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Indoor Navigation System using Augmented Reality and Artificial Intelligence

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Abstract - *Mobile phones are nowadays far more than simply devices to communicate with. Especially, smartphones are devices which help to make our everyday life and work much easier. The system will acquire the user's current location inside the building and ask the user to select the destination. The system will then provide the user with the best and shortest route according to the selected destination, using AI searching techniques. To perform the navigation, the user's location and route on the map will be updated periodically. A graphical map displayed on the screen will allow the user to mark the destination or do a simple search using the search field where the user can type in the destination or the name of the room. Then, a direction pointer or the path marked with the way-points in augmented reality view will help in directing the user towards the destination.*

***Key Words*: Augmented reality, artificial intelligence, a* search algorithm, indoor navigation, QR code.**

1. INTRODUCTION

Indoor Navigation means navigation inside buildings or closed walls. Since GPS does not work indoors, other positioning techniques are used where automatic positioning is required. These positioning techniques in turn tell the navigation system the location of the user inside a building.

There are a huge number of buildings constructed daily and most of them have many floors and can have really complex structures with numerous rooms and hallways. In large buildings such as malls, companies, hotels, resorts or even a cruise ship, a person visiting such a place for the first time or not familiar with, won't have an idea or will take time to find out the correct path to reach to some location inside the building which will end up in wastage of time. So, in such a place similar to a maze, people find it difficult to navigate through these buildings due to their complex structure.

Nowadays, people rely on their smartphones or the internet for day-to-day navigation. Often these smartphones use the Global Positioning System or GPS to provide accurate position information. But GPS cannot be used indoors effectively since microwaves get scattered by roofs, walls and other objects and hence the idea of 'Indoor Navigation'. So, the idea of 'Indoor Navigation' is all about navigating the users to find their way from their current position to the room or any destination inside the building wherever the user wishes to go. Using an 'Indoor Navigation System', users have the freedom and independence to find the destination without asking anyone and without reading the sign boards, which in turn saves time and effort that would be wasted if the user took a wrong path.

Using an internal map of the building and AR technology, the system finds the most efficient path to reach the destination in the shortest time possible. The user interface will allow the user to select the destination. The system then locates the user inside the building. Once both the source and the destination is known to the system, it then uses a pointer/marker using AR to point the path which the user has to take in order to reach the destination.

Section II presents the study of the existing systems, their working and limitations. Section III includes the architecture of the proposed system and the various scenarios in which it will function.

2. EXISTING SYSTEM

Currently, popular navigation systems that are in the market are smartphone applications or standalone devices that make use of mapping services and satellite localization. A navigation system usually displays a map on which both the navigation path and the current location of the user is shown. Along with this the system gives instructions to the user to follow the path, either visually or with the help of audio. Although these systems solve the problem of navigation efficiently, they lack in providing the user a good experience. There are many methods available to display the shortest path and navigate the user. One such method is guiding the user with the help of arrows. Another method is to tell the user how many steps to take and in which direction in order to reach the destination. The shortest path can also be displayed with the help of augmented reality techniques to enhance the user experience.

Indoor positioning system can locate people or objects inside buildings usually with the help of a smartphone or tablet. But, it cannot show you how to reach a desired location inside the building. Indoor navigation system uses the location provided by the indoor positioning system to help the user reach where they need to go. It also provides turn-by-turn directions that will get the user to the right spot.

This section provides information about currently existing indoor navigation systems that help in navigating inside a building. There are many approaches to implement indoor navigation systems. The most commonly used ones are as follows:

A. Using Wi-Fi

Wi-Fi is the most commonly used technology for indoor positioning. Wi-Fi access points are usually installed in most indoor spaces. To find the location of a device, nearby Wi-Fi hotspots and other wireless access points are used. In this the device's location is estimated using vectorization by tracking it relative to the location of the access points on the floor. The drawback of this method is that the location accuracy depends on the signal strength of the Wi-Fi which may suffer sometimes [1].

B. Using Bluetooth beacons

Bluetooth beacons are radio transmitters that send out signals via Bluetooth to mobile devices. These beacons are positioned at several locations inside a building. Therefore, it is possible to determine their position continuously and transmit it to the indoor navigation system. The total number of beacons required depends on the size of the building and the accuracy required. Beacons are easy to install since they can be operated with batteries. They are also cost effective. It works for relatively small range (up to 30m) [2].

Beacons have to be installed in proximity with each other. This makes it usage impractical and uneconomical. Another disadvantage of using beacons is its maintenance. The beacons don't require other maintenance other than changing its battery once in a while. If you have like 500 beacons, then changing the batteries may take a while.

C. Using QR code

QR codes can be used to provide a precise position of the user inside a closed building. A QR code is a 2D code that contains the location information. The QR codes are placed inside the building to determine the location of the user. The navigation system use these QR codes to provide accurate navigation. QR code for a floor X at point 'a' could be defined as: [4]

QR code (X,a) = URL for floor plan(X) + Location details(a) (eq. 1)

Location details (a) = Latitude, Longitude and Altitude of the graphical point a (eq. 2)

The important problem related with this QR code is that it contains both the URL for the floor plan as well as the location details of a graphical point and it takes a fair amount of time to generate such a QR code.

