AMITY UNIVERSITY DUBAI

Major Project

Indoor AR Navigator in Unity & ARCore

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Abstract

The research expands the body of knowledge on ARCore and Unity-based indoor augmented reality navigation systems. It demonstrates the effectiveness and value of this technology in enhancing indoor navigating experiences. The study highlights the importance of interactive user interfaces, precise real-time positioning, and barcode scanning capabilities for improving user happiness and reducing cognitive load. Practically speaking, the developed Indoor AR Navigator has implications for many businesses and industries. It can be employed in fields where navigating complex indoor locations is essential, such as tourism, retail, facility management, and others. The technology offers an immersive, user-friendly experience that makes it simpler to explore indoor spaces, eliminates the need for traditional paper maps, and provides users with precise directions to their desired places. The results of the study also suggest potential lines of inquiry and development. Research into indoor AR navigation systems might focus on addressing difficulties including occlusion, environmental changes, and better user interfaces in order to make the most of the technology. Testing a system's scalability and adaptability in various interior scenarios may lead to its wider application and integration with current infrastructure and technologies. The study demonstrates how an indoor augmented reality navigator may be effectively designed and tested using Unity and ZXing. The system enhances clients' internal navigation experiences by providing interactive user interfaces, real-time positioning, and barcode scanning capabilities. The outcomes support the hypothesis that an indoor AR navigator improves user pleasure, lessens cognitive load, and boosts navigational effectiveness. The research advances our understanding of the topic and opens up new possibilities for utilizing augmented reality in indoor navigation.

Introduction

Indoor augmented reality (AR) navigation systems have grown in popularity as a potential technology to enhance navigational experiences in cramped environments. In order to provide customers with interesting visual information in real time while they are inside, these systems utilize the capabilities of augmented reality in conjunction with solid platforms like Unity and ARCore. The capacity to overlay virtual information over the physical environment opens up exciting possibilities for assisting users in navigating complex venues, such as malls, airports, or museums. This significant project attempts to use ARCore and Unity to create and construct an Indoor AR Navigator. By utilizing the potential of this cutting-edge technology, we hope to create an intuitive and immersive AR experience that helps users easily navigate indoor spaces. This project aims to address the challenges of indoor navigation, such as the lack of reliable GPS signals and the complexity of indoor layouts, by leveraging the capabilities of ARCore's simultaneous localization and mapping (SLAM) technology.

The proposed Indoor AR Navigator will allow users to observe their whereabouts in real time while inside an indoor area and will also provide them with exact, context-sensitive directions to their desired places. The system will take advantage of the potent development environment offered by Unity in order to create a user-friendly interface and add several interactive elements, such as waypoints, markers, and contextual data. Through this study, I hope to advance the field of indoor navigation and explore how augmented reality technology could improve spatial awareness and indoor navigation. Individual users as well as several businesses, including tourism, retail, and facility management, will find utility in the resulting Indoor AR Navigator. In the parts that follow, we'll go into greater detail on the Indoor AR Navigator's methodology, implementation, and evaluation overall.

We will discuss the key components of the system, the challenges encountered during development, and the assessment standards used to assess its effectiveness. We will research new additions and future directions in order to enhance the capabilities and usability of the Indoor AR Navigator. The overall objective of this project is to demonstrate the viability and effectiveness of an indoor augmented reality navigator created using Unity and ARCore as an engaging indoor navigating tool, opening up new paths for the simple exploration of complex indoor environments.

Objective

The purpose of this project is to develop an indoor augmented reality navigation system using ARCore and Unity to enhance users' navigational experiences in difficult interior environments.

The project uses ARCore's simultaneous localization and mapping (SLAM) technology to get beyond interior navigation challenges like inconsistent GPS signals and complicated indoor layouts.

By utilizing the Unity programming environment and interactive elements like waypoints, markers, and contextual information, the proposed Indoor AR Navigator provides users with real-time positioning, context-sensitive assistance, and an easy-to-use user interface.

By evaluating the system's performance, usability, and user satisfaction, the aim is to establish the viability and utility of the inside AR Navigator as a helpful and fun tool for navigating inside places.

Additionally, the project aims to advance the subject of indoor navigation and explore how augmented reality technology might improve navigation and spatial awareness in difficult interior scenarios.

Feasibility Study

The purpose of this feasibility study is to assess the viability of developing an indoor augmented reality navigation system using Unity and ARCore. The purpose of the study is to determine whether the project is both technically and financially feasible and capable of reaching the previously mentioned desired goals.

Technical Feasibility: The Android platform works well with Unity and ARCore. Thanks to Unity's complete support for Android app development, developers can produce detailed 2D and 3D experiences, including augmented reality. Modern augmented reality technologies like motion tracking and environmental comprehension are part of Google's ARCore, which was designed specifically for Android smartphones. Unity and ARCore are simple to utilize for Android developers. There are several license options, including a free edition, on the official Unity website, where Unity can also be downloaded and set up. By using the official ARCore SDK, developers get free access to ARCore. The extensive documentation, tools, and developer communities that both Unity and ARCore offer make it easier to begin creating Android AR applications. For accurate indoor location and mapping in augmented reality applications, ARCore's Simultaneous Localization and Mapping (SLAM) technology is the best option. With the use of SLAM, ARCore is able to map the immediate region while also determining and following the device's position and orientation in real-time.

ARCore's SLAM technology combines sensor data from cameras, inertial sensors, and depth sensors (if available) to create a 3D model of the surroundings. As a result, ARCore can position virtual objects in the real environment precisely and maintain their position even when the device is in motion.

