ISSN No:-2456-2165

Augmented Reality based Indoor Navigation System

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Abstract:- Many-a-times we waste a lot of time figuring out directions in huge indoor spaces like hospitals, malls, colleges and many such places where outdoor navigation systems don't work. We intend to provide a solution to this root cause. The proposed system will bridge this gap of navigation in indoor places using Augmented Reality Technology and smartphones. This would act as a virtual guide to the user in indoor environments. Users can simply use their smartphones and they will get directions in real time through augmented reality on their screen. The directions would be provided using multiple factors such as sensor calculations, device orientation and image recognition using Computer Vision. The system would allow pedestrians to navigate through large indoor environments easily using just their Smartphone. This project will make available a scalable computer vision based navigation system for indoor environments. This system will eliminate use of any hardware devices in the current indoor navigation system other than the users' mobile device.

Keywords:- *Indoor Navigation, Computer Vision, Augmented Reality.*

I. INTRODUCTION

Indoor navigation systems for smartphones are crucial in complex indoor environments such as airports, shopping malls, hospitals. But until now very few indoor navigation systems have been adopted due to multiple reasons. The existing systems either make intensive use of hardware or have less accuracy.

After studying various existing systems and identifying their pros and cons we propose a system which will use a combination of computer vision and QR codes. This system will result in use of minimal hardware and high accuracy. The core of the is based on the continuous tracking of multiple sensors which are present in today's fast smartphone devices. This tracking reduces the requirement of additional hardware and getting better results.

II. RELATED WORK

There are three main approaches in which this problem has been approached before. Each of the approaches has its own pros and cons.

A. Satan [1] proposed a bluetooth beacon based approach.

Bluetooth Beacons emit radio frequency signals that can be used for distance calculation. Based on the distance from the beacons, the user's location is estimated.

The goal of the research was to create a user friendly Indoor Navigation System based on Bluetooth Positioning. The application generates a route between the users location and the known point of the destination. The test application was developed for Android and implemented in Java.

Symbolic positioning based indoor navigation application was designed which uses Bluetooth Low Energy Received Signal Strength Indication (RSSI) measurements to estimate the clients position. To determine the path, the application uses Dijkstra's shortest path algorithm to support undirected graphs. This system relies highly on the Bluetooth Beacons so if the intermediate beacons fail users location detection becomes hard.

D. Mamaeva, M. Adanasev [2] proposed another solution using the Quick Response codes. In their approach they put QR codes at specific locations on the floor such as intersections, corridors, staircases (Hub Locations). Using QR codes, the navigation map identifies the user's location.

An optimal route from point A to point B is based on A* search algorithm. Depending on the chosen path 3D arrow shows the direction towards destination. Thus, the user knows exactly where it is needed to make right turns or left turns. This approach has a major flaw: it is highly dependent on the QR codes placed in the environment if the QR codes are lost there is no way to detect the users location.

G. Gerstweier, E. Vonach [3] proposed a computer vision based approach they proposed design and development of a full mapping, tracking and visualization pipeline for large indoor environments using computer vision. They built a system called HyMoTrack which was an AR based navigation system without any external hardware requirement. Their System worked fine for a single building and single floor. The system was able to function offline by storing maps on the user's device.

J. Dong, M. Noreikis [4] proposed a similar approach with computer vision but instead of using the traditional complete vision based approaches they also utilised various sensors available in the mobile devices like Accelerometer, Gyroscope, Barometer, etc. This paper presents a better use of sensor data and a more accurate mode for indoor navigation. This system worked in multi floor buildings. This approach resulted in a more accurate approach than the previous one because of the use of sensor data.

III. METHODOLOGY

All these above approaches have their ups and downs. The beacon based approach requires lots of hardware and can lose its accuracy if some beacon goes down.

QR code based approach makes users scan multiple QR codes while traveling.

The CV based approach appears to be the optimal one as it does not involve any external elements for the operation of the system but it involves heavy computations to detect the users location when we have multiple buildings.

To resolve this issue we propose a combination of QR code and CV based approach.

We will add QR codes on entry points of the buildings which will be scanned by the user before entering the building so we will know in advance where to focus on.

We will have two main modules in the system The Tagging / Map generation Module and the User module.

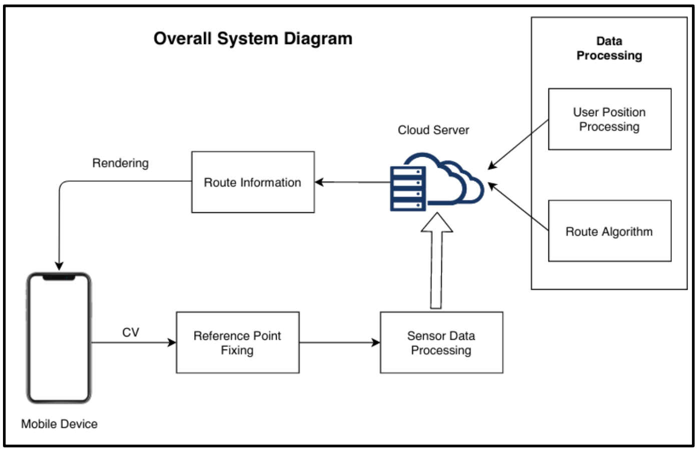

Fig 1:- Overall System Diagram

➢ *The Tagging Module:*

1. The tagging module will be used when we have to generate a map of the environment.
2. We will be mapping various locations based on coordinate systems so we will assume that the starting point is 0 0 0 (x y z).
3. After this we will continuously take the inputs from device sensors to map further coordinates.
4. The tagging module will involve use of computer vision to first extract the POI from the environment, some object detection and OCR will also be used to generate tags for locations.
5. These tags will be stored in a database with reference to their corresponding coordinates.
6. Finally the entire map will be generated which can be used for navigation.
7. When the device receives the route to be taken it will guide the user using AR.
8. While showing directions to users the system will use sensors to track users movement so that it can guide users properly.

