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AR INDOOR MAPPING AND NAVIGATIONS

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Abstract: This project addresses the challenges in navigating inside large and complex buildings faced by an individual unfamiliar with the building infrastructure and the insufficiency of traditional navigation tools in indoor spaces by developing an Augmented Reality (AR) based Indoor Navigation Application. The project focuses on creating digital maps of indoor spaces using manual mapping techniques and implementing location tracking using SLAM (Simultaneous Localisation and Mapping) algorithm and QR code technology for user's current location. By utilizing the AR Core library, the application overlays digital objects onto the real-world environment, providing users with an intuitive and immersive navigation experience. Path finding is achieved through the NavMesh tool in Unity, which calculates the shortest path to the desired destination. Unlike other existing technologies the proposed system eliminates the need for external hardware used for mapping and localization. This approach not only saves time, energy, and cost but also offers accurate indoor navigation without the dependence on external devices.

Index Terms **–** SLAM, ARCore, NavMesh, Indoor Positioning System, Indoor Navigation.

I. INTRODUCTION

The term 'navigation' collectively represent tasks that include tracking the user's position, planning feasible routes and guiding the user through the routes to reach the desired destination. Location-based services such as indoor and outdoor navigation are really helpful. Outdoor navigation is used to navigate outside the buildings with the help of The Global Positioning System (GPS) and Indoor navigation is used to navigate inside a building with different technologies without using GPS because in Indoor environments, the GPS cannot provide fair accuracy in tracking.

The Indoor Navigation System uses different Indoor Positioning System (IPS) technologies that tell the current location of the user and guides the user to the desired destination through a path integrated with augmented reality arrows.

Augmented Reality (AR) is the technology that lay over digital objects into real-world view environment. It also enhances the user experience.

Many people are confused between the terms AR and VR. The AR refers to Augmented Reality that adds computer generated images or digital objects into the real-world view environment. This makes the navigation feel more interactive and immersive. While VR refers to the Virtual Reality that replaces the real world environment by placing the user in artificially generated environment.

To solve the issue, an interior navigation system that doesn't require wireless technology or hardware installation should be used. Additionally, it makes use of interactive augmented reality to enhance navigation, lessening cognitive load and involving the user in more enjoyable activities.

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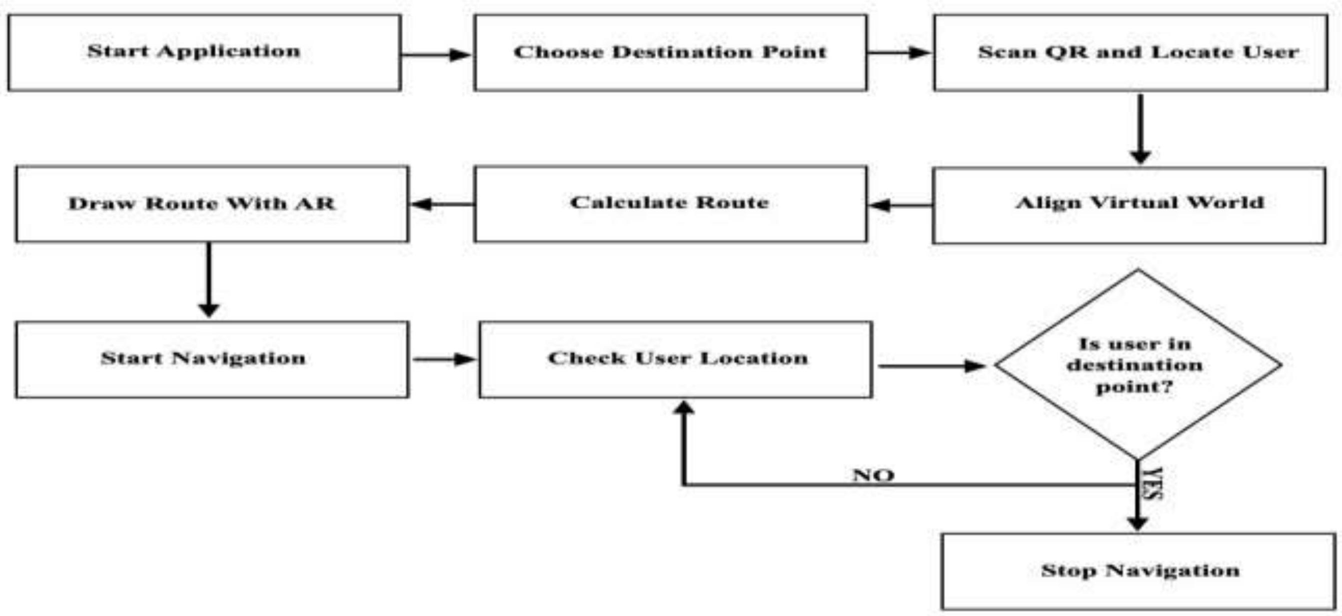
Block diagram:



Start app: The interface features a visually appealing start screen with a logo and a brief description of the app, creating an inviting first impression for users to engage with the system.