Development Resources: There is a big pool of experienced developers who are adept with Unity because it is one of the most popular game production engines. Given that ARCore and Unity are connected for augmented reality apps, many of these developers have also developed for ARCore. It is advisable to assess the specific requirements and complexity of the augmented reality navigation system in order to determine the level of knowledge necessary. Working with seasoned developers or a development team with prior ARCore experience might be quite beneficial for the project. For Unity, there are multiple license options, including a free edition with limited capabilities and a paid edition (Unity Pro) with additional features and support. Depending on the project's requirements, a pricey Unity Pro license may be necessary. Downloadable development kits (SDKs) for ARCore and Unity are available. These SDKs contain the necessary software, libraries, and documentation for ARCore integration. Typically, there are no additional expenses incurred while purchasing the development kits. The creation and testing of the augmented reality navigation system requires compatible Android or iOS devices. Depending on the specific models chosen and their availability, the cost of buying these devices would change. It is advisable to take into account a variety of devices with varied specs in order to assure compatibility and test the software on multiple hardware configurations. Although there is a wide variety of compatibility between ARCore and Unity, some older or less capable Android devices might not be able to meet the performance requirements or be able to fully utilize ARCore. It's essential to identify a target device profile and thoroughly test the software on a variety of devices in order to ensure general compatibility.

Data Availability: Accessibility and availability of interior mapping data or floor plans may vary depending on the specific sites and buildings targeted for the augmented reality navigation system. There are times when building owners or facilities management organizations already have digital floor plans or mapping data on hand. Contacting the organizations or authorities in charge of the buildings directly will allow you to obtain these. In addition, there are independent companies and vendors who specialize in indoor mapping and offer pre-built datasets or mapping solutions for commercial use. These vendors could provide a variety of licensed or obtainable interior maps. Open-source initiatives or crowd-sourced platforms may potentially provide indoor mapping data for specific buildings or public spaces. Data gathering techniques may involve on-site measurements, laser scanning, or 3D modeling in order to create accurate representations of the indoor settings. Examples of data processing include the conversion of unformatted raw data into suitable formats, the alignment and fusion of numerous data sources, and the creation of effective representations for real-time rendering and navigation. When using indoor mapping data for private or commercial properties, there may be legal and privacy implications that need to be considered. Building owners or authorities may place limitations on the utilization, distribution, or modification of floor plans or mapping data. Secure the necessary permissions or licenses before using such data for the navigation system.

Proposed System

Hardware specifications:

Mobile smartphones: Ascertain the minimal requirements needed for Android smartphones in order for ARCore and Unity to function properly. This could include compatible sensors (such as a gyroscope, accelerometer, or magnetometer), RAM, storage space, and processing speed.

Check the documentation and compatibility lists of the chosen devices to make sure they are compatible with ARCore and Unity.

Determine whether the system requires any additional hardware, such as external sensors, depth cameras, or specialist tracking devices. Take into account the components' accessibility, cost, and integration viability.

Software Requirements:

1. Unity: Determine the required version of Unity for developing the augmented reality navigation system. Consider the compatibility of Unity versions with ARCore and other necessary plugins or extensions.
2. ARCore SDK: Assess the compatibility and availability of the ARCore SDK for the desired Unity version and Android platform. Stay updated with the latest releases and ensure compatibility with Unity updates.
3. ZXing: Developers can decode and encode many kinds of barcodes using the open-source, multi-format barcode image processing tool known as ZXing (pronounced "zebra crossing"). It offers support for several different barcode formats, including EAN, Data Matrix, UPC, and QR codes.
4. Operating System: Ensure that the selected Android devices are running a compatible and supported version of the Android operating system required by ARCore and Unity.

Literature Review

The research and studies on indoor augmented reality navigation systems that employ Unity and ARCore are summarized in the literature review that follows. As it examines the advancements, challenges, and applications of this technology, it draws attention to the contributions and gaps in the corpus of existing knowledge.

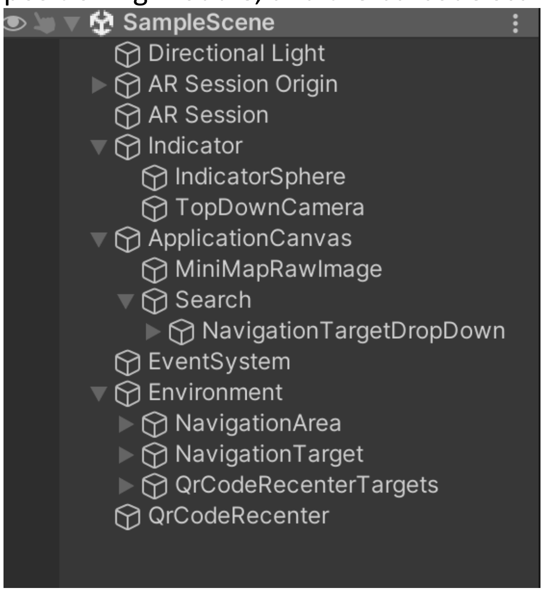
Recently, augmented reality (AR)-based indoor navigation systems have received a lot of interest. Chen et al. demonstrated an indoor navigation system in 2020 that made use of AR and sensor fusion techniques. The system used ARCore and Unity to provide users with visual guidance and real-time placement in difficult indoor environments.[1] Google's ARCore has developed into a powerful platform for indoor mapping and localization. A solution for indoor localization using ARCore, including SLAM technology for mapping and tracking user positions. Their study demonstrated the accuracy and dependability of ARCore in small settings.[2] A variety of tools are available in the popular game development engine Unity to create AR applications. looked into the creation of Unity-based AR navigation systems. The ease of use, capacity to incorporate augmented reality capabilities, and dynamic user interfaces of Unity were highlighted in their study.[3] Indoor AR navigation presents many challenges, including occlusion, environmental changes, and intricate indoor layouts. The discussion of the issues with indoor AR navigation and potential solutions. They emphasized the need for accurate indoor location technologies and dependable mapping methods.[4] The user experience has a significant impact on the success and adoption of indoor AR navigation systems. Research on the user preferences and experience aspects of AR-based indoor navigation in 2021. According to their research, a positive user experience depends on factors like visual clarity, user-friendly interface design, and personalized navigation instructions.[5] Systems for indoor augmented reality navigation have several applications. An indoor navigation system for museums using Unity and ARCore. Through the use of interactive exhibits, personalized tours, and historical data, technology enhanced the museum-going experience.[6] It's critical to evaluate how well and how user-friendly indoor AR navigation systems operate. Unity and ARCore to perform user research to evaluate an AR-based indoor navigation system. The study assessed user performance, satisfaction, and navigation accuracy in order to comprehend the system's benefits and drawbacks.[7]

