INDOOR NAVIGATION SYSTEM USING AUGMENTED REALITY

ABSTRACT

For navigation in today's world, people generally rely on GPS based applications to find an optimal route to their destination. But when it comes to indoor navigation, GPS fails as it uses satellite signals which cannot penetrate through the walls of tall buildings. To overcome this problem, we propose a solution with Indoor Navigation System implemented as an Android application. Indoor Navigation System refers to the technology that provides positioning and navigation facilities to help people locate other people or objects inside a building, or find a way to a Point-of-Interest inside the building. This application provides people the map of the indoor space along with their current location inside the building and the route to their destination inside the building with Augmented Reality elements, conveniently in our smartphones. The sensors in our smartphone and cameras are the only elements that would be required for this application. The use of Augmented Reality in the Indoor Navigation System gives the user an interactive experience with the indoor space, through its computer-generated augmentations or elements.

INTRODUCTION

In this age, almost every other street, road, and highway of our world is already mapped using Global Positioning System (GPS). It is a global navigation satellite system that was first brought into use by the U.S Department of Defense (USDOD). GPS provides real-time geo-location and information to the users, anywhere on earth. We can use Google Maps or some other GPS apps for our everyday commute and for long-distance traveling. It gives us the shortest and the most optimal path to reach our destination. However, the ease of navigation using GPS cannot be brought indoors. The navigation stays outdoors, and GPS satellites have no line of sight inside buildings. The tall walls of the buildings act as barriers to the signals which cannot penetrate them. Thus, for the simple reason that GPS signals cannot be received inside a building, a technology that can help us navigate in an indoor environment is required [6]. With the help of an indoor navigation system, a person can find his way inside a building just the same way he uses GPS for outdoors.

Indoor Navigation System refers to the technology that provides positioning and navigation facilities to help people locate other people or objects inside a building or find a way to a Point-of-Interest inside the building. To provide a complete indoor navigation system, some of the following components are required:

- A map of the indoor space: A complete representation of the building's indoor space by mapping floor plans, indoor positioning, and other relevant data.
- A user application: Typically, an app that runs on a smartphone that shows the map for navigation.

The location information (such as coordinates) and the indoor map data (such as stored points-of-interest) are put together in the application layer and is then fed into an Android or iOS-based application software, where additional user features are added to create a greater experience for the end-user [8]. Thus, a user can see his own location on a map on his own smartphone. The user's real-time location inside the building along with the route to his destination is rendered in his device through Augmented Reality [8]. The use of Augmented Reality in the Indoor Navigation System gives the user an interactive experience with the indoor space, through its computer-generated augmentations or elements.

WORKING PRINCIPLE

Indoor Navigation Systems are themselves very diverse in the method used for indoor positioning. A traditional Indoor Navigation System makes use of access points, beacons, or other similar devices that use Wi-Fi or Bluetooth technologies, must be mounted at different locations in the building. Such resources are used for absolute positioning, which calculates the location of an object or person in fixed coordinates, and for relative positioning, which tracks changes in relative position. One of the methods for estimating the absolute location of the user is fingerprinting-based positioning. The fingerprinting method determines the position of a person on the indoor map by measuring the distance of the person from each beacon in his immediate vicinity. Furthermore, there are numerous absolute positioning methods that use various sources such as RFID, LED, and ultrasound technologies to represent fixed coordinates.

Different concepts and methods for indoor positioning have been studied since the inception of Indoor Navigation technology. The area of Augmented Reality is the most sought-after among these technologies. In today's world, augmented reality (AR) is one of the fast-growing and most sought-after technologies. The fundamental concept of AR is that it superimposes 3D images on top of the physical world. As a result, augmented reality technology brings virtual objects into the real world. The use of augmented reality has completely changed the face of today's navigation systems. An Indoor Navigation System based on Augmented Reality will assist us in navigating large buildings using only our smartphones. The computer-generated 3D directional graphics on the absolute view of the indoor habitat are overlaid with AR.

RELATED WORKS

The existing systems of indoor navigation is implemented using any one of the following technologies:

- **Bluetooth Beacon-based Indoor Navigation System:** Bluetooth Beacons that need to be mounted inside the building are used to determine the location of the user and help the user to navigate from one point to another. This is a tedious process as it requires the installation of Bluetooth Beacons at precise locations inside the building such that no area is left uncovered, and the frequency of the beacons should not overlap. First, the Received Signal Strength Indication (RSSI) for each nearby beacon is measured and filtered. Then the distance from each beacon is determined with an algorithm that estimates the user's distance from the beacon. Finally, the user's real-time location is positioned on the map [1].

