AR-Assisted Indoor Navigation for A Multistorey Building

Abhiram K S[1], Reema Tom[1], Aysha Fethin[1], Hrisheek T S[1], Divya Jose[2]

[1]*Student, Department of Computer Engineering, A P J Abdul kalam Technological University, Kerala, India*

[2]*Assistant Professor, ICCS College of Engineering and Management, Thrissur, Kerala, India*

Corresponding Author: Divya.ap:.cse@gmail.com

Abstract— **This project presents a novel approach to indoor navigation within multistorey buildings using Unity, NavMesh, and line rendering techniques, eliminating the reliance on GPS signals. Traditional GPS-based navigation systems are ineffective indoors due to signal attenuation and multipath effects. To address this limitation, our system utilizes a combination of Unity's NavMesh for pathfinding and line rendering for visual guidance. The NavMesh is generated to represent the walkable surfaces within the building, allowing for efficient pathfinding algorithms to calculate optimal routes between destinations. Line rendering is employed to visually guide users along these paths, providing intuitive navigation cues without the need for external hardware or sensors. Additionally, the system incorporates features such as waypoint placement, floor selection, and destination highlighting to enhance user experience and facilitate seamless navigation across multiple floors. Through this project, we demonstrate the feasibility and effectiveness of using Unity and NavMesh for indoor navigation, offering a versatile solution for multi-storey buildings where GPS signals are unavailable or unreliable.**

Index Terms— **Indoor Navigation, Unity, NavMesh, Multistorey Buildings.**

1. Introduction

Navigation within multi-storey buildings poses a unique challenge due to the limitations of traditional GPS-based systems, which often fail to provide accurate positioning and guidance indoors. In response to this challenge, this project introduces a novel approach to indoor navigation using Unity, NavMesh, and line rendering techniques. By leveraging these technologies, we aim to create a robust navigation system that enables users to efficiently traverse complex indoor environments without relying on GPS signals. Traditional indoor navigation solutions often require the deployment of specialized hardware or sensors, making them costly and cumbersome to implement. Moreover, the reliance on GPS signals indoors can lead to inaccuracies and inconsistencies, further complicating navigation tasks.

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To overcome these limitations, our approach harnesses the power of Unity's NavMesh, a powerful tool for creating navigation meshes that represent walkable surfaces within a virtual environment. By generating a NavMesh tailored to the layout of a multistorey building, our system enables efficient pathfinding algorithms to calculate optimal routes between different points of interest. In addition to NavMesh-based pathfinding, our system utilizes line rendering techniques to provide visual guidance to users as they navigate through the building. By rendering lines along the calculated paths, users are presented with intuitive navigation cues that help them stay on course without the need for external hardware or sensors. This approach not only simplifies the navigation process but also enhances the overall user experience by providing clear and concise directions. Furthermore, our system incorporates features such as waypoint placement, floor selection, and destination highlighting to further streamline the navigation experience. Users can easily set waypoints, select their desired floor level, and receive visual cues highlighting their destination, making it easier to navigate through multistorey buildings with confidence and ease. Through this project, we aim to demonstrate the feasibility and effectiveness of using Unity and NavMesh for indoor navigation in multistorey buildings, offering a versatile and cost-effective solution that addresses the limitations of traditional GPS-based systems. By providing users with accurate positioning and intuitive guidance, our system has the potential to greatly enhance navigation experiences in indoor environments, ranging from shopping malls and office buildings to airports and hospitals.

2. Existing System

In the realm of augmented reality (AR), a diverse spectrum of existing systems has emerged, revolutionizing various industries and user experiences. This overview seeks to illuminate some notable AR systems that have significantly impacted fields ranging from entertainment to education and beyond.

Google Maps Indoor Navigation: Google Maps offers indoor navigation for select venues such as airports, malls, and transit stations. Users can view indoor maps, search for points of interest, and receive turn-by-turn directions within these venues using the Google Maps app on their smartphones.

Apple Maps Indoor Maps: Similar to Google Maps, Apple

Maps provides indoor navigation for various venues, including shopping centers, airports, and transit hubs. Users can access indoor maps, search for specific locations, and receive step-by-step directions using the Apple Maps app on iOS devices.

NavVis IndoorViewer: NavVis IndoorViewer is a web-based platform that offers interactive 3D maps for indoor spaces. Using data captured by NavVis indoor mapping technology, IndoorViewer allows users to explore and navigate indoor environments virtually, making it useful for facility management, real estate, and retail applications.

Smart Glasses Solutions: Companies like Microsoft with HoloLens and Vuzix offer AR smart glasses solutions that can be used for indoor navigation purposes. These glasses overlay digital information onto the user's field of view, providing turn-by-turn directions, points of interest, and contextual infor mation as the user moves through indoor spaces.