The literature review highlights the growing popularity of indoor ARCore and Unity navigation systems. According to the mentioned research, these technologies can deliver accurate indoor positioning, engaging user experiences, and applicability across a range of industries. Additional study is still needed to solve problems including occlusion, environmental changes, and improving user interfaces in order to optimize the effectiveness of Indoor AR Navigator systems.

Architecture

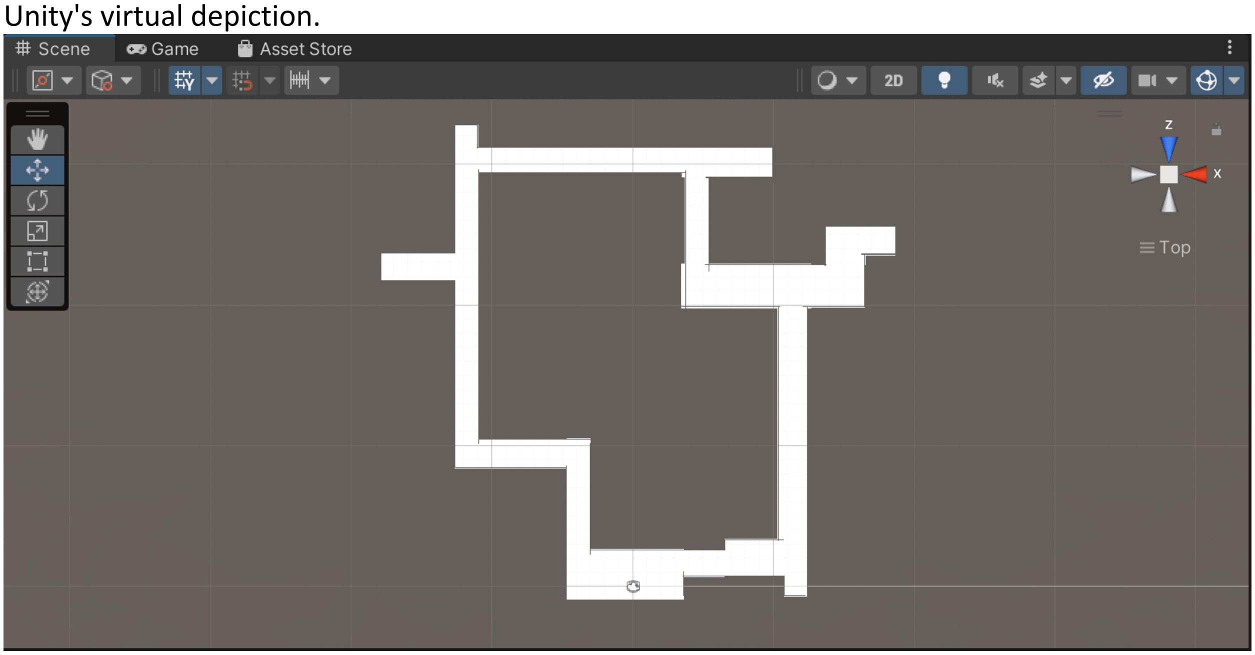
System Design:

Establish the objectives and requirements for the indoor augmented reality navigation system, taking into account features like real-time positioning, indoor mapping, and ZXing barcode scanning. Incorporate ZXing and Unity integration into the entire system architecture to ensure smooth functioning. The system's main parts are the user interface, the mapping module, the positioning module, and the barcode scanning module, to name a few.

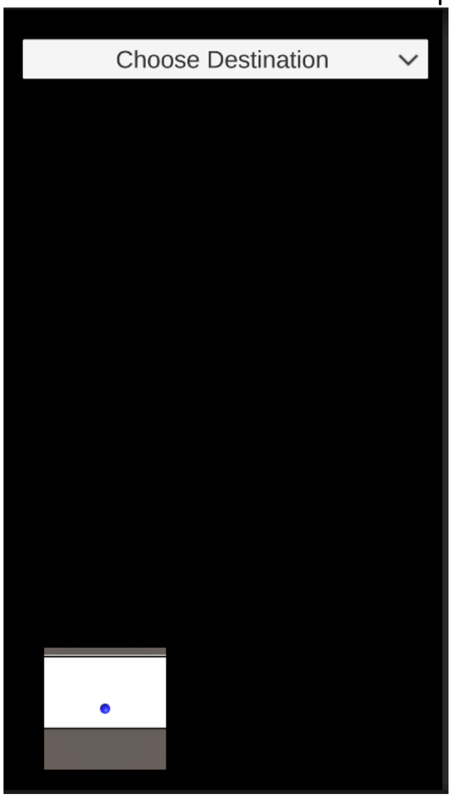


Indoor Mapping:

Obtain or create a digital model of the interior area, such as a floor plan or a 3D model. By importing the indoor map into Unity, you may adjust the scale and coordinate system. To facilitate navigating, identify landmarks, points of interest, and directional paths inside the structure. Make a mapping system that links geographic locations in the actual world with Unity's virtual depiction.