- **Wi-Fi-based Indoor Navigation System:** In a Wi-Fi positioning system, Wi-Fi transmitters or Access Points (AP) are used in place of Bluetooth beacons. The specific data collected from access points are sent to an algorithm that computes the user's position. The information is then used to display the user's real-time location on the map [6].

- **Infrared (IR) System:** Infrared light pulses are used for localization inside buildings. This also requires the installation of infrared receivers in every nook and corner of the indoor space. When the IR tag pulses, it is detected and read by the receivers.

PROPOSED SYSTEM

Along with its broad reach and potential applications, indoor navigation has been a fascinating research subject for many years. In this paper, we propose an interactive Indoor Navigation System that uses Augmented Reality for 3D directional graphics. This application uses marker-based localization for navigation in indoor environments. It is an Android application that can be implemented in a smartphone with no additional requirement other than the built-in sensors in the smartphone. Users can scan the QR code which contains their current location information and then select their destination within the building from a drop-down list. Both the current location and destination are then passed on to a route planner algorithm which gives an optimal solution of the route to that destination. The route is rendered in the smartphone in real-time using Augmented Reality (computer-generated augmentations) elements.

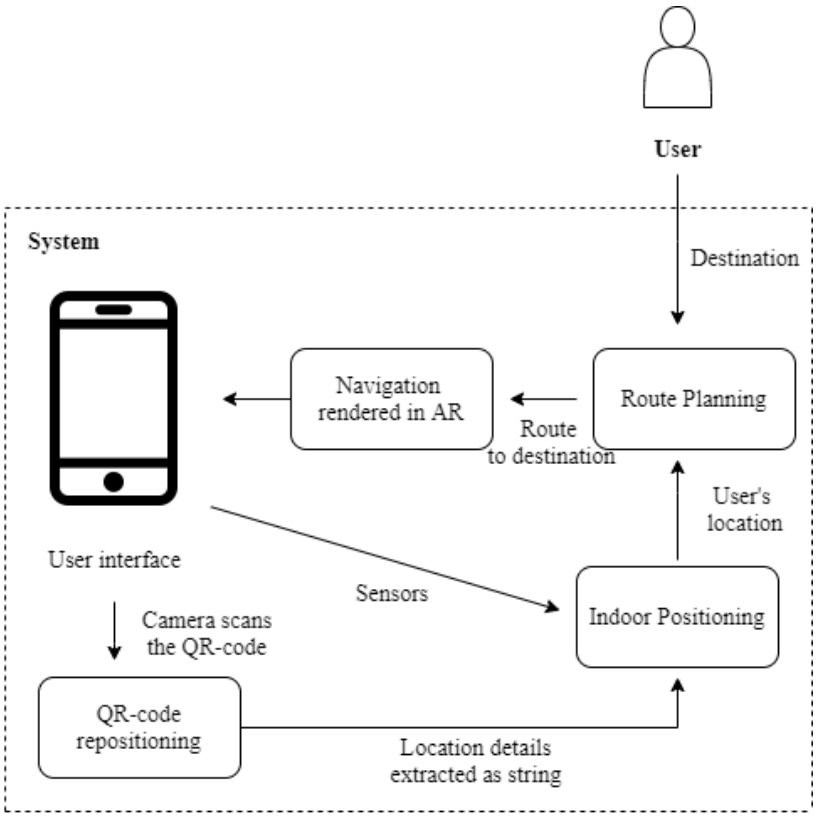

Fig. System Environment

IMPLEMENTATION

The entire project is developed in four phases of Map Localization, QRCode repositioning, Navigation and Path Rendering in AR. Initially, the floor plan of the indoor space is mapped with the building, and the mappable areas are identified from it. Various points-of-interest are then located in the building as the destinations. The walkable areas will then be identified. The location information of points-of-interest inside the building is encoded into QR codes using the libraries provided by AR Core. These are then placed inside the building. The markers inside the building and the indoor map are mapped using SDKs provided by the AR Core. This gives the exact location of the user in the building. After scanning the QR Code, the user wants to select the destination point to navigate. Users can scan the QR code/any marker which contains location information. After the detection of the marker, the user's current location extracted from it along with the destination are sent to the algorithm. The algorithm then calculates the optimal path to the destination. The route is rendered in the smartphone in real-time using Augmented Reality (computer-generated augmentations) elements. The AR element keeps generating the route till the point of destination. On reaching the destination the arrow along with the path and destination are deleted.

