Disha-Indoor Navigation App

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***Abstract*—Indoor navigation system or indoor positioning system is a branch of Location Based services.Indoor navigation system helps people to reach their destination by using the technology on its own or by collaborating with other technologies INS deals with the peculiarities of indoor environments (no GPS, navigation XYZ etc.) Such as closed room where GPS signals are hard to reach. Indoor navigation has become important owing to the advancements in architecture and logistics that have contributed to the development of massive buildings. Indoor navigation works on different technologies such as RFID, Wi-Fi, Bluetooth beacons etc. Modern new Augmented Reality technologies may also be used for indoor navigation. The proposed model offers a real-time view of the environment with the help of the augmented reality. The proposed system for indoor navigation positioning device utilizes augmented reality to help assess the surroundings as well as to make positioning more accurate, one could use Bluetooth beacons or Wi-Fi locations. The suggested method would utilize Augmented Reality to assess the direction using SLAM algorithms for spatial precision. The user would continue to use the phone camera to get the environments' real-time objects. For the user to reach the target destination the AR-software would carry the user to the correct spot. The user has to scan a particular QR code to gain the map for a particular building thus not having the map for every buildings.**

Keywords—Indoor Navigation System, Indoor Positioning System, Augmented Reality, QR-Code.

I. Introduction

The indoor positioning system issued to identify the location of an object where GPS(global positioning system) is not possible to use. IPS issued for multiple uses, such as navigating within a home, a store, an airport or an area where GPS is not accurate.There a lot of different technologies that are developed in IPS. These technologies help in determining the location of an object inside a building where the accuracy of GPS is not a lot.The proposed system overcomes the inaccuracies in GPS for indoor navigation. Also there are a lot of existing technologies that are used for indoor navigation . The main technologies used today are Wi-Fi fingerprinting and BLE(Bluetooth low energy) beacons .The proposed system is focused on overcoming these drawbacks to give a improved solution to indoor navigation.Indoor navigation can be done by a lot of different techniques as mentioned: Proximity-based system**:** The accuracy of the position of a person or object in a room is not that good. This system is relatively inexpensive compared to other systems. In the proximity-based method, as the name implies, the proximity of a individual to a checkpoint is calculated by transmitting signals from the mobile. These signals are then registered and

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measured in the back end system. When energy is not a concern but accuracy is then we implement proximity based system which is known as reader point based . It obtains more accurate location compared to reference point based but the sensors require higher energy level. Also as it transmits the tags continuously the device used by user will drain the device's battery faster. But energy is the main concern in all the systems used today ,so reference point based system is used . It does not consume as much energy as reader point as the tags are not transferred . This system is usually used with BLE . It uses those beacons as point of references and then detects the position of the user according to the beacon. These were widely used as energy was consumed in large amount and people could still their destination. Also they are roughly located every 100 feet and then the data points collected from the user device are transferred to the server by using encryption technique. Each of these approaches are affordable and are commonly employed in the indoor navigation industry but they do not have a high accuracy rating. These technologies are easy and include indoor navigation at the basic level. While proximity based sensors were a good technique for Indoor navigation they were not as accurate as expected on the other hand Wi-Fi fingerprinting was much more accurate than proximity sensors . They had an accuracy of about 5m. They collect the packets sent from the smart point in the Wi-Fi access points. Wi-Fi indoor positioning systems is fairly accurate.Its accuracy lies between three to five meters of the object location. This is due to the technology of time difference in arrival(TDOA) and its measurements. But to reach this degree of precision, you need at least three access points to sense the transmission of every message. Ultra band width technology had a fresh point overview towards INS. In this three of more ultra-wide-band readers transmit a very wide signal to a wide GHz range . These tags produce a little pulse inside them, which generates a quick coded, very large almost instantaneous pulse. Readers can then record very precise time calculations from the signals received back to the server. Radio frequency identification technique was also widely used because it was a cheaper alternative than Wi-Fi but also had low error rate as compared to proximity sensors. In this radio waves are transmitted by devices which are fixed at a certain distance. These are very precise, because the IR waves can not travel through walls or large objects construction objects, and so if the entity is supposed to be in that room, it is the entity is supposed to be in that room, it is in that room. This wall-mounted sensors interpret waves passing from the user devices to determine the location of the subject. The drawback of this system is that it requires a lot of infrastructure as well as wiring to set up all the sensors through the building. It is also very expensive for the installation and maintenance purposes of the entire infrared system.

