

Augmented Reality Navigation Application

Submitted in partial fulfilment of the
requirements for the award of Bachelor of
Technology degree in Information Technology

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **SRIJITH SAI L. (40120115), SURAVARAM DHANUSH (40120095), PAVAN AASHISH CH (40120131)** who carried out the project titled "**AUGMENTED REALITY NAVIGATION APPLICATION**" under my supervision from JAN 2024 to APR 2024.

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CHAPTER 6

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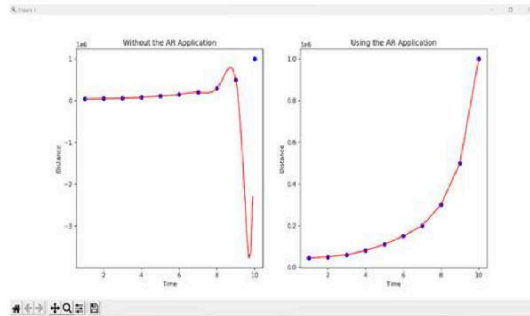


Fig. 6. Comparative Analysis

In Figure 6, a side-by-side comparison of the two groups A & B has been represented graphically. Here, Time is measured along the x-axis and Distance is measured along the y-axis. $y=1$ represents the exit as the distance is covered while $y=0$ is the starting point. Negative numbers imply that the user is either lost or walking in the wrong direction away from the exit.

Group A started at $y=0$, but eventually lost their way. This is visible in the graph where the curve dips below $y=-3$.

Group B began at $y=0$, and were directed to the safest, and shortest exit. All of them found the exit and were able to navigate to safety.

The results of our evaluation show that the AR-based navigation application is a viable solution for emergency situations. The application is able to find the safest and quickest path to the exit, even in complex and dangerous environments. This application is user-friendly, informative and effective as is demonstrated by the results of the user study. It provides an unparalleled user experience by integrating Machine Learning

concepts with Augmented Reality. Thus breaking the barriers between reality and the virtual world.

VI. CONCLUSION

This study has developed an augmented reality based navigation application for indoor environments with PlaceNote SDK, YOLO Object detection model and A* Algorithm with weighted modified costs. Safety is the primary principle. Future enhancements will include the YOLO model being further trained in more complex environments. This ensures that it tackles any sudden complications that may arise in emergency situations. The application will also incorporate a wider range of calamities and crises in addition to the existing choices.

This endeavour seeks to enhance the augmented reality experience, and transcend the horizons of the physical realm by expanding the definition of the known.

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overlaid to work in tandem with the A* pathfinding algorithm. Therefore, the user is directed out of the building as per standard fire safety protocols.

Screenshot (b) in Figure 3 portrays the corridor outside the office room. In the passageway, the camera scans the area and this real time data is supplied to the YOLO deep learning model. It proceeds to label the visual data and detects the elevators and staircase using a blend of computer vision and machine learning. Once the surroundings have been identified and labelled, each physical object is attributed a danger value $d(n)$ based on the threat analysed.

In the given scenario, YOLO identifies the elevator and assigns a higher danger value $d(n)$ to this node, whilst it captures the staircase and allocates a lower danger to it. Based on the aforementioned factors, weighted values i.e., costs are calculated by the modified A* algorithm.

The pragmatic approach is to cut the supply of electricity to the building to prevent electrical fires. As a precautionary measure elevator must be avoided to refrain from overloading the circuits. In recent times, most fire alarms automatically shut down the power supply although generators might still be in operation. Therefore, visual cues in the application dissuade the user from entering the elevator as the power might be cut off whilst the user is still inside.

Additionally, AR based textual cues such as “DO NOT USE THE LIFT!” appear on screen to further illustrate the safer routes with green overlays present to ensure that the user only takes the stairs. The guided route is represented in the form of an arrow superimposed near the stairs. The entire region of the lift in the corridor is covered in a red haze to indicate a ‘NO GO’ zone. Thus, the danger is averted complying with international UI/UX norms.

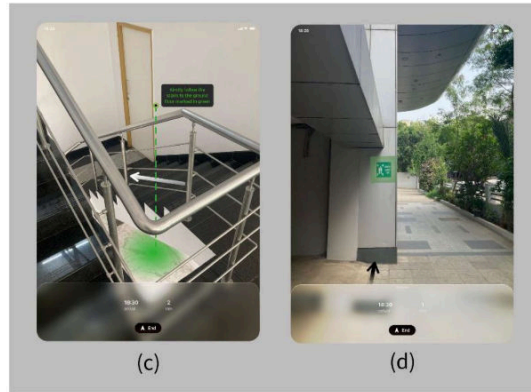


Fig. 4. Screenshot (c) & Screenshot (d)

Screenshot (c) in Figure 4 showcases the penultimate flight of stairs. The application successfully detects the ground floor as the user approaches it. The identified region is marked in green with arrows to direct the user to the desired location. It is further reinforced with an additional textual cue, “Kindly follow the stairs to the ground floor marked in green.” Screenshot (d) in

Figure 4 shows the user exiting the building from the nearest exit as directed by the application.

On exiting the building, the application detects an assembly point. As illustrated in Screenshot (d) of Figure 4, it highlights this region in green and superimposes navigational arrows onto the ground. The application informs them that they have arrived at an emergency assembly point and asks them to wait until authorities arrive, as seen in Figure 5.



Fig. 5. Snapshot-c

The application possesses an exclusive feature that permits architects, building managers, and registered stakeholders to upload a comprehensive list of the designated emergency assembly points. In the simulation, the emergency assembly locations were registered in the database, which enabled the application to determine the estimated time of approximately 3 minutes. This crucial factor enhances emergency preparedness and guided response within the building.

V. PERFORMANCE ANALYSIS

The proposed AR-based navigation application was tested in a simulated emergency scenario and a user study to determine the user-friendliness of the UI/UX as well as evaluate its potency in times of need.

a) Simulated emergency scenario: A simulated emergency scenario was constructed to evaluate the performance of the application in a realistic setting. The scenario involved an emergency fire drill in an office building. The application led the user to safety.

b) User study: A user study was conducted to evaluate the usability of the application. The user study involved 20 participants, who were segregated into two groups A & B. Group A was required to escape an expansive office building by themselves. Group B members were instructed to follow the AR application. Figure 6 represents a side-by-side comparison of Group A and Group B using two graphs.

b) Path 2:

$$\begin{aligned} d(n) &= 50 \text{ (elevator)} \\ h(n) &= 20 \text{ metres (to exit - 2)} \\ f(n) &= g(n) + h(n) + d(n) = 0 + 20 \text{ metres} + 50 \\ &= 70 \text{ metres} \end{aligned}$$

c) Path 3:

$$\begin{aligned} d(n) &= 0 \text{ (no danger)} \\ h(n) &= 25 \text{ metres (to exit - 2 via the staircase)} \\ f(n) &= g(n) + h(n) + d(n) = 0 + 25 \text{ metres} + 0 \\ &= 25 \text{ metres} \end{aligned}$$

Since Path 3 has the lowest total cost $f(n)$, the A* algorithm would select Path 3 as the safest path to the exit.

This example illustrates how a modified A* algorithm determines the safest path to the goal node in the AR disaster response application during calamities and crises.

D. Proposed modifications to A* algorithm

The proposed algorithm will always select the path that minimises the user's exposure to danger.

Step 1: Mapping

- 1.1 Scan the areas to be localised with the device camera such as entrances, common areas, and staircases and save it in a JSON file.

Step 2: Server Integration

- 2.1 Setup and obtain a licence key for PlaceNote.
- 2.2 Upload the map file to the PlaceNote SDK cloud database.

Step 3: Unity Implementation

- 3.1 Import the PlaceNote SDK into a Unity project.

Step 4: Waypoint Dropping

- 4.1 Scan the environment and drop waypoints along the desired path using the breadcrumb path creation.

Step 5: YOLO Object Detection

- 5.1 Use YOLO to identify objects in the environment.
- 5.2 Assign danger values objects based on threat level.

Step 6: A* Pathfinding

- 6.1 Use A* pathfinding algorithm to find the shortest and safest path from the user's location to the exit.
- 6.2 The danger values $d(n)$ detected by YOLO are added to the cost values of the nodes.

Step 7: User Interface

- 7.1 Display the path on the screen using AR elements, such as directional arrows and waypoints.
- 7.2 Display alerts to the user about nearby hazards.
- 7.3 Provide emergency contact information within the application.

Additional Steps

Pre-requirement: Training the YOLO Model

The YOLO object detection model needs to be trained on a dataset of images of the objects that are likely to be encountered in the disaster situation. This will help the model to accurately identify and classify objects in the environment.

Post-requirement: Integrating with First Responder Systems

The AR navigation app could be integrated with first responder systems to provide real-time information about the location of victims and hazards. This would help first responders to respond more quickly and effectively to disaster situations.

IV. RESULTS AND DISCUSSION

A. Results

The proposed AR-based navigation methodology has a number of advantages over traditional navigation systems. The proposed AR-based navigation methodology has a number of advantages over traditional navigation systems. First, it is able to provide real-time information about the environment to make informed decisions in emergency situations. Second, it provides wayfinding assistance. Third, it is easy to use as the user needs to only follow the path that is superimposed onto their screen view of the real world.

The proposed mechanism has the potential to save lives, reduce damage in emergency situations and can be used by first responders and civilians alike.

B. Discussion

Screenshots of the application are presented here, with relevant explanations.

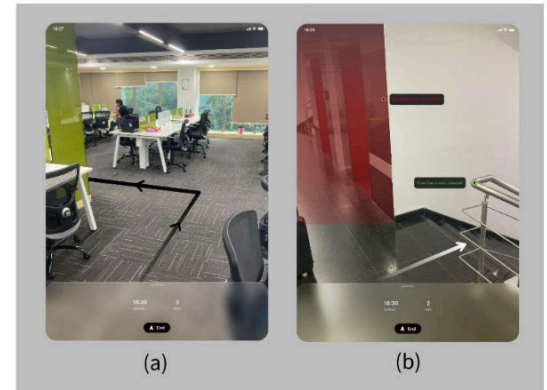


Fig. 3. Screenshot (a) & Screenshot (b)

Screenshot (a) in Figure 3 depicts a standard office. In the user study phase, a simulation was conducted in which the fire alarm was triggered. Upon hearing it, the user opened the application at once and selected the 'Fire Emergency' option among the listed calamities. This figure represents the beginning of the navigation $g(n)=0$. The application then chooses the most appropriate modus operandi for the selected scenario. In the instance of a fire, the ideal safety protocol is to find the safest and the quickest exit and leave in a systematic, organised manner by leveraging Deep Learning, Artificial Intelligence and Augmented Reality.

The black arrows on the carpet in Screenshot (a) directed towards the exit of the room are AR overlays onto the real world as markers for navigation and wayfinding. The AR elements are

building. This demands preparatory work for each map model and location.

In contrast, this AR based navigation system truly follows AR principles and employs a CreateMaps method in C# which allows the user to scan the area, chart out the layout of the building and plot Path Finding Anchors. Thus mapping the individual objects and blueprint of the rooms.

Users can experience true AR based Navigation as PlaceNote SDK is utilised to store these map models. It integrates ARKit with its cloud based storage and stores up to 50 maps for 50 users for free. PlaceNote SDK API (Application Programming Interface) requires a valid licence. An API key has been procured from the official source.

The rooms and passageways are scanned with the device camera. Consequently, the software simulates a 3D model of the layout of premises for augmented navigational assistance using the cross-platform solution PlaceNote SDK.

The mapped data is serialised, uploaded and stored within PlaceNote Database for future reference as a dictionary in a JSON (JavaScript Object Notation) file. Each place possesses an ID, time it was created and the GPS location i.e., the altitude, latitude and longitude. Metadata such as type and position as well as dimensions of the rooms and the building are also retained within the PlaceNote SDK Cloud Storage database.

B. Localisation

Localisation is the detection of the location of a device with respect to its environment. It comprises of numerous aspects namely Position tracking, Orientation, tracking, Map alignment, Obstacle detection, Wayfinding and AR Overlays. Navigation in emergency situations requires robust localisation and adaptability due to changing unforeseen circumstances.

Position tracking pinpoints the device location like GPS (Global Positioning System). This project adopts the usage of Waypoints or cloud anchors. They are dropped along like bread crumbs, visually represented by golden orbs using augmented reality techniques. Path-finding waypoints are recorded and define a walkable path.

Map Alignment refers to placing the user's live location in tangent to the 3D virtual map model that was developed in the previous stage. This is a vital step as it bridges the gap between the tangible physical environment and the digital map.

Augmented Reality elements are overlaid on the screen over the physical environment as seen from the camera. Alerts and additional directional information, including the location of wildfires, flood zones, and other hazardous areas thus providing the ultimate Augmented Reality experience.

Accurate localisation permits seamless integration of AR and the real world. Here the digital augmented reality elements and map models are integrated with the physical world using a camera whilst keeping track of the real time position.

Therefore, localisation is crucial for AR Navigation in emergency situations for users to stay aware of their surroundings, avoid hazards, find the quickest and safest way to their destination, coordinate with first responders and other

personnel, and get real-time information about the location of victims, and assess the damage caused.

C. Path Finding

Once the augmented reality elements have been integrated into the application, it must direct the user to the safest and quickest exit. To achieve this, the A* pathfinding algorithm is employed in two different ways.

YOLO object detection model identifies objects in the environment and assigns danger values that represent the level of danger an object poses, higher values indicate greater harm. For example, fire has a greater danger value than debris.

The A* algorithm is employed for path-finding. It locates the shortest path from the user's current location to the nearest exit by assigning a cost value to each node based on the distance to the next node and the danger values. After several iterations, the node with the lowest cost value is selected. Therefore, if there is a large pile of debris along the path, the A* algorithm will find a route that goes around the debris, even if it is slightly longer.

The A* algorithm initialises an open set and a closed set. $g(n)$ is the cost from the start node to the current node, $h(n)$ is defined as the heuristic estimate of cost from the current node to the goal node i.e., the exit and $d(n)$ determines the level of danger. Then the total cost $f(n)$ is calculated, as in:

$$f(n) = g(n) + h(n) + d(n)$$

A* algorithm evaluates cost of each path and selects the shortest path with the least cost. This implies that it will avoid obstacles and danger as those nodes have higher cost values.

This would be implemented as illustrated in the following contextual scenario.

1) *Context*: The user is trapped in the second floor of a building during a fire emergency. There are two exits, exit-1 and exit-2 on the ground floor. There are two options to safely reach the ground floor, one is to take the stairs and the other is to take the elevator.

2) *Implementation*: The user is 10 metres away from the nearest emergency exit – 'exit-1', and 20 metres from 'exit-2'. The available paths to the exit are:

a) *Path 1*: 10 metres long via exit-1, passing through the fire.

b) *Path 2*: 20 metres long via exit-2, while avoiding the fire, but taking the elevator.

c) *Path 3*: 25 metres long via exit-2, while avoiding both the fire and the elevator.

3) *Calculation*: The A* algorithm would calculate the total cost $f(n)$ for each path with the following constraints: User is at $g(n) = 0$; $d(n)$ for Fire = 100; $d(n)$ for Elevator = 50

a) *Path 1*:

$$d(n) = 100 \text{ (flames)}$$

$$h(n) = 10 \text{ metres (to exit - 1)}$$

$$f(n) = g(n) + h(n) + d(n) = 0 + 10 \text{ metres} + 100 = 110 \text{ metres}$$

5.3.2. IEEE RESEARCH PAPER

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Augmented Reality based navigation during Climate emergencies and crises.

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Abstract—We propose a novel augmented reality (AR) navigation methodology for buildings during emergency situations. The methodology addresses the challenges of existing AR navigation applications, which typically use pre-existing map models and are not able to provide accurate navigation instructions in real-time. The proposed methodology uses a combination of A* algorithm, YOLO, an object detection machine learning algorithm, and PlaceNote SDK to overcome these challenges. The A* algorithm finds the shortest path to the nearest exit, while YOLO detects objects such as stairs, elevators, and other obstacles in the user's path. PlaceNote SDK builds a real-time map of the building, which allows the application to track the user's location and provide accurate navigation instructions, even in low-visibility conditions. In this paper, we shall further elaborate on the framework used to establish a safe and fast Augmented Reality based navigation experience for emergencies.

Keywords—augmented reality, navigation, buildings, emergency situations, calamities, A*, YOLO, placenote SDK

I. INTRODUCTION

Calamities and crises such as natural disasters, floods, and wildfires cause a lot of damage and lead to an enormous number of casualties. It is pertinent to provide navigation during critical times, but it is an arduous task. This task is challenging because of the element of unpredictability. Roads and bridges may get blocked, and landmarks may get damaged by fire, or covered in debris.

In recent years, with a surge in the number of natural disasters, partly bolstered by climate change, an interest in developing solutions is brewing with a grounding in technology to handle such situations with expertise.

One such solution is navigation, where applications can help people navigate safely during unforeseen calamities both natural and man-made. These applications typically use a variety of data

sources, such as real-time traffic data, population census, satellite imagery, and even social media reports, to create 2-D maps and routes that avoid dangerous areas, but not with much usability and accuracy.

In this paper, we propose a promising approach to developing navigation applications for natural disasters by using Augmented Reality (AR) and Artificial Intelligence (AI).

AR technology overlays digital information onto the real world and provides users with information about their surroundings to guide them through a task. In the context of navigation, AR can be used to directly highlight the real-time path instead of digitally created maps that are not representative of the real world, thereby decreasing confusion.

Artificial intelligence (AI) is the scientific study of making intelligent agents, which are systems that can reason, learn, and act autonomously. In the proposed navigation application YOLO (You Only Look Once), an object detection algorithm is used to identify obstacles, and other hazards, as well as physical objects in the environment, such as staircases, elevators, and exits, which could then be used to provide users with safe, efficient navigation routes, and real-time information about the disaster situation. In this manner, AI is used to generate the best possible route for the user, taking into account various factors, such as the type of disaster, the severity of damage, and the user's current position in relation to his/her external environment.

Further into the paper, the literature survey is presented in Section 2 based on some existing AR-based navigation applications. Section 3 delves into the proposed work. The results are discussed in Section 4, followed by Section 5 dealing with Performance Analysis. Finally, Section 6 provides a conclusion to our article.

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performance caused by the A* search method and hidden walls was addressed by improving the 3D floor plan model and introducing invisible walls. A useful resource for future developments in indoor navigation systems and applications, this thorough survey paper offers insights into the research, development, and testing of the Android indoor navigation application.

[13] A mixed reality system that simulates an augmented reality navigation system for pedestrians was developed as part of a research project at the Augmented Reality Technische Universität München. A pilot study was carried out with the help of a controlled Mixed Reality environment, and the researchers came up with four different concepts regarding visualisation and error visualisation. According to the findings of the study, despite the fact that error visualisation has the capability of enhancing AR navigation systems, it is challenging to find suitable visualisations that are correctly understood by users. The purpose of this study is to investigate the feasibility of directing users towards a destination making use of 3D arrows, a line visualisation, and a virtual entity. Both discrete information, in which navigation hints are displayed in discrete steps, and continuous information, in which navigation hints are displayed continuously, are utilised by the system. The Flying Spirit, which is a 3D arrow with a trail of particles, and the AR Puppet, which is a virtual avatar, are the two systems that have been developed to provide guiding information. In order to evaluate the system properly, a variety of tasks were used, and each user was required to follow the hints provided until the system stopped operating on its own. Approximately forty-five minutes were spent on the evaluation process. Error visualisations for augmented reality navigation systems increased user awareness of tracking errors and helped users select the correct targets more frequently, according to the findings of a study that included eight participants. According to the findings of the study, users found the error visualisation of the virtual character to be the most helpful. The study also found that the location of the visualisation was more important than its appearance. However, the findings of the study also showed that there was no significant improvement in user awareness when error visualisations were used in the process of selecting a target.

III. CONCLUSION

The present state of advancement for indoor navigation systems, augmented reality-based indoor navigation systems are still in their early stages. Still, these systems could make a big difference in how people move around indoors. With augmented reality (AR) systems, users can get information that is not only accurate but also more up to date than with traditional navigation systems. Augmented reality (AR) systems can also give users more contextual information, like exactly where businesses and facilities are located nearby. The confluence of machine learning, augmented reality and artificial intelligence seem to have promising outcomes in relation to managing wayfinding in time, and in a way that ensures safety as well. Additionally, augmented reality systems can give users step-by-step navigation instructions, which makes it easier for them to find their destination.

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surveyed AR-based indoor location and navigation. The project reviews AR navigation methods and solutions for mobile devices. Location-based AR smartphone apps use the Augmented Reality Engine Application (AREA) project to combine AR and inertial tracking for indoor navigation and localization. A context-aware navigation system and machine-based and machine-less computer vision techniques are examined to reduce errors and improve user experiences. Due to the extensive use of mobile devices with many communication protocols, interior navigation systems are gaining popularity. AR technology is used to solve the problem of navigating unfamiliar indoor spaces. Modern indoor navigation technologies like GPS and SLAM consume batteries quickly. The suggested solution uses Google's AR Core and ARKIT for Android and iOS devices. AR Core uses 3D object representations for navigation and destination searching. The system asks users for their destination, initialises the camera, and locates them. AR Core places virtual things in real life using device location data and sensors. The system requires high-end Android or iOS devices with 512 MB RAM and a camera for nearby picture recognition for best performance. The system architecture includes Front-End, Middleware, and Back-End. Apple introduces its AR Kit, a set of tools and SDKs for iOS AR app development. Points, AR world mapping, lane identification, light estimation, anchors, face tracking, motion capture, people occlusion, and collaborative sessions are included. AR Kit integrates virtual items into AR experiences via picture recognition and tracking. The implementation procedure includes user destination input, camera startup, Firebase coordinate transfer, and AR arrows for waypoint navigation. AR-based indoor navigation offers rich interior views, better time management, and less staff interaction. However, some devices may not support AR Core services, restricting its use. This study presents an AR-based indoor navigation system for user engagement. For better navigation, the system can read QR codes, but it may not work with cheaper smartphones. Virtual reality is frequently associated with high-end computing, but the study admits privacy and battery life issues. The study also proposes integrating outside navigation algorithms with the proposed technology to address security concerns in protected infrastructure hiding applications.

[11] This article describes a university emergency response mobile AR system. Users can manipulate spatially recorded emergency response and navigation data. MARS uses feature extraction for internal location sensing owing to emergency GPS and WiFi failures to deliver building evacuation and outdoor navigation information via tablets and phones. A limited user survey and mobile phone usability questionnaire assessed MARS' efficacy. MARS helps emergency evacuation find exits using AR. This study introduces Unity 3D with Vuforia MARS for university emergencies. MARS uses Google Maps Places API to provide location-aware school, parking, and fuel station data. AR-based evacuation and department locators contextualise 2D floor maps in 3D. The indoor MARS system shows floor maps and room-numbered safety and evacuation instructions. The research presents a smartphone-based building evacuation system, and a brief MPUQ user survey evaluated MARS' indoor location sensor feature extraction. Google Maps Places API identifies outside structures, parking lots, and petrol stations. AR evacuation and department finders contextualise

indoor 2D floor maps in 3D. MARS intends to create a smartphone-controlled building evacuation system that displays the building's floor plan, room numbers and the user's location with a red pin for exact location sensing. The study suggests MARS improvements. This mobile AR system uses tag monitoring and identification for Android and iOS smartphones to provide emergency response and navigation data. Indoor MARS has AR Emergency Evacuation, Department Finder, and Buildings buttons, whereas outside MARS has Buildings, Parking, Food & Drinks, and Gas Stations buttons. MARS is an AR system with emergency evacuation and department discovery functions developed in two phases using Unity and Vuforia. Markers in Unity 3D let users zoom, interact, and visualise their position on floor plans. AR Department Finder lets users find their building departments. The new MARS buttons employ GPS to detect buildings, parking lots, restaurants and gas stations outdoors. A limited MARS study with ten participants showed that AR features are easily integrated, MARS accurately identifies exits, and users are confident using MARS for navigation. The mobile augmented reality system (MARS) helps indoor and outdoor users manage emergency response and navigation data and improve cognitive mapping using augmented building floor layouts.

[12] The study investigates the use of Augmented Reality (AR) and the A* Search Algorithm to improve Android indoor navigation systems. It does so by overcoming the shortcomings of traditional GPS indoor navigation caused by signal interferences and spatial limits. The study focuses on creating an Android-based application that will make it easier for new employees, visitors, and first-year students to find their way around the AMA International University-Bahrain campus. The suggested Android application is developed with Android Studio and Unity, paying close attention to cost-efficiency, occasional error reduction, app size management, and user accessibility for those with physical or mental disabilities. The main goal is to provide Android users with a quick and simple way to explore and navigate to important areas inside the university. Additionally, this research aims to develop an interior navigation system adapted to the distinct requirements of the varied user base of AMA International University-Bahrain, including students, faculty, visitors, and guests. The study uses a systematic questionnaire and stringent testing processes to identify and manage potential development risks in order to verify the system's efficacy and dependability. Key elements including gyroscope, accelerometer, and camera integration with AR algorithms are incorporated into the programme during development on Windows 10 desktops using Unity and Visual Studio, improving users' ability to find and travel to crucial campus regions. The use of Unified Modelling Language (UML) diagrams, which streamline and explain the application's architecture and functionalities, greatly speeds up the development process. Operational prerequisites for the software include support for the Android operating system, touchscreen usability, camera functionality, and at least 60 MB of internal storage. The "University Campus Indoor Navigation" beta version received tested by team members and volunteers which resulted in useful feedback that identified minor flaws and offered suggestions for improvements. The "favourites" feature and improvements to directional assistance were added as a result of user feedback. In particular, the app's inconsistent

results, which indicate an increase in spatial learning as an unintended byproduct.

[7] The purpose of this study is to present an augmented reality (AR) software that can evaluate a user's visual rating while also offering various navigation services, such as visual aids and auditory cues. Virtual Snellen charts are shown on augmented reality devices, and the application offers a number of visual aids dependent on the user's assessment. Using both visual and auditory signals to enhance efficiency and accuracy, the goal is to provide better service to persons with impaired vision. When an obstacle is encountered, object identification and depth estimation technologies are used to identify it and calculate the approximate distance between the user and the obstruction. On Microsoft HoloLens2, the results of object detection and depth estimation have shown good accuracy, and this work will be incorporated into the program in the near future. The augmented reality application is divided into three primary sections: visual rating measurement, visual cue strategy creation, and scene interpretation. Visual acuity is measured using a Snellen chart, and the subject is tested while listening to auditory instructions. The software has several advantages over conventional approaches, including portability, the ability to specify custom distances between the Snellen chart and the user, and clear voice instructions for self-testing. The software, built in Unity and optimized for Microsoft HoloLens 2, has mixed reality and sound capabilities. HoloLens can show a Snellen chart alongside voiceover guidance, and there are many virtual pie charts to illustrate routes. The YOLO4 technique has been employed for object recognition and the HMA-Depth technique for depth estimate. On Microsoft HoloLens2, the results of object detection and depth estimation have shown good accuracy.

[8] This research focuses on outdoor augmented reality (AR) navigation at Helan Mountain, China, with a concentration on prehistoric rock art. Through a dual-feature/GPS recognition technology, visitors have the chance to discover the history of these paintings. The first phase entails utilising a map and the GPS on a smartphone to visit several local sights. To accurately identify rock art and provide interactive contextual annotations, such as 3D explanations, pictures, and videos, the second stage makes use of feature-based recognition and tracking. By superimposing virtual content over cultural places, the study seeks to investigate how outdoor augmented reality can improve travellers' experiences. The devices under consideration range from cheaper AR HMDs to more expensive smartphones and tablets. The research focuses on the rock art on Helan Mountain and recommends a two-stage GPS feature detection approach. This technique comprises mapping the distribution of rock paintings for navigation and calculating user visibility using real-time GPS data and rock painting distances. Based on their height, rock paintings are divided into high- and low-position targets to increase participation. The study discovers that visitors to outdoor cultural heritage places are effectively immersed and educated using planar AR. This study's methodology involves using mobile devices to photograph high-altitude rock art. To prevent content overlap, a compass measures the device's pitch and yaw and converts the readings into direction vectors. For picture and plane detection, feature matching and a homography matrix are employed. The feature point filtering method used in the study lowers operating expenses. The performance and

usefulness of the outdoor AR software were evaluated among 30 users, including AR and non-AR users. Although some participants thought the system was unstable and inaccurate, the majority of participants thought AR could improve their experience. This study emphasises the usefulness and viability of AR navigation systems, especially in mountainous areas. The precision of GPS, update rates, algorithm stability for virtual superimposition, and detection in various lighting situations are all future objectives.

[9] This paper addresses difficulties in indoor location for navigation systems, which are essential in surveillance, robotics, and entertainment. Prior study used WLAN, RFID, IMU, and SLAM; however, these technologies by themselves were shown to be inaccurate and inefficient. A marker-based AR indoor navigation solution for 2D spaces is being proposed to address this problem. Integration with 3D humanoid agents is made easier by the use of Unity's AR Foundation Framework for iOS with ARKit. To make indoor navigation easier, room boundaries and obstructions are being recorded from a reference image. Pathfinding algorithms are used to determine the best routes between the user's current location and their desired destination. A 3D humanoid agent is guiding the user, demonstrating compatibility with low-end AR-enabled smartphones while attaining excellent precision at a reasonable cost. In order to map indoor environments, 3D AR Session space is now being converted to 2D. This method includes identifying the posture of the reference image, setting up area borders, identifying barriers, and arranging things. Accuracy is improved by narrowing the mapping region. A reference posture is necessary for the retrieval of saved place mappings. The relative pose of the AR Session is inferred from a static ground image using the Tracked Image Manager from the AR Foundation. The "Make Content Appear At" synchronisation technique developed by the AR Foundation uses QR codes to pinpoint visited areas and project object placements into the ground plane. Visibility graphs created with the Extremity Pathfinder Python programme make it easier to navigate dynamic routes from the user's current location to their destinations. Through two trials, the accuracy of the system is thoroughly checked. When comparing object lengths to 1D AR measurements, an average error rate of 0.99% is found. The second attempt is computing 0.78% positioning errors with a 99.2% accuracy rate in the 2D context. Guido, a mobile app and web-based management platform, employs the technology. Live user guidance is provided by a 3D humanoid helper. To ensure accurate indoor 2D layouts and localization, artificial objects are being superimposed on the live video feed using Unity's AR Foundation framework. The article suggests a precise interior mapping and navigation system for teamwork, multiplayer augmented reality games, and interactive experiences. The essay also looks at how application precision and performance are impacted by camera and sensor quality.

[10] This study examines indoor location and navigation for AR-enabled smartphone apps. The goal is to create a visual positioning and navigation system for mobile indoor navigation using AR to achieve precise real-time user location at a low cost. The research emphasises seamless device connectivity and precise 3D object representation to provide an effective indoor navigation solution using sensors and smartphones. Rhuta et al.,

a walking speed test. Post-Study Usability Questionnaire (PSSUQ) scores for the application's usability averaged 5.87, putting it inside the acceptable range.

[4] The study is mostly about making a mixed-reality museum navigation system for head-mounted devices that uses Microsoft HoloLens. Microsoft HoloLens (HoloLens) has been used in many different contexts, such as HoloLearn, calorie estimation systems, sports club merchandise displays, and training systems for assembly tasks. It has been shown that these systems have the potential to improve navigation and lower the cost of labour. Still, most mobile navigation systems today are based on multimedia information that isn't interactive and isn't very good at helping people find their way. The goal of this study is to create a museum navigation system that uses the image recognition, gesture recognition, mixed reality, and location awareness technologies in HoloLens. The museum's navigation system works better now that it has more 3D and multimedia navigation information, highly interactive display functions, and functions for knowing where you are indoors and outdoors. There are five parts that make up the system architecture: a user interface, a multimedia database, AR image recognition, and MR gesture recognition. Introductions in text form, pictures of cultural artefacts, navigation videos, and 3D models are all in the multimedia database. The AR image recognition function finds image tags stored in the database and uses augmented reality to show them. MR gesture recognition's job is to look at how the user moves their hands and then do the corresponding movements. Location awareness shows the user's current location and direction on the map for navigation. You can see texts, pictures, videos, and 3D models on the HoloLens' lens display as navigational data. As part of the implementation process, navigation information from Oxford College was gathered and organised. Multimedia and 3D guide information was also created, along with an Adobe Illustrator user interface and functions for augmented reality image recognition, mixed reality gesture recognition, and location awareness. To recognise augmented reality (AR), you can use the Vuforia ARSDK. To recognise gestures, you can use the Mixed Reality Toolkit (MRTK). The model got a classification rate of 96.88%, which shows how important its features are for telling microservices apart and correctly figuring out the overall risk level. The good results of the method show that distributed tracing lowers the security and privacy risks that come with microservices. Distributed tracing is a way to find privacy and security risks in many situations, such as when you outsource computing tasks or share computing resources.

[5] The researchers of this study have devised a navigation system that utilizes augmented reality (AR) technology for the purpose of navigating the premises of NTU "KhPI" located in Ukraine. The navigation system implemented in this project utilizes 3DUnity and the AR Foundation framework. Its primary objective is to facilitate navigation throughout the KhPI campus by enabling users to effectively traverse the landscape, locate specific buildings, and visualize the optimal routes between various buildings on a digital map. Real-time synchronization enables real-world users to experience virtual space, hence boosting the immersive and lifelike effects of augmented reality (AR) navigation. Location-based augmented reality (AR) navigation is a technology that enables the identification and

placement of virtual items on the ground without the need for specific markers. This technology employs a combination of GPS, accelerometers, digital compasses, and other highly precise equipment to ascertain the precise location on a given surface and overlay virtual data over the physical environment. The primary functionalities of GPS encompass the placement of three-dimensional objects within certain geographic coordinates, the activation of augmented reality hotspots, the placement of three-dimensional text markers on buildings, and the facilitation of seamless device location changes and header updates. The primary components of the augmented reality program encompass the camera tracking module, object storage module, visualization module, and interface module. The camera tracking module is responsible for analysing every frame of the video stream, with the objective of identifying a marker in a predictive manner. It then proceeds to ascertain the marker's spatial coordinates and then calculates the virtual camera's position in relation to the marker. The object storage module employs predetermined position, scale, and rotation parameters to position the requisite object for visualization inside the scene. The user has the ability to manipulate model and rendering parameters using the graphical user interface.

