Survey on Indoor navigation systems

Rahul Gupta[1*], Siraj Ansari[1], Umesh Patel[1], Neha Kunte[2]

[1]Student, Department of Computer Engineering, Atharva College of Engineering, Maharashtra, India
[2]Professor, Department of Computer Engineering, Atharva College of Engineering, Maharashtra, India

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****Corresponding author:***
Rahul Gupta
e-mail: *rahulgupta141998@gmail.com*

Abstract

Whenever People visit some places like hospitals, museums, and colleges they find difficult to navigate to a particular location. Using GPS for indoor navigation is not possible because GPS-enabled smartphones have accuracy within a 4.9 m (16 ft.) radius in an outdoor environment. Their accuracy reduces near trees, buildings, and bridges. Sometimes these places provide a 2D static map for navigation but it is difficult to interpret. This paper surveys on indoor navigation techniques. There are different are techniques available such as Wi-Fi-based, Bluetooth Beacon and Augmented reality-based techniques. This paper provides a study of different indoor navigation techniques.

1. INTRODUCTION

Indoor navigation has grabbed so much attraction in the last few years. Indoor navigation is a complex task due to the presence of obstacles, environmental changes, signal fluctuation or noise etc. GPS can be used for navigation in the outdoor environment but it cannot be used in an indoor environment due to its low accuracy. There are different method investigated for navigation in an indoor environment. Such methods include Wi-Fi-based, Bluetooth Beacon based, Augmented reality-based, RFID based etc. In the Wi-Fi-based technique, W-Fi signal is used as a fingerprint to collect data about the path from source to destination. Bluetooth beacons emit radio frequency signals which are used to calculate the distance of the user from the Bluetooth Beacon [9]. Based on the distance, the user location is calculated. In augmented reality-based technique, the path from source to destination is augmented in a real environment so the user does not need to interpret the path to the destination in the real environment. This technique uses computer vision to augment the path in a real environment. There are two localization methods in indoor navigation using augmented reality. First one is continuous localization in which location of the user is continuously informed to the user and second is discrete localization in which user needs to scan the target image to find out there current location and path to the destination.

2. RELATED WORK

2.1. Peer-to-Peer Indoor Navigation using Smartphones

Peer-to-Peer Indoor Navigation system collects user data every time user walk's through same the path for generating hints to navigate user next time on the same path. Any user travelled through a path collects trace information and share it with other user's [1]. A person may collect trace data for other user's or use data provided by another user to navigate on a path it depends whether previous data is available for that path or not. It uses Wi-Fi signals as a fingerprint to collect data about the path to the destination. It also uses magnetometer, barometer, and Gyroscope to identify the user current position, orientation, speed of walking, whether a person is in motion or stationary, etc. [1].

2.2. Bluetooth-based Indoor Navigation Mobile System

Bluetooth-based indoor navigation uses Bluetooth beacons for navigation. Bluetooth beacons emit radio frequency signals which are used to calculate the distance of the user from the Bluetooth Beacon [9]. Based on the distance, the user location is calculated. Dijkstra's algorithm is used to find the shortest path from source to the destination [9].

2.3. XYZ Indoor Navigation Through Augmented Reality: research in progress

Augmented Reality is used to display a directional arrow in a camera view so that a person can easily navigate inside a building. Therefore the user does not need to know their current location. This AR Navigation system relies on north-oriented space coordinates transformation and geomagnetic positioning. GPS is not required for AR navigation. The AR interface integrated with the magnetic positioning system is a unique solution for challenges faced during indoor

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navigation, which has been authenticated by testing of the proposed system showing a good performance.

3. TECHNIQUES

3.1. AR-Based

In Augmented Reality technique, it uses existing features to determine the user's position and provide navigation information. This technique uses Dijkstra's algorithm to find the shortest path from source to destination and according to algorithm application shows the arrow to the user. It uses discrete localization technique in which application shows direction after scanning the target image.

3.2. Bluetooth Based

In Bluetooth based technique, radiofrequency emitted by Bluetooth beacons are used to calculate the distance of the user from a Bluetooth Beacon [9]. This is distance is used to calculate user location. For calculating the shortest path from source to the destination Dijkstra's algorithm is used.

3.3. Wi-Fi Based

Wi-Fi Fingerprinting for navigating inside a closed premise use probability distribution comparison. The power of Wi-Fi and MAC is used for Wi-Fi fingerprinting. Fingerprints are known positions or locations inside a building. Offline fingerprinting can be done by visiting places which are already recognised. When the system gets connected to internet Wi-Fi fingerprint probability distributions are compared with fingerprint collected offline. A weighted average of the three offline positions that best match the online measurements is used for calculating the user position.