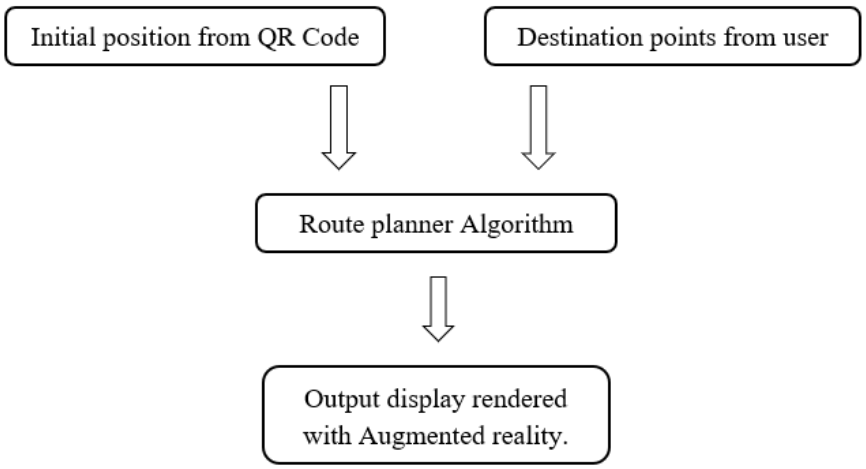

Fig. Workflow

RESULTS AND DISCUSSIONS

We proposed an AR-based Indoor Navigation System which uses QR-code for repositioning in indoor spaces. We demonstrated the application by rendering paths from one

point to another inside a building, with AR elements leading up to the destination. The user equipped with a phone can scan the markers inside a building through the camera mounted on his device. The application starts to run as soon as the user enters a destination and the system recognises the marker. The QR codes store the information for each POI, thus avoiding the installation and use of any other device for localization. This work provides a cost-effective solution to navigation in large indoor spaces.

CONCLUSION

Navigation with Augmented Reality has great potentials for future upgradations as it is one of the rapidly growing technologies. Since QR codes are being used, it can be updated any time with additional features. The application can be upgraded with an audio module for navigation and a brief information about the location can be rendered along with other options such as booking seminar halls in case of institutional buildings, or appointments in the case of hospitals, etc.

REFERENCES

1. Adam Satan (2018) – Bluetooth-based Indoor Navigation Mobile System, IEEE, 2018 19th International Carpathian Control Conference (ICCC)

2. Austin Corotan, Jianna Jian Zhang Irgen-Gioro (2019) - An Indoor Navigation Robot Using Augmented Reality, IEEE, 2019 5th International Conference on Control, Automation and Robotics (ICCAR)

3. Georg Gerstweiler (2018) - Guiding People in Complex Indoor Environments Using Augmented Reality, 2018 IEEE Conference on Virtual Reality and 3D User Interfaces 18-22 March, Reutlingen, Germany

4. Grinyak V., Devyatisilnyi A., Shurygin A. (2019) - Accuracy of Indoor Navigation with Bluetooth Beacons, 2019 International Multi-Conference on Industrial Engineering and Modern Technologies

5. Gupta, A., Bhatia, K., Gupta, K., & Vardhan, M. (2018). A Comparative Study of Marker-Based and Marker-Less Indoor Navigation in Augmented Reality, International Research Journal of Engineering and Technology (IRJET), 2018

6. Jirapat Sangthong (2018) – The Indoor Navigation Using Mapping Technique Based on Signal Strength Difference, IEEE, The 21st International Symposium on Wireless Personal Multimedia Communications (WPMC- 2018)

7. Ravinder Yadav, Vandit Jain, Himanika Chugh & Prasenjit Banerjee (2018) - Indoor Navigation System Using Visual Positioning System with Augmented Reality, IEEE, 2018 International Conference on Automation and Computational Engineering (ICACE)

8. Ying Zhuang, Yuhao Kang, Lina Huang, Zhixiang Fang (2018) - A Geocoding Framework for Indoor Navigation based on the QR Code, IEEE, 2018 Ubiquitous Positioning, Indoor Navigation and Location-Based Services (UPINLBS)