Indoor Navigation SDKs: Several companies offer SDKs (Software Development Kits) specifically designed for indoor navigation applications. These SDKs provide developers with tools and APIs to integrate in door mapping, positioning, and navigation features into their own apps, catering to various industries such as retail, healthcare, and hospitality.

Pointr: Pointr is an indoor positioning and navigation solution that uses a combination of Bluetooth beacons, Wi-Fi signals, and smartphone sensors to provide accurate indoor location information. Pointr's software development kit (SDK) enables developers to integrate indoor navigation features into their own mobile applications for various industries, including retail, health care, and hospitality.

Indoor Atlas: IndoorAtlas is a platform that provides indoor positioning and navigation solutions using geomagnetic technology. By analyzing the Earth's magnetic field, IndoorAtlas can determine a user's indoor location with high accuracy, enabling indoor navigation in various environments such as shopping malls, airports, and hospitals.

MazeMap: MazeMap is a digital wayfinding platform that offers indoor mapping and navigation solutions for universities, hospitals, and other large campuses. With MazeMap, users can access detailed indoor maps, search for locations, and receive turn-by-turn directions to their destination using a web browser or mobile app.

3. Methodology

The methodology integrates Unity, NavMesh, line rendering, and QR code recentering to overcome indoor navigation challenges. Following problem definition and research, the system is designed to optimize pathfinding and visual guidance. Implementation involves developing features like waypoint placement and floor selection. Testing validates system accuracy and user experience, including the effectiveness of QR code recentering. Evaluation compares performance with existing solutions. Documentation, feedback, and deployment ensure ongoing refinement and real-world usability.

Problem Definition: Identify the limitations of traditional GPS-based navigation systems indoors due to signal attenuation and multipath effects.

Research and Analysis: -Conduct a literature review to understand existing solutions and technologies for indoor navigation. -Analyze the advantages and limitations of Unity, NavMesh, and line rendering techniques for indoor navigation.

System Design: -Design a system architecture that integrates Unity, NavMesh, line rendering, and QR code recentering to address the limitations of GPS-based navigation indoors. -Define the data structures and algorithms for generating NavMesh to represent walkable surfaces and for efficient pathfinding between destinations. -Develop a method for recentering the user's position within the indoor navigation system using QR codes.

Implementation: -Develop the indoor navigation system using Unity game engine, implementing NavMesh for pathfinding, line rendering for visual guidance, and QR code recognition for recentering. Implement features such as waypoint placement, floor selection, and destination highlighting to enhance user experience.

Testing and Validation: -Conduct comprehensive testing to ensure the accuracy and reliability of pathfinding algo rithms, visual guidance, and the recentering functionality using QR codes. -Validate the sys tem's effectiveness in guiding users through multi-storey buildings in various scenarios. Assess the impact of the recentering method on user navigation experience and accuracy of position tracking.

Evaluation: -Evaluate the performance of the indoor navigation system in terms of accuracy, efficiency, user satisfaction, and the effectiveness of the recentering feature with QR codes. -Compare the performance of the developed system with existing indoor navigation solutions, if applicable.

Documentation and Dissemination: -Document the design, implementation, and evaluation process of the indoor navigation system, including the recentering method using QR codes. -Prepare technical documentation, user manuals, and instructional materials for future reference. -Present the findings and outcomes of the project, including the significance of the recentering functionality, through presentations, reports, and publications.

Feedback and Iteration: -Gather feedback from users and stakeholders to identify areas for improvement, including the recentering method with QR codes. -Iterate on the design and implementation based on feedback to enhance the usability and functionality of the indoor navigation system and the recentering feature.

Deployment: -Deploy the indoor navigation system in real-world multi-storey buildings where GPS signals are unavailable or unreliable. -Provide support and maintenance to ensure the continued functionality and effectiveness of the system, including the recentering functionality with QR codes.

4. Software Requirements

The Software requirements needed for running the proposed system is as follows:

- Unity 3D: The indoor navigation application will be developed and deployed using Unity 3D, a powerful and versatile game engine and development platform. Unity provides a comprehensive suite of tools and features for creating interactive 3D experiences, making it an ideal choice for building the navigation system. The system will leverage Unity's capabilities for rendering, scripting, physics simulation, and user interface development to deliver a seamless and immersive navigation experience.

