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Mobile Application Development for Indoor Navigation Using Slam and Augmented Reality

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ABSTRACT

Mobile application development is the process of creating software applications that run on a mobile device, and a typical mobile application utilizes a network connection to work with remote computing resources. As part of the development process, mobile User Interface (UI) design is also essential in the creation of mobile apps. Mobile UI considers constraints, contexts, screen, input, and mobility as outlines for design. The user is often focused on the interaction with their device, and the interface entails components of both hardware and software. Overall, mobile UI design's goal is mainly for an understandable, user-friendly interface. We intend to develop an application that performs Indoor Navigation. Indoor Navigation means the flexible guidance of people in confusing, unknown buildings and building complexes. The user of an indoor navigation system gets his own location displayed on a map on his own smart device. After selecting a destination or a point of interest, a route to the selected destination is displayed on the map. The user's position in and around the building is permanently updated by indoor positioning, so that the device always shows the current position on the route. Indoor navigation apps access those sensors in your phone and the environment around you to create a map to help you move to your desired location within the building quickly and easily. In short, they help you find your way in a large, confusing building.

Keywords : IoT, Mobility, Mobile Application, Navigation, Sensor.

I. INTRODUCTION

Mobile app development is a process for building mobile applications run on mobile devices, such as personal digital assistants, enterprise digital assistants or mobile phones. Hence, the mobile app development process requires creating software that can be installed on the device, and enabling backend services for data access through APIs, and testing the application on target devices.

Indoor Navigation deals with navigation within complex buildings. The implementation of this system in this project provides users with an instant guide

opening many possibilities. It makes it possible to build routes from one point to another. And also Step-by-step navigation is provided to users when they are along the university halls and buildings with a possibility to get notifications. Indoor navigation is done by Indoor Positioning System (IPS), which is a network of devices used to locate people or objects, where other satellite technologies and Global Positioning System (GPS) lack precision. IPS is a solution to locate objects or people inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices. To build a strong IPS a technology called SLAM is used. SLAM refers to a task of constructing an internal map of an unknown area while keeping track of its position inside the area. This allows for an IPS that can be used without any preparation beforehand. In addition to this technique, we also use Augmented Reality (AR) for superimposing walking directions over real-world streets. The map shows the location where we are heading and when to take a turn using the camera of the device. As SLAM involves localization and AR in Path showing, NavMesh is an algorithm that determines the optimal paths which will navigate the user in routes that can take them to their destination in minimal time. This whole project is built on UNITY SOFTWARE which is a cross platform application to build games and real time projects. All the above said technologies are inbuilt in this software. It has it's inbuilt IDE (Integrated Development Environment) to write programs.

II. RELATED WORK

R Dantu explains about "Methods and systems for Indoor Publication Classification Navigation" in which the methods and systems for indoor navigation utilize a smart phone equipped with various sensors. When a person whose initial position is unknown, and in some circumstances whose sight has been impaired, specifies a destination, the navigation system will calculate the coordinates of his/her present location from the sensor readings.

BL Davis, et.al., explained in "Mobile Device Indoor Navigation" A method for indoor navigation in a venue derives positioning of a mobile device based on sounds captured by the microphone of the mobile device from the ambient environment. It is particularly suited to operate on smart phones, where the sounds are captured using a microphone that captures sounds in a frequency range of human hearing.

B Gozick et.al., explained in "Magnetic maps for Indoor Navigation" that -Magnetic field fluctuations and anomalies inside buildings tend to have a great effect on the compass, which is one of the simplest navigation devices.Alternative navigation requires landmark identification, so those landmarks can be used as guideposts in assisting individuals. By employing a mobile phone with a built-in magnetometer, an extensive data set of 2000 measurements was collected.

H Huang, et.al., has surveyed in "A Survey of Mobile Indoor Navigation Systems" the following-With the gradual maturating of ubiquitous computing and the rapid advances in mobile devices and wireless communication, indoor Location Based Services have gained increasing interests as an important application of indoor ubiquitous computing. In this paper, an evaluation framework which combines the key aspects of indoor navigation for investigating mobile indoor navigation systems is proposed.