Choose destination: A fluid and user-friendly destination selection process is provided for users through intuitive search functionality, categorised browsing, or a list of predefined possibilities.

Locate user: The software makes use of the camera and augmented reality features of the device to precisely find and orient the user within the mapped region, ensuring accurate location for a dependable navigation experience.

Align virtual world: By offering visual signals and instructions, the interface helps users align the virtual world with the physical surroundings while preserving a constant user perspective. This enables seamless integration of AR content.

Calculate route: Based on the user's chosen location and the map of the surrounding area, the software intelligently determines the best route, taking into account things like distance, barriers, and favourite paths.

Draw route with AR: To assist users in following the calculated route, the interface superimposes augmented reality (AR) visualisations, such as arrows or highlighted paths, onto the real-world view. This gives users simple and straightforward navigational instructions.

Start navigation: With just a tap, users may start the navigation process, activate the AR guidance, and set out on their way to the desired location.

Check user location: Throughout the navigation process, the software continuously detects the user's location and refreshes the user interface in real-time to give accurate progress updates and guarantee users stay on the proper path.

Stop: Users have the option to pause AR guiding at any time, which gives them the freedom to explore or otherwise engage with the environment without active navigation.

II.LITERATURE REVIEW

The survey of previously published scholarly materials, such as books, journals, articles, and theses, that are connected to a certain topic or question is known as a literature survey or literature review. It involves looking up relevant literature on your selected topic or issue and evaluating it. It provides the most recent information available on the issue or topic you are writing about. In relation to the project, a literature review was done to better understand the concept, to develop ideas, to comprehend the approaches now in use, and to discover the limitations of those methodologies.

System for indoor navigation Systems known as interior navigation systems offer the best route between a starting point and a desired destination inside of a building. A positioning device that can process the anchor information to determine its own location and an anchor with its own specific location information are the two primary components of indoor navigation systems (Yang & Shao, 2015).

Although there are numerous potential indoor navigation services available on the market, the most appropriate one in terms of accuracy, responsiveness, and cost-effectiveness is still up for debate. Standard placement methods worldwide positioning system The most effective and well-known outdoor locating system is GPS. Through the use of satellites, it can pinpoint a person's position on Earth's surface in terms of longitude, latitude, and altitude (Olevall & Fuchs, 2017).

The radio signal from satellites is blocked by construction materials like roofs and walls, which contributes to the poor accuracy of determining an indoor position (Jekabsons, Kairish, &Zuravlyov, 2011).

WiFi-Based System: WiFi positioning is achieved through WiFi access points (APs), which provide a signal that enables mobile devices to detect their precise location at any given time (Zandbergen, 2009). [1]. Hu (2013) talked about the use of Wi-Fi based indoor positioning systems in smart phones and made the point that wireless networks are a viable option for interior positioning because they are inexpensive to set up and don't require specialised hardware.The WiFi signals experience time-correlated fading as a result of interference from other devices and moving objects, and the coverage is limited (Zandbergen, 2009).

Bluetooth-Based System: It has been determined that Bluetooth beacons are the most precise locating technology available. By placing hardware beacons around the facility, each of which contains a unique location dataset, it serves as location awareness. Then, using Bluetooth Low Energy technology, the beacon's message is sent as a signal to connect with the mobile device (Pokale et al., 2017) [2]. The precision and effectiveness of beacons transmitted are directly linked to the battery power consumption, despite claims that it just uses less battery power to broadcast advertising signals. . Additionally, per Olevall & Fuchs (2017).

