intensity of the received signal (RSSI) and uses the method of fingerprinting. The problem of Wi-Fi based indoor navigation [6] of the device consists in determining the position of user's devices with respect to access points. Many techniques exist to accomplish this using:

1) Received Signal Strength Intensity
2) Fingerprinting
3) Angle of arrival(AOA)
4) Time of flight(TOF)

Usually in most of cases the first step to determine someone's device's position is to determine the distance between the user's device and a few known access points. When the distances between the target device and access point is known, triangulation algorithms can be used to determine the relative position of the target device, using the known position of access points as a reference. Alternatively the angle of arriving signals at a target client device can be employed to determine the device's location based on triangulation algorithms. A combination of these techniques maybe used to increase the accuracy of the system.

A recent study as demonstrates the feasibility of indoor localization and has even been applied into an indoor navigational context operating on an Android device. However, the precision of the user location is not very well explored as the focus of the research was on traversing from point A to B. As such, it is more of a symbolic representation of locations.

It is, however, a useful first approximation of the user's location. Another approach, explored the issue of localization accuracy using multiple deterministic and probabilistic methods based on WLAN fingerprinting and tested the feasibility of crowd sourcing to improve the radio map precision in the database. A recently developed indoor positioning system named Red pin allows user to voluntarily upload their location to their server to help contribute and enhance the accuracy of their positioning system. By increasing the location point density, the fingerprint matching can also become more precise. And while multiple methods have been considered, they are all fingerprint matching related.

2.2.1 Positioning VS Localization:

Positioning is the determining the global world coordinates (i.e. 43.77568, 77.12243) while localization is the determining the relative coordinates (i.e. D.Y Patil Science and Engineering Building, Room 502). Positioning is important for trilateration method as coordinates must be known for access points to determine any distance. On the

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other hand, fingerprinting approach relies on symbolic representation and therefore does not require exact position or coordinates.

2.2.2 Finger-printing :

Wi-Fi fingerprinting requires RSS database which will be used for generating signal strength maps. Every reference point includes signal strength that is measured from all nearby access points. Live data can then be compared to the find the closest match from the database which stores the location of each reference point. Fingerprint matching algorithm generally consists of two components: the radio map and the estimation method. The radio map must be established as part of the training phase to building up the database. The most commonly used estimation method, and also used in this experiment, is the Nearest Neighbour method. Other methods include the Support Vector Machine, as well as Hidden Markov Model.

2.2.3 Trilateration:

Trilateration method uses distance from nearby AP with known Media Access Control (MAC) addresses, calculated from signal strength values, to approximate the distance to the user. It is important to note that different networks of AP, particular ones with different hardware configurations, may vary in calculating the distance. Unlike fingerprinting, this method does not require priori data collection.

Thus, using Wi-Fi beacons indoor positioning system can be implemented and high accuracy can be achieved.

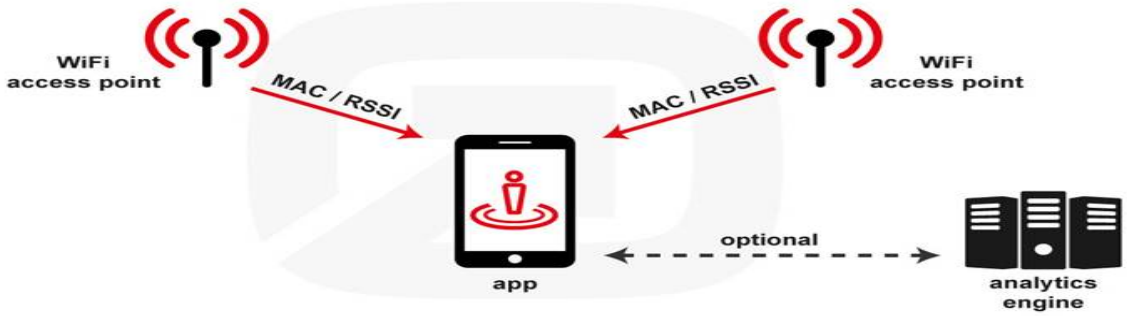

Fig. 2: Indoor Navigation using W-Fi architecture.

