Agumented Reality Driven-Indoor navigation system

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Abstract— **Large, intricate structures like airports, malls, hospitals, and institutions now require indoor navigation. Particularly for first-time visitors, traditional navigation techniques like maps and signboards are sometimes challenging to use. Additionally, using GPS-based navigation is challenging indoors due to poor or nonexistent GPS signals. By creating an indoor navigation system based on augmented reality (AR), this project seeks to address this issue. Using visual cues like QR codes, the system determines the user's present position and utilizes the phone's camera to display virtual directions (such as arrows) on the screen. Because of this, users can easily follow the route in real time and arrive at their destination without getting lost. Although the concept is for a collegiate facility, other locations such as shopping centers, hospitals, and airports may employ the same technology. It is a useful tool for interior navigation since it is interactive, easy to use, and GPS-free.**

Keywords--*Augmented Reality, Indoor Navigation, ARCore, QR Code, Pathfinding Algorithm, Mobile Application, Wayfinding.*

I. INTRODUCTION

Navigating with a large interior can be a disappointing task, especially in complex environments where layout and structure are unknown or there are ample signs. For users such as hospital visitors, shopping centre buyers, airport travelers, and more, this can lead to confusion and delays. GPS-based systems for navigating outdoor navigation have proven to be very effective, but fail indoors due to obstacles through walls and ceilings and weak signal penetration. Various technologies such as Wi-Fi fingerprints, BLE beacons, and QR code markers provide interior alternatives. By combining AR with these positioning methods, you can create navigation systems that not only accurately lead users, but also improve your experience by displaying visual information directly in the camera view. This study presents an AR-based indoor navigation system that provides user-oriented, reliable navigation aids in complex internal environments. Augmented Reality (AR) introduces promising solutions by directly overlapping virtual objects such as arrows and markings via smartphones and AR-enabled devices. AR allows users in the form of digital overlays to receive actual temporal and intuitive visual instructions on the device screen. This means that you need to remove the need for complex maps or ambiguous text instructions. By combining AR with multi-source interior positioning, the system can provide users with a seamless navigation experience with high accuracy and user-friendlyness smartphone or AR-enabled device. With AR, users can receive real-time, intuitive visual guidance in the form of digital overlays on their device screens, which eliminates the need for interpreting complex maps or ambiguous text directions. By combining AR with multi-source indoor positioning, this system can offer users a seamless navigation experience with high accuracy and ease of use.

II. METHODOLOGY

The proposed system integrates AR technology with several internal positioning methods to achieve an accurate and interactive navigation experience. The main components and processes are as follows:

1. Interior Positioning System Wi-Fi Positioning: The system uses Wi-Fi fingerprints by analyzing the signal strength of nearby Wi-Fi access points to estimate the user's position. Wi-Fi positioning provides a general location, but includes additional methods to improve accuracy. BLE Beacons: Bull beacons placed in the environment will emit signals to improve positional accuracy if Wi-Fi positioning is not enough. These beacons are particularly effective in correcting location drifts in high traffic or signaling areas. QR Code: QR Codes are strategically located at critical locations such as inputs, outputs, and important intersections, allowing users to scan their positions and calibrate again. QR markers provide an accurate reference point, which reduces cumulative positioning errors over a wide range of areas.

2. Augmented Reality Interface The AR interface is designed to directly present visual navigation instructions in a user's real view, leading to complex layouts. Interesting Point (POI) Markers: Important locations such as toilets, outputs, shops, and more have different symbols. This way users can quickly localize important facilities. Dynamic Update: The AR interface is updated in real time, when the user moves, recalculates, and displays the correct route and absorbs unexpected or directions of movement.

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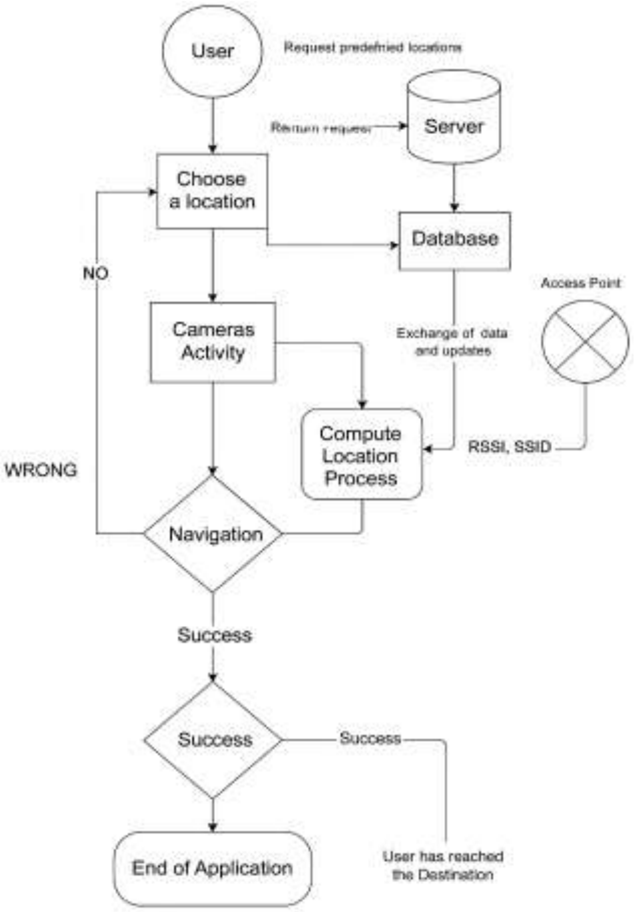