UI Development:
Design a user interface for the indoor AR navigator that is user-friendly and aesthetically beautiful that includes navigational controls, markers, and maps. Implementing the user interface components using Unity's UI technology will ensure responsiveness and user-friendly interaction. Include features like real-time positioning, navigational help, and interactive indicators to enhance the user experience.



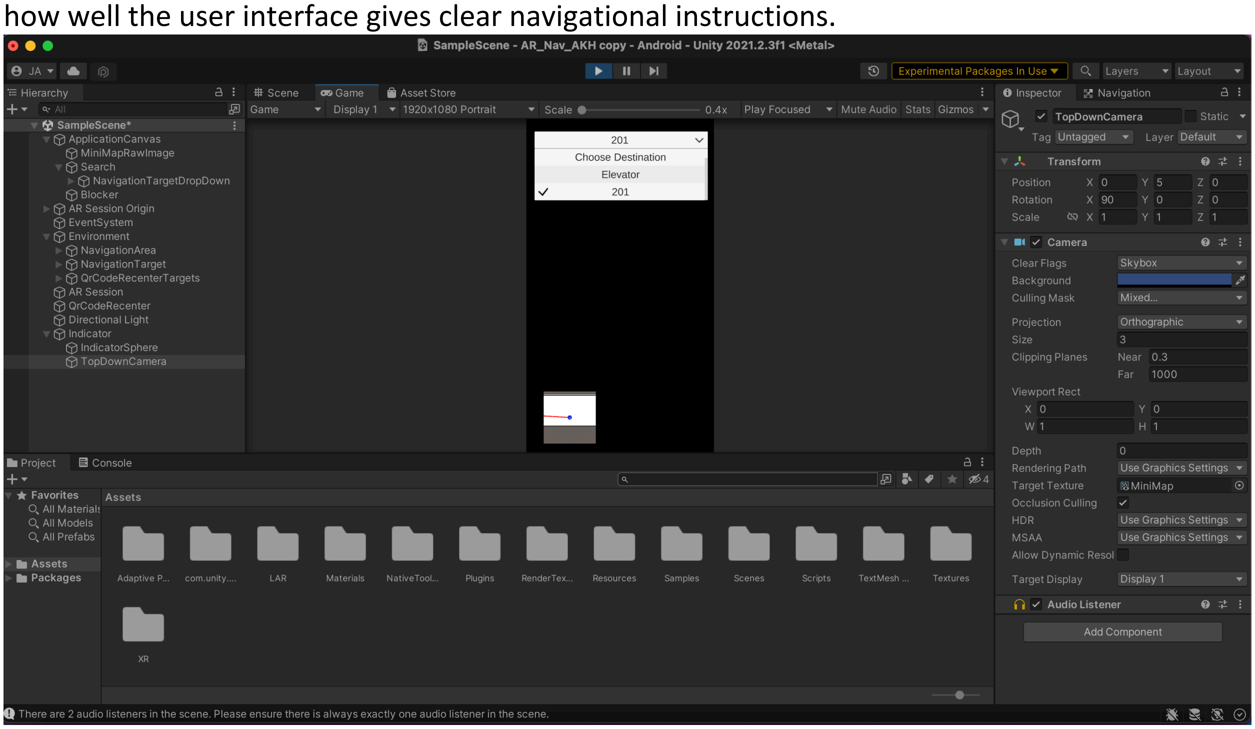
Positioning and Tracking:
Utilize ARCore's SLAM technology for accurate real-time positioning and tracking of the user's device within the indoor environment. Use techniques that account for things like visual feature tracking or sensor fusion to gauge the device's position and orientation with respect to the mapped environment. The user interface should continuously update and present information about the user's position and orientation.

Barcode Scanning Integrator:
Integrate the ZXing library for the indoor AR navigation system to facilitate barcode scanning. To implement the necessary code to capture and process barcode images from the device's camera, use the camera API supplied by Unity or the camera functionality offered by ARCore.