2.1 Drawbacks of existing system

- While active measurement systems like lidar are finding greater use in indoor measurement systems, the use of image/vision based acquisition systems will continue because of their higher resolution. A major problem in vision-based systems is feature measurement and detection under variable lighting conditions, which is a characteristic of indoor environments.
- Many measurement systems are designed for environments that contain as few visual obstructions as possible. Indoor environments are often busy and cluttered. Measurement under these conditions is difficult, particularly for vision-based systems. Under these conditions a measurement system has to be able to achieve two goals,

  (1)detect and remove obstacles automatically

  (2) measure the features of interest (e.g., walls)
- It’s known that acquisition systems that are able to combine the strengths of different sensor systems are able to deliver more reliable results. The development/improvement of new sensors and the combination of these sensors is on-going research.
- One of the significant challenges faced by vision-based measurement systems is the calibration of cameras and sensors. Accurate measurements require precise calibration to ensure that the captured images and data correspond accurately to real-world dimensions. Inconsistent or inaccurate calibration can lead to measurement errors, reducing the reliability and accuracy of the system.
- Vision-based measurement systems often require complex image processing and analysis algorithms to detect features and perform measurements. This high computational complexity can result in longer processing times, limiting the real-time capabilities of the system. Additionally, it may require more powerful hardware, increasing the cost and complexity of the system setup.

2.2 Augmented Reality

According to Silva, Oliveira, and Giraldi (2003) [4], augmented reality is a technique that places computer graphics that have been registered in 3D space on top of the real environment, which serves as the main setting for action. Additionally, both interact with real-time updates in which the user's movement directly affects the virtual element as it appears on the screen of the computer device. It varies from virtual reality in that it augments the current physical environment with certain virtual models rather than creating a whole new artificial one (Chavan, 2014).There are a few types of Augmented Realities as listed below:

- **Marker-based AR:** This sort of AR uses the phone camera to identify visual markers like QR and 2D. After several calculations that take into account the angle and distance between a mobile phone and the marker, the virtual object is then rendered over the marker
- **Marker-less AR or location-based AR:** It uses a location tool, such as a GPS, to determine the user's location and then displays pertinent virtual information like local landmarks or instructions to a destination in augmented view (Chanphearith, Santoso, & Suyoto, 2016).

• **Projection-based augmented reality (AR):** It casts light onto a real object, which people may subsequently interact with via sensors. By tracing the object's silhouette, the masking approach is utilised to align the projection picture with the object (Lee, Kim, Heo, Kim, & Shin, 2015).

• **Superimposition-based AR:** Superimposition-based AR determines a cluster of markers on a real object in order to estimate the local coordinate based on the optimization method (Argotti, Davis, Outters, & Rolland, 2002). After this is all obtained in the transformation matrices, the process of stereoscopic rendering happens to replace the original image with the augmented one.

In addition to that, there are many existing development softwares for AR like ARToolKit, ARKit, ARCore and Vuforia. Lastly, the advantage of AR is it provides a more "real" gaming experience through enhancing the perception of the user and their interaction. Furthermore, it is also applied in the education field where the supplementary interactive information like video and graphics make the learning process more interesting and easier to absorb new knowledge.

III.PROBLEM IDENTIFICATION

Traditional navigation tools like maps and signs have long been the go-to methods for guiding users, but they come with their own set of limitations. These tools can be cumbersome, requiring users to constantly refer to them, which can be tiring and distracting. Moreover, traditional navigation methods may not always provide the most efficient routes, leading to longer travel times and potential confusion for users. Additionally, these tools often lack real-time updates, making them less reliable in dynamic environments where conditions can change rapidly. Furthermore, traditional navigation tools may not be accessible to everyone, such as those with visual impairments or language barriers, limiting their effectiveness for a diverse user base. In today's digital age, there is a growing demand for more intuitive, interactive, and userfriendly navigation solutions that can adapt to individual needs and preferences.

3.1 Existing system

The current landscape of indoor navigation systems predominantly hinges on traditional tools such as maps, signs, and GPS-based solutions. While GPS has proven to be reliable for outdoor navigation, its efficacy diminishes significantly indoors. The indoor environment poses challenges for GPS signals, with walls, roofs, and other structures causing signal attenuation. As alternatives, WiFi-based and Bluetooth-based systems have emerged, aiming to provide indoor location services. However, these systems come with their own set of challenges. WiFi-based systems often have limited coverage areas and can suffer from signal interference due to various electronic devices operating within the vicinity. Bluetooth-based systems, on the other hand, can drain the battery life of mobile devices quickly due to continuous connectivity requirements. Vision-based navigation systems have also been explored, utilizing cameras and computer vision algorithms to guide users. However, these systems grapple with issues related to feature detection under varying lighting conditions and in cluttered indoor settings. The reliance on visual cues necessitates users to constantly refer to maps or directories, making the navigation process cumbersome and less intuitive, especially in expansive or intricate indoor spaces like shopping malls, airports, or hospitals. In summary, while there are several indoor navigation solutions available, each has its limitations, making indoor navigation a challenging problem to solve effectively.