L Ran, et.al., has deduced in "An Integrated Indoor / Outdoor Blind Navigation System and service"-There are many navigation systems for visually impaired people but few can provide dynamic interactions and adaptability to changes. None of these systems work seamlessly both indoors and outdoors. Drishti uses a precise position measurement system, a wireless

connection, a wearable computer, and a vocal communication interface to guide blind users and help them travel in familiar and unfamiliar environments independently and safely.

S Chumkamon et.al., says in "A blind Navigation system using RFID for Indoor Environments"-A location and tracking system becomes very important to our future world of pervasive computing, where information is all around us. Location is one of the most needed information for emerging and future applications. Since the public use of GPS satellites is allowed, several state-of-the-art devices become part of our life, e.g. a car navigator and a mobile phone with a built-in GPS receiver.

III. SYSTEM MODEL

This project is when a person has arrived at an unknown place it would be difficult to find the desired location. The person would have to find a direction board or seek help from others. This might even lead to loss of time and energy in finding the place. Google maps have been the best in saving time to find and locate places with the help of GPS. Though Google Maps is able to navigate through narrow streets and wide roads, it cannot be used within buildings and areas like airports, malls etc. Hence evolved the concept of Indoor Navigation, ,which deals with navigation within building. It does not work on GPS as it lacks accuracy within closed spaces.

There are various other technologies that can be used to track location here we use a concept called Simultaneous localization and mapping abbreviated as SLAM. When compared to GPS it has high accuracy in tracking the current position and can set-up its own Indoor positioning system. In Augmented Reality a computer generated image can be superimposed on the user's device which can help the user to navigate and find the destination on a 3d view.

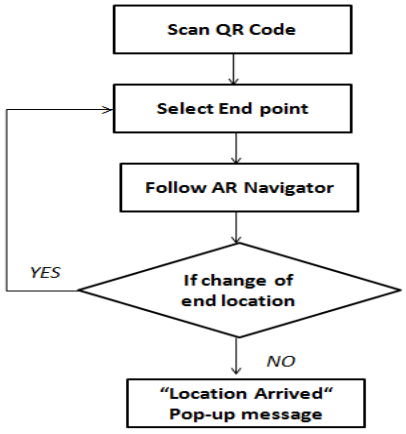

Figure 1. Work Flow Diagram

a. SCAN QR-CODE

A QR code (abbreviated from Quick Response code) is a type of matrix barcode (or two-dimensional barcode) . A barcode is a machine-readable optical label that contains information about the item to which it is attached. In practice, QR codes often contain data for a locator, identifier, or tracker that points to a website or application.

b. Select End Location

The next step would be choosing the end location .A drop-down containing the list of all end locations is used to choose the end location after the start point is pinned when the QR-code is scanned. When the End Location is chosen, a 2-dimensional map from the current location to the end location will be displayed.

c. Follow AR Navigator

Augmented reality (AR) is the real-time use of information in the form of text, graphics, audio, and other virtual enhancements integrated with real-world objects. Augmented reality is the rendering of digital images or data onto real-world objects. Here we use an ARROW as the AR object to navigate the user in a 3-dimensional view.

d. If Change of End Location

If the user desires to change his/her end location, they can select a different end location from the drop-down and get the route to the new desired end location.

e. End Location Arrived - Pop Up Message

When the user has arrived at the desired end location, the AR Arrow will disappear and a pop-up message saying "END LOCATION ARRIVED" will be displayed on the user's device.

IV. Proposed System

The proposed system has the following modules.

- QR Code Repositioning.
- ARCore based Localization.
- NavMesh navigation.
- AR Path showing.

a. QR Code Repositioning

A QR code is a type of barcode that can be read easily by a digital device and which stores information as a series of pixels in a square-shaped grid. Here we scan the QR code which sets that position as the start point for the navigation.

This module has the following sub-modules:

- Start position synchronization
- Import library function.
- Scripts.

1. Start position synchronization

The application starts its purpose when the QR Code is being scanned, which marks the start point on the map. The SLAM component then starts to build its own IPS.

2. Import library function.

The Unity software has its own in-built library functions. Here for QR Code Repositioning we use the ZXing library which helps to capture the QR Code and display the upcoming mode.This library accesses the camera of the device to capture the QR Code and marks the start point.