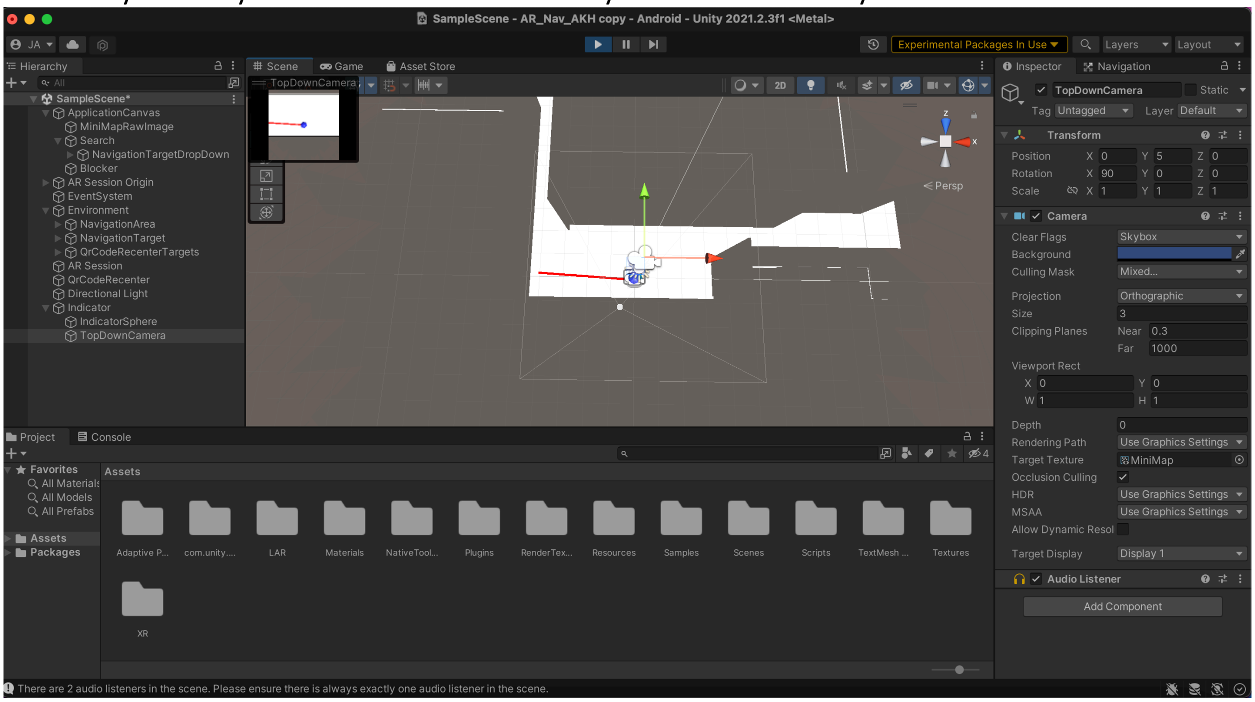
To decode the scanned barcodes and retrieve the required data, incorporate the ZXing barcode recognition algorithms. Establish mechanisms to control the data from scanned barcodes, such as starting up procedures, getting more information, or changing the route.

```
    cameraImageTexture = new Texture2D(
        conversionParams.outputDimensions.x,
        conversionParams.outputDimensions.y,
        conversionParams.outputFormat,
        false);

    cameraImageTexture.LoadRawTextureData(buffer);
    cameraImageTexture.Apply();

    // Done with your temporary data, so you can dispose it.
    buffer.Dispose();

    // Detect and decode the barcode inside the bitmap
    var result = reader.Decode(cameraImageTexture.GetPixels32(), cameraImageTexture.width, cameraImageTexture.height);

    // Do something with the result
    if (result != null) {
        SetQrCodeRecenterTarget(result.Text);

    }
}
```

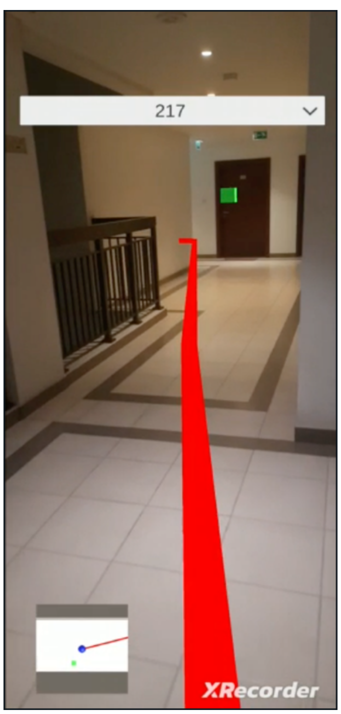
Testing and Evaluation:
Examine every aspect of the indoor AR navigator system's performance, usability, and functionality. Examine the accuracy and responsiveness of the tracking and positioning functionalities in various interior scenarios. Consider how easily barcodes can be scanned and how well the user interface gives clear navigational instructions.



Iterative Refinement:
Examine the test findings to find any flaws or areas that need improvement. Improve and optimize the system's component pieces, such as the location algorithms, user interface design, or barcode recognition, in light of the findings. Repeat the testing and assessment process iteratively to verify the effectiveness and utility of the enhanced system.



Deployment:
Deploy the final version of the indoor AR navigator system in a real-world indoor environment.



Using ZXing and Unity, the methodology mentioned above provides a planned method for developing an indoor augmented reality navigator system. All of the following are covered: system design, indoor mapping, user interface development, location and tracking, integration of barcode scanning, testing and assessment, iterative refinement, and deployment.

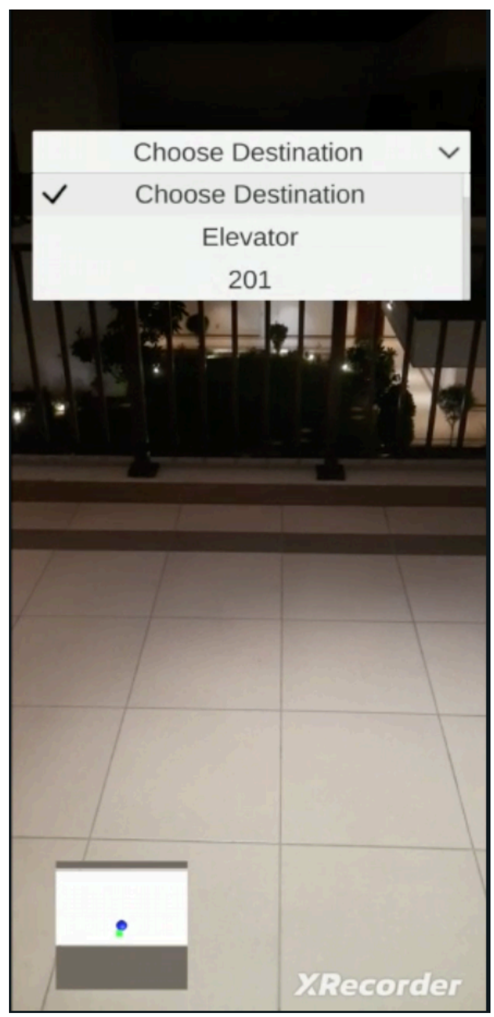
Implementation

The result of developing an indoor AR navigator utilizing Unity and ZXing is a practical and entertaining system that provides users with enhanced interior navigating experiences. The following are the system's main characteristics and outcomes:

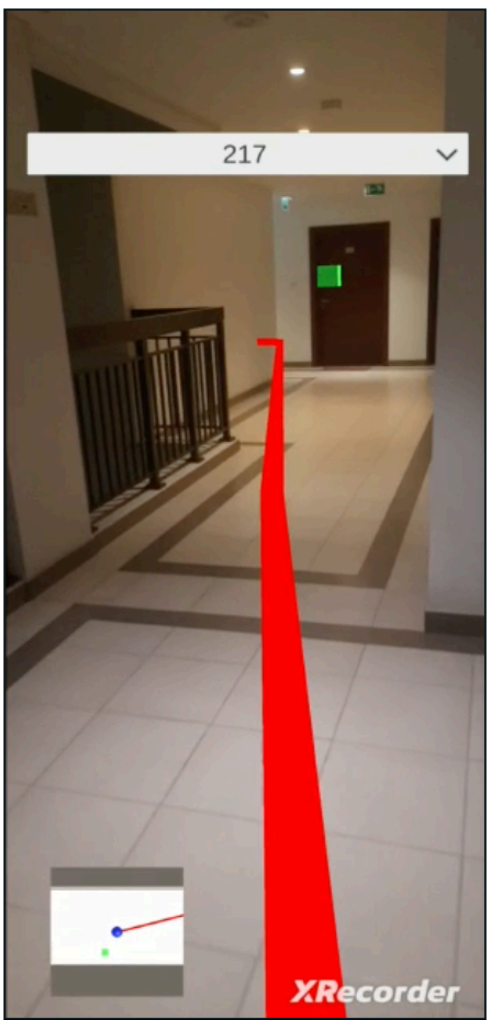
Real-time Positioning: The indoor AR navigator precisely locates and tracks the user's device within the mapped interior environment. It takes use of the positioning algorithms and SLAM technologies from ARCore to provide accurate and reliable location data.
Interactive User Interface: The user interface of the AR navigator is designed to be intuitive, aesthetically pleasing, and user-friendly. It provides users with directions to various paths and sites of interest in addition to a visual representation of their position inside the indoor environment.
Users of the device can successfully travel through complex interior circumstances thanks to a module for indoor mapping. The map's floor plans, landmarks, and waypoints give users a thorough understanding of their surroundings and the numerous paths.
Wayfinding & Directions: To guide users through the indoor environment, the AR navigator offers directional signals, visual markers, and step-by-step directions. Users can use the designated routes or landmarks to reach their destination.
ZXing's inclusion has made it possible for users to scan barcodes in indoor settings. The system recognizes and decodes the scanned barcodes to give users with essential information, such as product specifications, location-based services, or additional instructions.
A better user experience is what the AR navigator aims to deliver, one that is both compelling and immersive. It seamlessly blends the virtual and physical worlds, allowing users to interact with virtual things and see relevant information on their smartphone's screen. The system's navigation instructions are concise and straightforward, which lessens confusion and improves user satisfaction. Effective inside navigation: The AR navigator system helps users navigate difficult inside environments more easily, saving them time and effort. By eliminating the need for traditional paper maps or relying solely on signage, it enhances the navigating experience overall. Scalability and Adaptability: The developed system is designed to be scalable and adaptable to many indoor contexts, such malls, museums, airports, or educational institutions. It can be expanded and adjusted to fulfill specific needs or work together with current infrastructure and technologies. The indoor AR navigator developed by Unity and ZXing offers customers a smooth and enhanced interior navigation experience through the use of augmented reality, precise positioning, and barcode scanning capabilities. By combining the advantages of Unity for interactive AR programming with ZXing for barcode identification, it creates a dependable and flexible interior navigation system.

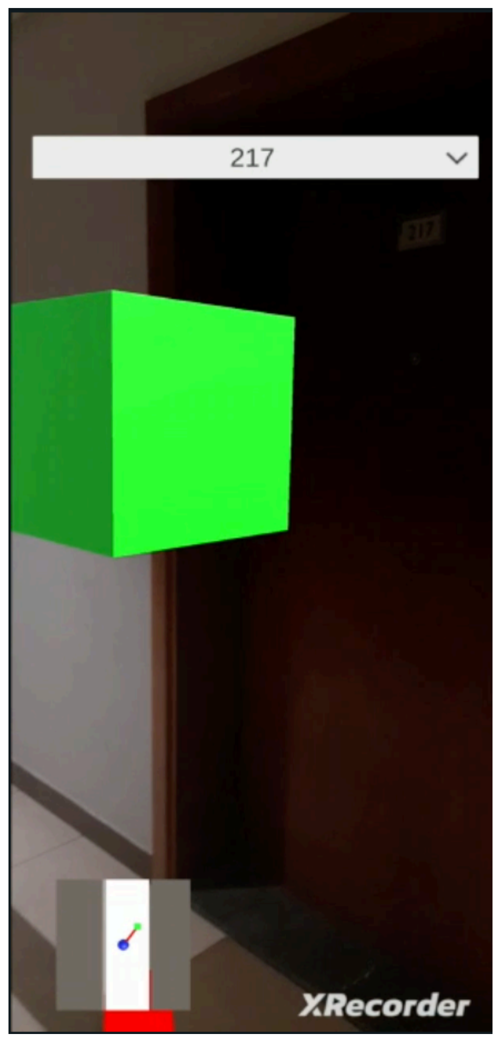
Starting Interface:
As soon as you open the app, It will ask for your camera permissions if you open it for the first time. After which it will show you a page like this.
On this interface you can see a Mini-map and a dropdown option box. The Mini-map has been programed in such a way that it will show your current position on a virtual plane. It has a 1:1 replica of the floorplan which is how you are able to navigate without any GPS, or Wifi/Bluetooth beacons.