[6] This ongoing study focuses on inside navigation because that's where people spend most of their time, and because GNSS signals aren't always reliable or consistently available within buildings, making augmented reality technology all the more necessary for indoor navigation services. The purpose of this research is to develop a spatial learning-enhancing augmented reality (AR) indoor navigation system. There aren't any easily identifiable landmarks in the Technical University of Munich's study area, and the numbering system is a bit of a mess. The research makes use of Microsoft's HoloLens 1, a wearable augmented reality headset that enables hands-free, location-independent movement. In order to get people where they need to go fast, the primary interface blends instructional text with virtual semantic landmarks. Users can follow the green arrows to get where they need to go, and the icons around the room are there to entice them to look around. In both Experiments 1 and 2, participants were asked to follow an inside route despite their lack of familiarity with the surrounding environment. It was decided that the green arrows were both comprehensible and aesthetically pleasing, while the icons fell short. In Experiment II, the researchers wanted to see what would happen if the arrows were made less noticeable by making them yellow. Feedback from Experiment III, in which participants drew a sketch map of the study route, confirmed that arrows are a natural sign of direction. Some of the participants made the wrong turns because they relied on their memories rather than the virtual POIs. Two participants were able to draw the virtual icons representing landmarks with 100% accuracy, suggesting that using virtual landmarks can aid in spatial learning. This research proves that HMDs can successfully be utilized for indoor navigation. Spatial learning can be aided by the use of virtual landmarks and directional arrows. However, if augmented reality technologies are not carefully crafted, they can cause safety issues. Involving additional users and investigating different avenues to enhance users' awareness of the physical world while navigating with augmented reality would allow for a more thorough evaluation of the preliminary

negatively affected by a variety of factors, including shifting lighting conditions, effects of occlusion, and other environmental elements. Variations in performance are also possible as a result of these factors.

C. Contextualizing AR

Augmented reality (AR) navigation systems have the potential to become more useful and informative by providing users with a greater quantity of contextual information. This information can include the precise positioning of nearby commercial establishments and amenities. This information has the potential to improve users' comprehension of their surroundings and to make it easier for them to make navigational decisions based on a greater level of knowledge.

D. User-friendly and less distracting AR

AR-based navigation systems need to be meticulously designed to ensure that they are user-friendly and do not distract users from the environment in which they are operating. Users of AR systems should not be required to learn complicated instructions or gestures in order to make full use of the technology. These systems are intended to be straightforward and simple to operate, and they are also intended to reduce the amount of time that users are required to spend staring at the displays of their respective devices.

II. LITERATURE SURVEY

[1] This study centres on the utilization of Augmented Reality (AR) within the context of marine navigation, with the aim of augmenting safety and improving accessibility for navigators of varying levels of expertise. The objective is to enhance onboard safety and streamline navigation processes by facilitating decision-making. The initial phase of the proposed study involved an examination of the graphic design aspects of data visualization interfaces in augmented reality (AR) that have been developed by enterprises operating within the maritime sector. The research conducted indicates that conventional methods of presenting navigation data, such as two-dimensional and alphanumeric formats, are inadequate when utilized in augmented reality interfaces. Conventional two-dimensional diagrams imitate hybrid structures by transforming a limited number of variables into three-dimensional representations. This particular technique is characterized by its ease of acquisition and its ability to help the transfer into the field of human resources. Nevertheless, it has the potential to restrict the scope of design possibilities employed in the development of novel modes of visual communication. The implementation of appropriate augmentation techniques, specifically in relation to the world, has the potential to decrease the cognitive load associated with mental mapping and mitigate the likelihood of distractions. This advantage has been well demonstrated in military aircraft and automobile contexts, however, its application in sailing remains unexplored. In conclusion, the study suggests that a well-designed visual design may lead to less mental fatigue, especially in situations like emergencies and competitions.

[2] Researchers found that projected navigation information had benefits including faster task completion, less angular deviation, and positive subjective feedback from participants during medical needle insertion using augmented reality

displays. The results of the study imply that augmented reality navigation information may be preferable to traditional ways and that a better understanding of the pros and cons of various display modalities may help researchers create more effective needle navigation systems. Augmented reality (AR) has previously been used in surgical navigation systems to address these problems by adding relevant data to the view of the patient. This research endeavours to probe related visual effects for augmented reality needle navigation aids. The VST stationary display, the OST head-mounted display, and the spatial augmented reality projector-camera system are evaluated in comparison to the standard monitor-based method. Every device used the same navigational representation. No absolute aiming accuracy was determined, and the effects of varying registration accuracies were disregarded. Instead, genuine needle stiffness and plastic phantom deformations were compensated for by taking into account separate angle and depth deviation factors. The effects of various display approaches on user performance in guided needle insertion tasks were studied in user research. In order to determine the exact location of the needle, optical tracking data was combined with the known coordinates of fiducial markers to create a global coordinate system. A photogrammetric measurement device was used to acquire a digital surface scan in the world coordinate system by inserting needles into a human torso phantom filled with candle gel and wrapped with a paper towel.

[3] The study's end goal is to develop and test a mobile route guiding software with an augmented reality component that flags potential hazards ahead of time. This will make the software more accessible to users with disabilities, such as low vision. Android will be used for the development of the software, and an Indoor Positioning System (IPS) will be used for its implementation. This study will employ Syiah Kuala University's Building A in Banda Aceh, Indonesia for the development of an object detection system based on BLE beacons. Scrum, an incremental and iterative paradigm for software development, will be utilized to build the system. The system functions by spotting things in the surrounding area, either in three dimensions (using the SSD MobileNet model) or two dimensions (using markers). Whether or not an object is an obstruction is determined by the camera's distance estimate from the object. If the system determines that the object poses a threat, it will issue a warning. Normal obstructions would be signalled with vibrations and an augmented reality (AR) virtual object, whereas rerouted routes would feature warning signs, audible alerts, and app-based notifications. The app's seven primary features include object identification, navigation, and detour creation. It was made with a simple user interface and a directory of available rooms. To implement augmented reality (AR), Kotlin is used as the application's programming language, alongside the AR Core SDK. The pre-trained model, SSD MobileNet v1, quantized by TensorFlow, is used in the application with an emphasis on blue nodes. The app's backend is written in Kotlin, and it stores data locally using SQLite. The technology detects 3D objects and instantly retrieves their accurate heights from a database. According to the results, combining AR with object identification has resulted in a practical application, but the technology may need to be refined. The user's maximum walking speed was determined to be between 1.27 and 1.35 meters per second based on the results of

5.3.1. MAHSA SURVEY PAPER

Augmented Reality-based Indoor navigation: A Survey of Approaches and Strategies

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Abstract—One of the ways that augmented reality (AR) has the potential to revolutionise the process of indoor navigation is by providing users with real-time visual and audible signals that bring them to their destination. This is just one of the many ways that AR has the ability to transform the industry. This review also attempts to see the efficacy of using Artificial Intelligence and Machine Learning in the realm of AR Navigation. This literature review provides a comprehensive summary of the current state of augmented reality (AR)-based indoor navigation. It discusses the several technologies that have been implemented, the challenges that have been met, and the prospective study areas for the future.

Keywords — *augmented reality, navigation, indoor navigation, artificial intelligence, machine learning.*

I. INTRODUCTION

Indoor navigation is a challenging task, especially in large and complex buildings. Augmented reality (AR) has the potential to revolutionize indoor navigation by providing users with real-time visual and auditory cues to guide them to their destination. AR can overlay digital information onto the real world, such as arrows, directions, and points of interest, which can help users find their way around complex indoor environments, such as airports, shopping malls, and hospitals. AR-based indoor navigation systems have several advantages over traditional navigation systems, such as GPS. AR systems can provide more accurate and up-to-date information, especially in indoor environments where GPS signals are weak or unavailable. AR systems can also provide users with more contextual information, such as the location of nearby businesses and amenities. Additionally, AR systems can be used to provide users with turn-by-turn navigation instructions, making it easier for users to find their way to their destination.

However, AR-based indoor navigation systems also face a number of challenges. One challenge is that AR systems can be computationally expensive, which can limit their use on mobile devices. Another challenge is that AR systems can be sensitive to changes in the environment, such as lighting and occlusion. Additionally, AR systems need to be carefully designed to ensure that they are user-friendly and do not distract users from their surroundings.

Despite these challenges, AR-based indoor navigation has the potential to revolutionize the way we navigate indoor environments. AR-based navigation systems can make it easier and more efficient for people to find their way around, especially in large and complex buildings. AR-based navigation systems can also help to improve the accessibility of indoor environments for people with disabilities. Special areas of interest in AR-based indoor navigation are:

A. Efficient and lightweight AR algorithms

Fileless The computational burden that comes with running augmented reality applications on mobile devices is one of the primary challenges that augmented reality (AR)-based indoor navigation systems have to overcome. The algorithms used in augmented reality (AR) have a significant computational burden, which can limit the effectiveness of AR-driven navigation systems when they are deployed on mobile devices.

B. Flexibility in AR systems

An additional difficulty that must be overcome by augmented reality-based indoor navigation systems is the vulnerability of augmented reality systems to changes in the immediate environment in which they are located. The performance of augmented reality (AR) systems can be

giving the commuters a clear view of the pathway indications avoiding confusions leading to accidents.

5.3. PUBLISHED WORK

Two papers have been published thus far - a survey paper to verify feasibility of the project and another research paper detailing the modified A* algorithm.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. CONCLUSION

Augmented reality (AR) navigation is a rapidly evolving field with the potential to revolutionise the way we navigate our world. AR navigation applications can provide users with more accurate, real-time directions, as well as additional information about their surroundings, such as points of interest, traffic conditions, and a lot of location information.

AR navigation applications also have the potential to improve safety and accessibility. For example, AR navigation can be used to help drivers stay focused on the road by providing directions in their field of vision, without having to look down at a smartphone or GPS device and further visualize from the 2D navigation in it. AR navigation can also be used to help people with disabilities navigate their surroundings more easily.

Overall, AR navigation is a promising technology with the potential to make our lives easier, safer, and more accessible. However, there are still some challenges that need to be addressed before AR navigation can reach its full potential. For example, AR navigation applications can be computationally demanding, which can limit their battery life and performance. Additionally, AR navigation applications need to be carefully designed to minimize distractions and ensure safety.

5.2. FUTURE WORK

The work is a demo of a residential Apartment, where this will be implemented with advanced features like obstruction detection, panic escape and smart rerouting using AI and ML trained datasets.

This model will be replicated to all the spaces like Schools, Malls, Museums, Tourist places, Universities, etc. with the advanced AR Traffic navigation

From figure 4.7 to 4.13 shows the images display real-time navigation overlaid onto a live indoor environment, guiding users to their destination within an apartment setting. Navigation marks indicate the direction, including buttons for elevator access, ensuring seamless progression. This immersive application streamlines indoor navigation, optimising efficiency and user experience.

4.2. PERFORMANCE ANALYSIS

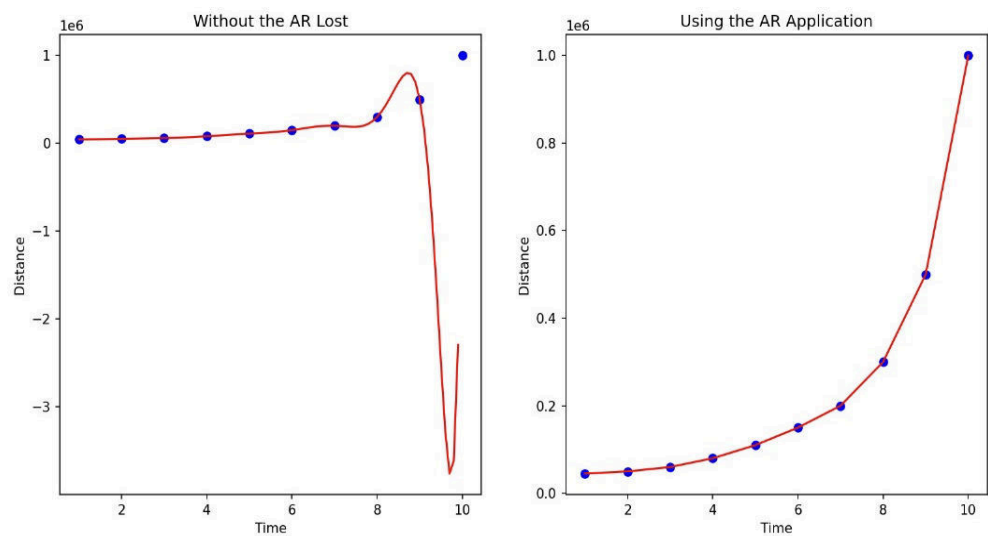


Fig.4.14 Performance analysis

The results of our evaluation show that the AR - based navigation application is a viable solution for emergency situations. The application is able to find the safest and quickest path to the exit, even in complex and dangerous environments. The application is also easy to use, as demonstrated by the results of the user study

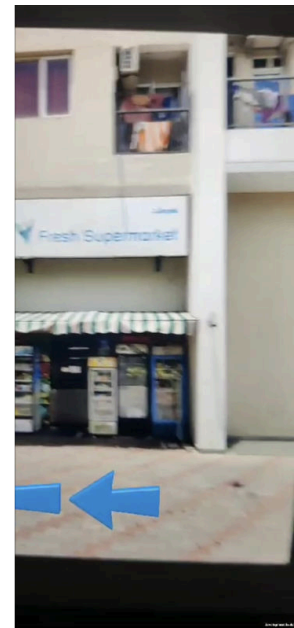
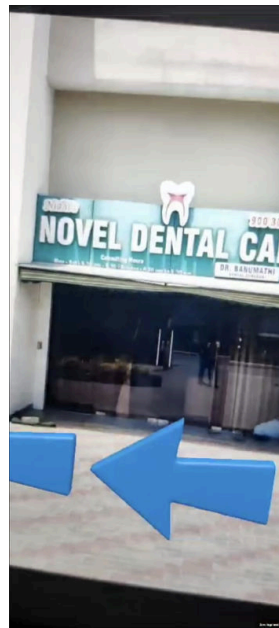
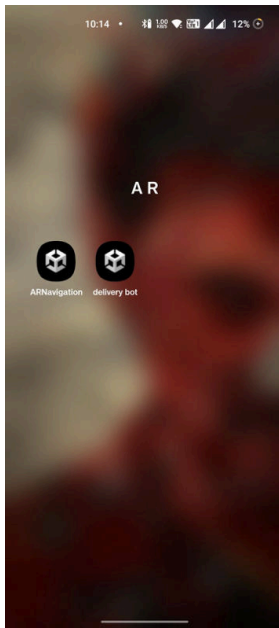


Fig 4.7. Application for the Augmented Based Navigation system.

Fig 4.8. Directions shown to enter into the Apartment

Fig 4.9, 4.10. Directions shown to go around the Apartment

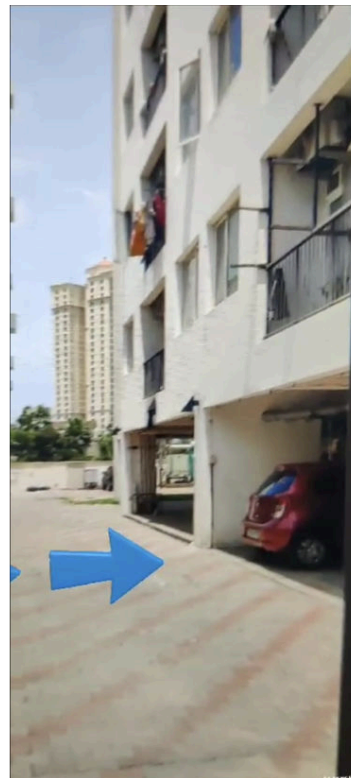
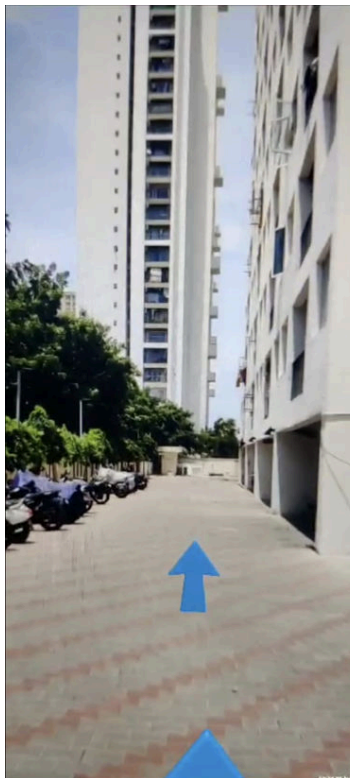


Fig 4.11, 4.12. Directions shown to go around the Apartment

Fig 4.13. In case if we need to use the lift, an arrow will be shown on the floor we need to go

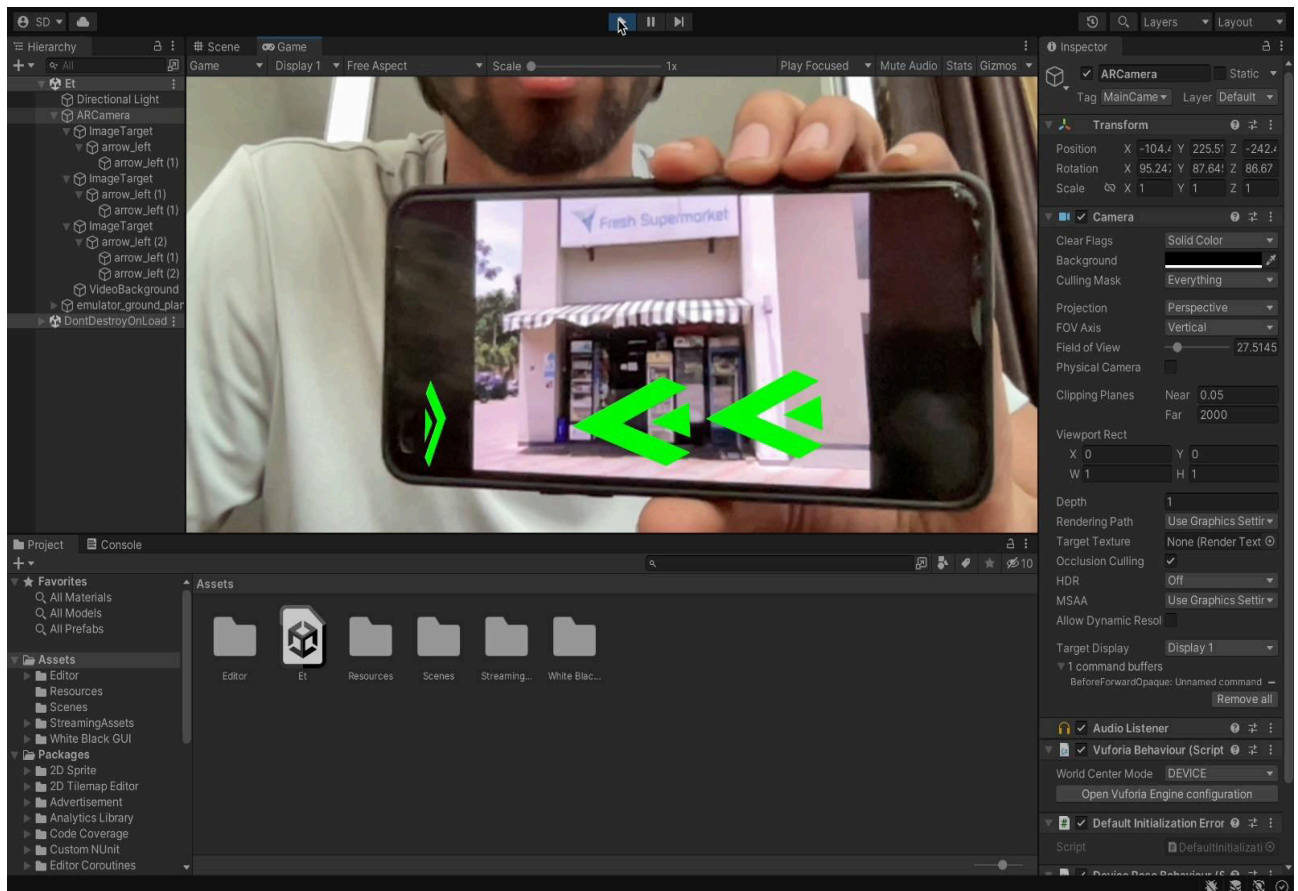


Fig.4.6. Augmented Indicator imposed on Real time image of residential mart

Figure 4.6 shows the image of the apartment's residential mart has been augmented with directions to the back of the apartment. Above we can see the directions are shown in such a way that it indicates to turn right. While augmenting in the real world, we can see that the arrows will be perfectly aligned which the environment

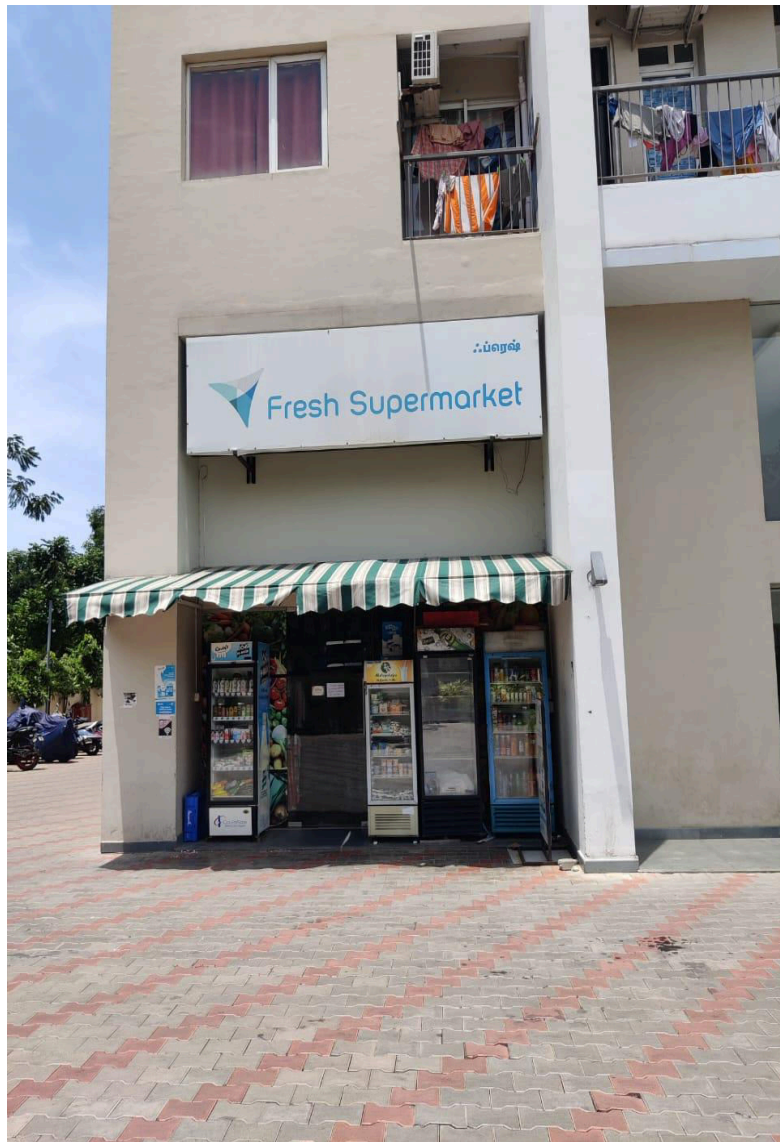


fig.4.5. Real-Time image showing super market of an Residential Apartment

Figure 4.5 shows a picture of the supermarket of a residential apartment. From here, we will walk to the back side of the apartment. And to go so we will be placing the Camera over this image to augment the 3D object for navigation. Here we will take a turn to the right to go back around the apartment. While taking the images we need to be with utmost care as it is an important part.



Fig.4.4. Augmented Indicator imposed on Real time image of Entrance

Figure 4.4 shows the unity page, where the Augmented reality navigators to enter the apartment are displayed on our screen when we point our camera at the image of the apartment entrance. Previously done work will be shown here as how we navigate. We can see that the arrow are augmented on the real time image or the image of the entrance.

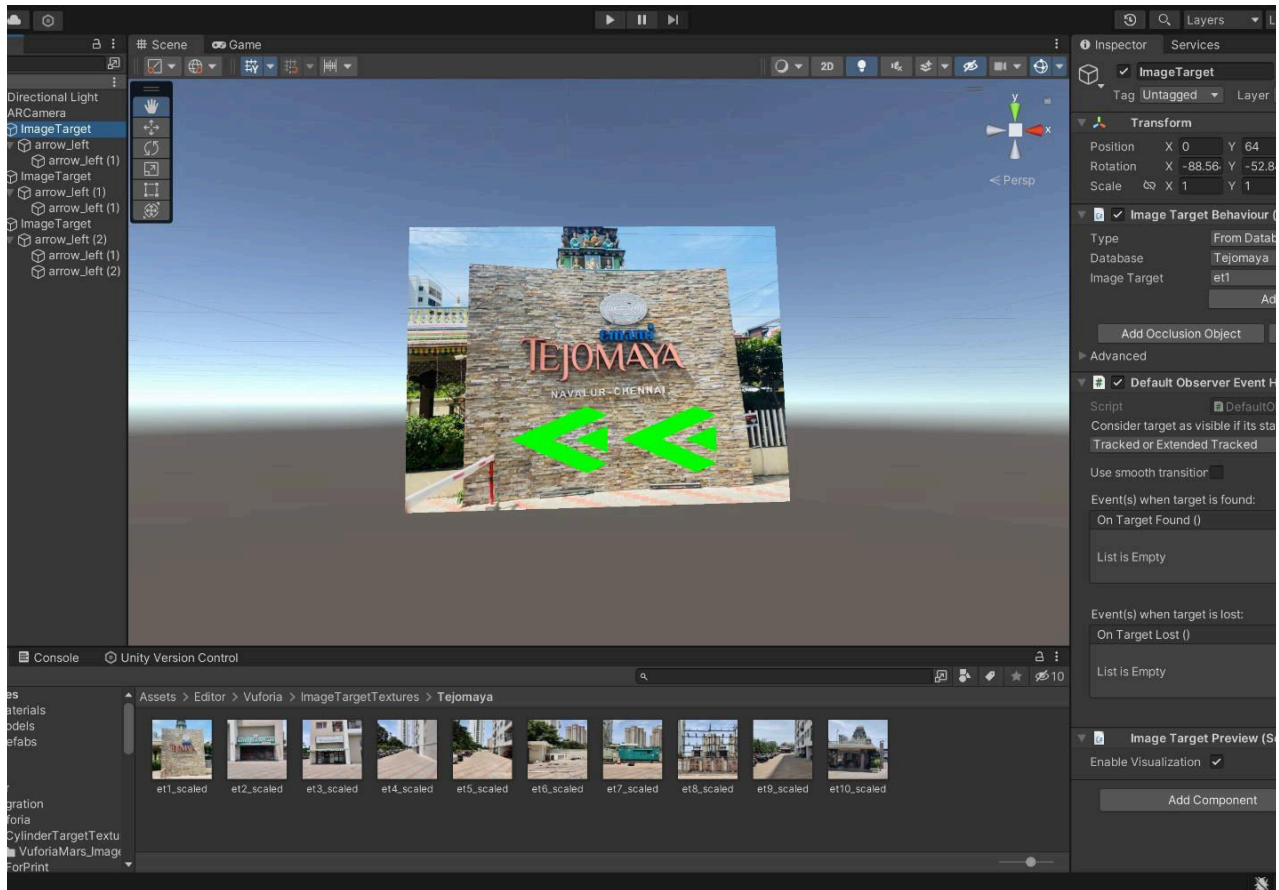


fig.4.3. Targeting AR indicators on Database of Real time images

Figure 4.3 shows the part in Unity where the images are targeted for getting imposed to display the augmented info through 3D objects like the arrow marks to provide indication. Here we add the direction in which way we want to navigate through the map. We can add detailed information also like turn this way or turn that way etc.



fig.4.2 Real-Time image showing Entrance of an Residential Apartment

Figure 4.2 shows a picture of the entrance of a residential apartment. From here, we will walk into the apartment. And to go so we will be placing the Camera over this image to augment the 3D object for navigation. The image captured with detail of light and dept in the image can make the picture very clear easy to make the process of Augmentation

CHAPTER 4

RESULTS AND DISCUSSION

4.1. RESULTS

This is a minute trial done in a residential community. And here are its results:

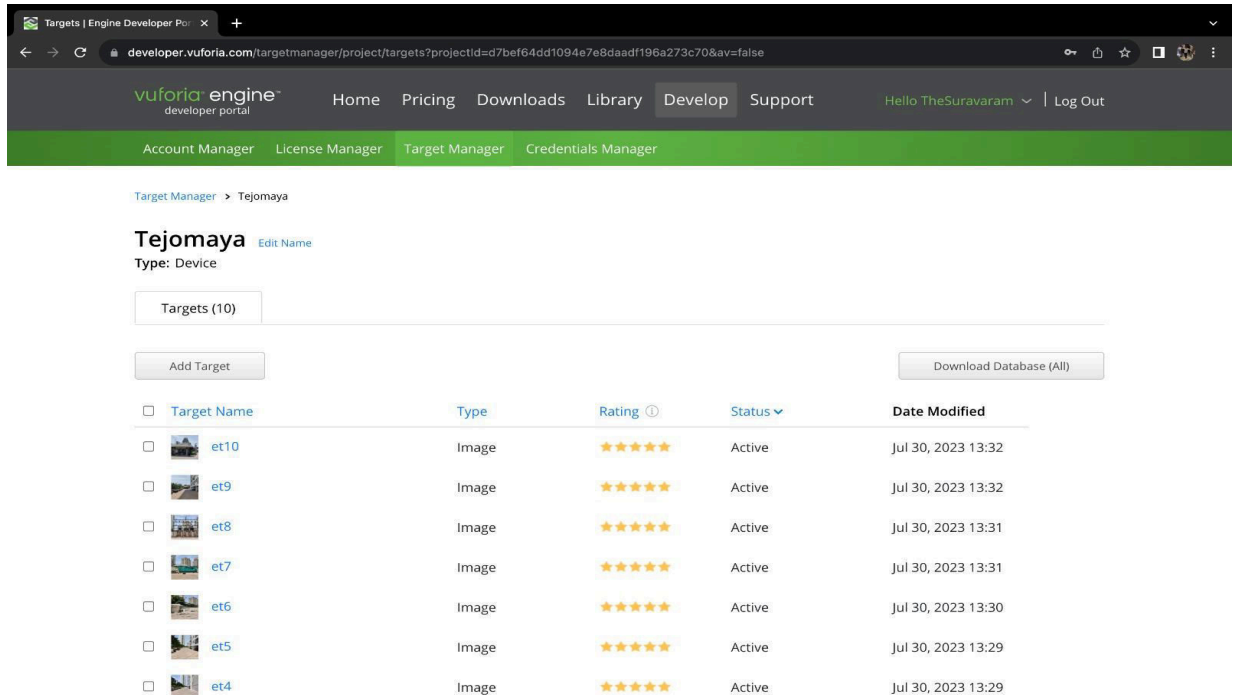


fig.4.1. Vuforia Engine Target Manager Page

Figure 4.1 shows the page where we upload the Target images of the places we want to navigate the direction in the vuforia engine and it gives us an rating for the augmentation of the image. Based on the star, we can tell the augmentability of the image we uploaded. More the stars , the more accurately the image can be augmented. Less stars means that the image we uploaded is not good or less augmentable.

3.9. Project Risks:

The following are some of the risks associated with this project:

- The data may not be accurate or complete.
- The machine learning model may not be able to accurately detect obstructions or generate emergency escape routes.
- The application may not be user-friendly.

3.9.1. Project Mitigation Strategies:

The following are some of the mitigation strategies that will be used to address the risks identified above:

- The data will be carefully collected and cleaned to ensure that it is accurate and complete.
- The machine learning model will be trained on a large dataset of data to improve its accuracy.
- The application will be designed with user-friendliness in mind.

3.6. ARCHITECTURE OF THE PROPOSED SYSTEM

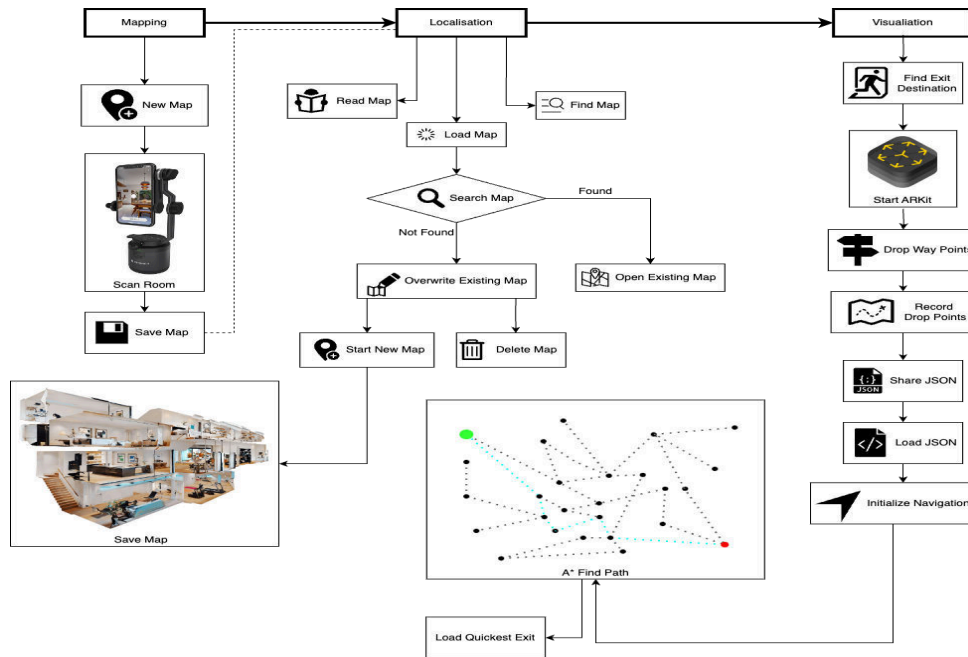


Fig 3.2 Workflow Architecture

The project is going to be executed in the following software. Unity 3D, Vuforia SDK and a set of training dataset models for smart detection. It is pertinent to be cognizant of the fact that the degree of usage of a particular software is directly proportional to the particular requirement that it maps to.