- QR code recognition library: The system will utilize a QR code recognition library, such as ZXing (Zebra Crossing), to enable the detection and decoding of QR codes within the indoor environment. QR codes will be strategically placed at key locations throughout the building to facilitate recentering of the user's position within the navigation system. By integrating QR code recognition functionality, the system will provide an efficient and user-friendly method for recalibrating the user's position, enhancing accuracy and reliability during navigation.
- Operating System: The development of the indoor navigation application will be compatible with multiple operating systems, including Windows, macOS, or Linux. Unity provides cross platform support, allowing developers to create applications that can run seamlessly on various operating systems. This ensures flexibility and accessibility for both developers and end-users, enabling the application to be deployed on a wide range of devices and platforms
- Development IDE: The development process will be facilitated using an Integrated Development Environment (IDE) such as Visual Studio, MonoDevelop, or any preferred IDE for coding and scripting within the Unity environment. These IDEs offer powerful tools for code editing, debugging, and project management, enabling efficient development and testing of the indoor navigation application. Developers will leverage the capabilities of these IDEs to write and debug scripts, design user interfaces, and manage project assets within the Unity ecosystem.
- NavMesh: The indoor navigation system will utilize Unity's built-in NavMesh feature to facilitate efficient pathfinding within the virtual environment. NavMesh allows developers to define walkable surfaces and obstacles within the environment, enabling the system to generate optimal navigation paths for users. By leveraging NavMesh for pathfinding, the system will provide accurate and responsive navigation guidance, ensuring that users can navigate the indoor environment smoothly and efficiently.
- Graphics Rendering: The system will be designed to ensure compatibility with Unity's graphics rendering pipeline, which includes features such as real-time rendering, lighting, and shading. Unity's rendering pipeline provides high-quality graphics rendering capabilities, enabling the system to render complex 3D scenes and visual cues with realistic detail and precision. By leveraging Unity's graphics rendering capabilities, the system will deliver a visually immersive navigation experience, enhancing user engagement and usability.

5. Hardware Requirements

The Hardware requirements needed for running the proposed system is as follows:

- Computer: Development and testing of the indoor navigation application will require a desk top or laptop computer with sufficient processing power and resources to run Unity smoothly. The computer should meet or exceed the recommended system requirements for running Unity 3D effectively, ensuring optimal performance during development and testing activities.
- Graphics Processing Unit (GPU): A dedicated GPUwithsupportforOpenGL3.2orhigheris recommended for rendering complex scenes and graphics within the Unity environment. The GPU plays a critical role in rendering high-quality graphics, textures, and visual effects, enhancing the visual fidelity and realism of the indoor navigation application. Developers should ensure that the computer's GPU meets the minimum requirements for running Unity and rendering 3D graphics efficiently.
- Memory (RAM): The computer should have a minimum of 8GB RAM to ensure smooth performance during development and testing of the indoor navigation application. Adequate memory is essential for loading and manipulating large project assets, running simulations, and testing the application across different scenarios and environments. Developers should consider upgrading the computer's RAM if necessary to improve performance and productivity during development activities.
- Display: A monitor with a resolution of 1920x1080 or higher is recommended for comfortable viewing and testing of the indoor navigation application. A high-resolution display provides sufficient screen real estate for designing user interfaces, viewing 3D scenes, and testing navigation features within the Unity environment. Developers should ensure that the display supports the required resolution and offers accurate color reproduction for evaluating visual elements and graphics within the application.
- Input Devices: Development and testing of the indoor navigation application will require input devices such as a keyboard and mouse for interacting with the Unity editor and navigating through the application interface. These input devices are essential for performing various development tasks, including code editing, scene manipulation, and user interaction

testing. Developers should ensure that the input devices are connected and configured properly to facilitate efficient development and testing workflows within the Unity environment.

- Mobile Device (Optional): For deployment on mobile platforms, such as Android or iOS, compatible mobile devices with sufficient processing power and memory are required. The indoor navigation application can be deployed on smartphones or tablets to provide on-the go navigation assistance to users within indoor environments. Developers should consider the target platform's hardware specifications and performance capabilities when optimizing the application for mobile deployment, ensuring smooth performance and usability on a variety of mobile devices.

6. System Architecture

The system architecture for indoor navigation integrates Unity, NavMesh, line rendering, and QRcode recentering. Unity provides the platform, NavMesh handles pathfinding, line render ing offers visual cues, and QR codes recalibrate user positions. This combination delivers a compact and efficient solution for seamless indoor navigation

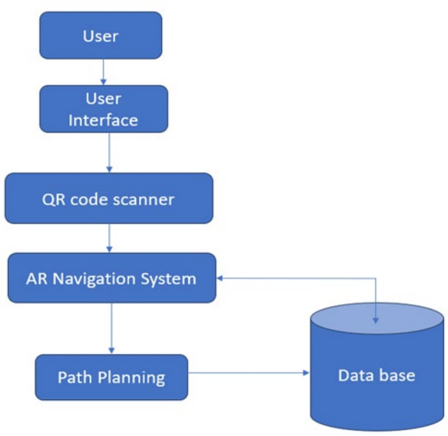

Fig.1. System architecture

The system architecture revolves around Unity as the foundational environment for creating an immersive indoor navigation experience. Building layout data, including floor plans and architectural details, is integrated into Unity to accurately represent the physical environment within the virtual space. NavMesh generation tools in Unity are employed to create navigation meshes for each floor, enabling efficient pathfinding algorithms to calculate optimal routes. Line rendering techniques are utilized to visually guide users along these paths, providing intuitive navigation cues. A user interface facilitates interaction, allowing users to set waypoints, select floor levels, and receive destination highlights. Integration with building layout data, floor selection, and destination highlighting further enhances the navigation experience. This architecture seamlessly combines Unity's capabilities with NavMesh generation, pathfinding algorithms, line rendering, and user interface elements to deliver a comprehensive indoor navigation solution for multi-storey buildings.