2.3 Navigation Using QR Code [7]:

One of the cost-effective smart phone solution for indoor navigation system can be obtained by using QR (Quick Response) codes. QR code is a small label usually placed on the wall containing the name of the map. QR codes are two dimensional codes where the data is encoded in an optically readable format. QR based systems require an advanced mobile phone capable of decoding QR codes, with a connection to the Internet. The indoor location plan should be made available to the user to provide correct navigation to the user. A floor plan needs to be created for the indoor location. Figure 3 depicts a sample floor pan where areas A to F denote important places in the floor. These areas could represent shop, escalator, lift, washroom, entrance, exit and soon.

Once floor plan is created, it is made available for the user through a URL link. Each floor should have the corresponding floor plan. Using any of the wireless technologies, this could be made accessible. Once the map is made accessible wirelessly, the URL of the floor plan is encrypted or encoded into the QR code. QR codes aid the user for indoor navigation. QR codes can be placed all along the pathway which provides the user accurate navigation. The navigation application in the mobile uses the mobile phone camera to read the frames. QR code(X,a)=URL for floor plan(X)+Location Details (a); Here Location Details(a) = Latitude, Longitude and Altitude of the geographical point a. A QR code is generated by the QR encoder. With the help of these QR codes link to the map of the indoor location and location details of the user are obtained. A QR detector processes the visual frames and checks for the QR code. Once a QR code is detected the QR detector forwards the QR code to QR decoder. The function of QR decoder component is to decode the QR code and obtains the code contents. This content will be accepted by content parser module whose functionality includes parsing to find out floor plan URL to download the floor plan and its location coordinates from the floor plan database or repository.

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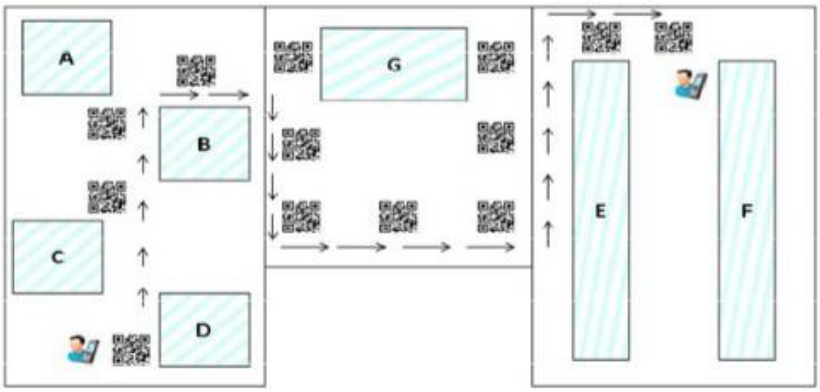

Fig 3: Sample floor with QR codes placed.

Once the floor plan is downloaded, the next component that is the plan handler overlays the plan on top of the geographical map using the location coordinates. In the final step of the QR based system the location details from the QR code is used to provide the user his/her current location.

III. CONCLUSION AND FUTURE WORK

In this paper, a method has been proposed for pedestrian indoor navigation system using the inertial smart phone sensors like accelerometer and gyroscope. No extra cost of hardware installation or beacons is required in the proposed system. Future work will include improving the measurement method of the walking steps to overcome the disadvantage of the currently used fixed-value of step length. The estimation of the step length could be obtained by the strength of the step acceleration movement (through a probabilistic algorithm) and through the personal information data entered by the user.
Knowing about the walls, doors, pillars and other elements can also fix the position errors if these elements are already included in the floor map, which will be a map image. An alternative to correct the errors might be the use of the integrated mobile phone's camera. The images taken live by the camera could be divided to partition the image into various regions. These regions can be more meaningful and easy toparse. Certainly this will reduce the errors and the overhead in the application.

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BIOGRAPHY

Ayush Mahajan, Akash Sasikumar, Priyanka Narwat, Meenakshi Sharma, Priyanka Nevrekar are pursuing Bachelor of Engineering in Information Technology Department, Dr. D.Y. Patil Institute Of Engineering And Technology, Savitribai Phule Pune University. We are currently working on the project named "Android Application For Indoor Navigation".