As discussed all these technologies have some or the other drawback. So the recent development in AR technology has given rise to the visual marker technique for indoor navigation. This technology is what is present in the proposed system. Visual indicators or markers are points or objects that are used by AR in the space. Such markers are recognized using various AR technologies such as Google AR Core or Apple AR Kit. When the marker is installed or positioned, the precise position is saved in the cloud such that the exact point is recovered when the consumer is present in that location.

Augmented reality**:** What augmented reality does is that it virtually enhances the physical world view in real time, directly or indirectly with computer-generated information. Augmented reality blends real-time world and virtual world which shows a 2D or 3D vision. It can display an image, video or object in the real world but can be viewed on display virtually.Marker-based AR also called image recognition, because it involves a specific visual marker and a camera to scan from a QR code or different sign, it can be anything. In some cases the AR device also calculates a marker's location to correctly determine the location of content. A slight calculation mistake in position of sign or object can create problems to display the object or visual. This technology called as marker-less based AR uses location - based or positioning augmented reality, which uses a GPS, a compass, a gyroscope and an accelerometer to provide user location-based data. Then, this data determines what AR content you find or obtain in a given area. With mobile availability this form of AR usually produces maps and directions, nearby business data. Super-imposition based AR replaces the original view with an augmented view, in whole or in partitions. Recognition of objects plays a critical function in which the entire project is virtually impossible. Quick Response Code: Quick response code, or QR code are bar-codes with 2D matrix. It is an optical mark readable by computing device which contains information about the object to which it was attached. A QR code in simple terms can be explained as blocks of black squares which is on a white background in a square shape, which can be read by a camera-like imaging system and analyzed using *Reed-Solomon* error correction before the image can be correctly interpreted. The required data are then extracted from patterns present in the image's horizontal as well as vertical components. In a QR code the three corners of the code contains three large square patterns(in-side each is a small black square surrounded by white bars). Those three square patterns are used to detect location. To match the QR code a further square is used. The other area used to encode the information embedded in it. A QR code has several different levels of error correction. Usually, higher correction degree means that it enables the removal of more blocks in the code, and this can also result in a longer code with a greater QR file size.

Further the paper is arranged in the following manners, section 2 of the paper is devoted to the literature survey and research on existing systems. Section 3 of paper is detailed description of the working of proposed systems. Remaining sections are the result obtained and the future improvements required in the system along with conclusion reached from the solution.

II. LITERATURE SURVEY

Today, there are a lot of methods by which indoor navigation are implemented but they are expensive. Wi-Fi tags collected by the central entity are checked based on their signal strength as well as the time stamp thus increasing accuracy. GPS is the technology used for determining the position on map that means an outdoor position.The system mentioned are a lot of methods by which indoor navigation are implemented but they ***are expensive*** and if not expensive ***they have high error rates*** like the BLE beacons have **low** ***accuracy but are inexpensive*** and in the contrary Wi-Fi gives ***accurate position if object (about 3-5 meters) but they are expensive: both in setup as well as maintenance.*** They also ***require a lot of physical devices or sensors*** in the premises of the building or located on the walls of the rooms. GPS ***cannot be used for indoor positioning or indoor navigation*** because the waves generated by the GPS cannot penetrate properly through construction material thus becoming a barrier for GPS to work.

In 2008, Sakmongkon Chumkamon Peranitti Tuvaphanthaphiphat, Phongsak Keeratiwintakorn they developed an navigation system using RFID for indoor environments for visually impaired people. Their proposed blind navigation system is composed of three parts, the track infrastructure, the navigation device, and the navigation server. The track infrastructure is made up of a number of RFID tags. Every tag can be inserted into a stone block and put it on a footpath. This stone block with RFID is then used by blind people for navigation.

In 2010, Alberto Serra, Davide Carboni, Valentina Marotto proposed in their paper system about indoor navigation through the use of sensors in the smart phone. Their system calculated the position if the object by determining the number of steps taken by the user from the point the user scanned the QR for map. Then their system will calculate and keep a record of the steps taken in order to determine the position of the object. In this system there was not a method to tolerate the error rate generate by the steps taken by individual as each step of an individual will vary.