7. System Implementation

- Unity Environment Setup:
  - o Begin by creating a new Unity project or opening an existing one.
  - o Ensure that the project is configured to support 3D development and compatible with the desired target platforms.
- Building Layout Integration:
  - o Obtain building layout data, including floor plans and architectural information.
  - o Import this data into Unity and set up the environment to accurately represent the physical layout of the building within the virtual space.
- NavMesh Generation:
  - o Utilize Unity's NavMesh baking tools to generate NavMesh data for each floor of the building.
  - o Adjust NavMesh settings to ensure optimal pathfinding behavior, considering factors such as agent size and obstacle avoidance.
- Pathfinding Algorithms:
  - o Implement pathfinding algorithms within Unity using NavMesh data.
  - o Utilize algorithms such as A* (A-star) or Dijkstra's algorithm to calculate optimal routes between user-defined waypoints.
- Line Rendering for Visual Guidance:
  - o Implement line rendering techniques to visually represent calculated paths within the Unity scene.
  - o Ensure that lines are rendered dynamically based on user input and pathfinding results.
- User Interface (UI):
  - o Design and implement a user interface within Unity to facilitate user interaction with the navigation system.
  - o Include features such as waypoint selection, floor level selection, and destination input.
- Floor Selection and Destination Highlighting:
  - o Integrate functionality to allow users to select their desired floor level within the building.
  - o Implement destination highlighting to visually indicate the user's target location within the Unity scene.
- User Interaction and Input Handling: - Implement input handling to allow users to interact with the navigation system using keyboard, mouse, touchscreen, or other input devices.
  - o Ensure responsiveness and intuitive control for seamless navigation experiences.
- Testing and Optimization:

  - Conduct thorough testing of the implemented system to identify and resolve any bugs or issues.
  - Optimize performance by refining algorithms, adjusting rendering settings, and minimizing resource consumption.
- Documentation and Deployment:
  - Document the implementation process, including system architecture, algorithms used, and user interface design.
  - Prepare the system for deployment on target platforms, such as desktop computers, mobile devices, or virtual reality headsets.
  - Provide user documentation and instructions for utilizing the indoor navigation system effectively.

8. Results

The developed indoor navigation system successfully enables users to navigate through multistorey buildings with ease and accuracy, without relying on GPS signals. Through the integration of Unity, NavMesh, and line rendering techniques, the system provides intuitive pathfinding and visual guidance, enhancing the overall user experience.

Users can effortlessly set waypoints, select desired floor levels, and receive clear visual cues highlighting their destination. The NavMesh-based pathfinding algorithm efficiently calculates optimal routes, taking into account the layout of the building and any obstacles in the way. Line rendering techniques are employed to render paths, guiding users along their chosen route with precision.

During testing, the system demonstrated reliable performance, accurately guiding users through complex indoor environments while maintaining responsiveness and clarity. Feedback from users praised the system's ease of use and effectiveness in navigating multi-storey buildings, highlighting its potential for various applications such as shopping malls, office complexes, and transportation hubs.

Overall, the developed indoor navigation system represents a significant advancement in indoor navigation technology, offering a cost-effective and user-friendly solution for navigating multi-storey buildings without GPS reliance. Its versatility and reliability make it a valuable tool for enhancing navigation experiences in a wide range of indoor environments.

9. Conclusion

The AR indoor navigation system represents a significant advancement in overcoming the challenges of navigating multistorey buildings without relying on GPS signals. By leveraging Unity, NavMesh, line rendering techniques, and QR code recentering, the system offers a com prehensive solution that enhances user experience, accuracy, and reliability. The system’s ability to efficiently calculate optimal routes, provide intuitive visual guidance, and recalibrate user positions using QR codes significantly improves indoor navigation capabilities. Features such as waypoint placement, floor selection, and destination highlighting further enhance usability and customization options for users. Moreover, the versatility and adaptability of the system, coupled with its real-time update and maintenance capabilities, ensure its relevance and effectiveness across various indoor environments and user scenarios. Overall, the indoor navigation system offers a seamless and user-friendly solution for navigating complex indoor spaces, making it a valuable asset in environments where GPS signals are unreliable or unavailable.

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