3.8. Project Scope:

The scope of this project includes the following:

- Collecting data on AR navigation, obstruction detection, and emergency escape routing.
- Cleaning and preparing the data.
- Training a machine learning model to detect obstructions and generate emergency escape routes.
- Testing the machine learning model on a validation dataset.
- Deploying the machine learning model to the AR navigation application.

locations in the database.

In the next step, the navigation indicators are augmented. This is done by adding virtual objects to the real-world environment to help users navigate. For example, arrows can be added to the ground to indicate the direction of travel.

These three steps form the foundation of the system. The database of locations provides the information that the system needs to function, the marked locations allow the system to identify the user's location, and the augmented navigation indicators help the user navigate the environment.

Over this foundation, we will train the datasets of obstructions. This is done by collecting data on the different types of obstructions that can be found in the environment. The data is then used to train a machine learning model that can identify obstructions.

The trained model will be used to detect obstructions in real time. This information will be used to update the navigation indicators and to provide warnings to the user.

For ease in navigation and routing after obstruction detection, we will use GMap API support. This will allow us to access real-time traffic data and to generate the most efficient routes.

Similarly, we shall also build a model that will help people in an emergency situation to escape in the most ideal route where he/she can stave of danger. This model will be trained on data from past emergencies and will be able to identify the safest route to escape.

The system will be a valuable tool for people who are navigating in unfamiliar environments. It will help them to find their way around, to avoid obstacles, and to escape from dangerous situations.

- **User Interaction Tracking:** The user interaction tracking component tracks the user's interactions with the AR environment.

The localization and mapping components work together to track the user's position and orientation in the real world and to create a map of the environment. The navigation component uses the map to calculate the best route for the user to take to their destination. The AR engine renders the virtual objects in the real world, using the localization and mapping data to position and orient the virtual objects correctly.

The object recognition component can be used to identify objects in the real world, such as specific landmarks or points of interest. This information can be used to provide the user with more context-aware navigation directions or to provide additional information about the objects that the user is interacting with.

The user interaction tracking component can be used to track the user's interactions with the AR environment, such as the user's gaze or gestures. This information can be used to control the AR experience and to provide the user with a more immersive experience.

The user interface provides the user with information and instructions, such as the user's current location and the directions to the destination. The user interface can be displayed on the screen of a mobile device, on a smart glasses device, or on another type of display device.

This is just a simplified example of an AR navigation architecture. More complex AR navigation applications may include additional components, such as a component for natural language processing or a component for machine learning.

Initially, a database of locations is created and initialised. This database will be used to store the locations of all the important points in the environment, such as exits, stairs, and elevators.

Next, the locations in the database are marked. This is done by assigning a unique identifier to each location. The identifiers can be used to refer to the

3.5. SYSTEM ARCHITECTURE

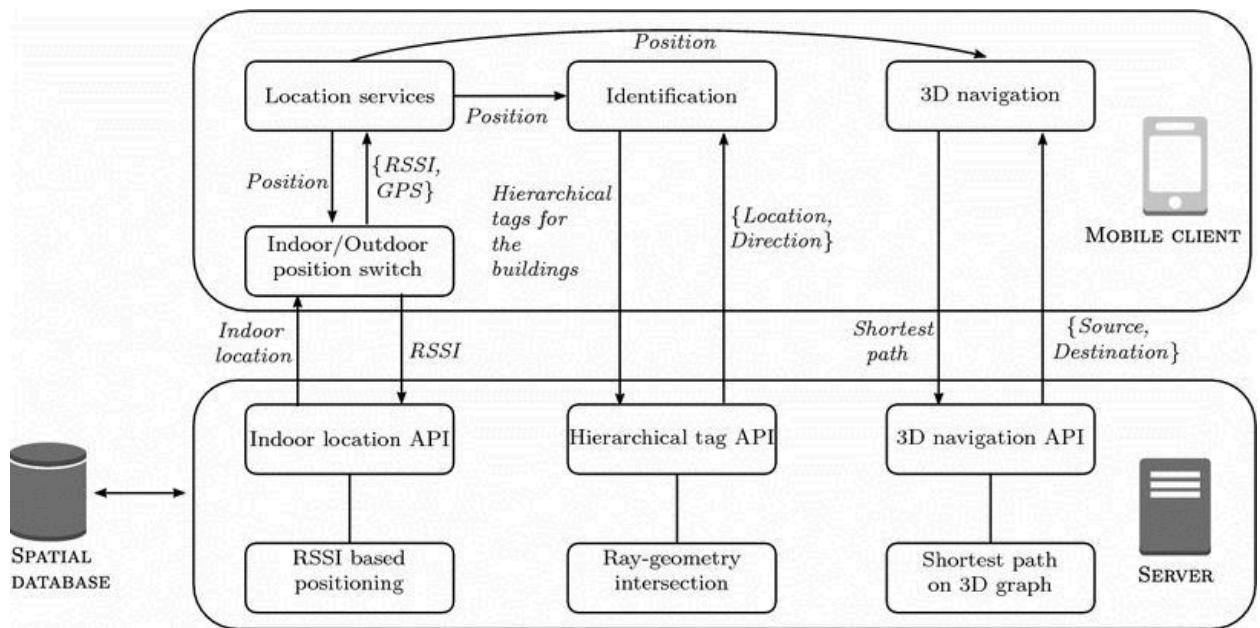


Fig 3.1 Framework Architecture of Vuforia Engine

Here is a more detailed architecture diagram for AR navigation:

- **Localization:** The localization component tracks the user's position and orientation in the real world.
- **Mapping:** The mapping component creates and maintains a map of the environment.
- **Navigation:** The navigation component calculates the best route for the user to take to their destination.
- **AR Engine:** The AR engine renders virtual objects in the real world.
- **User Interface:** The user interface provides the user with information and instructions.
- **Object Recognition:** The object recognition component identifies objects in the real world.

5.1 Use YOLO to identify objects in the environment.

5.2 Assign danger values objects based on threat level.

Step 6: A* Pathfinding

6.1 Use A* pathfinding algorithm to find the shortest and safest path from the user's location to the exit.

6.2 The danger values $d(n)$ detected by YOLO are added to the cost values of the nodes.

Step 7: User Interface

7.1 Display the path on the screen using AR elements, such as directional arrows and waypoints.

7.2 Display alerts to the user about nearby hazards.

7.3 Provide emergency contact information within the application.

3.4.4 Additional Steps

Pre-requirement: Training the YOLO Model The YOLO object detection model needs to be trained on a dataset of images of the objects that are likely to be encountered in the disaster situation. This will help the model to accurately identify and classify objects in the environment.

Post-requirement: Integrating with First Responder Systems The AR navigation app could be integrated with first responder systems to provide real-time information about the location of victims and hazards. This would help first responders to respond more quickly and effectively to disaster situations.

$$\begin{aligned}
 d(n) &= 100 \text{ (flames)} \\
 h(n) &= 10 \text{ metres (to exit - 1)} \\
 f(n) &= g(n) + h(n) + d(n) = 0 + 10 \text{ metres} + 100 \\
 &= 110 \text{ metre}
 \end{aligned}$$

b) Path 2:

$$\begin{aligned}
 d(n) &= 50 \text{ (elevator)} \\
 h(n) &= 20 \text{ metres (to exit - 2)} \\
 f(n) &= g(n) + h(n) + d(n) = 0 + 20 \text{ metres} + 50 \\
 &= 70 \text{ metres}
 \end{aligned}$$

c) Path 3:

$$\begin{aligned}
 d(n) &= 0 \text{ (no danger)} \\
 h(n) &= 25 \text{ metres (to exit - 2 via the staircase)} \\
 f(n) &= g(n) + h(n) + d(n) = 0 + 25 \text{ metres} + 0 \\
 &= 25 \text{ metres}
 \end{aligned}$$

Since Path 3 has the lowest total cost $f(n)$, the A* algorithm would select Path 3 as the safest path to the exit. This example illustrates how a modified A* algorithm determines the safest path to the goal node in the AR disaster response application during calamities and crises.

D) Proposed modifications to A* algorithm The proposed algorithm will always select the path that minimises the user's exposure to danger.

Step 1: Mapping

1.1 Scan the areas to be localised with the device camera such as entrances, common areas, and staircases and save it in a JSON file.

Step 2: Server Integration

2.1 Setup and obtain a licence key for PlaceNote.

2.2 Upload the map file to the PlaceNote SDK cloud database.

Step 3: Unity Implementation

3.1 Import the PlaceNote SDK into a Unity project.

Step 4: Waypoint Dropping

4.1 Scan the environment and drop waypoints along the desired path using the breadcrumb path creation.

Step 5: YOLO Object Detection

values indicate greater harm. For example, fire has a greater danger value than debris. The A* algorithm is employed for path-finding. It locates the shortest path from the user's current location to the nearest exit by assigning a cost value to each node based on the distance to the next node and the danger values. After several iterations, the node with the lowest cost value is selected. Therefore, if there is a large pile of debris along the path, the A* algorithm will find a route that goes around the debris, even if it is slightly longer. The A* algorithm initialises an open set and a closed set. $g(n)$ is the cost from the start node to the current node, $h(n)$ is defined as the heuristic estimate of cost from the current node to the goal node i.e., the exit and $d(n)$ determines the level of danger. Then the total cost $f(n)$ is calculated, as in:

$$f(n) = g(n) + h(n) + d(n)$$

A* algorithm evaluates cost of each path and selects the shortest path with the least cost. This implies that it will avoid obstacles and danger as those nodes have higher cost values. This would be implemented as illustrated in the following contextual scenario.

Context: The user is trapped in the second floor of a building during a fire emergency. There are two exits, exit-1 and exit-2 on the ground floor. There are two options to safely reach the ground floor, one is to take the stairs and the other is to take the elevator.

Implementation: The user is 10 metres away from the nearest emergency exit – 'exit-1', and 20 metres from 'exit-2'. The available paths to the exit are:

- a) Path 1: 10 metres long via exit-1, passing through the fire.
- b) Path 2: 20 metres long via exit-2, while avoiding the fire, but taking the elevator.
- c) Path 3: 25 metres long via exit-2, while avoiding both the fire and the elevator.

3) Calculation: The A* algorithm would calculate the total cost $f(n)$ for each path with the following constraints: User is at

$$g(n) = 0; d(n) \text{ for Fire} = 100; d(n) \text{ for Elevator} = 50$$

a) Path 1:

3.4.2 Localisation

Localisation is the detection of the location of a device with respect to its environment. It comprises of numerous aspects namely Position tracking, Orientation, tracking, Map alignment, Obstacle detection, Wayfinding and AR Overlays. Navigation in emergency situations requires robust localisation and adaptability due to changing unforeseen circumstances. Position tracking pinpoints the device location like GPS (Global Positioning System). This project adopts the usage of Waypoints or cloud anchors. They are dropped along like bread crumbs, visually represented by golden orbs using augmented reality techniques. Path-finding waypoints are recorded and define a walkable path. Map Alignment refers to placing the user's live location in tangent to the 3D virtual map model that was developed in the previous stage. This is a vital step as it bridges the gap between the tangible physical environment and the digital map. Augmented Reality elements are overlaid on the screen over the physical environment as seen from the camera. Alerts and additional directional information, including the location of wildfires, flood zones, and other hazardous areas thus providing the ultimate Augmented Reality experience. Accurate localisation permits seamless integration of AR and the real world. Here the digital augmented reality elements and map models are integrated with the physical world using a camera whilst keeping track of the real time position. Therefore, localisation is crucial for AR Navigation in emergency situations for users to stay aware of their surroundings, avoid hazards, find the quickest and safest way to their destination, coordinate with first responders and other personnel, and get real-time information about the location of victims, and assess the damage caused.

3.4.3 Path Finding

Once the augmented reality elements have been integrated into the application, it must direct the user to the safest and quickest exit. To achieve this, the A* pathfinding algorithm is employed in two different ways. YOLO object detection model identifies objects in the environment and assigns danger values that represent the level of danger an object poses, higher

PlaceNote SDK maps and stores spatial data for future retrieval. If the building were to collapse, debris may lie in places and a mere floor plan is insufficient. The machine learning model YOLO enhanced the field of computer vision and object detection. Here, YOLO is harnessed to identify obstructions in real-time situations. For instance, it will identify debris which was not there before. Subsequently, the objects assessed by YOLO are allotted danger values which are supplied to the A* algorithm. It then determines the suitable path and may redirect the user accordingly.

3.4.1 Mapping

The predicament with most navigation applications is the requirement of a pre-existing map model of the building. This is preloaded into Unity after which AR navigational features are programmed with relation to the structure and architecture of the building. This demands preparatory work for each map model and location. In contrast, this AR based navigation system truly follows AR principles and employs a CreateMaps method in C# which allows the user to scan the area, chart out the layout of the building and plot Path Finding Anchors. Thus mapping the individual objects and blueprint of the rooms. Users can experience true AR based Navigation as PlaceNote SDK is utilised to store these map models. It integrates ARKit with its cloud based storage and stores up to 50 maps for 50 users for free. PlaceNote SDK API (Application Programming Interface) requires a valid licence. An API key has been procured from the official source. The rooms and passageways are scanned with the device camera. Consequently, the software simulates a 3D model of the layout of premises for augmented navigational assistance using the cross-platform solution PlaceNote SDK. The mapped data is serialised, uploaded and stored within PlaceNote Database for future reference as a dictionary in a JSON (JavaScript Object Notation) file. Each place possesses an ID, time it was created and the GPS location i.e., the altitude, latitude and longitude. Metadata such as type and position as well as dimensions of the rooms and the building are also retained within the PlaceNote SDK Cloud Storage database.

emergency escape routes. There are a variety of machine learning models that can be used for this task, such as support vector machines, decision trees, and neural networks.

- Test the machine learning model on a validation dataset. This is a dataset that was not used to train the model. The purpose of this step is to evaluate the performance of the model on unseen data.
- Deploy the machine learning model to the AR navigation application. This involves integrating the model into the application so that it can be used to detect obstructions and generate emergency escape routes.

The above is just a general steps. The specific steps involved in developing an AR navigation application that uses machine learning may vary depending on the specific application and its own set of requirements and needs.

The proposed AR-based indoor navigation utilises YOLO,Unity based Augmented Reality, A* algorithm and PlaceNote SDK all of which operate in tandem for quick and safe navigation in dire circumstances. To build the application, there are three plausible methods. First, the placement of sensors in strategic points but this is not feasible on a global scale and it breaches privacy protocols. Second, RSSI Wi-Fi Fingerprinting that uses signal strength to determine the device's indoor location, but it is affected by inference, additionally iOS does not grant access to sensitive information like the MAC (Media Access Control) Address. The final most prudent option is to create a floor map of the layout of the building by scanning the rooms with the device camera and constructing a 3D model of the rooms. Mainstream options like ARCore pose notable limitations. ARCore uses Cloud Anchors which are stored for merely 24 hours which befits an AR Multiplayer game but the ephemeral nature of the data storage system does not yield itself to an AR based Navigation system. The time constraint indicates there will be no retention of maps over a prolonged passage of time. On the other hand, our augmented reality based indoor navigation methodology uses PlaceNote SDK, A* algorithm, and YOLO algorithm. The following Figure 1 illustrates the same.

Overall, Vuforia SDK is a powerful and versatile tool that can be used to create AR applications for a variety of purposes. It is a popular choice for developers of all levels of experience

3.3. OBJECTIVES :

- To develop an AR navigation application that can help the users to navigate through outdoors and indoors and can accurately detect obstructions in the user's path and even generate emergency escape routes. The application should be safe, effective, and user-friendly.
- To integrate AR for emergency navigation, providing real-time guidance for smoother indoor movement during critical situations, enhancing safety and efficiency in emergencies.
- To elevate user experience with interactive AR features, ensuring intuitive navigation indoors, minimising confusion, and optimising engagement for seamless exploration of indoor spaces.
- To showcase innovation through AR, computer vision, and spatial mapping technologies, creating a seamless indoor navigation experience that promotes exploration and discovery in diverse environments.

3.4. METHODOLOGY:

Here is a more detailed explanation of each step:

- Collect data on AR navigation, obstruction detection, and emergency escape routing. This data can be collected from a variety of sources, such as GPS data, map data, and video footage. The data should be labeled to indicate the presence or absence of obstructions and the location of emergency escape routes.
- Clean and prepare the data. This involves removing any errors or inconsistencies in the data. The data may also need to be normalized to ensure that it is in a format that can be used by the machine learning model.
- Train a machine learning model to detect obstructions and generate

Vuforia SDK is supported by a variety of devices, including smartphones, tablets, and head-mounted displays.

Vuforia SDK has a number of features that make it a popular choice for AR development:

- Accurate tracking: Vuforia SDK uses computer vision techniques to track the position and orientation of physical objects in the real world. This ensures that the virtual objects are overlaid accurately on the real world.
- Wide range of supported devices: Vuforia SDK is supported by a variety of devices, including smartphones, tablets, and head-mounted displays. This makes it a good choice for developers who want to create AR applications that can be used on a variety of devices.
- Easy to use: Vuforia SDK is relatively easy to use, even for developers who are new to AR development.
- Powerful features: Vuforia SDK has a number of powerful features, such as object recognition, image tracking, and environment mapping. These features can be used to create complex and immersive AR experiences.

Vuforia SDK is used by a wide range of companies and organizations to create AR applications for a variety of purposes. Some examples of Vuforia SDK applications include:

- Educational applications: Vuforia SDK can be used to create educational applications that overlay virtual objects on the real world. This can help students to learn more about different subjects in a more engaging and interactive way.
- Gaming applications: Vuforia SDK can be used to create gaming applications that overlay virtual objects on the real world. This can create a more immersive and engaging gaming experience.
- Navigation applications: Vuforia SDK can be used to create navigation applications that overlay directions and other information on the real world. This can help people to navigate more easily and efficiently.
- Enterprise applications: Vuforia SDK can be used to create enterprise applications for a variety of purposes, such as product training, maintenance, and marketing.

easy to use and has a wide range of features. It also supports a variety of platforms, including mobile devices, desktop computers, and consoles.

Here are some of the key features of Unity 3D:

- 3D graphics: Unity 3D supports a variety of 3D graphics features, including rendering, lighting, and animation.
- Physics: Unity 3D has a built-in physics engine that can be used to simulate the behavior of objects in the real world.
- Scripting: Unity 3D supports C# and JavaScript scripting, which allows developers to create custom features and behaviors for their games.
- Asset store: Unity has a built-in asset store where developers can download and purchase pre-made 3D models, textures, scripts, and other assets.

Unity 3D is used to create a wide variety of games, including:

- Mobile games: Unity is a popular choice for mobile game development because it is optimized for performance on mobile devices.
- Desktop games: Unity can also be used to create desktop games. Some popular desktop games that were created with Unity include Hearthstone, Cuphead, and RimWorld.
- Console games: Unity can also be used to create console games. Some popular console games that were created with Unity include Pokemon Go and Call of Duty: Mobile.

Unity 3D is a powerful and versatile game engine that can be used to create games for a variety of platforms. It is a popular choice for game developers of all levels of experience.

Vuforia SDK

Vuforia is a software development kit (SDK) that allows developers to create augmented reality (AR) applications. Vuforia SDK uses computer vision techniques to track the position and orientation of physical objects in the real world. This allows AR applications to overlay virtual objects on the real world.

paying attention to their surroundings. If the application is too distracting, it could lead to accidents. The AR application can be designed to be less distracting. For example, the application can be limited to displaying navigation instructions when the user is not moving.

To mitigate this risk, the AR application should be designed to be easy to use and understand. The instructions should be clear and concise, and they should not be too intrusive.

3.2. SOFTWARE AND HARDWARE REQUIREMENTS

3.2.1. HARDWARE REQUIREMENTS

CPU: x86 or x64 architecture with SSE2 instruction set support.

Memory: 8GB RAM or more.

Storage: 20GB of available disk space.

Graphics: OpenGL 3.2+ or Vulkan-capable GPU.

Mobile Device: Android 8.0 or above

3.2.2. SOFTWARE REQUIREMENTS

Operating system: Windows 7 (SP1+) or later, macOS High Sierra 10.13+, Ubuntu 20.04 and Ubuntu 18.04, or a supported version of Linux.

3.2.3. FRAMEWORKS

Unity 3D

Unity 3D is a cross-platform game engine developed by Unity Technologies. It is used to create 2D and 3D games, simulations, and other interactive experiences. Unity is a popular choice for game developers because it is

the safety of the user in the event of a fire, earthquake, or other emergency. The AR application can be pre-programmed with escape routes for different types of emergencies. The application can also allow users to customize their escape routes.

To mitigate this risk, the AR application can be designed to be easy to use and understand. The instructions should be clear and concise, and they should be tailored to the specific emergency.

Cybersecurity risks:

The AR application must be secure from cyberattacks. If the application is hacked, it could be used to spread malware or steal user data. The AR application can be protected by using strong encryption and authentication methods. The application can also be regularly scanned for vulnerabilities.

To mitigate this risk, the AR application should be developed using secure coding practices. The application should also be regularly updated with security patches.

Privacy risks:

The AR application must collect and use user data in a responsible manner. If the application collects too much data or uses it for unauthorized purposes, it could violate user privacy. The AR application should only collect the data that is necessary for its operation. The data should also be anonymized or pseudonymized to protect user privacy.

To mitigate this risk, the AR application should have a clear privacy policy that is easily accessible to users. The application should give users their privacy.

User distraction:

The AR application must not be so distracting that it prevents users from

CHAPTER 3

METHODOLOGY

3.1. RISK ANALYSIS OF THE PROJECT:

Accuracy of the AR data:

The AR data used to generate the navigation instructions must be accurate and up-to-date. This means that the data must be collected from reliable sources and must be regularly updated to reflect changes in the environment. If the data is inaccurate, it could lead to users getting lost or injured.

To mitigate this risk, the AR application can use a variety of methods to validate and verify the accuracy of the data. For example, the data can be cross-referenced with data from other sources, such as GPS data or map data. The data can also be checked for inconsistencies and errors.

Obstruction detection:

The AR application must be able to accurately detect obstructions in the user's path. This is important for preventing collisions and ensuring the safety of the user. The AR application can use a variety of sensors to detect obstructions, such as cameras, radar, and lidar. The application can also use machine learning to identify and track obstructions.

To mitigate this risk, the AR application can use a combination of sensors and machine learning techniques. The application can also be designed to be sensitive to changes in the environment, such as the presence of moving objects.

Emergency escape routing:

The AR application must be able to provide users with clear and accurate instructions for escaping from an emergency. This is important for ensuring

Deployment and distribution:

- Select suitable distribution channels and platforms for publishing the AR/VR application, such as app stores, digital marketplaces, or enterprise distribution systems.
- Create advertising materials, app descriptions, and images to entice consumers and increase downloads.
- Submit the application to the distribution channels you've chosen, following the rules for approval and publishing.

Content Creation and Asset Development:

- Create AR/VR content, including 3D models, animations, textures, and audio files.
- Optimise content for performance, scalability, and compatibility with the intended platforms and devices.

Software Development:

- Select the proper development tools, frameworks, and platforms for creating the AR/VR application.
- Implement essential features like rendering, user interaction, input handling, and scene management.
- Advanced features may need the integration of sensor data processing, tracking algorithms, and other APIs.

Quality Assurance (QA):

- Conduct thorough testing to discover and resolve bugs, performance difficulties, and usability concerns.
- To guarantee compatibility and consistency, test the application across several devices, platforms, and environments.
- Collect input from beta testers or user focus groups to determine user happiness and improve the user experience.

Optimisation & Performance Tuning:

- Optimise the application's performance, efficiency, and resource utilisation to enable seamless and responsive user interactions.
- Optimise frame rates and minimise latency by fine-tuning rendering parameters, asset loading algorithms, and memory management.
- To maximise performance, use techniques like level-of-detail rendering, occlusion culling, and asynchronous processing.

Hardware Acceleration: Using hardware-accelerated graphics APIs like Vulkan, DirectX, or Metal may outsource rendering duties to specialised GPU hardware, resulting in improved speed and efficiency in AR and VR applications.

Parallel processor: Using multi-threading, parallel computing, and GPU compute shaders, computational workloads may be distributed over numerous processor cores, increasing utilisation and throughput in AR and VR systems.

Optimised Algorithms: Creating and implementing efficient algorithms, data structures, and optimisation techniques that are suited to the unique needs of AR and VR applications can reduce computational overhead while increasing performance scalability.

Development and deployment:

AR navigation applications can be more difficult to develop and deploy than traditional navigation systems. This is because they require the use of computer vision techniques and other complex technologies.

Define objectives and use cases:

- Determine the goals, objectives, and target audience for the AR/VR application.
- Define particular use cases and scenarios for how AR/VR technology may offer value and meet user demands.

Conceptualisation and design:

- Brainstorm ideas and concepts for the AR/VR experience, taking into account user interaction, content display, and immersion.
- Create wireframes, storyboards, or prototypes to help you visualise the user interface, navigation flow, and content organisation.

Sophisticated Geometry and Physics Simulation: AR and VR applications frequently use sophisticated geometric models, physics simulations, and collision detection algorithms to realistically portray virtual objects, interactions, and environmental dynamics. To effectively compute forces, velocities, and collisions, processing resources are required for simulating actual physics behaviours such as gravity, friction, and object interactions.

Sensor Data Processing: Cameras, accelerometers, gyroscopes, and depth sensors are used in AR and VR systems to track user motions, gestures, and interactions in both the physical and virtual environments. Computational techniques are used to process sensor data in real time, conduct sensor fusion, and estimate user postures or gestures, all of which require CPU and GPU resources and have an influence on system performance.

Machine Learning and AI: Integrating machine learning algorithms, artificial intelligence (AI) models, and computer vision techniques into AR and VR systems incurs additional processing costs for training, inference, and real-time data analysis. In AR/VR settings, activities such as object detection, gesture recognition, and scene understanding need computing resources in order to handle enormous datasets and perform sophisticated algorithms effectively.

Power Consumption and Thermal Management: High computational costs in AR and VR systems can result in higher power consumption and heat generation, reducing device battery life, thermal performance, and user comfort. Managing power consumption and thermal dissipation is critical for preventing overheating, increasing energy economy, and ensuring long-term use without sacrificing performance or safety.

Rendering techniques such as level-of-detail (LOD) rendering, occlusion culling, and view frustum culling can help decrease computing costs by prioritising rendering operations depending on scene complexity, camera viewpoint, and visibility restrictions.

However, AR navigation applications also have some challenges of their own. For example, they can be more computationally expensive than traditional navigation systems. This can lead to battery drain and performance issues on mobile devices. Additionally, AR navigation applications can be more difficult to develop and deploy than traditional navigation systems.

Overall, AR navigation has the potential to be a more accurate, efficient, and engaging way to navigate. However, there are still some challenges that need to be addressed before AR navigation can become a mainstream technology.

Here are some additional details about the challenges of AR navigation:

Computational expense:

AR navigation applications require more processing power than traditional navigation systems. This can lead to battery drain and performance issues on mobile devices.

Real-Time Rendering: AR and VR apps rely on real-time rendering of immersive environments, 3D models, and graphical effects to provide users with seamless, responsive interactions and a feeling of presence. Real-time rendering necessitates a significant amount of processing power to produce constant frame rates, minimal latency, and high-quality images, particularly in challenging scenarios with dynamic lighting, complex geometry, and intricate textures.

Images Processing Unit (GPU) Intensive: The ability to render realistic images, visual effects, and animations in AR and VR environments is primarily reliant on GPU capabilities. GPUs use parallel calculations to conduct vertex transformations, rasterization, shading, and post-processing effects, which need substantial computing resources to maintain performance and visual accuracy.

the total cost of deploying AR/VR systems in workplace or institutional contexts.

Training and Support Expenses: Organisations suffer additional expenses when providing training, technical support, and continuing maintenance for AR and VR systems, notably in the form of staff training programmes, certification courses, and external consulting services. Training and support fees are necessary to ensure user competency, system stability, and long-term viability of AR/VR installations, but they can increase the total cost of ownership.

Total Cost of Ownership (TCO): The total cost of ownership for AR and VR systems includes not only the initial purchase price but also ongoing expenses like maintenance, upgrades, licensing renewals, content updates, and infrastructure development. To calculate the total cost of ownership (TCO) for AR/VR investments, all lifetime expenses must be included, as well as the return on investment (ROI) in terms of business value, productivity improvements, and competitive advantage.

AR navigation applications can potentially address some of the challenges of traditional navigation systems. For example, AR navigation applications can use computer vision techniques to track the user's location even in indoor environments, where GPS signals are not available. This can be a major advantage in large and complex buildings, such as airports, hospitals, and shopping malls.

AR navigation applications can also provide real-time information about the user's surroundings. This information can include the location of obstacles, the distance to the user's destination, and the best route to take. This information can help users avoid obstacles and make better navigation decisions. In addition, AR navigation applications can be more engaging than traditional navigation systems. AR applications can overlay virtual information on the real-world environment, which can make navigation more fun and intuitive.

High initial investment: For many organisations and users, the cost of obtaining AR and VR gear, software, and infrastructure is too expensive. High-end VR headsets, AR glasses, motion tracking systems, and content development tools can be expensive, making it difficult for people, small enterprises, and educational institutions to participate in the AR/VR ecosystem.

Hardware Costs: Organisations implementing immersive technology solutions may incur large costs for AR and VR hardware components such as head-mounted displays (HMDs), sensors, controllers, and computer systems. High-quality gear with sophisticated features, such as high-resolution screens, accurate tracking, and ergonomic design, is sometimes expensive, restricting accessibility and affordability for cost-conscious customers.

Software Licencing Fees: Depending on the licensing model and use conditions, AR and VR software platforms, development tools, and content production software may include licensing fees, subscription expenses, or royalties. Software expenses can increase the overall cost of adopting AR/VR solutions, especially for commercial applications that require access to proprietary development environments or expensive content libraries.

Content Production Costs: Creating high-quality AR and VR content, such as 3D models, animations, simulations, and interactive experiences, necessitates an investment in talent, resources, and production equipment.

Content creation costs, such as pay for artists, designers, and developers, as well as charges for software licences, hardware equipment, and production facilities, may be significant, particularly for large-scale projects or custom-tailoring experiences.

Infrastructure Requirements: Deploying AR and VR systems may necessitate investments in supporting infrastructure such as network infrastructure, computing resources, and storage solutions to manage data processing, content distribution, and system integration. Infrastructure expenditures, such as hardware acquisition, installation, maintenance, and scalability, can add to

Material development Challenges: Creating high-quality material for AR and VR experiences requires skill in digital content development tools and techniques, such as 3D modelling, animation, texture mapping, and spatial audio design. Content developers may encounter challenges in optimising assets for immersive settings, guaranteeing platform compatibility, and preserving consistency in user experience across several devices.

Integrating AR and VR devices with current corporate systems, databases, and processes can be challenging, necessitating customisation, setup, and interoperability testing to ensure seamless data interchange and compatibility with legacy infrastructure. Differences in data formats, protocols, and security requirements between AR/VR devices and current IT infrastructures can all cause integration issues.

Users and administrators of AR and VR systems may need training and assistance to efficiently use, maintain, and debug the technology. To successfully handle the complexity of AR and VR systems, training programmes, documentation, and technical support resources must be easily available, comprehensive, and suited to the demands and skill levels of users.

Addressing complexity in AR and VR systems necessitates a collaborative effort by developers, manufacturers, and stakeholders to simplify user interfaces, speed setup procedures, improve interoperability, and offer proper training and support. The AR and VR industry can overcome complexity-related challenges by adopting user-centric design principles, standardising hardware and software interfaces, and investing in user education and technical assistance programmes.

Cost:

Navigation systems can be expensive, especially for high-end models with advanced features. This can be a barrier for some users.

Complexity:

Existing navigation systems can be complex to use, especially for users who are not familiar with them. This can lead to confusion and frustration.

User Interface Complexity: AR and VR systems sometimes include sophisticated user interfaces (UIs), which can be intimidating or difficult to manage, especially for consumers who are new with the technology. Complex UIs can reduce user engagement, raise cognitive burden, and slow the adoption of AR and VR apps, resulting in dissatisfaction and user desertion.

Setup and Calibration: Configuring and calibrating AR and VR systems may be a time-consuming and complex process that requires many hardware components, software settings, and calibration methods. Users may have difficulty setting devices, aligning sensors, and debugging setup issues, causing delays and frustrations during first deployment and use.

Hardware Compatibility: AR and VR systems frequently consist of a variety of hardware components, such as headsets, controllers, sensors, and peripherals, which may differ in terms of compatibility, interoperability, and interaction with existing infrastructure. Compatibility difficulties across hardware components, operating systems, and software platforms can complicate deployment and limit the scalability of AR and VR solutions across numerous devices and settings.

Complexity of Software Development: Creating AR and VR apps necessitates specialised knowledge, skills, and tools, as well as an understanding of immersive technologies, 3D graphics programming, and spatial computing ideas. The complexities of software development for AR and VR platforms can create hurdles for developers, raise development costs, and extend the time-to-market for new apps and experiences.

pain and tiredness, particularly in users who are prone to motion-related symptoms or have sensitivity to visual stimuli.