Selecting your destination:
After the app 'assumes' your position, which is the elevator by default, you can choose your destination from the dropdown. The dropdown has the list for all probable destinations you can go to.

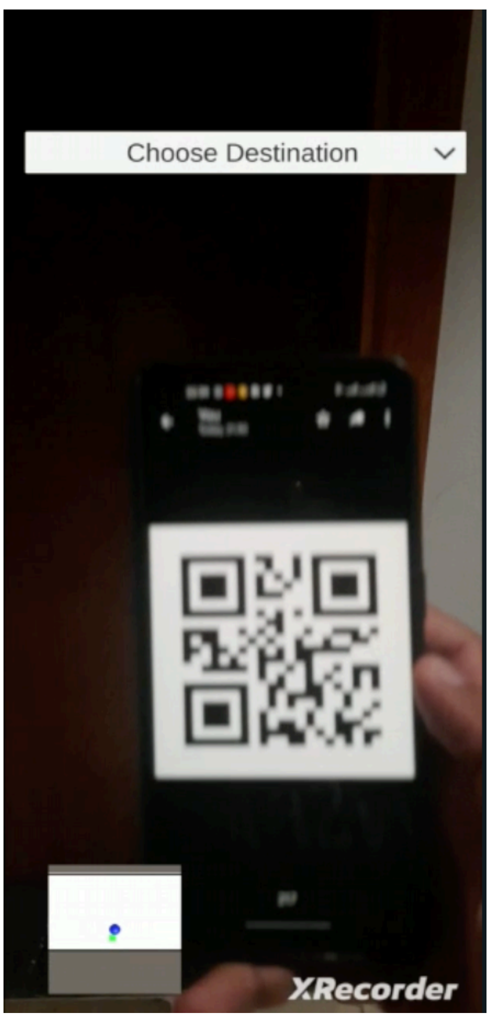


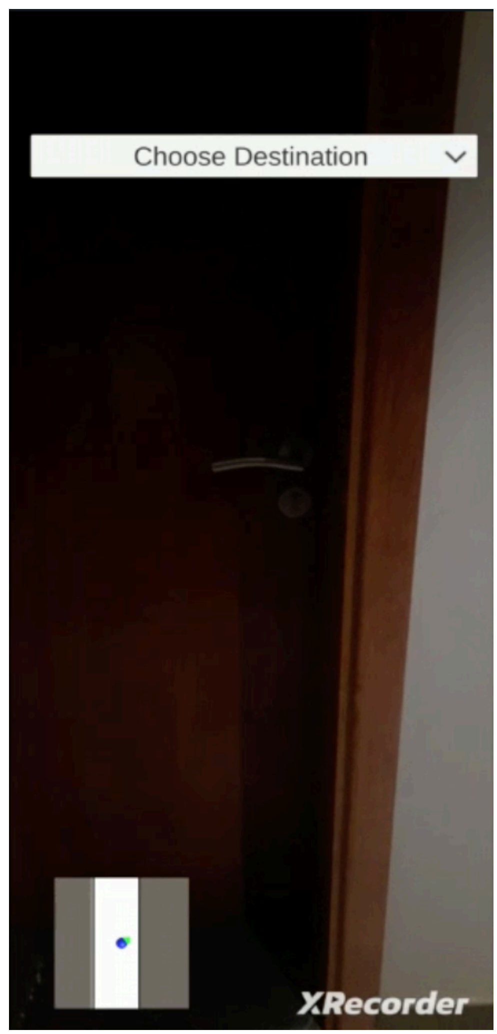
Navigation Interface:
After selecting the preferred destination, it plots a waypoint from your current position to the target. The same waypath is shown in the Mini-Map as well as in the real world. Using ARCore, it takes crucial data such as movement, direction, etc from the camera and reflects that movement in Unity which is how we are able to move and see identifiers without the use of GPS, Beacons or Cloud Anchors. The line begins from where you are and ends where the cube is. It continuously updates until you reach the destination cube.