3. Scripts

The Unity Software has its own in-built IDE into which we can write codes. Here we use C# programing language to write the program. in this module we have two scripts:

(i) start() function: this function comes under the ZXing library which captures the QR Code to mark the start point. This function also accesses the camera of the device.

(ii) update() function: this function also comes under the ZXing library which is used to check for other QR Codes (if any) to update the new start point.

After the QR Code is scanned the application displays the map and a drop-down with the available end-locations on the map.

b. AR CORE BASED LOCALIZATION

ARCore is Google's platform for building augmented reality experiences. Using different APIs, ARCore enables the device to sense its environment, understand the world and interact with information. Here Location-based AR means a markerless, position-based, and geo-based Augmented Reality. It relies on GPS, accelerometer, digital compass, and other technologies to identify a device's location and position with high accuracy. AR core based localization has the following sub-modules:

- Map Creation.
- Import packages.
- Scripts.

This part involves creating the map on which we are indoor navigating. The image has to be made plain and placed on the area provided in the unity gaming area. The map has to be scaled in real life and the units to be noted in meters.Afterwards we only need a blue dot, which can be a simple cylinder, and the ARCore Device prefab. The blue dot has a camera as a child that looks straight down and renders its view to a raw image used as a minimap. Here we are indoor navigating in our university campus hence we have placed the map of our college on the gaming area of the unity software. The figure below is the map of our college, all the measurements are in meters with the respective departments and other areas.

Few packages are imported into the software for better performance and flexibility. Here we use two packages, namely:

- Multiplayer HLAPI
- XR Legacy input helpers.

Multiplayer High Level API is used for gaming in host and player mode where multiple players or various OS versions can run at equal pace. The XR Legacy input helpers binds the Seeding Tool and 3D of Arm Model support for the Tracked-Pose-Driver.

The scripts used in this module are for triggering the AR component on to the project.It has the following two script functions.

1. Start() function: This function sets the initial position of the camera. The first blue-dot on the map makes the camera decide its position based on the other objects on the environment.
2. Update() function: in this function the position of the camera is updated when the person moves. The position is determined based on the difference of the current and the previous position.

c. NAVMESH NAVIGATION

A navigation mesh or NavMesh is an abstract data structure used in AI for pathfinding through complicated spaces. It is popularly used in games where AI is an integral feature of technology.

This module has the following sub-modules :

1. Pathfinding
2. NavMesh working
3. Scripts.

Pathfinding:

Pathfinding by a computer application is finding the shortest route between two points. This method searches a graph by starting at one vertex and exploring adjacent nodes until the destination is reached in the shortest route possible. Here we use the NavMesh algorithm to determine the shortest path to take from the selected start point. The Navmesh algorithm being a built-in feature in Unity makes it easy to determine the optimal path to the various destinations available on the map.

NavMesh Working:

NavMesh algorithm not only helps in determining the shortest path but also helps to distinguish the walkable and non-walkable areas on the map. Walkable areas would mean roads,corridors etc and non-walkable areas would be the walls and objects that are non-movable. The image below shows the map being separated as walkable and non walkable. Walkable regions are marked in blue and non walkable in black and white. This is done using the NavMesh algorithm.

Scripts:

Once the user selects the destination the NavigationController function, from the NavMesh algorithm,will constantly update its path from the blue dot to the set destination. A line renderer is used to indicate the calculated path on the map.

d. AR PATH SHOWING

This module performs showing the route to take using augmented reality. The AR object is the 3D component that interacts with the user by showing the right path to take amidst the 2D map route available on the application. This AR object will guide the user by keeping them within the map without which they may lose their track.

V. CONCLUSION

This proposed system contributes to the self-dependency of people when they end up at places where they are not familiar with the whereabouts of the different locations in the closed and yet wide area, for example malls, airports etc. It reduces the manual effort and also saves time in searching for a sign/direction board or requesting help from another individual. Besides that the project does not use the internet for mapping and localization, which would also mean that there would not be any issues with respect to signal strength. The UI being user-friendly while choosing the end location from a drop down making it easy to see the available end locations in the area. Developing the project on other SDK's can make it run on even IOS. Building the project on other

platforms may also help in navigation on different levels of floors.

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