Additionally, WiFi and Bluetooth-based systems, although promising, face issues like limited coverage, signal inconsistency, and battery drainage. Vision-based systems offer potential but struggle with challenges like feature detection in varying light conditions and cluttered environments. Overall, the existing solutions fall short in providing seamless and intuitive indoor navigation experiences, highlighting the need for more innovative and robust alternatives.

3.2 Proposed system

Our proposed system introduces an Augmented Reality (AR)-based indoor mapping and navigation solution designed to overcome the limitations of existing systems. Leveraging AR technology, the system offers an immersive navigation experience by overlaying digital directions, points of interest, and other relevant information onto the user's real-world view captured through a smartphone or tablet camera. Computer vision algorithms identify indoor landmarks and objects to superimpose AR features for guiding users through indoor spaces like malls, airports, and hospitals. This approach eliminates the need for traditional maps and directories, providing users with intuitive and interactive navigation assistance. Additionally, the system aims to improve location accuracy and user engagement by offering real-time information, interactive elements, and personalized navigation options. The proposed AR-based system promises to revolutionize indoor navigation by offering a more user-friendly, accurate, and engaging experience tailored to modern navigation needs.

IV.METHODOLOGY

The automatic tracking and mapping of indoor spaces for augmented reality navigation will be accomplished through a combination of image processing and AR technologies. Utilizing a 360-degree camera, live footage of indoor environments will be captured to provide real-time data on user positioning and orientation within the mapped space. Following the acquisition of this footage, a portable microprocessor and camera system will be employed for data processing and analysis. The processed data, including indoor locations, paths, and navigation indicators, will be integrated into an AR environment using tools such as Unity and the Stardust SDK. The central control system will then receive this augmented data to facilitate accurate and interactive indoor navigation for users. A detailed explanation of the methodologies and techniques employed for the seamless integration of AR navigation within indoor environments will be elaborated in the subsequent subsections.

4.1 Development Environment Setup:

In this initial phase of the project, the groundwork for the AR indoor mapping system was laid out meticulously. A new Unity project was created to act as the central hub for all development activities, ensuring a streamlined and organized approach to the project's implementation. Subsequently, the ARCore plugin was sourced from the Unity Asset Store and seamlessly integrated into the Unity environment. This plugin served as a cornerstone for AR development, offering essential tools like the AR camera for capturing the real-world environment, anchors for spatial mapping, and raycasts for accurate object detection and interaction.In addition to the ARCore plugin, the Stardust SDK package was introduced to the development environment.

4.2 Database Creation for Indoor Mapping:

The creation of a comprehensive database of indoor locations and paths was the next crucial step. This was achieved using the Stardust SDK editor tool, where 360-degree panoramic photos of indoor settings were captured using a specialized camera. These photos were then submitted to the Stardust SDK editor tool to craft a detailed map of the interior space, specifying paths between various locations and incorporating navigation indicators. The finalized database was exported as a file and seamlessly imported into the Unity project for further integration. Once the panoramic photos were captured, they were meticulously processed and submitted to the Stardust SDK editor tool. This powerful tool enabled the team to transform the raw photographic data into a structured and organized database of indoor locations and paths.

4.3 AR Integration for User Positioning:

With the database in place, the integration of AR capabilities to track the user's position and orientation within the indoor environment was executed. The ARCore plugin facilitated the tracking functionality using the camera. An AR camera was strategically placed within the scene to monitor user movements, and unique scripts were developed to manage user input, enabling actions like screen tapping for location selection and swiping for orientation adjustments. The Stardust SDK was employed to determine the user's precise location within the indoor environment, presenting relevant location data in augmented reality through a combination of raycasts, anchors, and UI elements.To ensure a seamless and intuitive user experience, additional features were incorporated to enhance the AR display. Directional arrows were integrated to guide users towards their desired destinations, while distance measurements provided valuable context on the proximity to selected locations.

4.4 User Experience Enhancements:

To elevate the user experience, several enhancements were incorporated into the AR display. Directional arrows, distance measurements, and voice-guided instructions were added to guide users effectively. Interactive components, including buttons and menus, were also integrated to enable users to customize their navigation experience. Options like switching between 2D and 3D modes, selecting color palettes, and altering the spoken language were made available. Furthermore, performance optimization techniques were applied by scaling down panoramic photographs and reducing the AR display quality to ensure a smooth and efficient user experience across various devices.In addition to these improvements, the system was designed with adaptability in mind, allowing for future updates and expansions. This flexibility ensures that the AR indoor mapping system can evolve with user needs and technological advancements, providing a lasting solution for indoor navigation challenges.