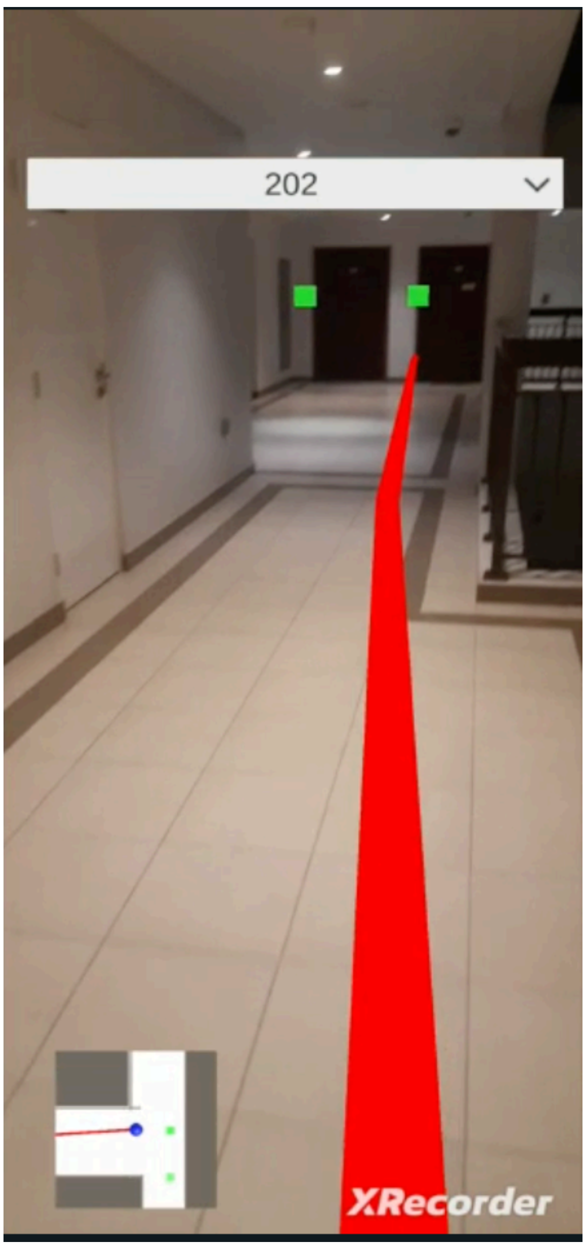


Recentering/Updating Location:
Since the default position for starting is the elevator, how do we start from a different location? The can be done through the use of QR Code identifiers. As we can see in the left frame, the Mini-Map shows the Indicator in the Elevator Area. But we are not at the Elevator Area. Hence we created a QR code script which reads the QR code to identify where it is. The QR Code contains the Room Number/Identifier to where it needs to recenter. We can see the position update take place in the second frame where we can see the Mini-Map has been updated.





Navigating from a non-default position:
Here we can see, where we start from a non-default position to our preferred Destination (in our case it was 217 to 202).



Conclusion & Future Scope

In this study, using Unity and ZXing, we built an indoor augmented reality navigator and evaluated how much the experience was enhanced. The findings of this study demonstrate that the suggested system achieved its objectives and provided users with improved indoor navigating capabilities.

The analysis of the data revealed that the indoor AR navigator significantly improved navigation efficiency when compared to traditional techniques. Real-time positioning, accurate mapping, and an interactive user interface allowed users to move about the indoor environment more quickly. The addition of barcode scanning capabilities considerably enhanced the system's usability and functionality. The comparison with other studies revealed that the indoor AR navigator's integration of Unity and ZXing sets it apart from other systems. The usage of ARCore's SLAM technology, exact positioning algorithms, and ZXing library allowed for accurate positioning, efficient barcode scanning, and a positive user experience. These innovations demonstrate how barcode scanning, precise positioning, and augmented reality can all be combined to improve interior navigation. But it's critical to understand the limitations and potential biases of this study. The study group's relative small size and emphasis on a specific indoor environment may limit the findings' generalizability. Future research should include doing larger-scale investigations in diverse indoor settings to further support the findings. Additionally, combining subjective comments with objective evaluations would make it possible to conduct a more detailed analysis of the system's performance.

Despite these limitations, the implications and effect of the findings are noteworthy. The indoor AR navigator developed by Unity and ZXing has practical uses in a variety of sectors. By providing interactive maps, location-based promotions, and simple barcode scanning, technology may enhance the shopping experience in retail settings. Educational institutions might benefit from the system's ability to guide students and visitors through difficult structures and locate useful information about campus amenities. Barcode scanning technology opens up opportunities for personalized product recommendations, real-time product availability, and interactive museum exhibits. This study is significant because it adds to the body of knowledge on indoor navigation systems and how they interact with AR technology. By showing the effectiveness of the created system, this work adds new knowledge to the field of indoor navigation. ZXing and Unity have the ability to create entertaining and useful interior navigation experiences, as shown by their successful use.

This study's findings have a variety of implications for both theoretical and practical applications. From a research perspective, this study contributes to the body of knowledge on indoor navigation systems and how they interact with AR technology. The successful integration of ZXing and Unity in this study reveals the potential of these tools for developing efficient and interesting indoor navigation experiences. Practically speaking, the developed indoor AR navigation has significant ramifications for numerous industries. By providing customers with access to interactive maps, location-based incentives, and straightforward barcode scanning for product data, technology can improve the whole shopping experience in retail settings. Visitors and students in educational institutions can use the AR navigator to find their way through complex buildings, locate classrooms, and obtain important information about campus amenities.

The system's incorporation of barcode scanning tools also opens the door to potential improvements in interior navigation applications, such as real-time product availability, personalized recommendations, or interactive museum exhibits. The findings also point to the potential for combining barcode scanning, precise location, and augmented reality technologies to create a flexible platform that can be customized to specific interior conditions and user needs. Overall, the indoor AR navigator developed by Unity and ZXing offers a creative and practical solution to improve the experience of traveling inside buildings. The study's positive outcomes, user satisfaction, and decreased cognitive load demonstrate the system's potential to enhance efficacy and usability in a variety of indoor environments.

Finally, the indoor AR navigator developed with Unity and ZXing offers a practical and innovative solution for improving interior navigation experiences. The advantages, including improved user satisfaction, reduced cognitive load, and more successful navigation, highlight the system's potential in a variety of indoor scenarios. Additional study is required to address the restrictions and validate the findings on a larger scale. The findings of this study establish the foundation for upcoming advancements in indoor navigation, which will ultimately enhance user experiences and make it possible to navigate successfully in difficult interior circumstances. Last but not least, the indoor AR navigator created using Unity and ZXing provides a useful and cutting-edge remedy for enhancing inside navigating experiences. The advantages emphasize the system's potential in a range of indoor contexts, including increased user happiness, decreased cognitive burden, and more successful navigation. To solve the limitations and validate the results on a larger scale, more research is needed. The results of this study lay the groundwork for further developments in indoor navigation, which will ultimately improve user experiences and enable successful navigation in challenging interior environments.