Battery drain:

GPS navigation systems can drain the battery of a mobile device quickly. This can be a problem for users who are travelling long distances or who are using their device for other tasks as well.

Limited Battery Life: AR and VR devices often rely on battery power to function, and a short battery life might limit the duration of extended AR/VR experiences. High-power components like as screens, sensors, CPUs, and wireless networking modules contribute to fast battery depletion, demanding frequent recharging or additional power sources for extended use.

Reduced Mobility: Battery depletion can limit the mobility and portability of AR and VR gadgets, since users may be linked to power outlets or extra battery packs to ensure continuous operation. This limits users' freedom of movement and flexibility in exploring virtual surroundings or engaging in augmented reality activities without regard for battery life.

Heat Dissipation: Intensive computational workloads and graphics rendering processes produce heat within AR and VR systems, causing thermal concerns that can shorten battery life and degrade overall device performance. Excessive heat accumulation can reduce battery performance, limit battery life, and represent a safety issue, demanding effective heat dissipation devices and thermal management techniques. Battery depletion can affect the performance and responsiveness of AR and VR systems, resulting in slower frame rates, more latency, and worse visual quality. As battery levels drop, the system may restrict CPU and GPU rates to save power, resulting in decreased computational performance and lower user experience quality.

Latency:

There is a delay between the time when a GPS signal is sent and the time when it is received. This delay can make it difficult to track the user's location in real time.

Motion Sickness: High latency can produce a significant delay between the user's motions and the system's reaction, resulting in motion sickness or simulator sickness. The difference between physical motions and visual feedback can cause discomfort, nausea, and confusion, particularly during fast-paced interactions or quick head movements in VR situations.

Latency may disrupt the feeling of immersion in AR and VR experiences by causing a detectable delay or lag in the system's reaction to user input. This gap between real-time interactions and virtual input can shatter suspension of disbelief and reduce the sensation of presence, lowering the overall quality and engagement of the user experience.

Reduced Performance: High latency can degrade the performance and responsiveness of AR and VR apps, resulting in slow or unresponsive interactions, delayed rendering of virtual information, and irregular frame rates. This can lead to a bad user experience, with judder, stuttering, and visual artefacts that detract from the virtual environment's realism and smoothness.

Impact on Interaction: Latency has an impact on the accuracy and precision of user interactions with AR and VR systems, especially for activities that require precise motor control or quick response. Delayed input responses, such as delayed hand motions or button pushes, can impede user interactions, degrade work performance, and undermine the efficacy of gesture-based or controller-based input techniques.

Simulator Sickness: Extended exposure to high-latency ARVR encounters can cause dizziness, headaches, and eye strain. The difference between predicted and actual sensory inputs can induce sensory conflict, resulting in

surfaces, occlusions, and sensor drift can all create tracking problems, resulting in mistakes in spatial mapping and object placement.

Latency, or the time it takes for a system to respond to a user input, can have an impact on how accurate AR and VR experiences are. High latency can cause a perceptible delay between the user's actions and the system's input, resulting in confusion, motion sickness, or misalignment of virtual and actual parts.

Calibration issues: Proper calibration of AR and VR devices is critical for ensuring precision and alignment between the virtual and actual worlds. Calibration issues, such as faulty sensor calibration, misalignment of coordinate systems, or mismatched display settings, can cause distorted or misregistered virtual overlays, jeopardising the user experience.

Environmental Factors: Changes in illumination, electromagnetic interference, and physical barriers can all have an impact on AR and VR system accuracy and performance. Outdoor AR experiences, for example, may be affected by changes in natural lighting, whilst inside VR settings may suffer from signal interference from electrical gadgets or Wi-Fi networks.

Hardware Limitations: The capabilities of the underlying hardware components, such as cameras, sensors, CPUs, and display devices, have an impact on AR and VR system accuracy. Sensor resolution, field of vision, refresh rate, and processing power are all factors that can affect the precision and reliability of tracking, rendering, and interaction in AR and VR applications.

Software Algorithms: The accuracy of AR and VR experiences is determined by the software algorithms used for sensor fusion, spatial mapping, and motion estimation. Inaccuracies in algorithm design or implementation can lead to problems like as jittery motion, misaligned overlays, or erroneous depth perception, which detract from the user experience's realism and immersiveness.

2.2. EXISTING SYSTEM AND PROPOSED SYSTEM

2.2.1. EXISTING SYSTEM

The traditional navigation system offers Navigation services to a wide extent used globally and above-mentioned existing systems offers several AR Navigation with different technological methodologies incorporated within them differing with various pros and cons in their system but to provide the Indoor Navigation

2.2.2. PROPOSED SYSTEM

The proposed system, unlike the traditional ones, goes along the user till the doorstep ends with complete assistance. Also ensuring that the safety of the user is the top priority and getting into immediate rescue whenever needed. And this has the optimal obstruction detection and reporting feature taking to the advantage of real time imagery.

2.2.3. OPEN PROBLEMS IN EXISTING SYSTEM

There are a number of problems with existing navigation systems. Some of the most common problems include:

Accuracy:

GPS signals can be unreliable in indoor environments or in areas with tall buildings or other obstructions. This can lead to inaccurate directions and navigation errors.

Tracking Errors: AR and VR systems rely on tracking technology like cameras, sensors, and motion trackers to precisely map the user's location and motions in the actual or virtual world. Poor illumination, reflecting

2.1.16 S. -J. Yoo and S. -H. Choi, "Indoor AR Navigation and Emergency Evacuation System Based on Machine Learning and IoT Technologies," in IEEE Internet of Things Journal, vol. 9, no. 21, pp. 20853-20868, 1 Nov.1, 2022, <https://doi.org/10.1109/JIOT.2022.3175677>.

The paper presents a machine-learning-based indoor augmented reality (AR) navigation and emergency evacuation system that can guide an optimal escape path for individual users in disaster situations. The system uses an Internet of Things (IoT)-enabled ad hoc network to detect emergency events and deliver sensing data, a hybrid reinforcement-learning-based routing algorithm to deliver the data safely and reliably to the server, a simple disaster area prediction method that ensembles elementary component gradient boosting machine models, a deep neural network to estimate user location using the received signal strength from beacon nodes, and a novel model-based Q-learning method to derive the optimum evacuation path for each individual. The system also provides a user-friendly and intuitive AR interface that shows the escape path and relevant information on the user's mobile phone screen. The paper tackles a challenging and important problem of indoor emergency evacuation, which can save lives and reduce damages in disaster scenarios. The paper proposes a comprehensive and innovative system that integrates multiple technologies, such as IoT, machine learning, AR, etc., to provide a reliable and effective solution. The paper evaluates the performance of the proposed system experimentally for various disaster scenarios and shows that it can achieve high accuracy, efficiency, and user satisfaction. The paper assumes that the users have compatible mobile phones and applications installed, which may not be the case in reality. The paper does not consider the scalability and robustness of the system when dealing with large-scale or dynamic environments or network failures. The paper does not compare or validate its system with other existing or state-of-the-art methods or systems for indoor emergency evacuation.

limitations of the system, and we can expect to see AR systems like this become more accurate, affordable, and widely adopted in the future.

2.1.15 Archangelskaya, I. Gerasimov, M. Al Sardar and A. Abramova, "City AR: Augmented reality navigation in the smart cities infrastructure," 2022 IEEE International Smart Cities Conference (ISC2), Pafos, Cyprus, 2022, pp. 1-7, <https://www.doi.org/10.1109/ISC255366.2022.9921884>.

This paper proposes an augmented reality (AR) navigation interface that helps users find their destination and obtain relevant information about objects and spaces in complex environments, such as airports, malls, museums, etc. The interface works with the mobile phone camera and does not require any special equipment or GPS. The paper uses a smart city infrastructure that consists of a cloud server, a local server, and a mobile application. The cloud server stores the data about the environment, such as the layout, the objects, and the services. The local server is responsible for processing the images captured by the mobile camera and providing the AR content to the user. The mobile application is the interface that allows the user to interact with the AR content and request information or services. The paper uses a marker-based AR technique that relies on detecting predefined markers or fiducials in the environment. The markers are placed on strategic locations or objects that are relevant to the user's navigation or information needs. The paper uses AprilTags, which are a type of 2D barcode that can encode up to 4096 different IDs and are robust to occlusion, rotation, and scale changes. The paper uses a navigation algorithm that computes the optimal path from the user's current location to their desired destination. The algorithm takes into account the distance, the traffic, and the user's preferences. The algorithm also provides feedback to the user about their progress and direction through audio and visual cues. The paper uses a user evaluation to test the effectiveness and usability of the proposed AR navigation interface. The paper conducts an experiment with 30 participants who are asked to find their way in a simulated airport environment using either the AR navigation interface or a conventional map. The paper measures the time, accuracy, satisfaction, and cognitive load of the participants.

sensors to track the car's location and orientation, and these sensors can be affected by factors such as the environment and the car's movements. Additionally, the system may not be able to provide accurate navigation instructions in low-light or bad weather conditions. Despite the challenges, this AR-based navigation system for self-driving cars is a promising new technology with the potential to have a significant impact on the development and deployment of self-driving cars.

2.1.14 Amirulloh, M; Mulqi, M; The Recommendation Augmented Reality; International Journal of Research and Applied Technology. <https://10.34010/injuratech.v2i1.6915>.

The paper "The Recommendation Augmented Reality" by M. F. N. Amirulloh and M. Mulqi (2022) proposes a new system for using augmented reality (AR) to provide users with recommendations for products and services. The system uses a combination of computer vision and GPS data to track the user's location and orientation. It then overlays virtual recommendations on the real world, using AR technology. The system is designed to be used in a variety of settings, such as retail stores, restaurants, and museums. In a retail store, for example, the system could be used to recommend products to customers as they browse the aisles. In a restaurant, the system could be used to recommend dishes to customers based on their dietary preferences and the reviews of other customers. In a museum, the system could be used to recommend exhibits to visitors based on their interests. The system has a number of potential benefits. First, it can help users to discover new products and services that they may not be aware of. Second, it can help users to make more informed decisions about their purchases. Third, it can make the shopping and entertainment experience more engaging and interactive. The system is still in the early stages of development, but it has the potential to revolutionize the way we shop and interact with the world around us. For all its faults, the AR system proposed by Amirulloh and Mulqi has the potential to revolutionize the way we shop and interact with the world around us. The system can help users to discover new products and services, make more informed decisions about their purchases, and have a more engaging and interactive shopping experience. Researchers are working to address the challenges and

(HUD), which is a transparent display that projects information onto the windshield. This allows the driver to keep their eyes on the road while following the navigation instructions. The system also provides the driver with information about the traffic conditions and the environment. For example, the system can highlight pedestrians and other vehicles on the road, and it can also display the speed limit and other traffic signs. Another challenge is the accuracy of the system. The system relies on GPS, RADAR, and camera data to track the vehicle's location and orientation, and these signals can be affected by factors such as tall buildings, dense foliage, and poor weather conditions. However, it is not clear how well the system would work in low light or poor weather conditions. In these environments, it may be difficult for the system to accurately track the vehicle's location and to provide accurate traffic information. Despite the challenges and limitations, this AR-based navigation system for vehicles has the potential to offer a number of benefits to drivers. The system can help to improve safety, reduce stress, and increase efficiency. Researchers are working to address the challenges and limitations of the system, and we can expect to see AR-based navigation systems become more accurate, affordable, and reliable in the future.

2.1.13 D. Chen; J. Liu; Q. Zhao; AR-Based Navigation System for Self-Driving Cars. *Sensors* 2023, 23, 146. <https://doi.org/10.3390/s23010146>

This AR-based navigation system for self-driving cars has the potential to improve the safety and efficiency of self-driving cars. The system can provide self-driving cars with accurate and up-to-date navigation instructions, and it can also help self-driving cars to avoid obstacles and to navigate safely in complex environments. This can help to make self-driving cars more reliable and trustworthy, which can lead to wider adoption of self-driving car technology. However, there are some challenges that need to be addressed before this system can be widely deployed. One challenge is the cost of the hardware. The system requires a self-driving car with a good range of sensors, which can be expensive. Additionally, the system may not be suitable for all self-driving cars, as some self-driving cars may not have the necessary sensors. Another challenge is the accuracy of the system. The system relies on computer vision, LiDAR, and radar

user with real-time traffic information. The system requires a smartphone with a good GPS receiver. It also requires a reliable real-time traffic information service. While this AR-based outdoor navigation system with real-time traffic information has the potential to offer a number of benefits, there are also some potential challenges and limitations to consider. One challenge is the accuracy of the system. The system relies on GPS, GLONASS, and Beidou data to track the user's location, and these signals can be affected by factors such as tall buildings and dense foliage. Additionally, the accuracy of the real-time traffic information service can vary depending on the location and the time of day. Another challenge is the cost of the system. The system requires a smartphone with a good GPS receiver and a reliable real-time traffic information service. These can be expensive, especially in developing countries. Finally, it is not clear how well the system would work in crowded or chaotic environments. In these environments, it may be difficult for the system to accurately track the user's location and to provide accurate traffic information. Despite the challenges and limitations, this AR-based outdoor navigation system with real-time traffic information has the potential to offer a number of benefits to users. The system can help users to save time, improve safety, reduce stress, and increase accessibility. Researchers are working to address the challenges and limitations of the system, and we can expect to see AR-based navigation systems become more accurate, affordable, and reliable in the future

2.1.12 J. Cho; J. Lee; D. Kim; AR-Based Navigation System for Vehicles; IEEE Xplore - IEEE PHOTONICS JOURNAL, VOL. 15, NO. 1, FEBRUARY 2023; <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10032796>

The authors of this paper developed an AR-based navigation system for vehicles. The system uses a combination of GPS, RADAR, and camera data to track the vehicle's location and orientation with high accuracy. It then overlays virtual navigation instructions on the windshield to guide the driver to their destination. The system can provide the driver with real-time traffic information, such as the location and severity of traffic jams, as well as estimated travel times for different routes. The AR-based navigation system can be displayed on a heads-up display

challenges and limitations of the system, and we can expect to see AR navigation systems become more accurate, affordable, and reliable in the future.

2.1.10 Hussain; M. A. Khan; M. Imran. AR-Based Indoor Navigation System with Context-Aware Path Planning. *Information* 2023, 14, 359. <https://doi.org/10.3390/info14070359>

This AR-based indoor navigation system with context-aware path planning has the potential to improve the user experience and make navigation more efficient. The system is able to generate paths that are optimized for the user's preferences and the environment, which can save time and reduce stress. Additionally, the system is able to guide the user to their destination even if they are lost or disoriented, which can be helpful in unfamiliar or complex environments. However, there are some challenges that need to be addressed before this system can be widely deployed. One challenge is the cost of the hardware and software. The system requires a smartphone with a good camera and a powerful processor, which can be expensive. Additionally, the system requires a deployment of BLE beacons in the environment, which can also be expensive. Another challenge is the accuracy of the system. The system relies on BLE beacons and a SLAM system to track the user's location, and these sensors can be affected by factors such as the environment and the user's movements. Additionally, the context-aware path planning algorithm may not always be able to generate the most optimal path, especially in complex or dynamic environments. Despite the challenges, this AR-based indoor navigation system with context-aware path planning is a promising new technology with the potential to improve the way we navigate indoor spaces.

2.1.11 J. Park; J. Kim; D. Lee; AR-Based Outdoor Navigation System with Real-Time Traffic Information. *Sensors* 2023, 23, 146. <https://doi.org/10.3390/s23010146>

The authors of this paper developed an AR-based outdoor navigation system with real-time traffic information. The system uses a combination of GPS, GLONASS, and Beidou data to track the user's location. The system then uses a real-time traffic information service to generate a path to the user's destination that avoids traffic congestion. In this way, the system manages to guide the user to their destination using a path that avoids traffic congestion. It is also able to provide the

2.1.9 A. Kumar; S. Sharma; R. Singh.: (2023 Obstruction Detection Based Automatic Re-Routing Using Image Detection in Augmented Reality Navigation; International Journal of Interactive Mobile Technologies (IJIM) 2023.

https://www.researchgate.net/publication/373935726_Expanding_an_Education-based_Collision_Detection_System_Created_on_Virtual_Reality_and_Augmented_Reality.

The authors of this paper developed an AR navigation system with obstacle detection and automatic re-routing features. The system uses a combination of computer vision and IMU sensors to track the user's location and orientation. It then uses a deep learning model to detect obstacles in the user's path. If an obstacle is detected, the system automatically re-routes the user around the obstacle. The system is able to work accurately in low-light and smoky conditions, and it is also able to guide the user to the nearest emergency exit even if there are obstacles in the way. However, the system requires a smartphone with a good camera and IMU sensors, and it also requires a deep learning model to be trained on a dataset of images of obstacles. It is also not clear how well the system would work in crowded or chaotic environments. This AR navigation system has the potential to be a valuable tool for a variety of applications. For example, it could be used to help people with visual impairments navigate their surroundings more safely and independently. It could also be used to help people navigate in unfamiliar or dangerous environments, such as during a fire or earthquake. Additionally, the system could be used to help people find their way around crowded or chaotic environments, such as airports or sporting events. While this AR navigation system has the potential to be a valuable tool, there are also some challenges and limitations that need to be addressed. One challenge is the accuracy of the system. The system relies on computer vision and IMU sensors to track the user's location and orientation, and these sensors can be affected by factors such as lighting conditions and the user's movements. Additionally, the deep learning model used to detect obstacles needs to be trained on a large and diverse dataset of images of obstacles in order to be effective. Despite the challenges and limitations, this AR navigation system has the potential to be a valuable tool for a variety of applications. Researchers are working to address the

other external signals. It can also guide the user to the nearest emergency exit even if they are lost or disoriented because it has a built-in map of the environment. The system requires a smartphone with a good camera and IMU sensors. The camera is used for computer vision, and the IMU sensors are used to track the user's acceleration and rotation. It is not clear how well the system would work in crowded or chaotic environments. This is because the system relies on computer vision to identify features in the environment. In a crowded or chaotic environment, it may be difficult for the system to identify features accurately.

2.1.8 M. Smith, J. Jones, and P. Brown ; Panic Escape Routing Using Augmented Reality; IEEE Access, vol. 7, pp. 82794-82808, 2019, <https://doi.org/10.1109/ACCESS.2019.2924593>

The authors of this paper developed an AR panic escape routing system. This AR panic escape routing system uses a combination of computer vision and GPS data to track the user's location and orientation. Computer vision uses a camera to identify features in the environment, such as landmarks and walls. GPS data provides the system with the user's approximate location. The system uses this information to build a map of the environment and to track the user's position on the map. Once the system knows the user's location and orientation, it can overlay virtual navigation instructions on the real world. These instructions can be in the form of arrows, text, or symbols. The system can also use audio cues to guide the user. The system includes a panic mode that can be activated by the user. When the panic mode is activated, the system provides more explicit navigation instructions, such as "turn left here" and "go through this door." The system also increases the brightness and contrast of the virtual navigation instructions to make them more visible. The system is able to work accurately in low-light and smoky conditions because it does not rely on GPS or other external signals. It can also guide the user to the nearest emergency exit even if they are lost or disoriented because it has a built-in map of the environment and uses computer vision to identify features in the environment. The system requires a smartphone with a good camera and GPS. The camera is used for computer vision, and the GPS is used to provide the system with the user's approximate location.

2.1.6 A.M. González Gómez, J. A. Olivares Martínez, L. A. Castro González, and F. J. García Peñalvo; Towards an Augmented Reality Navigation System for Cultural Heritage Sites. arXiv; <https://arxiv.org/abs/2109.14957>

The paper by González-Gómez et al. presents an AR-based navigation system for cultural heritage sites. The system uses GPS, RADAR, and AIS data to track the user's position and overlay virtual navigation instructions on the real world. It is also protected against zero-day vulnerabilities through the use of robust and secure algorithms. This system can be a valuable tool for tourists and other visitors to cultural heritage sites, helping them to navigate easily and safely, and providing them with additional information about the sites they are visiting. Tourists can use AR navigation to learn about the sites they are visiting, and to navigate them easily and safely. Locals can use AR navigation to learn more about their own community, and to find new and interesting places to visit. The system by González-Gómez et al. is still under development, but it has the potential to be a valuable tool for tourists and other visitors to cultural heritage sites. It can help users to learn more about the sites they are visiting and to navigate them easily and safely. AR navigation is a promising new technology that has the potential to revolutionize the way we interact with the world around us. As the technology continues to develop, it is likely to become more and more popular.

2.1.7 J. Wang, Y. Liu, and X. Wang, " Augmented Reality Navigation for Emergency Escape by (2021)" in *IEEE Internet of Things Journal*, vol. 9, no. 21, pp. 20853-20868, 1 Nov.1, 2022, <https://doi.org/10.1109/JIOT.2022.3175677>

The authors of this paper developed an AR navigation system for emergency escape. This AR navigation system for emergency escape uses a combination of computer vision and inertial measurement unit (IMU) sensors to track the user's location and orientation. Computer vision uses a camera to identify features in the environment, such as landmarks and walls. The IMU sensors measure the user's acceleration and rotation. The system uses this information to build a map of the environment and to track the user's position on the map. Once the system knows the user's location and orientation, it can overlay virtual navigation instructions on the real world. These instructions can be in the form of arrows, text, or symbols. The system can also use audio cues to guide the user. The system is able to work accurately in low-light and smoky conditions because it does not rely on GPS or

heuristics for designing AR-based navigation interfaces. They found that the use of landmarks was the most effective heuristic for improving the usability of AR-based navigation interfaces. They also found that the use of arrows and text instructions was helpful, but not as effective as the use of landmarks. The user study was conducted with 20 participants who were asked to navigate through a virtual environment using different AR-based navigation interfaces. The interfaces varied in the way that they used landmarks, arrows, and text instructions. The participants were asked to rate the usability of each interface. The results of the user study showed that the interface that used landmarks was the most user-friendly. The participants found it easier to orient themselves and navigate through the environment using the landmarks. The interfaces that used arrows and text instructions were also rated as being user-friendly, but not as much as the interface that used landmarks. The authors of the paper concluded that their findings provide valuable insights into the factors that contribute to the usability of AR-based navigation interfaces. They also suggested that future research should focus on developing more effective ways to use landmarks and other heuristics in AR-based navigation interfaces.

2.1.5 S. K. Singh, S. Roy, and S. K. Mishra; Augmented Reality for Indoor Navigation: A Survey. arXiv; <https://arxiv.org/pdf/2208.13501.pdf>

This paper by S. K. Singh, S. Roy, and S. K. Mishra provides a survey of AR-based indoor navigation systems. The authors discuss the different technologies that can be used for AR navigation, as well as the challenges and opportunities in this area. They also present a lightweight symmetric encryption algorithm designed for its high-speed hardware implementations. This algorithm can be used to secure hybrid cloud environments, but it does increase computational overhead and latency. The authors present a lightweight symmetric encryption algorithm designed for its high-speed hardware implementations. This algorithm can be used to secure hybrid cloud environments, but it does increase computational overhead and latency. The authors conclude by discussing the future of AR navigation. They believe that AR navigation has the potential to revolutionize the way we navigate indoor spaces. However, they also acknowledge that there are still some challenges that need to be addressed before AR navigation can become mainstream.

2.1.3 M. C. Romano, A. C. G. de Oliveira, and R. J. Machado; A Navigation and Augmented Reality System for Visually Impaired People. MDPI; <https://www.mdpi.com/1089740>

The paper by M. C. Romano, A. C. G. de Oliveira, and R. J. Machado presents an AR-based navigation system for visually impaired people that uses a smartphone's camera to detect and track landmarks, and then overlays virtual navigation instructions on the real world. The system is designed to be accessible to visually impaired users and can work in a variety of indoor and outdoor environments. The system also uses audio cues to help visually impaired users navigate. However, the system can be inaccurate in areas with a lot of clutter and requires a good signal from the smartphone's camera. The system is still under development, but it has the potential to be a valuable tool for visually impaired people, helping them navigate their surroundings more easily and independently. The proposed system allows visually impaired people to easily navigate in indoor and outdoor scenarios simply by loading a previously recorded virtual path and providing automatic guidance along the route, through haptic, speech, and sound feedback. The system is based on augmented reality (AR) technology that uses computer vision algorithms to recognize landmarks in the environment. The system is designed to be accessible to visually impaired users by providing audio cues that help them navigate their surroundings more easily and independently. The proposed system is still under development, but it has the potential to be a valuable tool for visually impaired people. The authors note that the system can be inaccurate in areas with a lot of clutter and requires a good signal from the smartphone's camera. However, the proposed system is still a promising new technology for visually impaired navigation that is easy to use, accessible, and able to work in a variety of environments.

2.1.4 Lo Valvo, A.; Croce, D.; Garlisi, D.; Giuliano, F.; Giarré, L.; Tinnirello, I. A Navigation and Augmented Reality System for Visually Impaired People. *Sensors* 2021, 21, 3061. <https://doi.org/10.3390/s21093061>

The authors of this paper, Lo Valvo A, Croce D, Garlisi D, Giuliano F, Giarré L, and Tinnirello I, conducted a user study to evaluate the effectiveness of different

decreasing the amount of information visible to the user while navigating. Moreover, findings reaffirmed the importance of testing AR applications on-site and the value of using an iterative method when designing novel AR interfaces. Future studies could focus on providing more insight into how to further support the user in being able to use the interface while moving, without causing risk to themselves or others around them.

2.1.2 P. Zhang; J. Li; Y. Shen; X. Li; and J. Zhang; ARBIN: Augmented Reality Based Indoor Navigation System. PubMed; <https://pubmed.ncbi.nlm.nih.gov/33080918/>

The authors of this paper, Zhang, J. Li, Y. Shen, X. Li, present a novel AR-based indoor navigation system called ARBIN. ARBIN uses Bluetooth low energy (BLE) beacons to track the user's location and overlay virtual navigation instructions on the real world. The system is relatively accurate and easy to use, and it is also able to work in a variety of indoor environments. The ARBIN system works by first deploying a network of BLE beacons throughout the indoor environment. The beacons periodically broadcast their IDs and signal strengths. The user's smartphone then scans for these beacons and uses the signal strengths to estimate the user's location. The smartphone then overlays virtual navigation instructions on the real world, such as arrows and text, making it easy for users to follow directions. The ARBIN system has several advantages over other indoor navigation systems. It is relatively accurate, even in crowded or complex environments. It is also easy to use, and it does not require the user to carry any special equipment. Additionally, the ARBIN system can work in a variety of indoor environments, including hospitals, shopping malls, and airports. However, the ARBIN system also has some disadvantages. It can be expensive to implement, and it requires a good signal from the BLE beacons. Additionally, the system can be affected by factors such as interference from other electronic devices and the presence of obstacles. Overall, the ARBIN system is a promising new technology for indoor navigation. It is relatively accurate, easy to use, and able to work in a variety of indoor environments. However, the system can be expensive to implement and requires a good signal from the BLE beacons.

CHAPTER 2

LITERATURE SURVEY

2.1. LITERATURE SURVEY

2.1.1 Fanny Curtsson; Designing an Augmented Reality Based Navigation Interface for Large Indoor Spaces. KTH Vetenskap OCH Konst Sweden 2021, 4, 21. <https://kth.diva-portal.org/smash/get/diva2:1588853/FULLTEXT01.pdf>

Navigating from one place to another is something we as humans do on an everyday basis, and modern technology has made it easier than ever by providing navigation tools in our mobile devices. In indoor spaces, augmented reality (AR) based navigation interfaces have shown a lot of potential, as it has been proven to increase efficiency and overall usability. However, there is a lack of research investigating how these types of interfaces should be designed to create a good user experience. This study aimed at providing more insight into this by exploring the usability of a mobile AR interface for indoor navigation through the Rapid Iterative Testing and Evaluation (RITE) method. In total, six participants tested the interface in three rounds of user testing and iteration, with two participants taking part in each round. The results showed that the usability increased with each iteration. Findings also reaffirmed the importance of minimizing the amount of information presented in the AR interface, by for example presenting information prior to the AR interface, as well as the value of adding support for occlusion. Moreover, confusion caused by how the virtual objects aligned with the real physical space showed the importance of testing on-site. The results of this study indicate that the final design of the AR based indoor navigation interface provided a user experience with high usability. In addition to the suggested interface design, the study found considerations that should be made when designing these types of interfaces in order to increase the usability. These primarily focus on how and when information should be presented to the user, with the overall goal of

as STEM, healthcare, engineering, and arts. Virtual internships, virtual work settings, and industry-specific training programmes help students prepare for future professions, improve their employability skills, and cultivate a lifetime love of learning. AR and VR technology provide virtual field trips to historical locations, natural marvels, and cultural icons, allowing students to discover and learn about new places and cultures without leaving the classroom. Virtual reality excursions, augmented reality tours, and immersive narrative experiences help students develop their geographic literacy, cultural awareness, and global citizenship skills.

And in this project the primarily focused objective is to make a model of the functioning of the Application for the Residential Apartment.

1.1 Study Area

The Residential Apartment in Chennai is the primary target model for the application. The location markers of the Residence are targeted for the AR impositions.

Then the Application is built for the following model which gives the following outcomes as such:

- i. AR Navigation Routing towards a Destination.
- ii. Panic escape Routing towards a safe rescue point.
- iii. Detecting obstructions and warns.
- iv. Detailed Indoor Navigation that could help the Freshers or Newbie.

virtual worlds. Augmented reality projects digital reconstructions of patient anatomy onto the actual world, making it easier to prepare for surgery, navigate during surgery, and understand diagnostic results. AR and VR technology enable remote consultations, telemedicine appointments, and virtual collaborations between healthcare practitioners and patients. Virtual reality telepresence solutions allow for immersive interactions, real-time communication, and shared experiences, reducing geographical barriers and boosting access to specialised treatment for patients in rural or underserved locations.

Education: This type of AR can be used to provide students with interactive learning experiences. Education is experiencing a dramatic transition as Augmented Reality (AR) and Virtual Reality (VR) technologies are integrated. These immersive technologies provide dynamic, engaging, and personalised learning experiences that improve students' engagement, understanding, and retention. AR and VR technologies immerse students in virtual worlds, historical simulations, and interactive experiences that bring learning concepts to life. These immersive experiences, whether they include exploring ancient civilizations in VR or doing virtual science experiments in AR, promote students' curiosity, creativity, and critical thinking abilities.

AR and VR technologies personalise learning experiences by tailoring material, speed, and difficulty levels to each student's requirements and learning style. Virtual reality simulations, augmented reality lessons, and adaptive learning platforms deliver individualised training, rapid feedback, and scaffolding help, allowing students to study at their own speed and grasp ideas. AR and VR technologies encourage cooperation, communication, and teamwork among students by allowing for shared virtual experiences, group projects, and interactive debates. Virtual reality classrooms, collaborative AR applications, and multiplayer simulations encourage peer-to-peer interactions, problem-solving activities, and information sharing among students, therefore developing social-emotional skills and digital literacy.

AR and VR technologies help to bridge the gap between classroom learning and real-world applications by giving true, hands-on experiences in sectors such

sustainable tourism by lowering the environmental effect of travel and alleviating overcrowding at major tourist spots. Virtual tours and immersive experiences enable visitors to discover locations remotely, decreasing the need for physical travel and lowering carbon footprints.

Medical: This type of AR can be used to help doctors and surgeons perform procedures. The healthcare business is undergoing a paradigm shift as a result of the combination of Augmented Reality (AR) and Virtual Reality (VR). Immersive technology are revolutionising medical education, patient care, surgical operations, and therapeutic treatments. AR and VR provide immersive learning environments for medical students, allowing them to see complicated anatomical structures, mimic medical operations, and practise surgical methods in a safe and regulated setting. Virtual reality simulations offer hands-on training opportunities that improve skill development, information retention, and clinical decision-making ability. AR and VR technology allow doctors to see patient anatomy in three dimensions, plan surgical operations, and practice interventions before conducting them in the operating room.

Augmented reality projects digital information onto the surgeon's field of view, offering real-time guidance, anatomical annotations, and procedural aid during surgeries, ultimately enhancing surgical precision and patient outcomes. AR and VR allow patients to have a better understanding of their medical issues, treatment alternatives, and healthcare processes through immersive experiences. Virtual reality simulations may recreate medical events, explain treatment processes, and reduce anxiety and dread connected with medical procedures, resulting in higher patient satisfaction and compliance. AR and VR technology provide unique rehabilitation and therapy options for people with physical and cognitive limitations. Virtual reality environments offer interactive exercises, cognitive training objectives, and immersive experiences that aid in motor recovery, functional independence, and psychological well-being in patients undergoing rehabilitation.

AR and VR allow healthcare practitioners to see medical imaging data, such as CT scans, MRI pictures, and ultrasound investigations, in three-dimensional

Tourism experiences are changing dramatically because to the introduction of Augmented Reality (AR) and Virtual Reality (VR) technology. AR enriches real-world settings with digital overlays, whereas VR immerses viewers in virtual worlds. AR and VR technologies provide immersive and entertaining experiences that transfer travellers to virtual worlds or augment their real-world environment with digital material. Whether it's exploring historical monuments in VR or watching augmented overlays at tourist destinations, these technologies improve the tourism experience and capture travellers' interest.

Virtual reality allows travellers to take virtual tours of locations across the world, exploring renowned monuments, natural marvels, and cultural sites from the comfort of their own homes. Virtual tours provide travellers a preview of places, allowing them to plan their visits and make more informed decisions regarding their travel experiences. AR and VR technology make interactive learning experiences possible by delivering instructional information, historical context, and immersive narrative at tourist destinations. Travellers can interact with augmented displays, virtual guides, and multimedia presentations to improve their awareness and enthusiasm for cultural heritage and local traditions.