In 2011, Usra OZDENIZCI, Kerem OK, Vedat COSKUN, Mehmet N . AYDIN the developed their indoor navigation system through the help of NFC. They used NFC device along with Dijkstra's shortest path algorithm for their development of indoor app. In their system, the user only had to carry a NFC enabled mobile or card . Their Indoor navigation application must already be loaded to the card . The user just needs to touch the card that has NFC technology to get the URL of map or information of the indoor infrastructure.

In 2013, Sebastian Kasprzak ; Andreas Komninos ; Peter Barrie proposed their system which was a feature based indoor navigation along with AR. They used the building features as markers for detecting the location of object. The disadvantage in using this system is that if a marker is taken down from the building it will be difficult to locate the user or object.

In 2014, Dongsoo Han, Sukhoon Jung, Minkyu Lee, and Giwan Yoon developed a Wi-Fi based indoor navigation in the COEX complex. They used Wi-Fi Radio Map Construction for acquiring accurate markings and the map of a floor. In their system it was observed that they also had to do a lot of manual works such as marking the Wi-Fi points so as to get the accurate markings at each point. This will require manual labor to do so and also will require a lot of time if there is multistory building.

In 2017, uanqing Zheng, Member, IEEE, ACM, Guobin Shen, Liqun Li, Chunshui Zhao, Mo Li,Senior Member and Feng Zhao all wrote a paper on indoor navigation app which was called TRAVI-NAVI. In their app they were providing self deployed indoor navigation through mobile phones. When the person walks, Travi-Navi captures the images of the route the person is walking and tests the Wi-Fi fingerprints and IMU sensors. The application captures images and then Travi-Navi automatically deploys the navigation system. The problem with that is if the camera of the mobile phone must be good to take the in the whole room. Also distorted images will cause a problem. Along with that it also has a lot of manual work.

In 2017, Iman Abu Hashish , Gianmario Motta, Michela Meazza, Guoqing Bu, Kaixu Liu and Lorenzo Duico wrote a paper about indoor navigation using techniques like Deduced reckoning known as Dead Reckoning (DR), does not require already deployed infrastructure or sensor. DR calculates the current position of the user from the previous position and by adding the estimated direction and distance. This system was tested using a wearable device.

In 2018, Adam Satan proposed a Bluetooth based indoor navigation system. In their system, they measured the RSS (received strength signal) from the user device.Their system used a five step process is determining the location of the user or object. Their system will give the accurate location when the user is between the beacons otherwise the location is not accurate. So depending on the number of beacons surrounding the infrastructure their accuracy will be determined In 2019, Joshi, R., Hiwale, A., Birajdar, S., &Gound, R. proposed a paper on indoor navigation using AR in which they explained about the VPS(virtual positioning system) technology along with VBN(vision based navigation system). They explained how these techniques could be used to established a indoor navigation system without external devices or sensor.

The summary of how different technologies were used in which year is given in table(1). The table also explains the features and challenges of different technologies used in indoor navigation system.

Literature Survey			
Year	**Methodology**	**Features**	**Challenges**
2008	RFID	RFID tags are to be deployed so the accuracy factors better than other methods	Cost of RFID tags are very high. Also they are battery operated so expensive maintenance is required.
2010	Smart phone sensors	No external devices such as Wi-Fi Bluetooth, DR are required	Error rate was high
2011	NFC	Less cost than RFID tag .Ease	Same as RFID ,it is short ranges a

		of use can be done	lot of devices are to be deployed
2013	Augmented Reality	No external infrastructure with okay accuracy	Uses building features as markers for detecting the location which is not that reliable
2014	Wi-Fi	7step development of process focused on a single building	It was focused on a single Building and the development process is also time consuming
2017	IMU and Wi-Fi fingerprinting	Self deployed so no floor plans or tag were needed	With the help of image the navigation was created so distorted images were useless and not accurate
2017	DR (dead reckoning)	Self deployed uses MEMS and various sensors	Estimation is done so errors are very high
2018	Bluetooth	Uses RSSI to determine position	Already established path will be easy to calculate but changes will be difficult
2019	VBN ,VPS	VBN and VPN combined provided better accuracy	Have to maintain the map of each and every building