Fig.1 Use case Diagram

3. Navigation Algorithms

The system is based on paths of paths such as the * or dijkstra-s algorithm that calculates the optimal route based on the user's l ocation and goals. Collected over time to improve system perfor mance. Machine learning models adapt to localization by learnin g from historical data and optimizing both accuracy and user sati sfaction.

4.User Interaction

The user interacts with the system via a mobile app interface. Th e most important feature is the

Input Mechanism: Users can specify goals by entering or selecti ng a predefined list of points.

III. FUTURE SCOPE

Augmented Reality (AR) has immense potential for the future of indoor navigation. As AR hardware like smart glasses becomes more affordable and widely adopted, indoor navigation will move beyond smartphones, offering hands-free, real-time guidance. Integration with AI and machine learning can enable personalized routes based on user preferences, accessibility needs, or real-time crowd data. With advancements in 5G and edge computing, AR navigation can become faster and more responsive, even in large, complex indoor environments. Moreover, future systems may integrate voice commands, multi-language support, and real-time assistance, making them more inclusive and user-friendly. Industries like retail, healthcare, education, and tourism stand to benefit greatly from smart AR navigation experiences.

IV. LITERATURE SURVEY

The proposed system integrates AR technology with multiple indoor positioning methods to deliver an accurate and interactive navigation experience. Key components and processes are as follows:

A. Indoor Positioning System

1. **Wi-Fi Fingerprinting:** This system leverages Wi-Fi fingerprinting by analyzing the signal strengths from existing Wi-Fi access points to determine a user's location. This method is cost-effective as it utilizes existing infrastructure, but its accuracy can be affected by signal interference and environmental changes.

2. **BLE Beacons:** Bluetooth Low Energy (BLE) beacons offer energy-efficient and precise indoor positioning. They transmit signals that are detected by mobile devices, allowing for triangulation or proximity-based localization. However, signal reflection in complex environments can lead to positioning errors.

3. **QR Code/Visual Markers:** QR codes and visual markers are strategically placed throughout the indoor environment. Users scan these markers with their smartphone cameras, which provides precise location data and orientation. This marker-based approach is highly reliable but requires constant user interaction through scanning.

B. Augmented Reality (AR) Integration

1. **ARCore/ARKit:** These SDKs (Software Development Kits) are crucial for enabling AR capabilities on mobile devices. They provide functionalities such as motion tracking, environmental understanding, and light estimation, which allow the system to accurately overlay virtual content onto the real world.

2. **3D Model and Pathfinding:** A detailed 3D model of the indoor space is created using tools like Blender. This model serves as the digital twin of the environment, enabling the pathfinding algorithm (e.g., A*) to calculate optimal routes between selected points.

3. **Real-Time AR Overlays:** Once the user's location is determined and the path is calculated, AR overlays—such as directional arrows, virtual pathways, and points of interest—are projected onto the live camera feed of the user's device. These dynamic overlays provide intuitive, step-by-step guidance.

C. System Workflow

1. **Initialization:** The user launches the AR navigation app and scans a nearby QR code or relies on Wi-Fi/BLE positioning to establish an initial precise location and orientation.

2. **Destination Selection:** Users can select a destination from a predefined list or search for a specific location within the building.

3. **Path Calculation:** The pathfinding algorithm processes the user's current location and selected destination, calculating the most efficient route through the 3D building model.

4. **AR Guidance:** The calculated path is translated into AR overlays, which are displayed on the user's screen. As the user moves, the system continuously updates their position and adjusts the AR cues in real-time, rerouting if deviations occur.

5. **User Interface:** The interface is designed to be intuitive, providing clear visual and optional auditory guidance, minimizing the need for manual input and ensuring a smooth navigation experience.

V. CONCLUSION

This research proposes an innovative approach to indoor navigation by leveraging AR technology to provide users with an intuitive, visual navigation experience. By combining multiple positioning technologies—Wi-Fi, BLE beacons, and QR codes—the system addresses the inherent limitations of each method, delivering improved accuracy and real-time guidance within complex indoor environments. Preliminary testing indicates that AR-driven navigation offers substantial benefits in terms of usability, accuracy, and user satisfaction, making it a promising solution for large indoor spaces. The future scope of this research suggests potential for further improvements, particularly in scalability and personalization, which could lead to broader adoption and a more tailored user experience.

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