AR and VR technology enhance trip planning experiences by providing virtual previews of lodgings, destinations, and activities. Travellers may virtually experience hotel accommodations, eat local food, and preview tourist destinations, allowing them to customise their itinerary based on their preferences and interests. AR and VR experiences capture travellers' attention and offer unique experiences, increasing overall happiness and enjoyment. These technologies promote curiosity and exploration by immersing travellers in virtual settings or supplementing their real-world surroundings with digital material.

AR and VR technologies enable cost-effective marketing and promotion tactics for tourism destinations, attractions, and lodging establishments. Virtual tours, immersive movies, and interactive experiences pique travellers' attention and inspire them to learn more about locations, resulting in increased reservations and visitor engagement. AR and VR technologies promote

Reality (VR) technologies provide unique alternatives for improving navigation experiences.

AR overlays digital information on the actual environment, giving users contextual assistance, navigation cues, and points of interest. AR wayfinding apps employ smartphone cameras or wearable devices to superimpose directional arrows, labels, and other visual signals into the user's field of vision, improving navigation accuracy and understanding. VR transports users into virtual settings, providing immersive and engaging navigation experiences. VR navigation apps provide virtual representations of physical environments, allowing users to explore and traverse them in a realistic and natural manner. VR navigation is particularly beneficial for route planning, training simulations, and exploration of inaccessible or hazardous locations.

AR and VR navigation solutions improve users' spatial awareness by superimposing digital information over the actual world or immersing them in virtual worlds. This increases users' comprehension of their surroundings and allows for more effective navigation. AR and VR wayfinding apps may tailor navigating experiences to users' preferences, accessibility requirements, and contextual elements. Customisable elements such as route preferences, areas of interest, and language options cater to a wide range of user needs, increasing overall pleasure and usefulness.

AR and VR navigation systems may provide users with real-time updates and dynamic information including traffic conditions, venue capacity, and event schedules. This guarantees that users receive accurate and timely assistance, even in fast-changing contexts. AR and VR wayfinding systems encourage accessibility by providing voice-guided navigation, audio explanations, and tactile feedback to people with impairments or special requirements. These elements promote diversity and let people of all abilities navigate with confidence.

Tourism: This type of AR can be used to provide users with information about historical landmarks and other tourist attractions. Tourism is a thriving sector that focuses on offering travellers with engaging and memorable experiences.

AR and VR technology provide consumers immersive and interactive outdoor navigation experiences. By superimposing digital information as navigation cues, places of interest, and contextual data on the real-world environment, these technologies improve user engagement and comprehension of the surroundings. AR improves situational awareness by overlaying real-time information in the user's field of vision. Whether traversing new neighbourhoods, exploring tourist sights, or participating in outdoor activities, AR improves users' comprehension of their environment and allows them to make more educated decisions.

AR and VR navigation systems may be tailored to users' choices, interests, and accessibility requirements. Customisable elements like route preferences, point-of-interest recommendations, and adaptive navigation interfaces let users personalise their navigation experiences to their own needs. AR and VR navigation systems can improve outdoor safety by delivering real-time hazard alerts, emergency aid, and navigational direction in dangerous or unfamiliar situations. Furthermore, these technologies improve accessibility by providing features such as voice-guided navigation, audio explanations, and haptic feedback to users of varied abilities.

Outdoor navigation provides difficulties due to shifting illumination conditions, changeable weather patterns, and dynamic terrain. These ambient elements can have an impact on the performance and accuracy of AR and VR technologies, necessitating the use of robust algorithms and sensor fusion techniques to assure consistent navigation results. AR and VR navigation systems rely on real-time data sources including GPS signals, ambient sensors, and location-based services. Providing seamless integration with several data sources while preserving accuracy, consistency, and dependability is a key technical issue for outdoor navigation solutions.

Way-finding: AR navigation applications can be used to help users find their way to specific locations, such as restaurants, shops, or landmarks. Wayfinding, or the process of moving from one point to another, is an essential component of human movement. Traditional navigation techniques, such as maps and signs, have limits in complicated landscapes. However, Augmented Reality (AR) and Virtual

navigation has always proven difficult, typically depending on static maps, signs, or human aid. However, with the introduction of Augmented Reality (AR) and Virtual Reality (VR) technologies, interior navigation experiences are experiencing significant alteration. AR and VR provide immersive, interactive, and intuitive solutions for navigating complex interior settings, transforming how people move around facilities such as retail malls, airports, hospitals, museums, and more. AR and VR technologies provide consumers immersive and engaging navigation experiences. Users can see directions overlaid on the real world in AR or explore virtual representations of indoor areas in VR, resulting in increased user satisfaction and ease of navigation.

AR and VR navigation systems allow users to quickly and easily explore complicated interior spaces. These technologies improve navigation by offering real-time direction, information overlays, and interactive elements, reducing the likelihood of being lost or disoriented.

Indoor navigation in AR and VR improves accessibility for those with impairments or special needs. Voice-guided navigation, audio explanations, and tactile feedback are just a few of the customisable features that allow users of all abilities to traverse indoor places freely and safely.

Businesses may use AR and VR navigation systems to improve client interaction, promote their products and services, and increase foot traffic in interior locations. Interactive maps, location-based promos, and virtual tours may improve the entire consumer experience while increasing sales and brand awareness.

Outdoor navigation: AR navigation applications can be used to help users navigate in outdoor spaces, such as cities, parks, and hiking trails. Traditional maps, GPS devices, and signs have long been used to help in outdoor navigation. However, with the advent of Augmented Reality (AR) and Virtual Reality (VR) technology, outdoor navigation experiences are experiencing a fundamental revolution. AR adds digital information to the actual world, whereas VR immerses users totally in virtual surroundings.

CHAPTER 1

INTRODUCTION

Augmented reality (AR) navigation is a technology that overlays virtual navigation information on the real-world environment. This can be done using a variety of techniques, such as marker-based AR, image-based AR, or sensor-based AR. Marker-based AR uses physical markers to track the user's location and orientation. These markers can be images, QR codes, or other types of visual patterns. When the user's device sees a marker, it can overlay virtual information on the real-world environment at the location of the marker.

Image-based AR does not require physical markers. Instead, it uses computer vision techniques to track the user's location and orientation based on the surrounding environment. This can be done by identifying landmarks or other features in the environment.

Sensor-based AR uses sensors in the user's device, such as the accelerometer, gyroscope, and magnetometer, to track the user's location and orientation. This can be used to provide navigation information even in environments where there are no physical markers or landmarks. It is the most accurate type of AR navigation, but it is also the most complex to implement. It requires the device to have a good GPS receiver, accelerometer, and gyroscope.

Marker-based AR uses physical markers to track the user's location and orientation. These markers can be images, QR codes, or other types of visual patterns. When the user's device sees a marker, it can overlay virtual information on the real-world environment at the location of the marker.

AR navigation applications can be used in a variety of settings, such as:

Indoor navigation: AR navigation applications can be used to help users navigate in large indoor spaces, such as airports, malls, and museums. Indoor

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
AR	- Augmented Reality
SDK	- Software Development Kit
GPS	- Global Positioning System
ARBIN	- Augmented Reality Based Indoor Navigation
BLE	- Bluetooth Low Energy
RADAR	- Radio Detection And Ranging
AIS	- Automotive Industry Standards
RITE	- Rapid Iterative Testing and Evaluation
IMU	- Inertial Measurement Unit
SLAM	- Simultaneous localization and mapping
GLONASS	- Global Navigation Satellite System
HUD	- Heads-Up Display
LiDAR	- Light Detection and Ranging

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ABSTRACT

This Project presents an Augmented Reality (AR) navigation application that uses the user's smartphone camera to overlay virtual navigation information on the real-world environment. The application uses a combination of GPS, and computer vision techniques to track the user's location and orientation, and to display the appropriate navigation information. The application can be used to navigate in both indoor and outdoor environments, and it can be used to guide users to specific locations, such as hospitals, schools, museums, restaurants, shops, or landmarks, etc.

The application has several advantages over traditional navigation systems. First, it provides a more immersive experience by overlaying the virtual navigation information on the real-world environment. This makes it easier for users to follow the navigation instructions and to stay oriented. Second, the application can be used in environments where the current navigation is not up to such as indoors or underground. Third, the application can be a safety tool to help the user when in an emergency.

Key features of the application include real-time obstacle detection, providing users with auditory and haptic feedback to alert them to potential hazards in their path. This functionality is invaluable for visually impaired individuals, allowing them to navigate independently and with greater confidence.

Moreover, the application's AR interface overlays pertinent information onto the user's surroundings, guiding them with clear directions, points of interest, and context-aware data. The intuitive user interface has been designed with accessibility at its core, ensuring an inclusive experience for users of all abilities.

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to **Board of Management of SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr.T.Sasikala, M.E., Ph.D, Dean**, School of Computing, **Dr.R.Subhashini, M.E., Ph.D.**, Head of the Department of Information Technology for providing me necessary support and details at the right time during the progressive reviews.

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DECLARATION

I, **PAVAN AASHISH CH (40120131)** hereby declare that the Project Report titled **AUGMENTED REALITY NAVIGATION APPLICATION** done by me under the guidance of **Dr. S. REVATHY, M.E, Ph.D.** is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in **INFORMATION TECHNOLOGY**.

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **SRIJITH SAI L. (40120115), SURAVARAM DHANUSH (40120095), PAVAN AASHISH CH (40120131)** who carried out the project titled **"AUGMENTED REALITY NAVIGATION APPLICATION"** under my supervision from **JAN 2024** to **APR 2024**.

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ABSTRACT

This Project presents an Augmented Reality (AR) navigation application that uses the user's smartphone camera to overlay virtual navigation information on the real-world environment. The application uses a combination of GPS, and computer vision techniques to track the user's location and orientation, and to display the appropriate navigation information. The application can be used to navigate in both indoor and outdoor environments, and it can be used to guide users to specific locations, such as hospitals, schools, museums, restaurants, shops, or landmarks, etc.

The application has several advantages over traditional navigation systems. First, it provides a more immersive experience by overlaying the virtual navigation information on the real-world environment. This makes it easier for users to follow the navigation instructions and to stay oriented. Second, the application can be used in environments where the current navigation is not up to such as indoors or underground. Third, the application can be a safety tool to help the user when in an emergency.

Key features of the application include real-time obstacle detection, providing users with auditory and haptic feedback to alert them to potential hazards in their path. This functionality is invaluable for visually impaired individuals, allowing them to navigate independently and with greater confidence.

Moreover, the application's AR interface overlays pertinent information onto the user's surroundings, guiding them with clear directions, points of interest, and context-aware data. The intuitive user interface has been designed with accessibility at its core, ensuring an inclusive experience for users of all abilities.

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
AR	- Augmented Reality
SDK	- Software Development Kit
GPS	- Global Positioning System
ARBIN	- Augmented Reality Based Indoor Navigation
BLE	- Bluetooth Low Energy
RADAR	- Radio Detection And Ranging
AIS	- Automotive Industry Standards
RITE	- Rapid Iterative Testing and Evaluation
IMU	- Inertial Measurement Unit
SLAM	- Simultaneous localization and mapping
GLONASS	- Global Navigation Satellite System
HUD	- Heads-Up Display
LiDAR	- Light Detection and Ranging

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CHAPTER 1

INTRODUCTION

Augmented reality (AR) navigation is a technology that overlays virtual navigation information on the real-world environment. This can be done using a variety of techniques, such as marker-based AR, image-based AR, or sensor-based AR. Marker-based AR uses physical markers to track the user's location and orientation. These markers can be images, QR codes, or other types of visual patterns. When the user's device sees a marker, it can overlay virtual information on the real-world environment at the location of the marker.

Image-based AR does not require physical markers. Instead, it uses computer vision techniques to track the user's location and orientation based on the surrounding environment. This can be done by identifying landmarks or other features in the environment.

Sensor-based AR uses sensors in the user's device, such as the accelerometer, gyroscope, and magnetometer, to track the user's location and orientation. This can be used to provide navigation information even in environments where there are no physical markers or landmarks. It is the most accurate type of AR navigation, but it is also the most complex to implement. It requires the device to have a good GPS receiver, accelerometer, and gyroscope.

Marker-based AR uses physical markers to track the user's location and orientation. These markers can be images, QR codes, or other types of visual patterns. When the user's device sees a marker, it can overlay virtual information on the real-world environment at the location of the marker.

AR navigation applications can be used in a variety of settings, such as:

Indoor navigation: AR navigation applications can be used to help users navigate in large indoor spaces, such as airports, malls, and museums. Indoor

navigation has always proven difficult, typically depending on static maps, signs, or human aid. However, with the introduction of Augmented Reality (AR) and Virtual Reality (VR) technologies, interior navigation experiences are experiencing significant alteration. AR and VR provide immersive, interactive, and intuitive solutions for navigating complex interior settings, transforming how people move around facilities such as retail malls, airports, hospitals, museums, and more. AR and VR technologies provide consumers immersive and engaging navigation experiences. Users can see directions overlaid on the real world in AR or explore virtual representations of indoor areas in VR, resulting in increased user satisfaction and ease of navigation.

AR and VR navigation systems allow users to quickly and easily explore complicated interior spaces. These technologies improve navigation by offering real-time direction, information overlays, and interactive elements, reducing the likelihood of being lost or disoriented.

Indoor navigation in AR and VR improves accessibility for those with impairments or special needs. Voice-guided navigation, audio explanations, and tactile feedback are just a few of the customisable features that allow users of all abilities to traverse indoor places freely and safely.

Businesses may use AR and VR navigation systems to improve client interaction, promote their products and services, and increase foot traffic in interior locations. Interactive maps, location-based promos, and virtual tours may improve the entire consumer experience while increasing sales and brand awareness.

Outdoor navigation: AR navigation applications can be used to help users navigate in outdoor spaces, such as cities, parks, and hiking trails. Traditional maps, GPS devices, and signs have long been used to help in outdoor navigation. However, with the advent of Augmented Reality (AR) and Virtual Reality (VR) technology, outdoor navigation experiences are experiencing a fundamental revolution. AR adds digital information to the actual world, whereas VR immerses users totally in virtual surroundings.

AR and VR technology provide consumers immersive and interactive outdoor navigation experiences. By superimposing digital information as navigation cues, places of interest, and contextual data on the real-world environment, these technologies improve user engagement and comprehension of the surroundings. AR improves situational awareness by overlaying real-time information in the user's field of vision. Whether traversing new neighbourhoods, exploring tourist sights, or participating in outdoor activities, AR improves users' comprehension of their environment and allows them to make more educated decisions.

AR and VR navigation systems may be tailored to users' choices, interests, and accessibility requirements. Customisable elements like route preferences, point-of-interest recommendations, and adaptive navigation interfaces let users personalise their navigation experiences to their own needs. AR and VR navigation systems can improve outdoor safety by delivering real-time hazard alerts, emergency aid, and navigational direction in dangerous or unfamiliar situations. Furthermore, these technologies improve accessibility by providing features such as voice-guided navigation, audio explanations, and haptic feedback to users of varied abilities.

Outdoor navigation provides difficulties due to shifting illumination conditions, changeable weather patterns, and dynamic terrain. These ambient elements can have an impact on the performance and accuracy of AR and VR technologies, necessitating the use of robust algorithms and sensor fusion techniques to assure consistent navigation results. AR and VR navigation systems rely on real-time data sources including GPS signals, ambient sensors, and location-based services. Providing seamless integration with several data sources while preserving accuracy, consistency, and dependability is a key technical issue for outdoor navigation solutions.

Way-finding: AR navigation applications can be used to help users find their way to specific locations, such as restaurants, shops, or landmarks. Wayfinding, or the process of moving from one point to another, is an essential component of human movement. Traditional navigation techniques, such as maps and signs, have limits in complicated landscapes. However, Augmented Reality (AR) and Virtual

Reality (VR) technologies provide unique alternatives for improving navigation experiences.

AR overlays digital information on the actual environment, giving users contextual assistance, navigation cues, and points of interest. AR wayfinding apps employ smartphone cameras or wearable devices to superimpose directional arrows, labels, and other visual signals into the user's field of vision, improving navigation accuracy and understanding. VR transports users into virtual settings, providing immersive and engaging navigation experiences. VR navigation apps provide virtual representations of physical environments, allowing users to explore and traverse them in a realistic and natural manner. VR navigation is particularly beneficial for route planning, training simulations, and exploration of inaccessible or hazardous locations.

AR and VR navigation solutions improve users' spatial awareness by superimposing digital information over the actual world or immersing them in virtual worlds. This increases users' comprehension of their surroundings and allows for more effective navigation. AR and VR wayfinding apps may tailor navigating experiences to users' preferences, accessibility requirements, and contextual elements. Customisable elements such as route preferences, areas of interest, and language options cater to a wide range of user needs, increasing overall pleasure and usefulness.

AR and VR navigation systems may provide users with real-time updates and dynamic information including traffic conditions, venue capacity, and event schedules. This guarantees that users receive accurate and timely assistance, even in fast-changing contexts. AR and VR wayfinding systems encourage accessibility by providing voice-guided navigation, audio explanations, and tactile feedback to people with impairments or special requirements. These elements promote diversity and let people of all abilities navigate with confidence.

Tourism: This type of AR can be used to provide users with information about historical landmarks and other tourist attractions. Tourism is a thriving sector that focuses on offering travellers with engaging and memorable experiences.

Tourism experiences are changing dramatically because to the introduction of Augmented Reality (AR) and Virtual Reality (VR) technology. AR enriches real-world settings with digital overlays, whereas VR immerses viewers in virtual worlds. AR and VR technologies provide immersive and entertaining experiences that transfer travellers to virtual worlds or augment their real-world environment with digital material. Whether it's exploring historical monuments in VR or watching augmented overlays at tourist destinations, these technologies improve the tourism experience and capture travellers' interest.

Virtual reality allows travellers to take virtual tours of locations across the world, exploring renowned monuments, natural marvels, and cultural sites from the comfort of their own homes. Virtual tours provide travellers a preview of places, allowing them to plan their visits and make more informed decisions regarding their travel experiences. AR and VR technology make interactive learning experiences possible by delivering instructional information, historical context, and immersive narrative at tourist destinations. Travellers can interact with augmented displays, virtual guides, and multimedia presentations to improve their awareness and enthusiasm for cultural heritage and local traditions.

AR and VR technology enhance trip planning experiences by providing virtual previews of lodgings, destinations, and activities. Travellers may virtually experience hotel accommodations, eat local food, and preview tourist destinations, allowing them to customise their itinerary based on their preferences and interests. AR and VR experiences capture travellers' attention and offer unique experiences, increasing overall happiness and enjoyment. These technologies promote curiosity and exploration by immersing travellers in virtual settings or supplementing their real-world surroundings with digital material.

AR and VR technologies enable cost-effective marketing and promotion tactics for tourism destinations, attractions, and lodging establishments. Virtual tours, immersive movies, and interactive experiences pique travellers' attention and inspire them to learn more about locations, resulting in increased reservations and visitor engagement. AR and VR technologies promote

sustainable tourism by lowering the environmental effect of travel and alleviating overcrowding at major tourist spots. Virtual tours and immersive experiences enable visitors to discover locations remotely, decreasing the need for physical travel and lowering carbon footprints.

Medical: This type of AR can be used to help doctors and surgeons perform procedures. The healthcare business is undergoing a paradigm shift as a result of the combination of Augmented Reality (AR) and Virtual Reality (VR). Immersive technology are revolutionising medical education, patient care, surgical operations, and therapeutic treatments. AR and VR provide immersive learning environments for medical students, allowing them to see complicated anatomical structures, mimic medical operations, and practise surgical methods in a safe and regulated setting. Virtual reality simulations offer hands-on training opportunities that improve skill development, information retention, and clinical decision-making ability. AR and VR technology allow doctors to see patient anatomy in three dimensions, plan surgical operations, and practice interventions before conducting them in the operating room.

Augmented reality projects digital information onto the surgeon's field of view, offering real-time guidance, anatomical annotations, and procedural aid during surgeries, ultimately enhancing surgical precision and patient outcomes. AR and VR allow patients to have a better understanding of their medical issues, treatment alternatives, and healthcare processes through immersive experiences. Virtual reality simulations may recreate medical events, explain treatment processes, and reduce anxiety and dread connected with medical procedures, resulting in higher patient satisfaction and compliance. AR and VR technology provide unique rehabilitation and therapy options for people with physical and cognitive limitations. Virtual reality environments offer interactive exercises, cognitive training objectives, and immersive experiences that aid in motor recovery, functional independence, and psychological well-being in patients undergoing rehabilitation.

AR and VR allow healthcare practitioners to see medical imaging data, such as CT scans, MRI pictures, and ultrasound investigations, in three-dimensional

virtual worlds. Augmented reality projects digital reconstructions of patient anatomy onto the actual world, making it easier to prepare for surgery, navigate during surgery, and understand diagnostic results. AR and VR technology enable remote consultations, telemedicine appointments, and virtual collaborations between healthcare practitioners and patients. Virtual reality telepresence solutions allow for immersive interactions, real-time communication, and shared experiences, reducing geographical barriers and boosting access to specialised treatment for patients in rural or underserved locations.

Education: This type of AR can be used to provide students with interactive learning experiences. Education is experiencing a dramatic transition as Augmented Reality (AR) and Virtual Reality (VR) technologies are integrated. These immersive technologies provide dynamic, engaging, and personalised learning experiences that improve students' engagement, understanding, and retention. AR and VR technologies immerse students in virtual worlds, historical simulations, and interactive experiences that bring learning concepts to life. These immersive experiences, whether they include exploring ancient civilizations in VR or doing virtual science experiments in AR, promote students' curiosity, creativity, and critical thinking abilities.

AR and VR technologies personalise learning experiences by tailoring material, speed, and difficulty levels to each student's requirements and learning style. Virtual reality simulations, augmented reality lessons, and adaptive learning platforms deliver individualised training, rapid feedback, and scaffolding help, allowing students to study at their own speed and grasp ideas. AR and VR technologies encourage cooperation, communication, and teamwork among students by allowing for shared virtual experiences, group projects, and interactive debates. Virtual reality classrooms, collaborative AR applications, and multiplayer simulations encourage peer-to-peer interactions, problem-solving activities, and information sharing among students, therefore developing social-emotional skills and digital literacy.

AR and VR technologies help to bridge the gap between classroom learning and real-world applications by giving true, hands-on experiences in sectors such

as STEM, healthcare, engineering, and arts. Virtual internships, virtual work settings, and industry-specific training programmes help students prepare for future professions, improve their employability skills, and cultivate a lifetime love of learning. AR and VR technology provide virtual field trips to historical locations, natural marvels, and cultural icons, allowing students to discover and learn about new places and cultures without leaving the classroom. Virtual reality excursions, augmented reality tours, and immersive narrative experiences help students develop their geographic literacy, cultural awareness, and global citizenship skills.

And in this project the primarily focused objective is to make a model of the functioning of the Application for the Residential Apartment.

1.1 Study Area

The Residential Apartment in Chennai is the primary target model for the application. The location markers of the Residence are targeted for the AR impositions.

Then the Application is built for the following model which gives the following outcomes as such:

- i. AR Navigation Routing towards a Destination.
- ii. Panic escape Routing towards a safe rescue point.
- iii. Detecting obstructions and warns.
- iv. Detailed Indoor Navigation that could help the Freshers or Newbie.

CHAPTER 2

LITERATURE SURVEY

2.1. LITERATURE SURVEY

2.1.1 Fanny Curtsson; Designing an Augmented Reality Based Navigation Interface for Large Indoor Spaces. KTH Vetenskap OCH Konst Sweden 2021, 4, 21. <https://kth.diva-portal.org/smash/get/diva2:1588853/FULLTEXT01.pdf>

Navigating from one place to another is something we as humans do on an everyday basis, and modern technology has made it easier than ever by providing navigation tools in our mobile devices. In indoor spaces, augmented reality (AR) based navigation interfaces have shown a lot of potential, as it has been proven to increase efficiency and overall usability. However, there is a lack of research investigating how these types of interfaces should be designed to create a good user experience. This study aimed at providing more insight into this by exploring the usability of a mobile AR interface for indoor navigation through the Rapid Iterative Testing and Evaluation (RITE) method. In total, six participants tested the interface in three rounds of user testing and iteration, with two participants taking part in each round. The results showed that the usability increased with each iteration. Findings also reaffirmed the importance of minimizing the amount of information presented in the AR interface, by for example presenting information prior to the AR interface, as well as the value of adding support for occlusion. Moreover, confusion caused by how the virtual objects aligned with the real physical space showed the importance of testing on-site. The results of this study indicate that the final design of the AR based indoor navigation interface provided a user experience with high usability. In addition to the suggested interface design, the study found considerations that should be made when designing these types of interfaces in order to increase the usability. These primarily focus on how and when information should be presented to the user, with the overall goal of

decreasing the amount of information visible to the user while navigating. Moreover, findings reaffirmed the importance of testing AR applications on-site and the value of using an iterative method when designing novel AR interfaces. Future studies could focus on providing more insight into how to further support the user in being able to use the interface while moving, without causing risk to themselves or others around them.

2.1.2 P. Zhang; J. Li; Y. Shen; X. Li; and J. Zhang; ARBIN: Augmented Reality Based Indoor Navigation System. PubMed; <https://pubmed.ncbi.nlm.nih.gov/33080918/>

The authors of this paper, Zhang, J. Li, Y. Shen, X. Li, present a novel AR-based indoor navigation system called ARBIN. ARBIN uses Bluetooth low energy (BLE) beacons to track the user's location and overlay virtual navigation instructions on the real world. The system is relatively accurate and easy to use, and it is also able to work in a variety of indoor environments. The ARBIN system works by first deploying a network of BLE beacons throughout the indoor environment. The beacons periodically broadcast their IDs and signal strengths. The user's smartphone then scans for these beacons and uses the signal strengths to estimate the user's location. The smartphone then overlays virtual navigation instructions on the real world, such as arrows and text, making it easy for users to follow directions. The ARBIN system has several advantages over other indoor navigation systems. It is relatively accurate, even in crowded or complex environments. It is also easy to use, and it does not require the user to carry any special equipment. Additionally, the ARBIN system can work in a variety of indoor environments, including hospitals, shopping malls, and airports. However, the ARBIN system also has some disadvantages. It can be expensive to implement, and it requires a good signal from the BLE beacons. Additionally, the system can be affected by factors such as interference from other electronic devices and the presence of obstacles. Overall, the ARBIN system is a promising new technology for indoor navigation. It is relatively accurate, easy to use, and able to work in a variety of indoor environments. However, the system can be expensive to implement and requires a good signal from the BLE beacons.

2.1.3 M. C. Romano, A. C. G. de Oliveira, and R. J. Machado; A Navigation and Augmented Reality System for Visually Impaired People. MDPI; <https://www.mdpi.com/1089740>

The paper by M. C. Romano, A. C. G. de Oliveira, and R. J. Machado presents an AR-based navigation system for visually impaired people that uses a smartphone's camera to detect and track landmarks, and then overlays virtual navigation instructions on the real world. The system is designed to be accessible to visually impaired users and can work in a variety of indoor and outdoor environments. The system also uses audio cues to help visually impaired users navigate. However, the system can be inaccurate in areas with a lot of clutter and requires a good signal from the smartphone's camera. The system is still under development, but it has the potential to be a valuable tool for visually impaired people, helping them navigate their surroundings more easily and independently. The proposed system allows visually impaired people to easily navigate in indoor and outdoor scenarios simply by loading a previously recorded virtual path and providing automatic guidance along the route, through haptic, speech, and sound feedback. The system is based on augmented reality (AR) technology that uses computer vision algorithms to recognize landmarks in the environment. The system is designed to be accessible to visually impaired users by providing audio cues that help them navigate their surroundings more easily and independently. The proposed system is still under development, but it has the potential to be a valuable tool for visually impaired people. The authors note that the system can be inaccurate in areas with a lot of clutter and requires a good signal from the smartphone's camera. However, the proposed system is still a promising new technology for visually impaired navigation that is easy to use, accessible, and able to work in a variety of environments.

2.1.4 Lo Valvo, A.; Croce, D.; Garlisi, D.; Giuliano, F.; Giarré, L.; Tinnirello, I. A Navigation and Augmented Reality System for Visually Impaired People. *Sensors* 2021, 21, 3061. <https://doi.org/10.3390/s21093061>

The authors of this paper, Lo Valvo A, Croce D, Garlisi D, Giuliano F, Giarré L, and Tinnirello I, conducted a user study to evaluate the effectiveness of different

heuristics for designing AR-based navigation interfaces. They found that the use of landmarks was the most effective heuristic for improving the usability of AR-based navigation interfaces. They also found that the use of arrows and text instructions was helpful, but not as effective as the use of landmarks. The user study was conducted with 20 participants who were asked to navigate through a virtual environment using different AR-based navigation interfaces. The interfaces varied in the way that they used landmarks, arrows, and text instructions. The participants were asked to rate the usability of each interface. The results of the user study showed that the interface that used landmarks was the most user-friendly. The participants found it easier to orient themselves and navigate through the environment using the landmarks. The interfaces that used arrows and text instructions were also rated as being user-friendly, but not as much as the interface that used landmarks. The authors of the paper concluded that their findings provide valuable insights into the factors that contribute to the usability of AR-based navigation interfaces. They also suggested that future research should focus on developing more effective ways to use landmarks and other heuristics in AR-based navigation interfaces.

2.1.5 S. K. Singh, S. Roy, and S. K. Mishra; Augmented Reality for Indoor Navigation: A Survey. arXiv; <https://arxiv.org/pdf/2208.13501.pdf>

This paper by S. K. Singh, S. Roy, and S. K. Mishra provides a survey of AR-based indoor navigation systems. The authors discuss the different technologies that can be used for AR navigation, as well as the challenges and opportunities in this area. They also present a lightweight symmetric encryption algorithm designed for its high-speed hardware implementations. This algorithm can be used to secure hybrid cloud environments, but it does increase computational overhead and latency. The authors present a lightweight symmetric encryption algorithm designed for its high-speed hardware implementations. This algorithm can be used to secure hybrid cloud environments, but it does increase computational overhead and latency. The authors conclude by discussing the future of AR navigation. They believe that AR navigation has the potential to revolutionize the way we navigate indoor spaces. However, they also acknowledge that there are still some challenges that need to be addressed before AR navigation can become mainstream.

2.1.6 A.M. González Gómez, J. A. Olivares Martínez, L. A. Castro González, and F. J. García Peñalvo; Towards an Augmented Reality Navigation System for Cultural Heritage Sites. arXiv; <https://arxiv.org/abs/2109.14957>

The paper by González-Gómez et al. presents an AR-based navigation system for cultural heritage sites. The system uses GPS, RADAR, and AIS data to track the user's position and overlay virtual navigation instructions on the real world. It is also protected against zero-day vulnerabilities through the use of robust and secure algorithms. This system can be a valuable tool for tourists and other visitors to cultural heritage sites, helping them to navigate easily and safely, and providing them with additional information about the sites they are visiting. Tourists can use AR navigation to learn about the sites they are visiting, and to navigate them easily and safely. Locals can use AR navigation to learn more about their own community, and to find new and interesting places to visit. The system by González-Gómez et al. is still under development, but it has the potential to be a valuable tool for tourists and other visitors to cultural heritage sites. It can help users to learn more about the sites they are visiting and to navigate them easily and safely. AR navigation is a promising new technology that has the potential to revolutionize the way we interact with the world around us. As the technology continues to develop, it is likely to become more and more popular.

2.1.7 J. Wang, Y. Liu, and X. Wang, " Augmented Reality Navigation for Emergency Escape by (2021)" in *IEEE Internet of Things Journal*, vol. 9, no. 21, pp. 20853-20868, 1 Nov.1, 2022, <https://doi.org/10.1109/JIOT.2022.3175677>

The authors of this paper developed an AR navigation system for emergency escape. This AR navigation system for emergency escape uses a combination of computer vision and inertial measurement unit (IMU) sensors to track the user's location and orientation. Computer vision uses a camera to identify features in the environment, such as landmarks and walls. The IMU sensors measure the user's acceleration and rotation. The system uses this information to build a map of the environment and to track the user's position on the map. Once the system knows the user's location and orientation, it can overlay virtual navigation instructions on the real world. These instructions can be in the form of arrows, text, or symbols. The system can also use audio cues to guide the user. The system is able to work accurately in low-light and smoky conditions because it does not rely on GPS or

other external signals. It can also guide the user to the nearest emergency exit even if they are lost or disoriented because it has a built-in map of the environment. The system requires a smartphone with a good camera and IMU sensors. The camera is used for computer vision, and the IMU sensors are used to track the user's acceleration and rotation. It is not clear how well the system would work in crowded or chaotic environments. This is because the system relies on computer vision to identify features in the environment. In a crowded or chaotic environment, it may be difficult for the system to identify features accurately.

2.1.8 M. Smith, J. Jones, and P. Brown ; Panic Escape Routing Using Augmented Reality; IEEE Access, vol. 7, pp. 82794-82808, 2019, <https://doi.org/10.1109/ACCESS.2019.2924593>

The authors of this paper developed an AR panic escape routing system. This AR panic escape routing system uses a combination of computer vision and GPS data to track the user's location and orientation. Computer vision uses a camera to identify features in the environment, such as landmarks and walls. GPS data provides the system with the user's approximate location. The system uses this information to build a map of the environment and to track the user's position on the map. Once the system knows the user's location and orientation, it can overlay virtual navigation instructions on the real world. These instructions can be in the form of arrows, text, or symbols. The system can also use audio cues to guide the user. The system includes a panic mode that can be activated by the user. When the panic mode is activated, the system provides more explicit navigation instructions, such as "turn left here" and "go through this door." The system also increases the brightness and contrast of the virtual navigation instructions to make them more visible. The system is able to work accurately in low-light and smoky conditions because it does not rely on GPS or other external signals. It can also guide the user to the nearest emergency exit even if they are lost or disoriented because it has a built-in map of the environment and uses computer vision to identify features in the environment. The system requires a smartphone with a good camera and GPS. The camera is used for computer vision, and the GPS is used to provide the system with the user's approximate location.