➢ *User Module:*

1. The user module will be used to track users real time location as well as to guide users to their destination.
2. The user will be required to start by scanning the QR code on the entrance of the building that he wants to go in. This QR code will provide the system which building to search into.
3. If a user does not scan the QR code then also the system will be able to determine users location by scanning the user environment for a checkpoint using CV it will just take more computation on system side as it will have to search the entire map.
4. After determining the user's current location the system will ask the user to enter the destination.
5. Then we will compute the optimal path from source to destination using a routing algorithm.
6. When the device receives the route to be taken it will guide the user using AR.
7. While showing directions to users the system will use sensors to track users movement so that it can guide users properly.

IV. SYSTEM ARCHITECTURE

➢ *Tagging Module:*

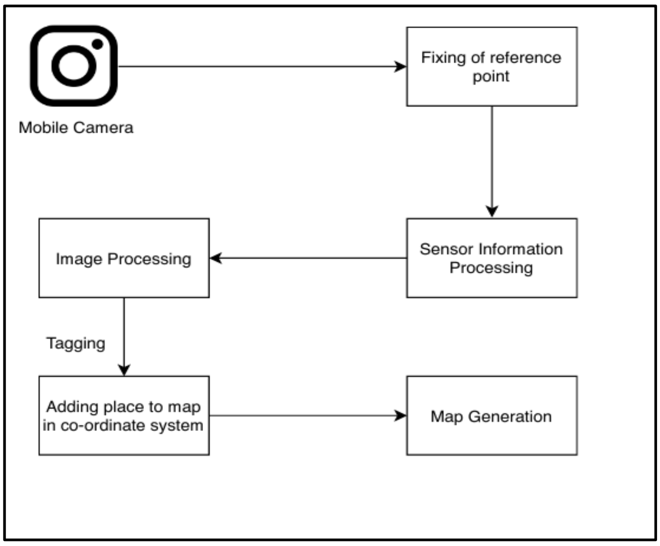

Fig 2:- Tagging Module

1. *Fixing of reference point:*

In this stage, the reference point is fixed by scanning the QR code at the entrance of the building. Reference point acts as a starting point for the coordinate structure of the building. By using an inbuilt smartphone camera, QR code is scanned and starting coordinates will be obtained. This information will help the system to know in advance where to focus on.

2. *Sensor Information Processing:*

In this stage, data of various sensors is processed. Accelerometer sensor and gyroscope data will be used to detect movement of the user and the compass is used to get the direction of movement while a Barometer will be used to detect floor change as the user travels.

3. *Image Processing:*

In this stage, the whole building is tagged in terms of various image checkpoints. Every image is mapped with particular coordinates. All this image data is processed and stored in a database.

4. *Adding place to map in coordinate system:*

In addition to the image processing system if we want to add any custom checkpoint in the system we can add it manually and it will be labelled using user input and stored in the database the same way that other checkpoints will be stored.

5. *Map Generation:*

All the details related to the checkpoint like images, coordinates, relative position to reference point etc. are stored in one database and act as a Map.

➢ *User Module:*

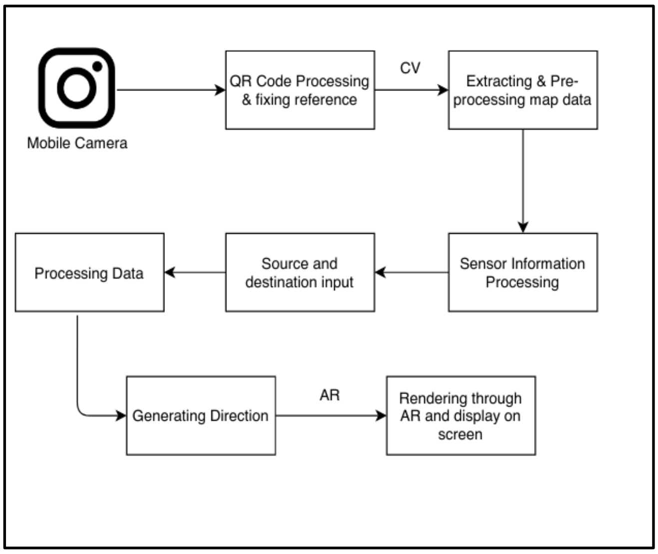

Fig 3:- User Module

1. *Extracting & Preprocessing map data:*

When the user will scan the QR on the entrance point, the system will load and preprocess the map database of that building.

2. *Source and destination input:*

In this stage, user will input the destination where he/she wants to go and by using map data system will automatically get source point

3. *Generating Direction:*

In this stage the system will generate directions towards the destination point. System will use a map database to generate direction and the path from source to destination.

4. *Rendering through AR and display on screen:*

As the user will move towards destination, directions will be shown on the smartphone screen. Augmented Reality based objects will be used to show directions.

All other phases of the user module are common with the tagging module.

V. CONCLUSION

In this paper, we have proposed a complete framework specially designed for an Augmented Reality based Indoor navigation system. After evaluating various approaches we concluded that a QR based approach combined with a Vision based approach would be better due to its higher accuracy, efficiency, moderate cost as compared to other approaches. The system will help users to tag any indoor location and get directions to various indoor places by using sensors in their smartphone devices and Augmented Reality Projections. In Future, the scope can be extended to a QR less mechanism, which will also work for outdoor places.

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