4.5 Testing and Optimization:

The final phase involved rigorous testing and optimization to validate the system's functionality and performance. The AR indoor mapping system was rigorously tested using the ARCore developer mode on a diverse range of Android devices. Performance optimization was prioritized by reducing the size of panoramic photos and adjusting the quality settings for the AR display, ensuring seamless operation and a consistent user experience across different platforms and devices.Additionally, real-world testing scenarios were simulated to assess the system's accuracy and reliability in various indoor environments. User acceptance testing was conducted to gather feedback on usability, functionality, and overall satisfaction with the AR indoor mapping system. Based on the collected data and insights, iterative refinements were made to enhance system performance and address any identified issues or limitations.

Figure 1: Flowchart of AR-Based Indoor Navigation App

V.CONCLUSION

Our project focuses on developing an AR-based Indoor Navigation Application that addresses the challenge of indoor navigation and overcomes the limitations of traditional navigation tools and GPS systems. We utilized the SLAM algorithm and QR code technology for real-time positioning and mapping, eliminating the need for external hardware. The application overlays digital objects in the user's real-world view and calculate optimized routes using the NavMesh tool in Unity. Through our project, we aimed to enhance indoor navigation, provide a user-friendly platform, save time and energy, and enhance user experience within indoor environments.

Figure 2: User Interface of Scan QR Code

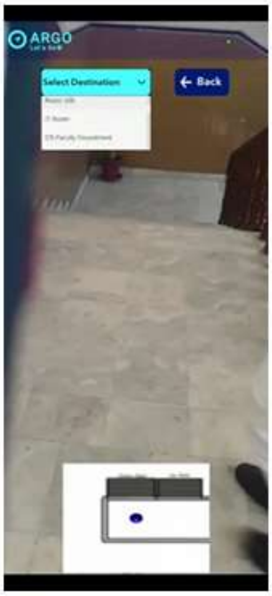


Figure 3: User Interface of Select Destination

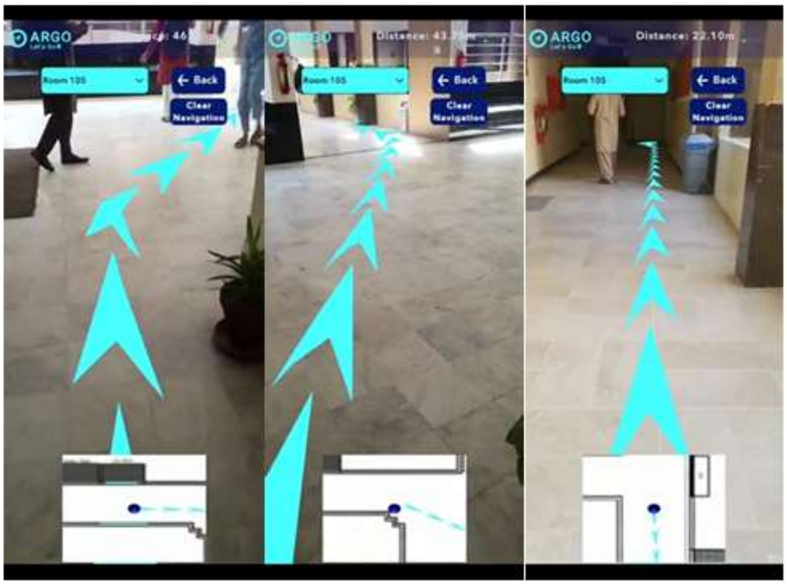


Figure 4: User Interface of Augmented-Reality Arrows showing path of Reaching Destination

Figure 5: User Interface

VI. FUTURE ENHANCEMENTS

In future work, we aim to address the limitations encountered during the implementation of the AR indoor mapping system and explore new possibilities to enhance its functionality and accessibility. One of the key enhancements will be extending the scope of application to multiple floors, allowing users to navigate seamlessly across different levels of indoor spaces. Additionally, we plan to incorporate redirection capabilities to handle instances where users take incorrect paths, guiding them back on track towards their intended destination.

Expanding the compatibility of the system to iOS devices is also on our agenda to reach a broader range of users across various mobile platforms. To improve accessibility, especially for visually impaired users, we intend to integrate a voice assistant feature that provides audio guidance and instructions during navigation. This feature aims to enhance user experience by offering an inclusive navigation solution tailored to the needs of visually impaired individuals.

Overall, these future enhancements and explorations aim to elevate the functionality, accessibility, and user experience of the AR indoor mapping system, making it more versatile, user-friendly, and inclusive for a wider range of users across different platforms and navigation scenarios.

VII. REFERENCES

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