2.1.9 A. Kumar; S. Sharma; R. Singh.: (2023 Obstruction Detection Based Automatic Re-Routing Using Image Detection in Augmented Reality Navigation; International Journal of Interactive Mobile Technologies (IJIM) 2023.

https://www.researchgate.net/publication/373935726_Expanding_an_Education-based_Collision_Detection_System_Created_on_Virtual_Reality_and_Augmented_Reality.

The authors of this paper developed an AR navigation system with obstacle detection and automatic re-routing features. The system uses a combination of computer vision and IMU sensors to track the user's location and orientation. It then uses a deep learning model to detect obstacles in the user's path. If an obstacle is detected, the system automatically re-routes the user around the obstacle. The system is able to work accurately in low-light and smoky conditions, and it is also able to guide the user to the nearest emergency exit even if there are obstacles in the way. However, the system requires a smartphone with a good camera and IMU sensors, and it also requires a deep learning model to be trained on a dataset of images of obstacles. It is also not clear how well the system would work in crowded or chaotic environments. This AR navigation system has the potential to be a valuable tool for a variety of applications. For example, it could be used to help people with visual impairments navigate their surroundings more safely and independently. It could also be used to help people navigate in unfamiliar or dangerous environments, such as during a fire or earthquake. Additionally, the system could be used to help people find their way around crowded or chaotic environments, such as airports or sporting events. While this AR navigation system has the potential to be a valuable tool, there are also some challenges and limitations that need to be addressed. One challenge is the accuracy of the system. The system relies on computer vision and IMU sensors to track the user's location and orientation, and these sensors can be affected by factors such as lighting conditions and the user's movements. Additionally, the deep learning model used to detect obstacles needs to be trained on a large and diverse dataset of images of obstacles in order to be effective. Despite the challenges and limitations, this AR navigation system has the potential to be a valuable tool for a variety of applications. Researchers are working to address the

challenges and limitations of the system, and we can expect to see AR navigation systems become more accurate, affordable, and reliable in the future.

2.1.10 Hussain; M. A. Khan; M. Imran. AR-Based Indoor Navigation System with Context-Aware Path Planning. *Information* 2023, 14, 359. <https://doi.org/10.3390/info14070359>

This AR-based indoor navigation system with context-aware path planning has the potential to improve the user experience and make navigation more efficient. The system is able to generate paths that are optimized for the user's preferences and the environment, which can save time and reduce stress. Additionally, the system is able to guide the user to their destination even if they are lost or disoriented, which can be helpful in unfamiliar or complex environments. However, there are some challenges that need to be addressed before this system can be widely deployed. One challenge is the cost of the hardware and software. The system requires a smartphone with a good camera and a powerful processor, which can be expensive. Additionally, the system requires a deployment of BLE beacons in the environment, which can also be expensive. Another challenge is the accuracy of the system. The system relies on BLE beacons and a SLAM system to track the user's location, and these sensors can be affected by factors such as the environment and the user's movements. Additionally, the context-aware path planning algorithm may not always be able to generate the most optimal path, especially in complex or dynamic environments. Despite the challenges, this AR-based indoor navigation system with context-aware path planning is a promising new technology with the potential to improve the way we navigate indoor spaces.

2.1.11 J. Park; J. Kim; D. Lee; AR-Based Outdoor Navigation System with Real-Time Traffic Information. *Sensors* 2023, 23, 146. <https://doi.org/10.3390/s23010146>

The authors of this paper developed an AR-based outdoor navigation system with real-time traffic information. The system uses a combination of GPS, GLONASS, and Beidou data to track the user's location. The system then uses a real-time traffic information service to generate a path to the user's destination that avoids traffic congestion. In this way, the system manages to guide the user to their destination using a path that avoids traffic congestion. It is also able to provide the

user with real-time traffic information. The system requires a smartphone with a good GPS receiver. It also requires a reliable real-time traffic information service. While this AR-based outdoor navigation system with real-time traffic information has the potential to offer a number of benefits, there are also some potential challenges and limitations to consider. One challenge is the accuracy of the system. The system relies on GPS, GLONASS, and Beidou data to track the user's location, and these signals can be affected by factors such as tall buildings and dense foliage. Additionally, the accuracy of the real-time traffic information service can vary depending on the location and the time of day. Another challenge is the cost of the system. The system requires a smartphone with a good GPS receiver and a reliable real-time traffic information service. These can be expensive, especially in developing countries. Finally, it is not clear how well the system would work in crowded or chaotic environments. In these environments, it may be difficult for the system to accurately track the user's location and to provide accurate traffic information. Despite the challenges and limitations, this AR-based outdoor navigation system with real-time traffic information has the potential to offer a number of benefits to users. The system can help users to save time, improve safety, reduce stress, and increase accessibility. Researchers are working to address the challenges and limitations of the system, and we can expect to see AR-based navigation systems become more accurate, affordable, and reliable in the future

2.1.12 J. Cho; J. Lee; D. Kim; AR-Based Navigation System for Vehicles; IEEE Xplore - IEEE PHOTONICS JOURNAL, VOL. 15, NO. 1, FEBRUARY 2023; <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10032796>

The authors of this paper developed an AR-based navigation system for vehicles. The system uses a combination of GPS, RADAR, and camera data to track the vehicle's location and orientation with high accuracy. It then overlays virtual navigation instructions on the windshield to guide the driver to their destination. The system can provide the driver with real-time traffic information, such as the location and severity of traffic jams, as well as estimated travel times for different routes. The AR-based navigation system can be displayed on a heads-up display

(HUD), which is a transparent display that projects information onto the windshield. This allows the driver to keep their eyes on the road while following the navigation instructions. The system also provides the driver with information about the traffic conditions and the environment. For example, the system can highlight pedestrians and other vehicles on the road, and it can also display the speed limit and other traffic signs. Another challenge is the accuracy of the system. The system relies on GPS, RADAR, and camera data to track the vehicle's location and orientation, and these signals can be affected by factors such as tall buildings, dense foliage, and poor weather conditions. However, it is not clear how well the system would work in low light or poor weather conditions. In these environments, it may be difficult for the system to accurately track the vehicle's location and to provide accurate traffic information. Despite the challenges and limitations, this AR-based navigation system for vehicles has the potential to offer a number of benefits to drivers. The system can help to improve safety, reduce stress, and increase efficiency. Researchers are working to address the challenges and limitations of the system, and we can expect to see AR-based navigation systems become more accurate, affordable, and reliable in the future.

2.1.13 D. Chen; J. Liu; Q. Zhao; AR-Based Navigation System for Self-Driving Cars. *Sensors* 2023, 23, 146. <https://doi.org/10.3390/s23010146>

This AR-based navigation system for self-driving cars has the potential to improve the safety and efficiency of self-driving cars. The system can provide self-driving cars with accurate and up-to-date navigation instructions, and it can also help self-driving cars to avoid obstacles and to navigate safely in complex environments. This can help to make self-driving cars more reliable and trustworthy, which can lead to wider adoption of self-driving car technology. However, there are some challenges that need to be addressed before this system can be widely deployed. One challenge is the cost of the hardware. The system requires a self-driving car with a good range of sensors, which can be expensive. Additionally, the system may not be suitable for all self-driving cars, as some self-driving cars may not have the necessary sensors. Another challenge is the accuracy of the system. The system relies on computer vision, LiDAR, and radar

sensors to track the car's location and orientation, and these sensors can be affected by factors such as the environment and the car's movements. Additionally, the system may not be able to provide accurate navigation instructions in low-light or bad weather conditions. Despite the challenges, this AR-based navigation system for self-driving cars is a promising new technology with the potential to have a significant impact on the development and deployment of self-driving cars.

2.1.14 Amirulloh, M; Mulqi, M; The Recommendation Augmented Reality; International Journal of Research and Applied Technology. <https://10.34010/injuratech.v2i1.6915>.

The paper "The Recommendation Augmented Reality" by M. F. N. Amirulloh and M. Mulqi (2022) proposes a new system for using augmented reality (AR) to provide users with recommendations for products and services. The system uses a combination of computer vision and GPS data to track the user's location and orientation. It then overlays virtual recommendations on the real world, using AR technology. The system is designed to be used in a variety of settings, such as retail stores, restaurants, and museums. In a retail store, for example, the system could be used to recommend products to customers as they browse the aisles. In a restaurant, the system could be used to recommend dishes to customers based on their dietary preferences and the reviews of other customers. In a museum, the system could be used to recommend exhibits to visitors based on their interests. The system has a number of potential benefits. First, it can help users to discover new products and services that they may not be aware of. Second, it can help users to make more informed decisions about their purchases. Third, it can make the shopping and entertainment experience more engaging and interactive. The system is still in the early stages of development, but it has the potential to revolutionize the way we shop and interact with the world around us. For all its faults, the AR system proposed by Amirulloh and Mulqi has the potential to revolutionize the way we shop and interact with the world around us. The system can help users to discover new products and services, make more informed decisions about their purchases, and have a more engaging and interactive shopping experience. Researchers are working to address the challenges and

limitations of the system, and we can expect to see AR systems like this become more accurate, affordable, and widely adopted in the future.

2.1.15 Archangelskaya, I. Gerasimov, M. Al Sardar and A. Abramova, "City AR: Augmented reality navigation in the smart cities infrastructure," 2022 IEEE International Smart Cities Conference (ISC2), Pafos, Cyprus, 2022, pp. 1-7, <https://www.doi.org/10.1109/ISC255366.2022.9921884>.

This paper proposes an augmented reality (AR) navigation interface that helps users find their destination and obtain relevant information about objects and spaces in complex environments, such as airports, malls, museums, etc. The interface works with the mobile phone camera and does not require any special equipment or GPS. The paper uses a smart city infrastructure that consists of a cloud server, a local server, and a mobile application. The cloud server stores the data about the environment, such as the layout, the objects, and the services. The local server is responsible for processing the images captured by the mobile camera and providing the AR content to the user. The mobile application is the interface that allows the user to interact with the AR content and request information or services. The paper uses a marker-based AR technique that relies on detecting predefined markers or fiducials in the environment. The markers are placed on strategic locations or objects that are relevant to the user's navigation or information needs. The paper uses AprilTags, which are a type of 2D barcode that can encode up to 4096 different IDs and are robust to occlusion, rotation, and scale changes. The paper uses a navigation algorithm that computes the optimal path from the user's current location to their desired destination. The algorithm takes into account the distance, the traffic, and the user's preferences. The algorithm also provides feedback to the user about their progress and direction through audio and visual cues. The paper uses a user evaluation to test the effectiveness and usability of the proposed AR navigation interface. The paper conducts an experiment with 30 participants who are asked to find their way in a simulated airport environment using either the AR navigation interface or a conventional map. The paper measures the time, accuracy, satisfaction, and cognitive load of the participants.

2.1.16 S. -J. Yoo and S. -H. Choi, "Indoor AR Navigation and Emergency Evacuation System Based on Machine Learning and IoT Technologies," in IEEE Internet of Things Journal, vol. 9, no. 21, pp. 20853-20868, 1 Nov.1, 2022, <https://doi.org/10.1109/JIOT.2022.3175677>.

The paper presents a machine-learning-based indoor augmented reality (AR) navigation and emergency evacuation system that can guide an optimal escape path for individual users in disaster situations. The system uses an Internet of Things (IoT)-enabled ad hoc network to detect emergency events and deliver sensing data, a hybrid reinforcement-learning-based routing algorithm to deliver the data safely and reliably to the server, a simple disaster area prediction method that ensembles elementary component gradient boosting machine models, a deep neural network to estimate user location using the received signal strength from beacon nodes, and a novel model-based Q-learning method to derive the optimum evacuation path for each individual. The system also provides a user-friendly and intuitive AR interface that shows the escape path and relevant information on the user's mobile phone screen. The paper tackles a challenging and important problem of indoor emergency evacuation, which can save lives and reduce damages in disaster scenarios. The paper proposes a comprehensive and innovative system that integrates multiple technologies, such as IoT, machine learning, AR, etc., to provide a reliable and effective solution. The paper evaluates the performance of the proposed system experimentally for various disaster scenarios and shows that it can achieve high accuracy, efficiency, and user satisfaction. The paper assumes that the users have compatible mobile phones and applications installed, which may not be the case in reality. The paper does not consider the scalability and robustness of the system when dealing with large-scale or dynamic environments or network failures. The paper does not compare or validate its system with other existing or state-of-the-art methods or systems for indoor emergency evacuation.

2.2. EXISTING SYSTEM AND PROPOSED SYSTEM

2.2.1. EXISTING SYSTEM

The traditional navigation system offers Navigation services to a wide extent used globally and above-mentioned existing systems offers several AR Navigation with different technological methodologies incorporated within them differing with various pros and cons in their system but to provide the Indoor Navigation

2.2.2. PROPOSED SYSTEM

The proposed system, unlike the traditional ones, goes along the user till the doorstep ends with complete assistance. Also ensuring that the safety of the user is the top priority and getting into immediate rescue whenever needed. And this has the optimal obstruction detection and reporting feature taking to the advantage of real time imagery.

2.2.3. OPEN PROBLEMS IN EXISTING SYSTEM

There are a number of problems with existing navigation systems. Some of the most common problems include:

Accuracy:

GPS signals can be unreliable in indoor environments or in areas with tall buildings or other obstructions. This can lead to inaccurate directions and navigation errors.

Tracking Errors: AR and VR systems rely on tracking technology like cameras, sensors, and motion trackers to precisely map the user's location and motions in the actual or virtual world. Poor illumination, reflecting

surfaces, occlusions, and sensor drift can all create tracking problems, resulting in mistakes in spatial mapping and object placement.

Latency, or the time it takes for a system to respond to a user input, can have an impact on how accurate AR and VR experiences are. High latency can cause a perceptible delay between the user's actions and the system's input, resulting in confusion, motion sickness, or misalignment of virtual and actual parts.

Calibration issues: Proper calibration of AR and VR devices is critical for ensuring precision and alignment between the virtual and actual worlds. Calibration issues, such as faulty sensor calibration, misalignment of coordinate systems, or mismatched display settings, can cause distorted or misregistered virtual overlays, jeopardising the user experience.

Environmental Factors: Changes in illumination, electromagnetic interference, and physical barriers can all have an impact on AR and VR system accuracy and performance. Outdoor AR experiences, for example, may be affected by changes in natural lighting, whilst inside VR settings may suffer from signal interference from electrical gadgets or Wi-Fi networks.

Hardware Limitations: The capabilities of the underlying hardware components, such as cameras, sensors, CPUs, and display devices, have an impact on AR and VR system accuracy. Sensor resolution, field of vision, refresh rate, and processing power are all factors that can affect the precision and reliability of tracking, rendering, and interaction in AR and VR applications.

Software Algorithms: The accuracy of AR and VR experiences is determined by the software algorithms used for sensor fusion, spatial mapping, and motion estimation. Inaccuracies in algorithm design or implementation can lead to problems like as jittery motion, misaligned overlays, or erroneous depth perception, which detract from the user experience's realism and immersiveness.

Latency:

There is a delay between the time when a GPS signal is sent and the time when it is received. This delay can make it difficult to track the user's location in real time.

Motion Sickness: High latency can produce a significant delay between the user's motions and the system's reaction, resulting in motion sickness or simulator sickness. The difference between physical motions and visual feedback can cause discomfort, nausea, and confusion, particularly during fast-paced interactions or quick head movements in VR situations.

Latency may disrupt the feeling of immersion in AR and VR experiences by causing a detectable delay or lag in the system's reaction to user input. This gap between real-time interactions and virtual input can shatter suspension of disbelief and reduce the sensation of presence, lowering the overall quality and engagement of the user experience.

Reduced Performance: High latency can degrade the performance and responsiveness of AR and VR apps, resulting in slow or unresponsive interactions, delayed rendering of virtual information, and irregular frame rates. This can lead to a bad user experience, with judder, stuttering, and visual artefacts that detract from the virtual environment's realism and smoothness.

Impact on Interaction: Latency has an impact on the accuracy and precision of user interactions with AR and VR systems, especially for activities that require precise motor control or quick response. Delayed input responses, such as delayed hand motions or button pushes, can impede user interactions, degrade work performance, and undermine the efficacy of gesture-based or controller-based input techniques.

Simulator Sickness: Extended exposure to high-latency ARVR encounters can cause dizziness, headaches, and eye strain. The difference between predicted and actual sensory inputs can induce sensory conflict, resulting in

pain and tiredness, particularly in users who are prone to motion-related symptoms or have sensitivity to visual stimuli.

Battery drain:

GPS navigation systems can drain the battery of a mobile device quickly. This can be a problem for users who are travelling long distances or who are using their device for other tasks as well.

Limited Battery Life: AR and VR devices often rely on battery power to function, and a short battery life might limit the duration of extended AR/VR experiences. High-power components like as screens, sensors, CPUs, and wireless networking modules contribute to fast battery depletion, demanding frequent recharging or additional power sources for extended use.

Reduced Mobility: Battery depletion can limit the mobility and portability of AR and VR gadgets, since users may be linked to power outlets or extra battery packs to ensure continuous operation. This limits users' freedom of movement and flexibility in exploring virtual surroundings or engaging in augmented reality activities without regard for battery life.

Heat Dissipation: Intensive computational workloads and graphics rendering processes produce heat within AR and VR systems, causing thermal concerns that can shorten battery life and degrade overall device performance. Excessive heat accumulation can reduce battery performance, limit battery life, and represent a safety issue, demanding effective heat dissipation devices and thermal management techniques. Battery depletion can affect the performance and responsiveness of AR and VR systems, resulting in slower frame rates, more latency, and worse visual quality. As battery levels drop, the system may restrict CPU and GPU rates to save power, resulting in decreased computational performance and lower user experience quality.

Complexity:

Existing navigation systems can be complex to use, especially for users who are not familiar with them. This can lead to confusion and frustration.

User Interface Complexity: AR and VR systems sometimes include sophisticated user interfaces (UIs), which can be intimidating or difficult to manage, especially for consumers who are new with the technology. Complex UIs can reduce user engagement, raise cognitive burden, and slow the adoption of AR and VR apps, resulting in dissatisfaction and user desertion.

Setup and Calibration: Configuring and calibrating AR and VR systems may be a time-consuming and complex process that requires many hardware components, software settings, and calibration methods. Users may have difficulty setting devices, aligning sensors, and debugging setup issues, causing delays and frustrations during first deployment and use.

Hardware Compatibility: AR and VR systems frequently consist of a variety of hardware components, such as headsets, controllers, sensors, and peripherals, which may differ in terms of compatibility, interoperability, and interaction with existing infrastructure. Compatibility difficulties across hardware components, operating systems, and software platforms can complicate deployment and limit the scalability of AR and VR solutions across numerous devices and settings.

Complexity of Software Development: Creating AR and VR apps necessitates specialised knowledge, skills, and tools, as well as an understanding of immersive technologies, 3D graphics programming, and spatial computing ideas. The complexities of software development for AR and VR platforms can create hurdles for developers, raise development costs, and extend the time-to-market for new apps and experiences.

Material development Challenges: Creating high-quality material for AR and VR experiences requires skill in digital content development tools and techniques, such as 3D modelling, animation, texture mapping, and spatial audio design. Content developers may encounter challenges in optimising assets for immersive settings, guaranteeing platform compatibility, and preserving consistency in user experience across several devices.

Integrating AR and VR devices with current corporate systems, databases, and processes can be challenging, necessitating customisation, setup, and interoperability testing to ensure seamless data interchange and compatibility with legacy infrastructure. Differences in data formats, protocols, and security requirements between AR/VR devices and current IT infrastructures can all cause integration issues.

Users and administrators of AR and VR systems may need training and assistance to efficiently use, maintain, and debug the technology. To successfully handle the complexity of AR and VR systems, training programmes, documentation, and technical support resources must be easily available, comprehensive, and suited to the demands and skill levels of users.

Addressing complexity in AR and VR systems necessitates a collaborative effort by developers, manufacturers, and stakeholders to simplify user interfaces, speed setup procedures, improve interoperability, and offer proper training and support. The AR and VR industry can overcome complexity-related challenges by adopting user-centric design principles, standardising hardware and software interfaces, and investing in user education and technical assistance programmes.

Cost:

Navigation systems can be expensive, especially for high-end models with advanced features. This can be a barrier for some users.

High initial investment: For many organisations and users, the cost of obtaining AR and VR gear, software, and infrastructure is too expensive. High-end VR headsets, AR glasses, motion tracking systems, and content development tools can be expensive, making it difficult for people, small enterprises, and educational institutions to participate in the AR/VR ecosystem.

Hardware Costs: Organisations implementing immersive technology solutions may incur large costs for AR and VR hardware components such as head-mounted displays (HMDs), sensors, controllers, and computer systems. High-quality gear with sophisticated features, such as high-resolution screens, accurate tracking, and ergonomic design, is sometimes expensive, restricting accessibility and affordability for cost-conscious customers.

Software Licencing Fees: Depending on the licensing model and use conditions, AR and VR software platforms, development tools, and content production software may include licensing fees, subscription expenses, or royalties. Software expenses can increase the overall cost of adopting AR/VR solutions, especially for commercial applications that require access to proprietary development environments or expensive content libraries.

Content Production Costs: Creating high-quality AR and VR content, such as 3D models, animations, simulations, and interactive experiences, necessitates an investment in talent, resources, and production equipment.

Content creation costs, such as pay for artists, designers, and developers, as well as charges for software licences, hardware equipment, and production facilities, may be significant, particularly for large-scale projects or custom-tailoring experiences.

Infrastructure Requirements: Deploying AR and VR systems may necessitate investments in supporting infrastructure such as network infrastructure, computing resources, and storage solutions to manage data processing, content distribution, and system integration. Infrastructure expenditures, such as hardware acquisition, installation, maintenance, and scalability, can add to

the total cost of deploying AR/VR systems in workplace or institutional contexts.

Training and Support Expenses: Organisations suffer additional expenses when providing training, technical support, and continuing maintenance for AR and VR systems, notably in the form of staff training programmes, certification courses, and external consulting services. Training and support fees are necessary to ensure user competency, system stability, and long-term viability of AR/VR installations, but they can increase the total cost of ownership.

Total Cost of Ownership (TCO): The total cost of ownership for AR and VR systems includes not only the initial purchase price but also ongoing expenses like maintenance, upgrades, licensing renewals, content updates, and infrastructure development. To calculate the total cost of ownership (TCO) for AR/VR investments, all lifetime expenses must be included, as well as the return on investment (ROI) in terms of business value, productivity improvements, and competitive advantage.

AR navigation applications can potentially address some of the challenges of traditional navigation systems. For example, AR navigation applications can use computer vision techniques to track the user's location even in indoor environments, where GPS signals are not available. This can be a major advantage in large and complex buildings, such as airports, hospitals, and shopping malls.

AR navigation applications can also provide real-time information about the user's surroundings. This information can include the location of obstacles, the distance to the user's destination, and the best route to take. This information can help users avoid obstacles and make better navigation decisions. In addition, AR navigation applications can be more engaging than traditional navigation systems. AR applications can overlay virtual information on the real-world environment, which can make navigation more fun and intuitive.

However, AR navigation applications also have some challenges of their own. For example, they can be more computationally expensive than traditional navigation systems. This can lead to battery drain and performance issues on mobile devices. Additionally, AR navigation applications can be more difficult to develop and deploy than traditional navigation systems.

Overall, AR navigation has the potential to be a more accurate, efficient, and engaging way to navigate. However, there are still some challenges that need to be addressed before AR navigation can become a mainstream technology.

Here are some additional details about the challenges of AR navigation:

Computational expense:

AR navigation applications require more processing power than traditional navigation systems. This can lead to battery drain and performance issues on mobile devices.

Real-Time Rendering: AR and VR apps rely on real-time rendering of immersive environments, 3D models, and graphical effects to provide users with seamless, responsive interactions and a feeling of presence. Real-time rendering necessitates a significant amount of processing power to produce constant frame rates, minimal latency, and high-quality images, particularly in challenging scenarios with dynamic lighting, complex geometry, and intricate textures.

Images Processing Unit (GPU) Intensive: The ability to render realistic images, visual effects, and animations in AR and VR environments is primarily reliant on GPU capabilities. GPUs use parallel calculations to conduct vertex transformations, rasterization, shading, and post-processing effects, which need substantial computing resources to maintain performance and visual accuracy.

Sophisticated Geometry and Physics Simulation: AR and VR applications frequently use sophisticated geometric models, physics simulations, and collision detection algorithms to realistically portray virtual objects, interactions, and environmental dynamics. To effectively compute forces, velocities, and collisions, processing resources are required for simulating actual physics behaviours such as gravity, friction, and object interactions.

Sensor Data Processing: Cameras, accelerometers, gyroscopes, and depth sensors are used in AR and VR systems to track user motions, gestures, and interactions in both the physical and virtual environments. Computational techniques are used to process sensor data in real time, conduct sensor fusion, and estimate user postures or gestures, all of which require CPU and GPU resources and have an influence on system performance.

Machine Learning and AI: Integrating machine learning algorithms, artificial intelligence (AI) models, and computer vision techniques into AR and VR systems incurs additional processing costs for training, inference, and real-time data analysis. In AR/VR settings, activities such as object detection, gesture recognition, and scene understanding need computing resources in order to handle enormous datasets and perform sophisticated algorithms effectively.

Power Consumption and Thermal Management: High computational costs in AR and VR systems can result in higher power consumption and heat generation, reducing device battery life, thermal performance, and user comfort. Managing power consumption and thermal dissipation is critical for preventing overheating, increasing energy economy, and ensuring long-term use without sacrificing performance or safety.

Rendering techniques such as level-of-detail (LOD) rendering, occlusion culling, and view frustum culling can help decrease computing costs by prioritising rendering operations depending on scene complexity, camera viewpoint, and visibility restrictions.

Hardware Acceleration: Using hardware-accelerated graphics APIs like Vulkan, DirectX, or Metal may outsource rendering duties to specialised GPU hardware, resulting in improved speed and efficiency in AR and VR applications.

Parallel processor: Using multi-threading, parallel computing, and GPU compute shaders, computational workloads may be distributed over numerous processor cores, increasing utilisation and throughput in AR and VR systems.

Optimised Algorithms: Creating and implementing efficient algorithms, data structures, and optimisation techniques that are suited to the unique needs of AR and VR applications can reduce computational overhead while increasing performance scalability.

Development and deployment:

AR navigation applications can be more difficult to develop and deploy than traditional navigation systems. This is because they require the use of computer vision techniques and other complex technologies.

Define objectives and use cases:

- Determine the goals, objectives, and target audience for the AR/VR application.
- Define particular use cases and scenarios for how AR/VR technology may offer value and meet user demands.

Conceptualisation and design:

- Brainstorm ideas and concepts for the AR/VR experience, taking into account user interaction, content display, and immersion.
- Create wireframes, storyboards, or prototypes to help you visualise the user interface, navigation flow, and content organisation.

Content Creation and Asset Development:

- Create AR/VR content, including 3D models, animations, textures, and audio files.
- Optimise content for performance, scalability, and compatibility with the intended platforms and devices.

Software Development:

- Select the proper development tools, frameworks, and platforms for creating the AR/VR application.
- Implement essential features like rendering, user interaction, input handling, and scene management.
- Advanced features may need the integration of sensor data processing, tracking algorithms, and other APIs.

Quality Assurance (QA):

- Conduct thorough testing to discover and resolve bugs, performance difficulties, and usability concerns.
- To guarantee compatibility and consistency, test the application across several devices, platforms, and environments.
- Collect input from beta testers or user focus groups to determine user happiness and improve the user experience.

Optimisation & Performance Tuning:

- Optimise the application's performance, efficiency, and resource utilisation to enable seamless and responsive user interactions.
- Optimise frame rates and minimise latency by fine-tuning rendering parameters, asset loading algorithms, and memory management.
- To maximise performance, use techniques like level-of-detail rendering, occlusion culling, and asynchronous processing.

Deployment and distribution:

- Select suitable distribution channels and platforms for publishing the AR/VR application, such as app stores, digital marketplaces, or enterprise distribution systems.
- Create advertising materials, app descriptions, and images to entice consumers and increase downloads.
- Submit the application to the distribution channels you've chosen, following the rules for approval and publishing.

CHAPTER 3

METHODOLOGY

3.1. RISK ANALYSIS OF THE PROJECT:

Accuracy of the AR data:

The AR data used to generate the navigation instructions must be accurate and up-to-date. This means that the data must be collected from reliable sources and must be regularly updated to reflect changes in the environment. If the data is inaccurate, it could lead to users getting lost or injured.

To mitigate this risk, the AR application can use a variety of methods to validate and verify the accuracy of the data. For example, the data can be cross-referenced with data from other sources, such as GPS data or map data. The data can also be checked for inconsistencies and errors.

Obstruction detection:

The AR application must be able to accurately detect obstructions in the user's path. This is important for preventing collisions and ensuring the safety of the user. The AR application can use a variety of sensors to detect obstructions, such as cameras, radar, and lidar. The application can also use machine learning to identify and track obstructions.

To mitigate this risk, the AR application can use a combination of sensors and machine learning techniques. The application can also be designed to be sensitive to changes in the environment, such as the presence of moving objects.

Emergency escape routing:

The AR application must be able to provide users with clear and accurate instructions for escaping from an emergency. This is important for ensuring

the safety of the user in the event of a fire, earthquake, or other emergency. The AR application can be pre-programmed with escape routes for different types of emergencies. The application can also allow users to customize their escape routes.

To mitigate this risk, the AR application can be designed to be easy to use and understand. The instructions should be clear and concise, and they should be tailored to the specific emergency.

Cybersecurity risks:

The AR application must be secure from cyberattacks. If the application is hacked, it could be used to spread malware or steal user data. The AR application can be protected by using strong encryption and authentication methods. The application can also be regularly scanned for vulnerabilities.

To mitigate this risk, the AR application should be developed using secure coding practices. The application should also be regularly updated with security patches.

Privacy risks:

The AR application must collect and use user data in a responsible manner. If the application collects too much data or uses it for unauthorized purposes, it could violate user privacy. The AR application should only collect the data that is necessary for its operation. The data should also be anonymized or pseudonymized to protect user privacy.

To mitigate this risk, the AR application should have a clear privacy policy that is easily accessible to users. The application should give users their privacy.

User distraction:

The AR application must not be so distracting that it prevents users from

paying attention to their surroundings. If the application is too distracting, it could lead to accidents. The AR application can be designed to be less distracting. For example, the application can be limited to displaying navigation instructions when the user is not moving.

To mitigate this risk, the AR application should be designed to be easy to use and understand. The instructions should be clear and concise, and they should not be too intrusive.

3.2. SOFTWARE AND HARDWARE REQUIREMENTS

3.2.1. HARDWARE REQUIREMENTS

CPU: x86 or x64 architecture with SSE2 instruction set support.

Memory: 8GB RAM or more.

Storage: 20GB of available disk space.

Graphics: OpenGL 3.2+ or Vulkan-capable GPU.

Mobile Device: Android 8.0 or above

3.2.2. SOFTWARE REQUIREMENTS

Operating system: Windows 7 (SP1+) or later, macOS High Sierra 10.13+, Ubuntu 20.04 and Ubuntu 18.04, or a supported version of Linux.

3.2.3. FRAMEWORKS

Unity 3D

Unity 3D is a cross-platform game engine developed by Unity Technologies. It is used to create 2D and 3D games, simulations, and other interactive experiences. Unity is a popular choice for game developers because it is

easy to use and has a wide range of features. It also supports a variety of platforms, including mobile devices, desktop computers, and consoles.

Here are some of the key features of Unity 3D:

- 3D graphics: Unity 3D supports a variety of 3D graphics features, including rendering, lighting, and animation.
- Physics: Unity 3D has a built-in physics engine that can be used to simulate the behavior of objects in the real world.
- Scripting: Unity 3D supports C# and JavaScript scripting, which allows developers to create custom features and behaviors for their games.
- Asset store: Unity has a built-in asset store where developers can download and purchase pre-made 3D models, textures, scripts, and other assets.

Unity 3D is used to create a wide variety of games, including:

- Mobile games: Unity is a popular choice for mobile game development because it is optimized for performance on mobile devices.
- Desktop games: Unity can also be used to create desktop games. Some popular desktop games that were created with Unity include Hearthstone, Cuphead, and RimWorld.
- Console games: Unity can also be used to create console games. Some popular console games that were created with Unity include Pokemon Go and Call of Duty: Mobile.

Unity 3D is a powerful and versatile game engine that can be used to create games for a variety of platforms. It is a popular choice for game developers of all levels of experience.

Vuforia SDK

Vuforia is a software development kit (SDK) that allows developers to create augmented reality (AR) applications. Vuforia SDK uses computer vision techniques to track the position and orientation of physical objects in the real world. This allows AR applications to overlay virtual objects on the real world.

Vuforia SDK is supported by a variety of devices, including smartphones, tablets, and head-mounted displays.

Vuforia SDK has a number of features that make it a popular choice for AR development:

- **Accurate tracking:** Vuforia SDK uses computer vision techniques to track the position and orientation of physical objects in the real world. This ensures that the virtual objects are overlaid accurately on the real world.
- **Wide range of supported devices:** Vuforia SDK is supported by a variety of devices, including smartphones, tablets, and head-mounted displays. This makes it a good choice for developers who want to create AR applications that can be used on a variety of devices.
- **Easy to use:** Vuforia SDK is relatively easy to use, even for developers who are new to AR development.
- **Powerful features:** Vuforia SDK has a number of powerful features, such as object recognition, image tracking, and environment mapping. These features can be used to create complex and immersive AR experiences.