4. CHALLENGES

4.1. AR-Based

AR technology is growing day-by-day and it is going to be used in future. It can be used for developing an indoor navigation system. But there is a lot of limitation present in it. The primary goal of AR-based indoor navigation system is to augment the 3D path in the real environment. The limitation of AR-based indoor navigation system are as follows:

- The AR-based indoor navigation system has many technical Challenges like Unity 3D engine, limitation of hardware, awareness of AR technology among the common people, and education.
- AR application is like common applications which can run in any mobile devices like smartphones or tablets. AR-based indoor navigation system requires common hardware elements like cameras, displays, motion sensors, powerful processors and high-speed internet connectivity. But AR-based indoor navigation system also requires other hardware elements like Google Glass, HoloLens, AR headsets, and Meta which are expensive and not commonly used by common people. These hardware elements can improve the performance and experience of the user.
- As AR is a new technology, there is less content available for the development of AR application. Nowadays, huge content is developing day-by-day. Due to the lack of interactive content, development of AR-based indoor navigation system is difficult.
- As AR is a new technology, there is a lack of awareness of AR technology among common people. Whenever a new technology is released, it takes time to learn by users. Also, new features are added frequently which make difficult for common people to learn.

4.2. Bluetooth Based:

Bluetooth is the most commonly used technology and it can be used for developing an indoor navigation system. But there is a lot of limitation present in it. The limitation of Bluetooth based indoor navigation is as follows:

- Bluetooth based indoor navigation system has relatively low accuracy. Because beacons can determine the accuracy in the range of 1-3 meters. The accuracy can be further improved through the use of Ultra-Wideband technology which provides an accuracy of 10-30 cm.
- Bluetooth based indoor navigation system requires additional hardware called beacons which are must-have tools. Due to an increase in the number of Beacons for the large area the overall expense of Bluetooth based navigation system also increases.
- Bluetooth based indoor navigation system requires the creation of an application for user and installation on the client's mobile devices.
- Bluetooth based indoor navigation system has a relatively small range. Because beacons can able to broadcast a signal up to 30m. But this distance in a real environment is much smaller due to the presence of obstacles such as walls and noise in the environment.

4.3. Wi-Fi Based

Wi-Fi is the most commonly used technology and it can be used for developing an indoor navigation system. In a Wi-Fi-based indoor navigation system, localization is affected by different factors based on whether the mobile device is connected to Wi-Fi or not:

- If the mobile device is not connected to Wi-Fi, there are latency times of up to 5 minutes that result from sending of "probe request", which is handled by the

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	AR BASED	*BLUETOOTH BASED*	*WIFI BASED*
COST	Moderate cost as compared to Wi-Fi Based Navigation	Highest as required Bluetooth beacon installations.	Higher as required hardware installations.
ACCURACY Y	Depends on the number of markers used.	1-3 meter accuracy.	5-15 meters accuracy because the accuracy depends on the shielding through people, walls, ceilings, and also by the number of access points.
CONVENIENT ENCE	Better than both Bluetooth and Wi-Fi-based as it provides an interactive interface and is independent of any networking device.	It requires the installation of beacons at a specific distance so that the signal strength may not reduce at someplace in the building	Better than Bluetooth-Based but require routers for navigation.

mobile OS. Due to MAC randomization, the mobile device or the actual number of mobile devices in an area can be determined ambiguously.

- If the mobile device is connected to Wi-Fi, there are no or very fewer latency times. As there is no MAC randomization, which means that the mobile device can be identified uniquely.

Wi-Fi-based indoor positioning system has accuracy in the range of 5-15 meters. Further, the accuracy depends on the shielding through people, walls, ceilings, and also by the number of access points. The results can improve through the use of mobile device sensors and floor level can also be determined.

5. COMPARATIVE STUDY

6. CONCLUSION

Among the different methods of indoor navigation surveyed Bluetooth Beacon based on Wi-Fi-based methods requires external hardware such as Wi-Fi access points and Bluetooth beacons. On the other hand, augmented reality-based indoor navigation can be implemented without need any external hardware. Augmented reality-based navigation can be combined with Wi-Fi-based or Bluetooth based techniques to improve the accuracy of indoor navigation. Augmented reality-based navigation can be implemented with Head-mounted display or with handheld devices like a smartphone. There are two methods to implement indoor navigation using augmented reality first one is marker-based which is easy to implement and the second one is markerless which is hard to implement but provide more flexible and accurate results.

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