3. METHODOLOGY

The aim of the proposed system is to develop an AR based indoor navigation system which would help the user to reach his/her destination in the shortest time possible. The system uses artificial intelligence to find the shortest path and then displays it to the user using AR. The application uses the second floor of Main block of Agnel Institute of Technology and Design as the prototype location. It can navigate from every location to all the rooms and exits on that floor. The application uses a few methodologies to complete the application.

A. Creation of Map

The indoor map of the floor was created by taking measurements of the floor using a measuring tape. These readings were then given to an app such as AR Plan 3D Ruler by Grymala to create the 2D map. The readings were taken in meters. The following figure shows the 2D map created.

Fig -1: 2D floor plan showing walk-able path with tag names assigned to each room for easy reference

B. A* Search Algorithm

Peter Hart, Nils Nilsson and Bertram Raphael of Stanford Research Institute first published the algorithm in 1968. It can be seen as an extension of Edsger Djikstra's 1959 algorithm. A* achieves better performance by using heuristics to guide its search. A* is often used for the common pathfinding problem in applications such as video games, but was originally designed as a graph traversal algorithm [4].

The rooms are considered as nodes. Figure 2 shows the resulting example from calculating the shortest path with A* algorithm from node A to node F. The heuristic values for each node are as follows: A=4, B=5, C=5, D=4, E=2 and F=0. The actual values for each node are as given in the figure. We use the following formula to calculate the estimated cost of each node:

$$f(n) = g(n) + h(n) \quad \text{(eq. 3)}$$

There is only one path from node A to node B, but there are 2 paths from node B. We have to find the minimum cost path between these two. We find that the estimated cost of node C is 12 which is greater than the estimated cost of node E which is 8. So we choose the node E to continue the path. Next, we compare the estimated cost of node C and node F.

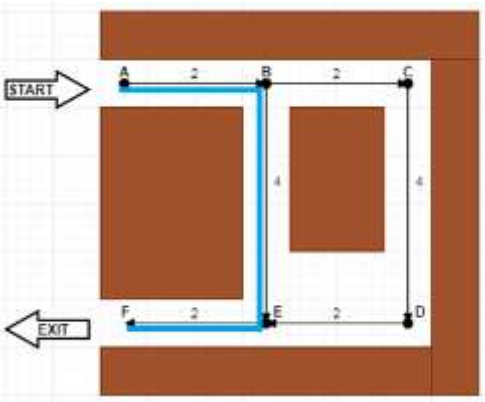

Fig -2: A* algorithm example

Since node F has the least estimated cost, we choose node F. Therefore, we reach from node A to F with a total cost of 8.

4. FLOW OF THE APPLICATION

The flowchart of the application is divided into 4 steps as shown in the figure below:

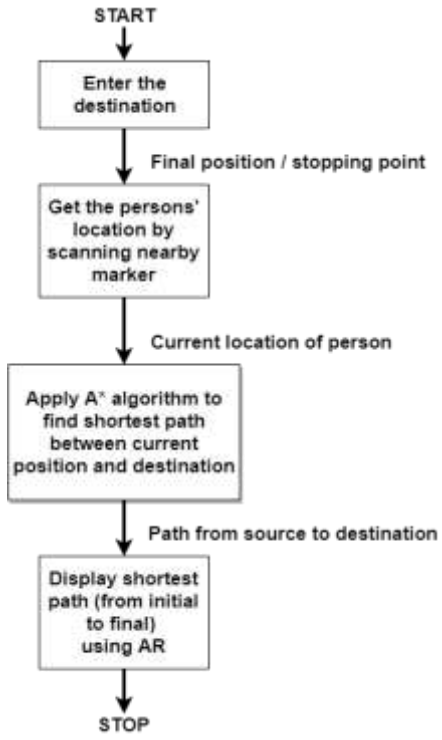

Fig -3: Flow diagram of overall application

A. Choose the destination

The user can select the destination by tapping on the 'SEARCH' bar and a drop-down list will pop-up as shown in figure 4. This list allows the user to choose the destination from all the rooms as well as the exits provided on the floor.

Fig -4: Drop-down list to select destination

B. Get the current location

Each room is assigned a unique marker. The user will be asked to scan the nearby QR code in order to locate the user inside the building. These QR codes will be scanned by using the device's camera. Figure 5 shows the QR code for the room 'LBC 2' which is one of the labs present on that floor.

Fig -5: QR code for 'LBC 2'

C. Navigation

Once both the current location and destination is known to the system, the system uses A* algorithm to find the shortest path possible between these nodes. This algorithm uses artificial intelligence to find the shortest path possible between any two given nodes.

D. Display shortest path

Instead of looking at the 2D map while navigating, AR can be used to enhance the user's experience. The user will be guided to the destination with the help of augmented arrows. Below is a screenshot during navigation.

Fig -6: Showing direction using augmented arrow

The user can also view the 2D view of the map in the bottom left corner of the screen by tapping on the 'switch' button to see how far they have come from the starting point. The user will be notified when they reach their destination. The user will then have the option of either starting the navigation again with a new source and a new destination or exiting the app. Anytime during navigation, the user can choose to change the destination.

5. CONCLUSION

With the proposed system, the user can reach the destination in the shortest time possible. With the implementation of A* algorithm, the shortest path to the destination is found in the least time possible. The app uses augmented reality to direct the user towards the destination thereby enhancing user experience. By making this system real-time, it can further be used in disaster recovery systems to help people in escaping a building in a fire emergency or any other emergencies.

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