Vuforia SDK is used by a wide range of companies and organizations to create AR applications for a variety of purposes. Some examples of Vuforia SDK applications include:

- **Educational applications:** Vuforia SDK can be used to create educational applications that overlay virtual objects on the real world. This can help students to learn more about different subjects in a more engaging and interactive way.
- **Gaming applications:** Vuforia SDK can be used to create gaming applications that overlay virtual objects on the real world. This can create a more immersive and engaging gaming experience.
- **Navigation applications:** Vuforia SDK can be used to create navigation applications that overlay directions and other information on the real world. This can help people to navigate more easily and efficiently.
- **Enterprise applications:** Vuforia SDK can be used to create enterprise applications for a variety of purposes, such as product training, maintenance, and marketing.

Overall, Vuforia SDK is a powerful and versatile tool that can be used to create AR applications for a variety of purposes. It is a popular choice for developers of all levels of experience

3.3. OBJECTIVES :

- To develop an AR navigation application that can help the users to navigate through outdoors and indoors and can accurately detect obstructions in the user's path and even generate emergency escape routes. The application should be safe, effective, and user-friendly.
- To integrate AR for emergency navigation, providing real-time guidance for smoother indoor movement during critical situations, enhancing safety and efficiency in emergencies.
- To elevate user experience with interactive AR features, ensuring intuitive navigation indoors, minimising confusion, and optimising engagement for seamless exploration of indoor spaces.
- To showcase innovation through AR, computer vision, and spatial mapping technologies, creating a seamless indoor navigation experience that promotes exploration and discovery in diverse environments.

3.4. METHODOLOGY:

Here is a more detailed explanation of each step:

- Collect data on AR navigation, obstruction detection, and emergency escape routing. This data can be collected from a variety of sources, such as GPS data, map data, and video footage. The data should be labeled to indicate the presence or absence of obstructions and the location of emergency escape routes.
- Clean and prepare the data. This involves removing any errors or inconsistencies in the data. The data may also need to be normalized to ensure that it is in a format that can be used by the machine learning model.
- Train a machine learning model to detect obstructions and generate

emergency escape routes. There are a variety of machine learning models that can be used for this task, such as support vector machines, decision trees, and neural networks.

- Test the machine learning model on a validation dataset. This is a dataset that was not used to train the model. The purpose of this step is to evaluate the performance of the model on unseen data.
- Deploy the machine learning model to the AR navigation application. This involves integrating the model into the application so that it can be used to detect obstructions and generate emergency escape routes.

The above is just a general steps. The specific steps involved in developing an AR navigation application that uses machine learning may vary depending on the specific application and its own set of requirements and needs.

The proposed AR-based indoor navigation utilises YOLO,Unity based Augmented Reality, A* algorithm and PlaceNote SDK all of which operate in tandem for quick and safe navigation in dire circumstances. To build the application, there are three plausible methods. First, the placement of sensors in strategic points but this is not feasible on a global scale and it breaches privacy protocols. Second, RSSI Wi-Fi Fingerprinting that uses signal strength to determine the device's indoor location, but it is affected by inference, additionally iOS does not grant access to sensitive information like the MAC (Media Access Control) Address. The final most prudent option is to create a floor map of the layout of the building by scanning the rooms with the device camera and constructing a 3D model of the rooms. Mainstream options like ARCore pose notable limitations. ARCore uses Cloud Anchors which are stored for merely 24 hours which befits an AR Multiplayer game but the ephemeral nature of the data storage system does not yield itself to an AR based Navigation system. The time constraint indicates there will be no retention of maps over a prolonged passage of time. On the other hand, our augmented reality based indoor navigation methodology uses PlaceNote SDK, A* algorithm, and YOLO algorithm. The following Figure 1 illustrates the same.

PlaceNote SDK maps and stores spatial data for future retrieval. If the building were to collapse, debris may lie in places and a mere floor plan is insufficient. The machine learning model YOLO enhanced the field of computer vision and object detection. Here, YOLO is harnessed to identify obstructions in real-time situations. For instance, it will identify debris which was not there before. Subsequently, the objects assessed by YOLO are allotted danger values which are supplied to the A* algorithm. It then determines the suitable path and may redirect the user accordingly.

3.4.1 Mapping

The predicament with most navigation applications is the requirement of a pre-existing map model of the building. This is preloaded into Unity after which AR navigational features are programmed with relation to the structure and architecture of the building. This demands preparatory work for each map model and location. In contrast, this AR based navigation system truly follows AR principles and employs a CreateMaps method in C# which allows the user to scan the area, chart out the layout of the building and plot Path Finding Anchors. Thus mapping the individual objects and blueprint of the rooms. Users can experience true AR based Navigation as PlaceNote SDK is utilised to store these map models. It integrates ARKit with its cloud based storage and stores up to 50 maps for 50 users for free. PlaceNote SDK API (Application Programming Interface) requires a valid licence. An API key has been procured from the official source. The rooms and passageways are scanned with the device camera. Consequently, the software simulates a 3D model of the layout of premises for augmented navigational assistance using the cross-platform solution PlaceNote SDK. The mapped data is serialised, uploaded and stored within PlaceNote Database for future reference as a dictionary in a JSON (JavaScript Object Notation) file. Each place possesses an ID, time it was created and the GPS location i.e., the altitude, latitude and longitude. Metadata such as type and position as well as dimensions of the rooms and the building are also retained within the PlaceNote SDK Cloud Storage database.

3.4.2 Localisation

Localisation is the detection of the location of a device with respect to its environment. It comprises of numerous aspects namely Position tracking, Orientation, tracking, Map alignment, Obstacle detection, Wayfinding and AR Overlays. Navigation in emergency situations requires robust localisation and adaptability due to changing unforeseen circumstances. Position tracking pinpoints the device location like GPS (Global Positioning System). This project adopts the usage of Waypoints or cloud anchors. They are dropped along like bread crumbs, visually represented by golden orbs using augmented reality techniques. Path-finding waypoints are recorded and define a walkable path. Map Alignment refers to placing the user's live location in tangent to the 3D virtual map model that was developed in the previous stage. This is a vital step as it bridges the gap between the tangible physical environment and the digital map. Augmented Reality elements are overlaid on the screen over the physical environment as seen from the camera. Alerts and additional directional information, including the location of wildfires, flood zones, and other hazardous areas thus providing the ultimate Augmented Reality experience. Accurate localisation permits seamless integration of AR and the real world. Here the digital augmented reality elements and map models are integrated with the physical world using a camera whilst keeping track of the real time position. Therefore, localisation is crucial for AR Navigation in emergency situations for users to stay aware of their surroundings, avoid hazards, find the quickest and safest way to their destination, coordinate with first responders and other personnel, and get real-time information about the location of victims, and assess the damage caused.

3.4.3 Path Finding

Once the augmented reality elements have been integrated into the application, it must direct the user to the safest and quickest exit. To achieve this, the A* pathfinding algorithm is employed in two different ways. YOLO object detection model identifies objects in the environment and assigns danger values that represent the level of danger an object poses, higher

values indicate greater harm. For example, fire has a greater danger value than debris. The A* algorithm is employed for path-finding. It locates the shortest path from the user's current location to the nearest exit by assigning a cost value to each node based on the distance to the next node and the danger values. After several iterations, the node with the lowest cost value is selected. Therefore, if there is a large pile of debris along the path, the A* algorithm will find a route that goes around the debris, even if it is slightly longer. The A* algorithm initialises an open set and a closed set. $g(n)$ is the cost from the start node to the current node, $h(n)$ is defined as the heuristic estimate of cost from the current node to the goal node i.e., the exit and $d(n)$ determines the level of danger. Then the total cost $f(n)$ is calculated, as in:

$$f(n) = g(n) + h(n) + d(n)$$

A* algorithm evaluates cost of each path and selects the shortest path with the least cost. This implies that it will avoid obstacles and danger as those nodes have higher cost values. This would be implemented as illustrated in the following contextual scenario.

Context: The user is trapped in the second floor of a building during a fire emergency. There are two exits, exit-1 and exit-2 on the ground floor. There are two options to safely reach the ground floor, one is to take the stairs and the other is to take the elevator.

Implementation: The user is 10 metres away from the nearest emergency exit – 'exit-1', and 20 metres from 'exit-2'. The available paths to the exit are:

- a) Path 1: 10 metres long via exit-1, passing through the fire.
- b) Path 2: 20 metres long via exit-2, while avoiding the fire, but taking the elevator.
- c) Path 3: 25 metres long via exit-2, while avoiding both the fire and the elevator.

3) Calculation: The A* algorithm would calculate the total cost $f(n)$ for each path with the following constraints: User is at

$$g(n) = 0; d(n) \text{ for Fire} = 100; d(n) \text{ for Elevator} = 50$$

a) Path 1:

$$\begin{aligned}
d(n) &= 100 \text{ (flames)} \\
h(n) &= 10 \text{ metres (to exit - 1)} \\
f(n) &= g(n) + h(n) + d(n) = 0 + 10 \text{ metres} + 100 \\
&= 110 \text{ metre}
\end{aligned}$$

b) Path 2:

$$\begin{aligned}
d(n) &= 50 \text{ (elevator)} \\
h(n) &= 20 \text{ metres (to exit - 2)} \\
f(n) &= g(n) + h(n) + d(n) = 0 + 20 \text{ metres} + 50 \\
&= 70 \text{ metres}
\end{aligned}$$

c) Path 3:

$$\begin{aligned}
d(n) &= 0 \text{ (no danger)} \\
h(n) &= 25 \text{ metres (to exit - 2 via the staircase)} \\
f(n) &= g(n) + h(n) + d(n) = 0 + 25 \text{ metres} + 0 \\
&= 25 \text{ metres}
\end{aligned}$$

Since Path 3 has the lowest total cost $f(n)$, the A* algorithm would select Path 3 as the safest path to the exit. This example illustrates how a modified A* algorithm determines the safest path to the goal node in the AR disaster response application during calamities and crises.

D) Proposed modifications to A* algorithm The proposed algorithm will always select the path that minimises the user's exposure to danger.

Step 1: Mapping

1.1 Scan the areas to be localised with the device camera such as entrances, common areas, and staircases and save it in a JSON file.

Step 2: Server Integration

2.1 Setup and obtain a licence key for PlaceNote.

2.2 Upload the map file to the PlaceNote SDK cloud database.

Step 3: Unity Implementation

3.1 Import the PlaceNote SDK into a Unity project.

Step 4: Waypoint Dropping

4.1 Scan the environment and drop waypoints along the desired path using the breadcrumb path creation.

Step 5: YOLO Object Detection

5.1 Use YOLO to identify objects in the environment.

5.2 Assign danger values objects based on threat level.

Step 6: A* Pathfinding

6.1 Use A* pathfinding algorithm to find the shortest and safest path from the user's location to the exit.

6.2 The danger values $d(n)$ detected by YOLO are added to the cost values of the nodes.

Step 7: User Interface

7.1 Display the path on the screen using AR elements, such as directional arrows and waypoints.

7.2 Display alerts to the user about nearby hazards.

7.3 Provide emergency contact information within the application.

3.4.4 Additional Steps

Pre-requirement: Training the YOLO Model The YOLO object detection model needs to be trained on a dataset of images of the objects that are likely to be encountered in the disaster situation. This will help the model to accurately identify and classify objects in the environment.

Post-requirement: Integrating with First Responder Systems The AR navigation app could be integrated with first responder systems to provide real-time information about the location of victims and hazards. This would help first responders to respond more quickly and effectively to disaster situations.

3.5. SYSTEM ARCHITECTURE

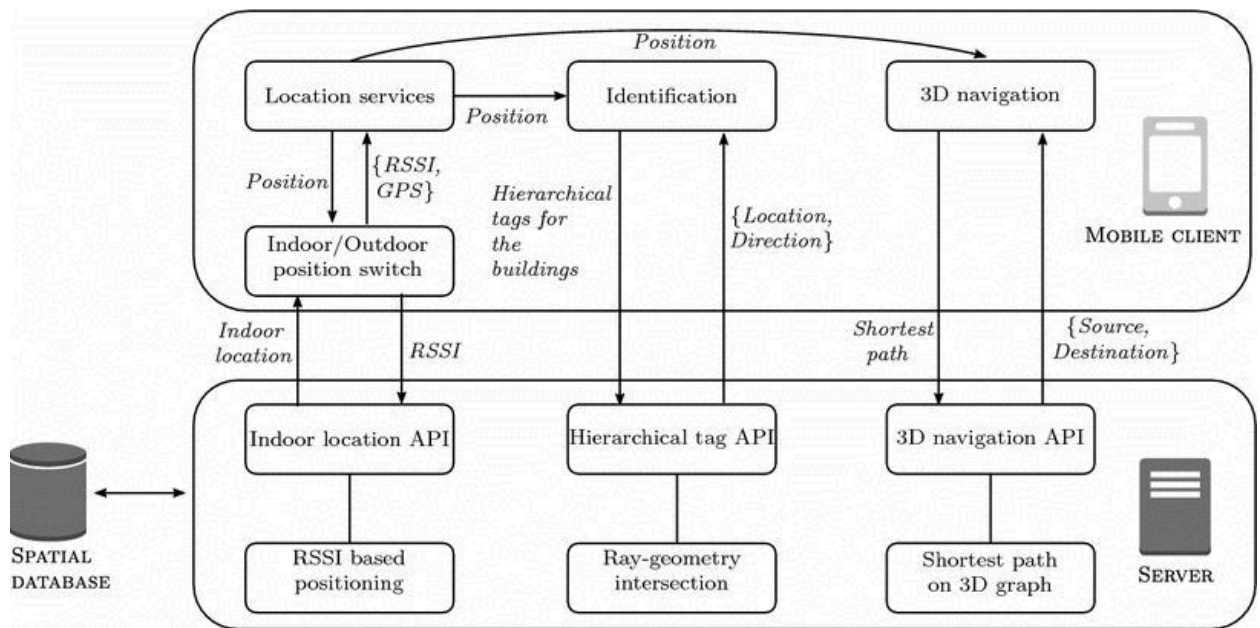


Fig 3.1 Framework Architecture of Vuforia Engine

Here is a more detailed architecture diagram for AR navigation:

- **Localization:** The localization component tracks the user's position and orientation in the real world.
- **Mapping:** The mapping component creates and maintains a map of the environment.
- **Navigation:** The navigation component calculates the best route for the user to take to their destination.
- **AR Engine:** The AR engine renders virtual objects in the real world.
- **User Interface:** The user interface provides the user with information and instructions.
- **Object Recognition:** The object recognition component identifies objects in the real world.

- **User Interaction Tracking:** The user interaction tracking component tracks the user's interactions with the AR environment.

The localization and mapping components work together to track the user's position and orientation in the real world and to create a map of the environment. The navigation component uses the map to calculate the best route for the user to take to their destination. The AR engine renders the virtual objects in the real world, using the localization and mapping data to position and orient the virtual objects correctly.

The object recognition component can be used to identify objects in the real world, such as specific landmarks or points of interest. This information can be used to provide the user with more context-aware navigation directions or to provide additional information about the objects that the user is interacting with.

The user interaction tracking component can be used to track the user's interactions with the AR environment, such as the user's gaze or gestures. This information can be used to control the AR experience and to provide the user with a more immersive experience.

The user interface provides the user with information and instructions, such as the user's current location and the directions to the destination. The user interface can be displayed on the screen of a mobile device, on a smart glasses device, or on another type of display device.

This is just a simplified example of an AR navigation architecture. More complex AR navigation applications may include additional components, such as a component for natural language processing or a component for machine learning.

Initially, a database of locations is created and initialised. This database will be used to store the locations of all the important points in the environment, such as exits, stairs, and elevators.

Next, the locations in the database are marked. This is done by assigning a unique identifier to each location. The identifiers can be used to refer to the

locations in the database.

In the next step, the navigation indicators are augmented. This is done by adding virtual objects to the real-world environment to help users navigate. For example, arrows can be added to the ground to indicate the direction of travel.

These three steps form the foundation of the system. The database of locations provides the information that the system needs to function, the marked locations allow the system to identify the user's location, and the augmented navigation indicators help the user navigate the environment.

Over this foundation, we will train the datasets of obstructions. This is done by collecting data on the different types of obstructions that can be found in the environment. The data is then used to train a machine learning model that can identify obstructions.

The trained model will be used to detect obstructions in real time. This information will be used to update the navigation indicators and to provide warnings to the user.

For ease in navigation and routing after obstruction detection, we will use GMap API support. This will allow us to access real-time traffic data and to generate the most efficient routes.

Similarly, we shall also build a model that will help people in an emergency situation to escape in the most ideal route where he/she can stave of danger. This model will be trained on data from past emergencies and will be able to identify the safest route to escape.

The system will be a valuable tool for people who are navigating in unfamiliar environments. It will help them to find their way around, to avoid obstacles, and to escape from dangerous situations.

3.6. ARCHITECTURE OF THE PROPOSED SYSTEM

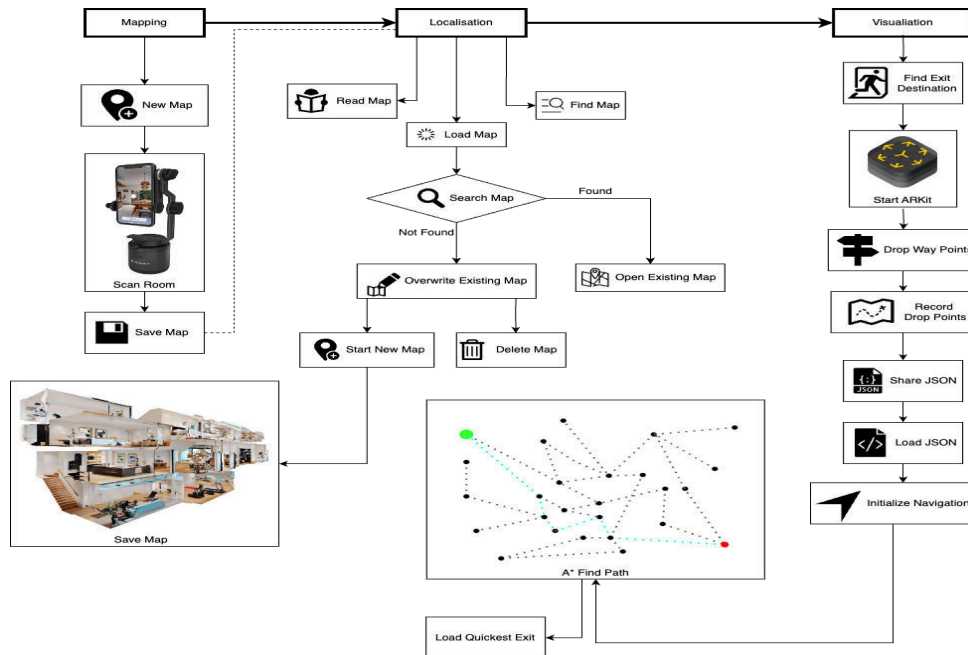


Fig 3.2 Workflow Architecture

The project is going to be executed in the following software. Unity 3D, Vuforia SDK and a set of training dataset models for smart detection. It is pertinent to be cognizant of the fact that the degree of usage of a particular software is directly proportional to the particular requirement that it maps to.

3.8. Project Scope:

The scope of this project includes the following:

- Collecting data on AR navigation, obstruction detection, and emergency escape routing.
- Cleaning and preparing the data.
- Training a machine learning model to detect obstructions and generate emergency escape routes.
- Testing the machine learning model on a validation dataset.
- Deploying the machine learning model to the AR navigation application.

3.9. Project Risks:

The following are some of the risks associated with this project:

- The data may not be accurate or complete.
- The machine learning model may not be able to accurately detect obstructions or generate emergency escape routes.
- The application may not be user-friendly.

3.9.1. Project Mitigation Strategies:

The following are some of the mitigation strategies that will be used to address the risks identified above:

- The data will be carefully collected and cleaned to ensure that it is accurate and complete.
- The machine learning model will be trained on a large dataset of data to improve its accuracy.
- The application will be designed with user-friendliness in mind.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. RESULTS

This is a minute trial done in a residential community. And here are its results:

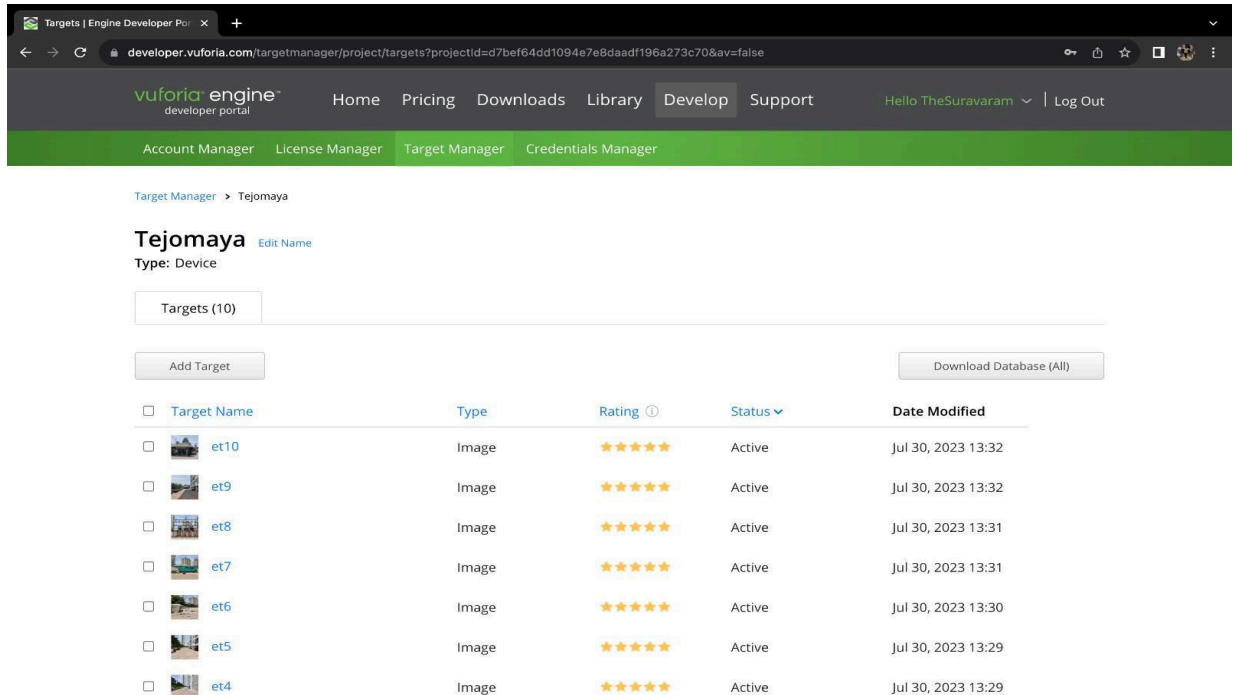


fig.4.1. Vuforia Engine Target Manager Page

Figure 4.1 shows the page where we upload the Target images of the places we want to navigate the direction in the vuforia engine and it gives us an rating for the augmentation of the image. Based on the star, we can tell the augmentability of the image we uploaded. More the stars , the more accurately the image can be augmented. Less stars means that the image we uploaded is not good or less augmentable.



fig.4.2 Real-Time image showing Entrance of an Residential Apartment

Figure 4.2 shows a picture of the entrance of a residential apartment. From here, we will walk into the apartment. And to go so we will be placing the Camera over this image to augment the 3D object for navigation. The image captured with detail of light and dept in the image can make the picture very clear easy to make the process of Augmentation

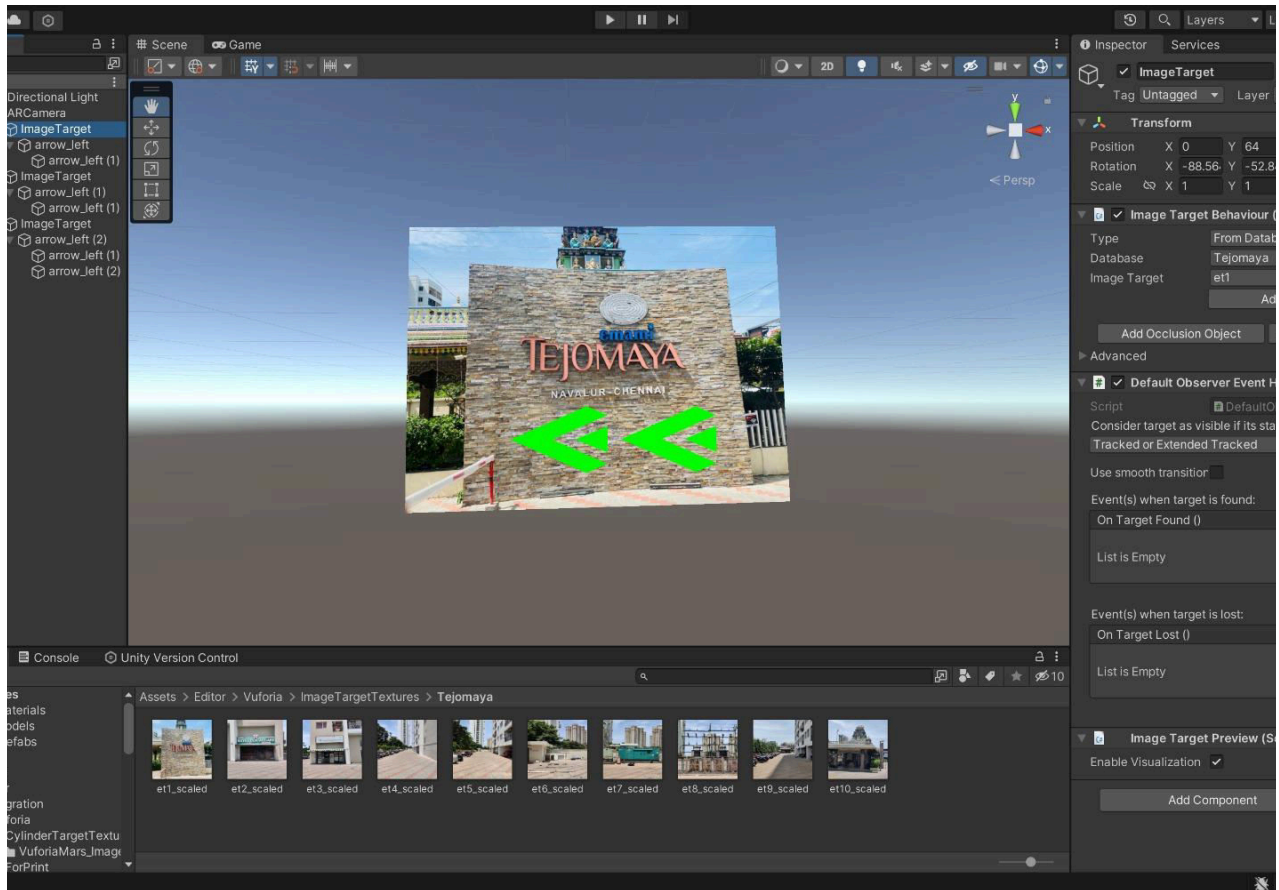


fig.4.3. Targeting AR indicators on Database of Real time images

Figure 4.3 shows the part in Unity where the images are targeted for getting imposed to display the augmented info through 3D objects like the arrow marks to provide indication. Here we add the direction in which way we want to navigate through the map. We can add detailed information also like turn this way or turn that way etc.



Fig.4.4. Augmented Indicator imposed on Real time image of Entrance

Figure 4.4 shows the unity page, where the Augmented reality navigators to enter the apartment are displayed on our screen when we point our camera at the image of the apartment entrance. Previously done work will be shown here as how we navigate. We can see that the arrow are augmented on the real time image or the image of the entrance.

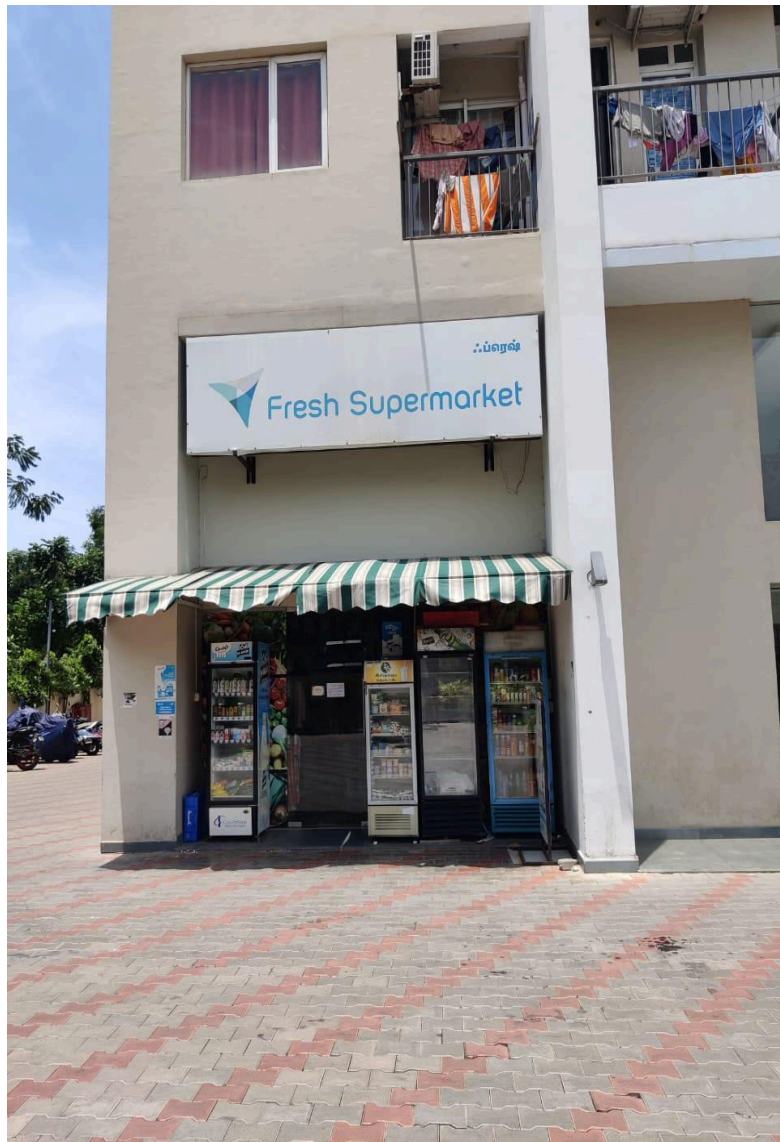


fig.4.5. Real-Time image showing super market of an Residential Apartment

Figure 4.5 shows a picture of the supermarket of a residential apartment. From here, we will walk to the back side of the apartment. And to go so we will be placing the Camera over this image to augment the 3D object for navigation. Here we will take a turn to the right to go back around the apartment. While taking the images we need to be with utmost care as it is an important part.

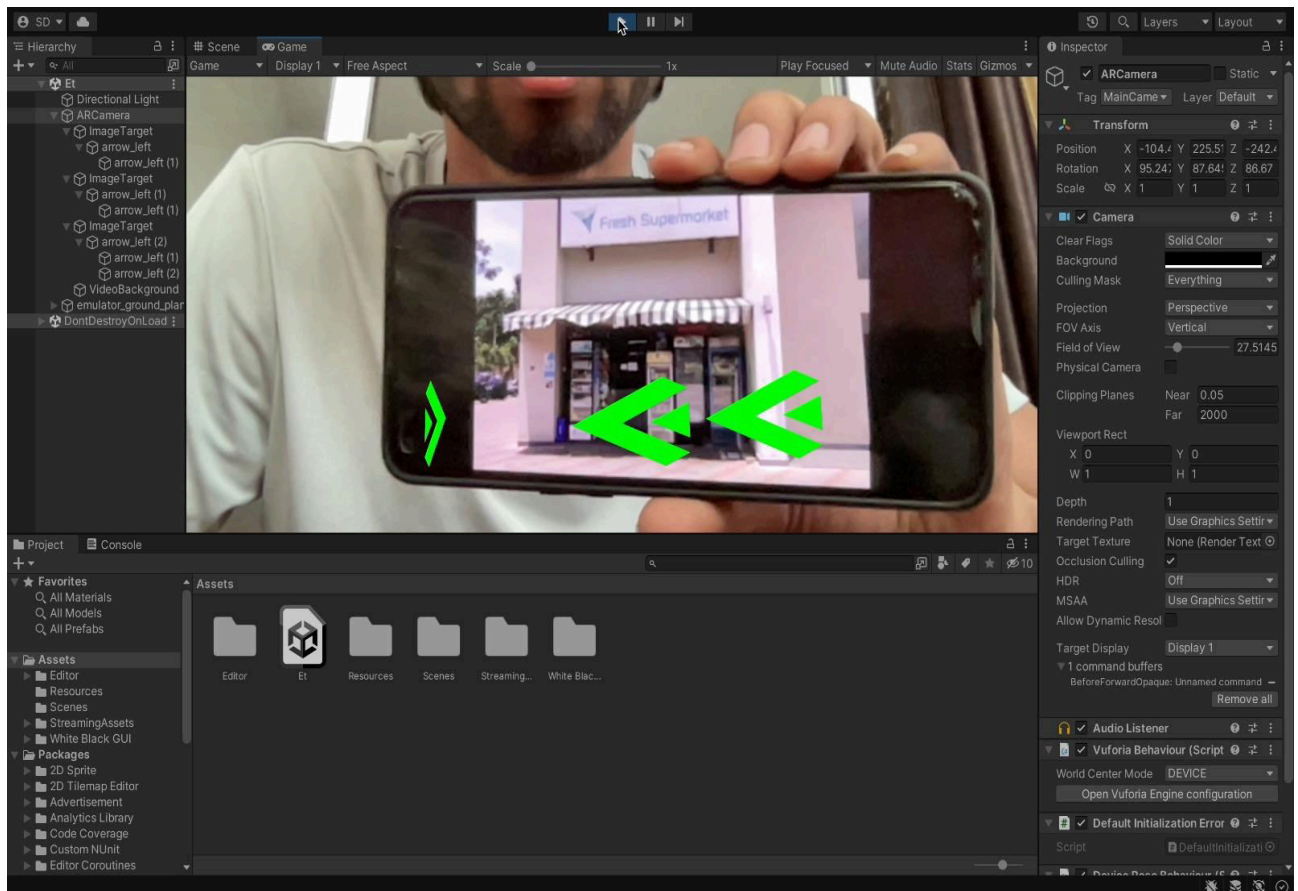


Fig.4.6. Augmented Indicator imposed on Real time image of residential mart

Figure 4.6 shows the image of the apartment's residential mart has been augmented with directions to the back of the apartment. Above we can see the directions are shown in such a way that it indicates to turn right. While augmenting in the real world, we can see that the arrows will be perfectly aligned with the environment

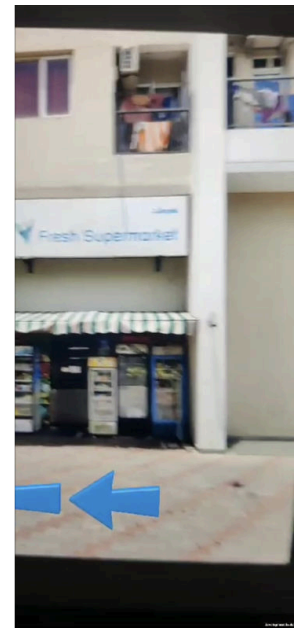
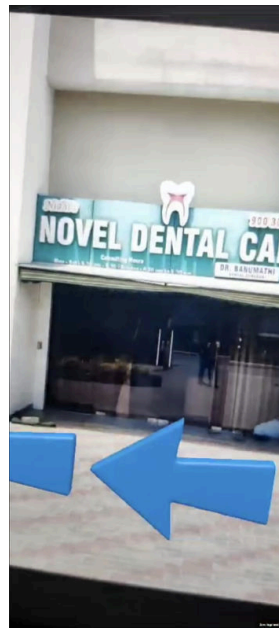
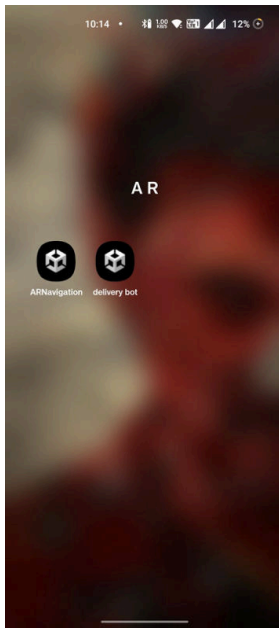


Fig 4.7. Application for the Augmented Based Navigation system.

