Agumented Reality Driven-Indoor navigation system

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***Abstract*—Indoor navigation presents unique challenges in complex environments such as airports, hospitals, malls, and large office buildings, where traditional GPS-based systems are ineffective due to weak or absent satellite signals. This research explores the development of an indoor navigation system using augmented reality (AR) technology to overcome these limitations and improve user experience. The proposed system provides real-time visual cues, including directional arrows, path markers, and text overlays, on a user's smartphone or AR-enabled device, guiding them through the space by augmenting their real-world view. By combining multiple positioning technologies—Wi-Fi fingerprinting, Bluetooth Low Energy (BLE) beacons, and QR-code markers—the system achieves high localization accuracy in a way that is both cost-effective and scalable for large indoor spaces. The indoor positioning component of the system dynamically integrates data from Wi-Fi access points and BLE beacons to estimate the user's position with greater precision, while strategically placed QR-code markers allow for calibration and correction of position drift. These combined positioning techniques enable the system to maintain reliability, even in areas where individual positioning methods might struggle due to signal interference or physical obstructions. The augmented reality interface is developed using AR SDKs like AR Core and ARKit, allowing for an intuitive user experience where navigation information is seamlessly superimposed onto the environment. A* pathfinding algorithm calculates optimal routes, taking into account real-time factors such as obstacles or reroutes due to changes in the user's path. This real-time adaptability ensures that users receive accurate and up-to-date guidance to their destinations.**

***Index Terms*—AR, AR Core, A* path finding Algorithm, QR code, Indoor Navigation, smartphone,WiFi.**

I. INTRODUCTION

Navigating large indoor spaces can be a daunting task, particularly in complex environments where layout and structure are unfamiliar or lack sufficient signage. For users such as visitors in hospitals, shoppers in malls, or travellers in airports, finding the correct route to a desired destination within such facilities can lead to confusion and delays. While GPS-based systems have proven highly effective for outdoor navigation, they fail indoors due to interference and weak signal penetration through walls and ceilings.

Indoor navigation systems (INS) have emerged as viable solutions to fill this gap. Various technologies such as Wi-Fi fingerprinting, BLE beacons, and QR-code markers provide indoor positioning alternatives, but they often require extensive infrastructure or lack precision. By combining AR with these positioning methods, it is possible to create a navigation system that not only accurately guides users but also improves the experience by displaying visual cues directly on their camera view. This study presents an AR-based indoor navigation system designed to provide user-centric, reliable navigation assistance in complex indoor settings. Augmented Reality (AR) introduces a promising solution by overlaying virtual objects, such as arrows and markers, directly onto the user's real-world view through a 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 multiple indoor positioning methods to deliver an accurate and interactive navigation experience. Key components and processes are as follows:

1. Indoor Positioning System

Wi-Fi Positioning: The system leverages Wi-Fi fingerprinting by analyzing the signal strengths from nearby Wi-Fi access points to estimate the user's location. While Wi-Fi positioning provides a general location, additional methods are incorporated to improve accuracy. BLE Beacons: BLE beacons placed throughout the environment emit signals to enhance positional accuracy where Wi-Fi positioning alone is insufficient. These beacons are particularly effective for correcting positional drift in high-traffic or signal-weak areas. QR-Codes: QR codes are strategically placed at key locations, such as entrances, exits, and major intersections, allowing users to scan and recalibrate their position. QR markers provide a precise reference point, reducing cumulative positioning errors over long distances.

2. Augmented Reality Interface

The AR interface is designed to present visual navigation cues directly onto the user's real-world view, guiding them through complex layouts:

Directional Cues: Using an AR SDK (such as AR Core or ARKit), arrows and symbols are overlaid on the user's camera view to indicate the direction and distance to the next checkpoint or destination. Point of Interest (POI) Markers: Key locations, such as restrooms, exits, and shops, are marked with distinct icons. This allows users to locate important facilities quickly.

Dynamic Updates: The AR interface updates in real time as the user moves, recalculating and displaying the correct route to accommodate any unexpected changes in direction or movement.