Table:1:Summary of literature survey

III. PROPOSED SYSTEM

The system proposed, implements indoor navigation using Augmented Reality (AR). AR has a lot of features and is a new emerging technology. It is used in different games and virtual experiences and simulation.As shown in *Fig.1,* the proposed solution uses different SDKs such as Map box or Place note to create a geotiff image of a building or infrastructures' map. After a geotiff image is created using a blueprint or a building map, it is integrated with system which provides AR support like Vuforia's unity or ARCore by Google .After that the integrated map or geotiff image is scaled to the real world level(how people perceive things) and then the markers are inserted. These visual markers are dropped at some locations in the geotiff image provided. The location of the drop markers is then stored in a database in it is used to determine the path from the position of the user to the destination of the user. This path is then shown to the user through the help of graphics such as an arrow, and the user is taken to the destination. The user will scan the QR code deployed at the entrance of the building. After scanning the QR code the user will get an option to select the destination. The system will use Zxing-QR code library to generate QR-code. This provides two purposes as the system will also know where the user is and that will be the starting point of the user. From their the paths will be calculated to its destination. After scanning the QR the map of the building or infrastructure will be deployed into the application which will be used by the user for finding its path towards its destination. The user will be guided towards its destination using the graphics such as arrows which will show the whole path to the user. After the destination if the user will be highlighted and then user will know it has reached its destination.

IV. RESULTS

A. Actual results:

As shown in the *Fig.5*, when navigating through the rooms or even outside arrows will be shown to guide you. These arrows also called as augmented reality objects helps the user to find the destination it requires. . As shown in the *Fig.4* the QR code is scanned which then takes us to the destination entered.

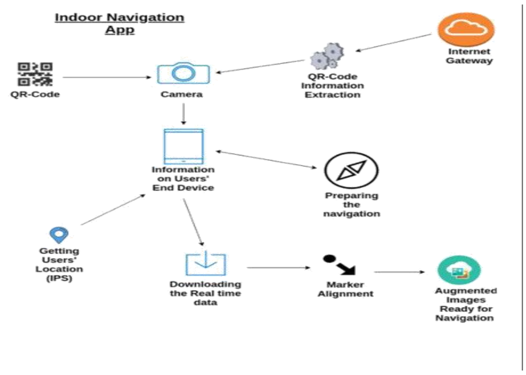

Fig.1. Indoor Navigation System

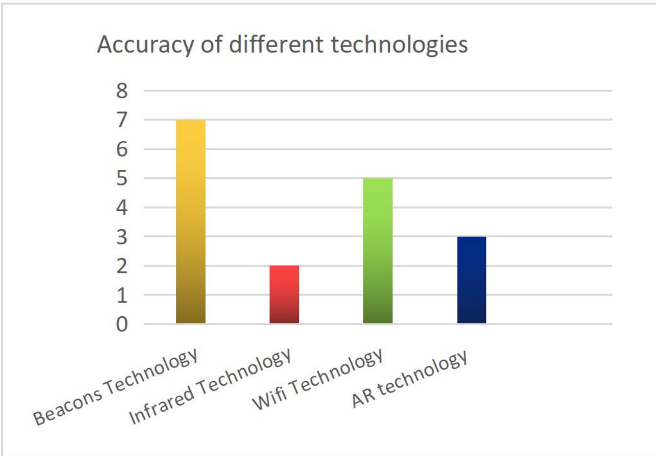

Fig.2 Accuracy of different technologies

By the research done by various people and using some of the technology, it is shown in the graph the accuracy factor of each the technology. In the X-axis the names of the technologies are mentioned whose accuracy rate was determined. These all technologies are used for indoor navigation system these technologies were used earlier for indoor navigation but still some of the technology is used even today. As shown in the *Fig.2* Beacons technology which is called as Bluetooth beacons have accuracy up to 7m which means that the location can deflect about 5-7m. These technologies will have a higher accuracy if the number of beacons are high are in clustered manner throughout the building or infrastructure. When the beacons are scattered and are in less number than the deflection from original position will be higher. As infrared rays cannot pass through a heavy object or obstacle, the deflection rate is about 1-2m and thus accuracy is high. But as infrared rays cannot pass through obstacles the proper positioning is very important. Also it may happen that readers cannot read the tags sent by user so determining position will be difficult. The Wi-Fi technology has greater accuracy than Bluetooth as it provides with the time the signal is received as well as the strength. Wi-Fi finger printing is an expensive set up along with that the maintenance cost is also high. The proposed system used uses AR technology which also have a higher accuracy rate .The location when deflected will be about 1-2m.