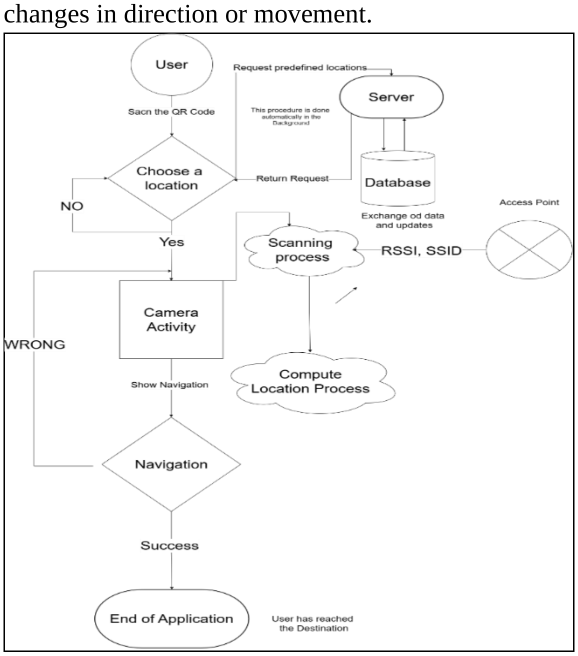

Fig.1 Activity Diagram

3. Navigation Algorithm

The system relies on a pathfinding algorithm, such as A* or Dijkstra's algorithm, to compute the optimal route based on the user's position and destination:

Route Calculation: The algorithm considers obstacles and adjusts the path in real time if the user deviates from the original route.

User Feedback Loop: User feedback on route accuracy is collected to improve system performance over time. Machine learning models adjust location estimations by learning from historical data, optimizing both accuracy and user satisfaction.

4. User Interaction

Users interact with the system through a mobile app interface. Key features include:

Input Mechanisms: Users can specify their destination by typing or selecting from a list of predefined points of interest.

Voice Commands: For hands-free navigation, voice commands are supported, allowing users to control the system verbally.

Accessibility Options: High-contrast visuals and optional audio cues enhance accessibility, catering to users with varying needs.

III. FUTURE SCOPE

This AR-based indoor navigation system will soon be improved to include:

• IoT Integration: Contextual navigation based on real-time environmental data may be possible by connecting to IoT-enabled devices (such as smart doors or lights).

• Personalized Navigation: Using machine learning, routes can be customized according to user preferences, taking into account things like user habits or accessibility requirements.

• Compatibility with AR Wearables: By extending the system to AR glasses or headsets, hands-free navigation would be possible, offering a more engaging experience.

• Improved Positioning with SLAM: By using simultaneous localization and mapping (SLAM), navigation may become more flexible and less dependent on physical markers.

IV. LITERATURE SURVEY

The mobile augmented reality (AR)-based indoor navigation system developed in this project successfully provides a cost-effective and efficient navigation solution within Sunway University's campus. By leveraging existing mobile sensors such as magnetic fields, Wi-Fi signals, and inertial sensors, alongside ARCore for immersive guidance, the system avoids the need for additional hardware installations, making it affordable and scalable.The system employs Indoor Atlas for indoor positioning and an Ant Colony Optimization (ACO) algorithm for pathfinding, ensuring a balance between accuracy and computational efficiency. The AR robot guide enhances user experience by offering a first-person view, making navigation more intuitive compared to traditional map-based methods.User surveys indicated positive feedback regarding the system's effectiveness, ease of use, and clarity of directions. The majority of users expressed satisfaction with the app and showed interest in using it in the future. However, some areas for improvement were highlighted, such as allowing the AR guide to pause and wait for users at each checkpoint, which would further enhance usability.Future work could focus on refining the AR guidance system, enhancing real-time interaction with users, and extending the system to more complex environments, such as multi-floor navigation, while considering user feedback for continuous improvement.

The limitations of GPS in indoor contexts have led to a growing interest in indoor navigation systems (INS). Numerous positioning methods have been investigated, such as vision-based methods, Wi-Fi, BLE beacons, and magnetic field positioning. Every one of these approaches has unique benefits and difficulties.

1. Wi-Fi-based Positioning: Cost-effective and widely accessible in buildings, but less accurate due to signal interference from obstructions like walls.
2. BLE Beacons: Economical and energy-efficient, but they have problems with signal reflection that lead to positioning inaccuracies, particularly in complicated surroundings.
3. Magnetic Field Positioning: This method avoids the requirement for extra infrastructure by using natural magnetic fields for positioning. However, precision can be distorted by interference from metal objects.
4. Important Features of AR Navigation:
   1. Real-Time Assistance: AR systems are appropriate for indoor navigation systems in complicated contexts like big buildings or industries because they offer dynamic information about the user's surroundings, such as identifying directions or routes.
   2. Human-Computer Interaction (HCI): By providing natural ways to engage with digital instructions or maps while carrying out physical tasks, AR-based navigation is directly related to enhancing HCI.
   3. Difficulties with Navigation Systems: To successfully deploy AR systems, indoor localization and rendering accuracy issues must be resolved. This is especially important in real-time situations.

   Through the use of augmented reality's capabilities for real-time information visualization and the integration of data from RFID tags or indoor positioning systems, these systems can help users navigate challenging situations, such as college buildings or

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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