The above *Fig.3* ,shows the performance factor of different technologies compared to the technology used in the proposed solution. The main two factors for comparison were cost and accuracy. When given a paper , Wi-Fi and AR technologies to use the, the accuracy and ease of use were the factors in concern along with error correction. As seen the accuracy of AR and paper maps are more compared to Wi-Fi. Paper maps are traditional methods for navigation though accurate they may have some typing errors which could cause problems. That Is hard to navigate through the help of paper maps so the ease of use was less. When talking about Wi-Fi it gives the user the directions to go as well as AR gives the direction, the only difference being AR also shows the surroundings while giving the direction. The initial cost of paper maps for user is less as well as for the producer because it is compensated when the paper maps were sold. The cost of Wi-Fi is high as it requires a initial external set up. The cost of AR is not high in the sense of money but it is in the sense of time. It requires a lot of coding and integration with environment for developing the AR navigation. The cost of AR for the users is less as they just require a smart phone with AR compatible with it. The maintenance cost is the cost over time if something changes. If there is change in the infrastructure, the paper map will not be changed if the change is insignificant. If a sensor of the Wi-Fi gets destroyed or is malfunctioning then the cost of repairing it is high. In AR if there is a change in the infrastructure then the software has to be updated. When navigation with the help of paper map if user goes in the wrong direction then the user has to rectify itself which is high so the error correction rate is low. Whereas in AR or Wi-Fi if the users take a wrong direction it will get notified so the error correction rate is high.

B. *Research Analysis*

As mentioned in the proposed system the first step to navigate to the destination will be scanning the Qr code. The QR code is scanned in first and map is downloading from the cloud .This map will be the map of the placed of which you have the scanned the QR code. These will have a huge benefit as the person need not download all the maps to all the places but rather the maps user actually requires . This will eventually then will save space in the users smart phone .

Fig.5 shows the point from where the navigation will start towards your destination. It calculates the direction and distance in the back end to provide the user with the proper route. The user will then walk according to the route shown by the application.

As shown in *Fig.6*, The way-points will guide the user till the destination has arrived. Once the destination arrives the user will know through a voice command and then the route discovery process will stop. The user then can close the system once it reaches the destination.

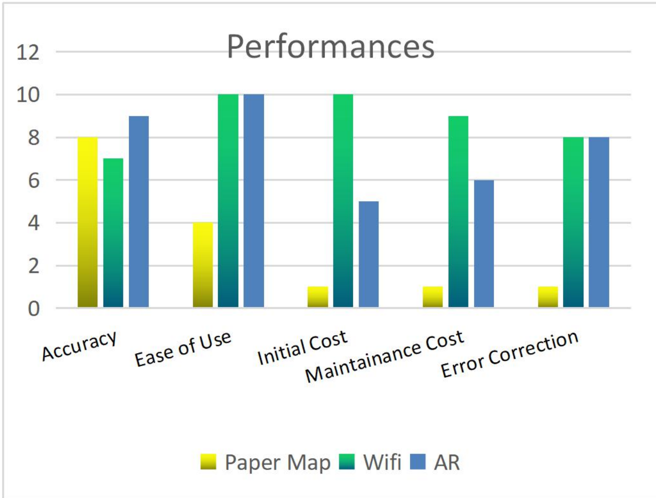

Fig.3.Performance of different technology

Fig.4. QR code scanning and processing

Fig.5.Starting point initialization and dropping way points

Fig.6.Way points guiding the destination

V. CONCLUSION AND FUTURE ENHANCEMENTS

In today's world, indoor navigation has become very important due to advances in architectural fields and building infrastructure. Indoor navigation is a need that can be used anywhere from buildings to malls to airports. As we have already discussed that the existing solutions are accurate but expensive or inaccurate but cheap. We therefore proposed this system which is inexpensive as well as has low error rate. This proposed system will make it easier for users to navigate within the building. Indoor navigation system will benefit a lot of users. Also with the increasing demand of market for indoor navigation , the proposed system can be one of the most inexpensive option available .In conclusion, the proposed system can be influenced by the use of voice assistant for the visual impaired. This system can be used for indoor navigation with ease without a lot of sensors and good accuracy as with the help of AR different levels of the buildings can also be detected.

Also in for future, we could make this project better by adding different features such as feedback from the user when a place gets changed or there is a change in the environment which is not similar to the one in the map retrieved by the user from the cloud can be added. Also auto-generation of map that is the dynamic making of the map without the geotiff image can be done which help the admin to add the map with ease.Adding of obstacle detection feature can help visually impaired people in greater sense.

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