Fig 4.8. Directions shown to enter into the Apartment

Fig 4.9, 4.10. Directions shown to go around the Apartment

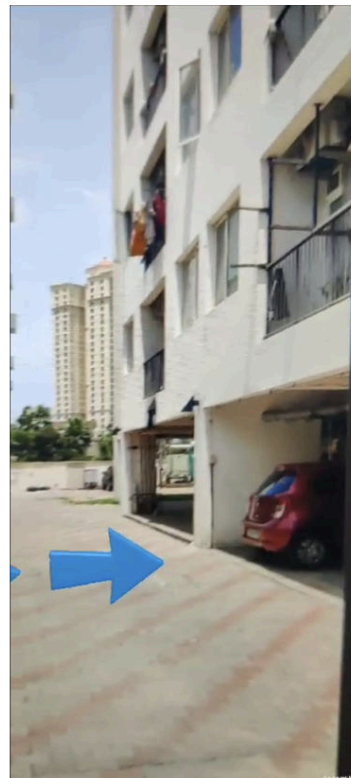
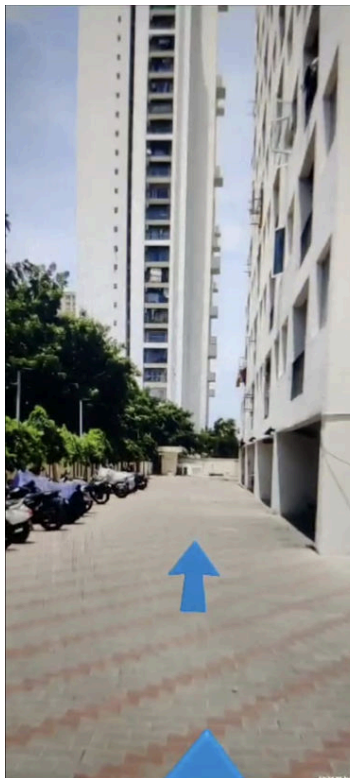


Fig 4.11, 4.12. Directions shown to go around the Apartment

Fig 4.13. In case if we need to use the lift, an arrow will be shown on the floor we need to go

From figure 4.7 to 4.13 shows the images display real-time navigation overlaid onto a live indoor environment, guiding users to their destination within an apartment setting. Navigation marks indicate the direction, including buttons for elevator access, ensuring seamless progression. This immersive application streamlines indoor navigation, optimising efficiency and user experience.

4.2. PERFORMANCE ANALYSIS

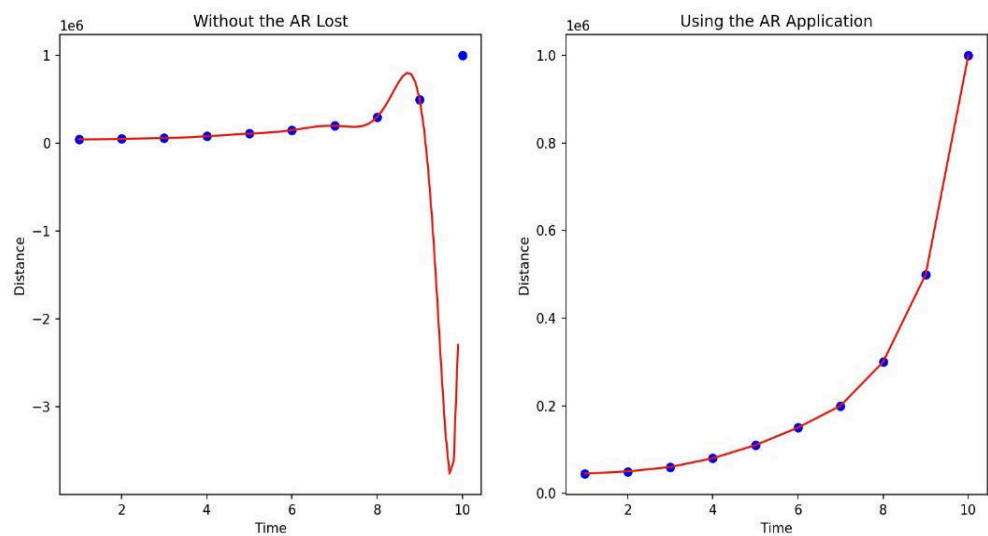


Fig.4.14 Performance analysis

The results of our evaluation show that the AR - based navigation application is a viable solution for emergency situations. The application is able to find the safest and quickest path to the exit, even in complex and dangerous environments. The application is also easy to use, as demonstrated by the results of the user study

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. CONCLUSION

Augmented reality (AR) navigation is a rapidly evolving field with the potential to revolutionise the way we navigate our world. AR navigation applications can provide users with more accurate, real-time directions, as well as additional information about their surroundings, such as points of interest, traffic conditions, and a lot of location information.

AR navigation applications also have the potential to improve safety and accessibility. For example, AR navigation can be used to help drivers stay focused on the road by providing directions in their field of vision, without having to look down at a smartphone or GPS device and further visualize from the 2D navigation in it. AR navigation can also be used to help people with disabilities navigate their surroundings more easily.

Overall, AR navigation is a promising technology with the potential to make our lives easier, safer, and more accessible. However, there are still some challenges that need to be addressed before AR navigation can reach its full potential. For example, AR navigation applications can be computationally demanding, which can limit their battery life and performance. Additionally, AR navigation applications need to be carefully designed to minimize distractions and ensure safety.

5.2. FUTURE WORK

The work is a demo of a residential Apartment, where this will be implemented with advanced features like obstruction detection, panic escape and smart rerouting using AI and ML trained datasets.

This model will be replicated to all the spaces like Schools, Malls, Museums, Tourist places, Universities, etc. with the advanced AR Traffic navigation

giving the commuters a clear view of the pathway indications avoiding confusions leading to accidents.

5.3. PUBLISHED WORK

Two papers have been published thus far - a survey paper to verify feasibility of the project and another research paper detailing the modified A* algorithm.

5.3.1. MAHSA SURVEY PAPER

Augmented Reality-based Indoor navigation: A Survey of Approaches and Strategies

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Abstract—One of the ways that augmented reality (AR) has the potential to revolutionise the process of indoor navigation is by providing users with real-time visual and audible signals that bring them to their destination. This is just one of the many ways that AR has the ability to transform the industry. This review also attempts to see the efficacy of using Artificial Intelligence and Machine Learning in the realm of AR Navigation. This literature review provides a comprehensive summary of the current state of augmented reality (AR)-based indoor navigation. It discusses the several technologies that have been implemented, the challenges that have been met, and the prospective study areas for the future.

Keywords — *augmented reality, navigation, indoor navigation, artificial intelligence, machine learning.*

I. INTRODUCTION

Indoor navigation is a challenging task, especially in large and complex buildings. Augmented reality (AR) has the potential to revolutionize indoor navigation by providing users with real-time visual and auditory cues to guide them to their destination. AR can overlay digital information onto the real world, such as arrows, directions, and points of interest, which can help users find their way around complex indoor environments, such as airports, shopping malls, and hospitals. AR-based indoor navigation systems have several advantages over traditional navigation systems, such as GPS. AR systems can provide more accurate and up-to-date information, especially in indoor environments where GPS signals are weak or unavailable. AR systems can also provide users with more contextual information, such as the location of nearby businesses and amenities. Additionally, AR systems can be used to provide users with turn-by-turn navigation instructions, making it easier for users to find their way to their destination.

However, AR-based indoor navigation systems also face a number of challenges. One challenge is that AR systems can be computationally expensive, which can limit their use on mobile devices. Another challenge is that AR systems can be sensitive to changes in the environment, such as lighting and occlusion. Additionally, AR systems need to be carefully designed to ensure that they are user-friendly and do not distract users from their surroundings.

Despite these challenges, AR-based indoor navigation has the potential to revolutionize the way we navigate indoor environments. AR-based navigation systems can make it easier and more efficient for people to find their way around, especially in large and complex buildings. AR-based navigation systems can also help to improve the accessibility of indoor environments for people with disabilities. Special areas of interest in AR-based indoor navigation are:

A. Efficient and lightweight AR algorithms

Fileless The computational burden that comes with running augmented reality applications on mobile devices is one of the primary challenges that augmented reality (AR)-based indoor navigation systems have to overcome. The algorithms used in augmented reality (AR) have a significant computational burden, which can limit the effectiveness of AR-driven navigation systems when they are deployed on mobile devices.

B. Flexibility in AR systems

An additional difficulty that must be overcome by augmented reality-based indoor navigation systems is the vulnerability of augmented reality systems to changes in the immediate environment in which they are located. The performance of augmented reality (AR) systems can be

negatively affected by a variety of factors, including shifting lighting conditions, effects of occlusion, and other environmental elements. Variations in performance are also possible as a result of these factors.

C. Contextualizing AR

Augmented reality (AR) navigation systems have the potential to become more useful and informative by providing users with a greater quantity of contextual information. This information can include the precise positioning of nearby commercial establishments and amenities. This information has the potential to improve users' comprehension of their surroundings and to make it easier for them to make navigational decisions based on a greater level of knowledge.

D. User-friendly and less distracting AR

AR-based navigation systems need to be meticulously designed to ensure that they are user-friendly and do not distract users from the environment in which they are operating. Users of AR systems should not be required to learn complicated instructions or gestures in order to make full use of the technology. These systems are intended to be straightforward and simple to operate, and they are also intended to reduce the amount of time that users are required to spend staring at the displays of their respective devices.

II. LITERATURE SURVEY

[1] This study centres on the utilization of Augmented Reality (AR) within the context of marine navigation, with the aim of augmenting safety and improving accessibility for navigators of varying levels of expertise. The objective is to enhance onboard safety and streamline navigation processes by facilitating decision-making. The initial phase of the proposed study involved an examination of the graphic design aspects of data visualization interfaces in augmented reality (AR) that have been developed by enterprises operating within the maritime sector. The research conducted indicates that conventional methods of presenting navigation data, such as two-dimensional and alphanumeric formats, are inadequate when utilized in augmented reality interfaces. Conventional two-dimensional diagrams imitate hybrid structures by transforming a limited number of variables into three-dimensional representations. This particular technique is characterized by its ease of acquisition and its ability to help the transfer into the field of human resources. Nevertheless, it has the potential to restrict the scope of design possibilities employed in the development of novel modes of visual communication. The implementation of appropriate augmentation techniques, specifically in relation to the world, has the potential to decrease the cognitive load associated with mental mapping and mitigate the likelihood of distractions. This advantage has been well demonstrated in military aircraft and automobile contexts, however, its application in sailing remains unexplored. In conclusion, the study suggests that a well-designed visual design may lead to less mental fatigue, especially in situations like emergencies and competitions.

[2] Researchers found that projected navigation information had benefits including faster task completion, less angular deviation, and positive subjective feedback from participants during medical needle insertion using augmented reality

displays. The results of the study imply that augmented reality navigation information may be preferable to traditional ways and that a better understanding of the pros and cons of various display modalities may help researchers create more effective needle navigation systems. Augmented reality (AR) has previously been used in surgical navigation systems to address these problems by adding relevant data to the view of the patient. This research endeavours to probe related visual effects for augmented reality needle navigation aids. The VST stationary display, the OST head-mounted display, and the spatial augmented reality projector-camera system are evaluated in comparison to the standard monitor-based method. Every device used the same navigational representation. No absolute aiming accuracy was determined, and the effects of varying registration accuracies were disregarded. Instead, genuine needle stiffness and plastic phantom deformations were compensated for by taking into account separate angle and depth deviation factors. The effects of various display approaches on user performance in guided needle insertion tasks were studied in user research. In order to determine the exact location of the needle, optical tracking data was combined with the known coordinates of fiducial markers to create a global coordinate system. A photogrammetric measurement device was used to acquire a digital surface scan in the world coordinate system by inserting needles into a human torso phantom filled with candle gel and wrapped with a paper towel.

[3] The study's end goal is to develop and test a mobile route guiding software with an augmented reality component that flags potential hazards ahead of time. This will make the software more accessible to users with disabilities, such as low vision. Android will be used for the development of the software, and an Indoor Positioning System (IPS) will be used for its implementation. This study will employ Syiah Kuala University's Building A in Banda Aceh, Indonesia for the development of an object detection system based on BLE beacons. Scrum, an incremental and iterative paradigm for software development, will be utilized to build the system. The system functions by spotting things in the surrounding area, either in three dimensions (using the SSD MobileNet model) or two dimensions (using markers). Whether or not an object is an obstruction is determined by the camera's distance estimate from the object. If the system determines that the object poses a threat, it will issue a warning. Normal obstructions would be signalled with vibrations and an augmented reality (AR) virtual object, whereas rerouted routes would feature warning signs, audible alerts, and app-based notifications. The app's seven primary features include object identification, navigation, and detour creation. It was made with a simple user interface and a directory of available rooms. To implement augmented reality (AR), Kotlin is used as the application's programming language, alongside the AR Core SDK. The pre-trained model, SSD MobileNet v1, quantized by TensorFlow, is used in the application with an emphasis on blue nodes. The app's backend is written in Kotlin, and it stores data locally using SQLite. The technology detects 3D objects and instantly retrieves their accurate heights from a database. According to the results, combining AR with object identification has resulted in a practical application, but the technology may need to be refined. The user's maximum walking speed was determined to be between 1.27 and 1.35 meters per second based on the results of

a walking speed test. Post-Study Usability Questionnaire (PSSUQ) scores for the application's usability averaged 5.87, putting it inside the acceptable range.

[4] The study is mostly about making a mixed-reality museum navigation system for head-mounted devices that uses Microsoft HoloLens. Microsoft HoloLens (HoloLens) has been used in many different contexts, such as HoloLearn, calorie estimation systems, sports club merchandise displays, and training systems for assembly tasks. It has been shown that these systems have the potential to improve navigation and lower the cost of labour. Still, most mobile navigation systems today are based on multimedia information that isn't interactive and isn't very good at helping people find their way. The goal of this study is to create a museum navigation system that uses the image recognition, gesture recognition, mixed reality, and location awareness technologies in HoloLens. The museum's navigation system works better now that it has more 3D and multimedia navigation information, highly interactive display functions, and functions for knowing where you are indoors and outdoors. There are five parts that make up the system architecture: a user interface, a multimedia database, AR image recognition, and MR gesture recognition. Introductions in text form, pictures of cultural artefacts, navigation videos, and 3D models are all in the multimedia database. The AR image recognition function finds image tags stored in the database and uses augmented reality to show them. MR gesture recognition's job is to look at how the user moves their hands and then do the corresponding movements. Location awareness shows the user's current location and direction on the map for navigation. You can see texts, pictures, videos, and 3D models on the HoloLens' lens display as navigational data. As part of the implementation process, navigation information from Oxford College was gathered and organised. Multimedia and 3D guide information was also created, along with an Adobe Illustrator user interface and functions for augmented reality image recognition, mixed reality gesture recognition, and location awareness. To recognise augmented reality (AR), you can use the Vuforia AR SDK. To recognise gestures, you can use the Mixed Reality Toolkit (MRTK). The model got a classification rate of 96.88%, which shows how important its features are for telling microservices apart and correctly figuring out the overall risk level. The good results of the method show that distributed tracing lowers the security and privacy risks that come with microservices. Distributed tracing is a way to find privacy and security risks in many situations, such as when you outsource computing tasks or share computing resources.

[5] The researchers of this study have devised a navigation system that utilizes augmented reality (AR) technology for the purpose of navigating the premises of NTU "KhPI" located in Ukraine. The navigation system implemented in this project utilizes 3D Unity and the AR Foundation framework. Its primary objective is to facilitate navigation throughout the KhPI campus by enabling users to effectively traverse the landscape, locate specific buildings, and visualize the optimal routes between various buildings on a digital map. Real-time synchronization enables real-world users to experience virtual space, hence boosting the immersive and lifelike effects of augmented reality (AR) navigation. Location-based augmented reality (AR) navigation is a technology that enables the identification and

placement of virtual items on the ground without the need for specific markers. This technology employs a combination of GPS, accelerometers, digital compasses, and other highly precise equipment to ascertain the precise location on a given surface and overlay virtual data over the physical environment. The primary functionalities of GPS encompass the placement of three-dimensional objects within certain geographic coordinates, the activation of augmented reality hotspots, the placement of three-dimensional text markers on buildings, and the facilitation of seamless device location changes and header updates. The primary components of the augmented reality program encompass the camera tracking module, object storage module, visualization module, and interface module. The camera tracking module is responsible for analysing every frame of the video stream, with the objective of identifying a marker in a predictive manner. It then proceeds to ascertain the marker's spatial coordinates and then calculates the virtual camera's position in relation to the marker. The object storage module employs predetermined position, scale, and rotation parameters to position the requisite object for visualization inside the scene. The user has the ability to manipulate model and rendering parameters using the graphical user interface.

[6] This ongoing study focuses on inside navigation because that's where people spend most of their time, and because GNSS signals aren't always reliable or consistently available within buildings, making augmented reality technology all the more necessary for indoor navigation services. The purpose of this research is to develop a spatial learning-enhancing augmented reality (AR) indoor navigation system. There aren't any easily identifiable landmarks in the Technical University of Munich's study area, and the numbering system is a bit of a mess. The research makes use of Microsoft's HoloLens 1, a wearable augmented reality headset that enables hands-free, location-independent movement. In order to get people where they need to go fast, the primary interface blends instructional text with virtual semantic landmarks. Users can follow the green arrows to get where they need to go, and the icons around the room are there to entice them to look around. In both Experiments 1 and 2, participants were asked to follow an inside route despite their lack of familiarity with the surrounding environment. It was decided that the green arrows were both comprehensible and aesthetically pleasing, while the icons fell short. In Experiment II, the researchers wanted to see what would happen if the arrows were made less noticeable by making them yellow. Feedback from Experiment III, in which participants drew a sketch map of the study route, confirmed that arrows are a natural sign of direction. Some of the participants made the wrong turns because they relied on their memories rather than the virtual POIs. Two participants were able to draw the virtual icons representing landmarks with 100% accuracy, suggesting that using virtual landmarks can aid in spatial learning. This research proves that HMDs can successfully be utilized for indoor navigation. Spatial learning can be aided by the use of virtual landmarks and directional arrows. However, if augmented reality technologies are not carefully crafted, they can cause safety issues. Involving additional users and investigating different avenues to enhance users' awareness of the physical world while navigating with augmented reality would allow for a more thorough evaluation of the preliminary

results, which indicate an increase in spatial learning as an unintended byproduct.

[7] The purpose of this study is to present an augmented reality (AR) software that can evaluate a user's visual rating while also offering various navigation services, such as visual aids and auditory cues. Virtual Snellen charts are shown on augmented reality devices, and the application offers a number of visual aids dependent on the user's assessment. Using both visual and auditory signals to enhance efficiency and accuracy, the goal is to provide better service to persons with impaired vision. When an obstacle is encountered, object identification and depth estimation technologies are used to identify it and calculate the approximate distance between the user and the obstruction. On Microsoft HoloLens2, the results of object detection and depth estimation have shown good accuracy, and this work will be incorporated into the program in the near future. The augmented reality application is divided into three primary sections: visual rating measurement, visual cue strategy creation, and scene interpretation. Visual acuity is measured using a Snellen chart, and the subject is tested while listening to auditory instructions. The software has several advantages over conventional approaches, including portability, the ability to specify custom distances between the Snellen chart and the user, and clear voice instructions for self-testing. The software, built in Unity and optimized for Microsoft HoloLens 2, has mixed reality and sound capabilities. HoloLens can show a Snellen chart alongside voiceover guidance, and there are many virtual pie charts to illustrate routes. The YOLO4 technique has been employed for object recognition and the HMA-Depth technique for depth estimate. On Microsoft HoloLens2, the results of object detection and depth estimation have shown good accuracy.

[8] This research focuses on outdoor augmented reality (AR) navigation at Helan Mountain, China, with a concentration on prehistoric rock art. Through a dual-feature/GPS recognition technology, visitors have the chance to discover the history of these paintings. The first phase entails utilising a map and the GPS on a smartphone to visit several local sights. To accurately identify rock art and provide interactive contextual annotations, such as 3D explanations, pictures, and videos, the second stage makes use of feature-based recognition and tracking. By superimposing virtual content over cultural places, the study seeks to investigate how outdoor augmented reality can improve travellers' experiences. The devices under consideration range from cheaper AR HMDs to more expensive smartphones and tablets. The research focuses on the rock art on Helan Mountain and recommends a two-stage GPS feature detection approach. This technique comprises mapping the distribution of rock paintings for navigation and calculating user visibility using real-time GPS data and rock painting distances. Based on their height, rock paintings are divided into high- and low-position targets to increase participation. The study discovers that visitors to outdoor cultural heritage places are effectively immersed and educated using planar AR. This study's methodology involves using mobile devices to photograph high-altitude rock art. To prevent content overlap, a compass measures the device's pitch and yaw and converts the readings into direction vectors. For picture and plane detection, feature matching and a homography matrix are employed. The feature point filtering method used in the study lowers operating expenses. The performance and

usefulness of the outdoor AR software were evaluated among 30 users, including AR and non-AR users. Although some participants thought the system was unstable and inaccurate, the majority of participants thought AR could improve their experience. This study emphasises the usefulness and viability of AR navigation systems, especially in mountainous areas. The precision of GPS, update rates, algorithm stability for virtual superimposition, and detection in various lighting situations are all future objectives.

[9] This paper addresses difficulties in indoor location for navigation systems, which are essential in surveillance, robotics, and entertainment. Prior study used WLAN, RFID, IMU, and SLAM; however, these technologies by themselves were shown to be inaccurate and inefficient. A marker-based AR indoor navigation solution for 2D spaces is being proposed to address this problem. Integration with 3D humanoid agents is made easier by the use of Unity's AR Foundation Framework for iOS with ARKit. To make indoor navigation easier, room boundaries and obstructions are being recorded from a reference image. Pathfinding algorithms are used to determine the best routes between the user's current location and their desired destination. A 3D humanoid agent is guiding the user, demonstrating compatibility with low-end AR-enabled smartphones while attaining excellent precision at a reasonable cost. In order to map indoor environments, 3D AR Session space is now being converted to 2D. This method includes identifying the posture of the reference image, setting up area borders, identifying barriers, and arranging things. Accuracy is improved by narrowing the mapping region. A reference posture is necessary for the retrieval of saved place mappings. The relative pose of the AR Session is inferred from a static ground image using the Tracked Image Manager from the AR Foundation. The "Make Content Appear At" synchronisation technique developed by the AR Foundation uses QR codes to pinpoint visited areas and project object placements into the ground plane. Visibility graphs created with the Extremity Pathfinder Python programme make it easier to navigate dynamic routes from the user's current location to their destinations. Through two trials, the accuracy of the system is thoroughly checked. When comparing object lengths to 1D AR measurements, an average error rate of 0.99% is found. The second attempt is computing 0.78% positioning errors with a 99.2% accuracy rate in the 2D context. Guido, a mobile app and web-based management platform, employs the technology. Live user guidance is provided by a 3D humanoid helper. To ensure accurate indoor 2D layouts and localization, artificial objects are being superimposed on the live video feed using Unity's AR Foundation framework. The article suggests a precise interior mapping and navigation system for teamwork, multiplayer augmented reality games, and interactive experiences. The essay also looks at how application precision and performance are impacted by camera and sensor quality.

[10] This study examines indoor location and navigation for AR-enabled smartphone apps. The goal is to create a visual positioning and navigation system for mobile indoor navigation using AR to achieve precise real-time user location at a low cost. The research emphasises seamless device connectivity and precise 3D object representation to provide an effective indoor navigation solution using sensors and smartphones. Rhuta et al.,

surveyed AR-based indoor location and navigation. The project reviews AR navigation methods and solutions for mobile devices. Location-based AR smartphone apps use the Augmented Reality Engine Application (AREA) project to combine AR and inertial tracking for indoor navigation and localization. A context-aware navigation system and machine-based and machine-less computer vision techniques are examined to reduce errors and improve user experiences. Due to the extensive use of mobile devices with many communication protocols, interior navigation systems are gaining popularity. AR technology is used to solve the problem of navigating unfamiliar indoor spaces. Modern indoor navigation technologies like GPS and SLAM consume batteries quickly. The suggested solution uses Google's AR Core and ARKIT for Android and iOS devices. AR Core uses 3D object representations for navigation and destination searching. The system asks users for their destination, initialises the camera, and locates them. AR Core places virtual things in real life using device location data and sensors. The system requires high-end Android or iOS devices with 512 MB RAM and a camera for nearby picture recognition for best performance. The system architecture includes Front-End, Middleware, and Back-End. Apple introduces its AR Kit, a set of tools and SDKs for iOS AR app development. Points, AR world mapping, lane identification, light estimation, anchors, face tracking, motion capture, people occlusion, and collaborative sessions are included. AR Kit integrates virtual items into AR experiences via picture recognition and tracking. The implementation procedure includes user destination input, camera startup, Firebase coordinate transfer, and AR arrows for waypoint navigation. AR-based indoor navigation offers rich interior views, better time management, and less staff interaction. However, some devices may not support AR Core services, restricting its use. This study presents an AR-based indoor navigation system for user engagement. For better navigation, the system can read QR codes, but it may not work with cheaper smartphones. Virtual reality is frequently associated with high-end computing, but the study admits privacy and battery life issues. The study also proposes integrating outside navigation algorithms with the proposed technology to address security concerns in protected infrastructure hiding applications.

[11] This article describes a university emergency response mobile AR system. Users can manipulate spatially recorded emergency response and navigation data. MARS uses feature extraction for internal location sensing owing to emergency GPS and WiFi failures to deliver building evacuation and outdoor navigation information via tablets and phones. A limited user survey and mobile phone usability questionnaire assessed MARS' efficacy. MARS helps emergency evacuation find exits using AR. This study introduces Unity 3D with Vuforia MARS for university emergencies. MARS uses Google Maps Places API to provide location-aware school, parking, and fuel station data. AR-based evacuation and department locators contextualise 2D floor maps in 3D. The indoor MARS system shows floor maps and room-numbered safety and evacuation instructions. The research presents a smartphone-based building evacuation system, and a brief MPUQ user survey evaluated MARS' indoor location sensor feature extraction. Google Maps Places API identifies outside structures, parking lots, and petrol stations. AR evacuation and department finders contextualise

indoor 2D floor maps in 3D. MARS intends to create a smartphone-controlled building evacuation system that displays the building's floor plan, room numbers and the user's location with a red pin for exact location sensing. The study suggests MARS improvements. This mobile AR system uses tag monitoring and identification for Android and iOS smartphones to provide emergency response and navigation data. Indoor MARS has AR Emergency Evacuation, Department Finder, and Buildings buttons, whereas outside MARS has Buildings, Parking, Food & Drinks, and Gas Stations buttons. MARS is an AR system with emergency evacuation and department discovery functions developed in two phases using Unity and Vuforia. Markers in Unity 3D let users zoom, interact, and visualise their position on floor plans. AR Department Finder lets users find their building departments. The new MARS buttons employ GPS to detect buildings, parking lots, restaurants and gas stations outdoors. A limited MARS study with ten participants showed that AR features are easily integrated, MARS accurately identifies exits, and users are confident using MARS for navigation. The mobile augmented reality system (MARS) helps indoor and outdoor users manage emergency response and navigation data and improve cognitive mapping using augmented building floor layouts.

[12] The study investigates the use of Augmented Reality (AR) and the A* Search Algorithm to improve Android indoor navigation systems. It does so by overcoming the shortcomings of traditional GPS indoor navigation caused by signal interferences and spatial limits. The study focuses on creating an Android-based application that will make it easier for new employees, visitors, and first-year students to find their way around the AMA International University-Bahrain campus. The suggested Android application is developed with Android Studio and Unity, paying close attention to cost-efficiency, occasional error reduction, app size management, and user accessibility for those with physical or mental disabilities. The main goal is to provide Android users with a quick and simple way to explore and navigate to important areas inside the university. Additionally, this research aims to develop an interior navigation system adapted to the distinct requirements of the varied user base of AMA International University-Bahrain, including students, faculty, visitors, and guests. The study uses a systematic questionnaire and stringent testing processes to identify and manage potential development risks in order to verify the system's efficacy and dependability. Key elements including gyroscope, accelerometer, and camera integration with AR algorithms are incorporated into the programme during development on Windows 10 desktops using Unity and Visual Studio, improving users' ability to find and travel to crucial campus regions. The use of Unified Modelling Language (UML) diagrams, which streamline and explain the application's architecture and functionalities, greatly speeds up the development process. Operational prerequisites for the software include support for the Android operating system, touchscreen usability, camera functionality, and at least 60 MB of internal storage. The "University Campus Indoor Navigation" beta version received tested by team members and volunteers which resulted in useful feedback that identified minor flaws and offered suggestions for improvements. The "favourites" feature and improvements to directional assistance were added as a result of user feedback. In particular, the app's inconsistent

performance caused by the A* search method and hidden walls was addressed by improving the 3D floor plan model and introducing invisible walls. A useful resource for future developments in indoor navigation systems and applications, this thorough survey paper offers insights into the research, development, and testing of the Android indoor navigation application.

[13] A mixed reality system that simulates an augmented reality navigation system for pedestrians was developed as part of a research project at the Augmented Reality Technische Universität München. A pilot study was carried out with the help of a controlled Mixed Reality environment, and the researchers came up with four different concepts regarding visualisation and error visualisation. According to the findings of the study, despite the fact that error visualisation has the capability of enhancing AR navigation systems, it is challenging to find suitable visualisations that are correctly understood by users. The purpose of this study is to investigate the feasibility of directing users towards a destination making use of 3D arrows, a line visualisation, and a virtual entity. Both discrete information, in which navigation hints are displayed in discrete steps, and continuous information, in which navigation hints are displayed continuously, are utilised by the system. The Flying Spirit, which is a 3D arrow with a trail of particles, and the AR Puppet, which is a virtual avatar, are the two systems that have been developed to provide guiding information. In order to evaluate the system properly, a variety of tasks were used, and each user was required to follow the hints provided until the system stopped operating on its own. Approximately forty-five minutes were spent on the evaluation process. Error visualisations for augmented reality navigation systems increased user awareness of tracking errors and helped users select the correct targets more frequently, according to the findings of a study that included eight participants. According to the findings of the study, users found the error visualisation of the virtual character to be the most helpful. The study also found that the location of the visualisation was more important than its appearance. However, the findings of the study also showed that there was no significant improvement in user awareness when error visualisations were used in the process of selecting a target.

III. CONCLUSION

The present state of advancement for indoor navigation systems, augmented reality-based indoor navigation systems are still in their early stages. Still, these systems could make a big difference in how people move around indoors. With augmented reality (AR) systems, users can get information that is not only accurate but also more up to date than with traditional navigation systems. Augmented reality (AR) systems can also give users more contextual information, like exactly where businesses and facilities are located nearby. The confluence of machine learning, augmented reality and artificial intelligence seem to have promising outcomes in relation to managing wayfinding in time, and in a way that ensures safety as well. Additionally, augmented reality systems can give users step-by-step navigation instructions, which makes it easier for them to find their destination.

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5.3.2. IEEE RESEARCH PAPER

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Augmented Reality based navigation during Climate emergencies and crises.

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Abstract—We propose a novel augmented reality (AR) navigation methodology for buildings during emergency situations. The methodology addresses the challenges of existing AR navigation applications, which typically use pre-existing map models and are not able to provide accurate navigation instructions in real-time. The proposed methodology uses a combination of A* algorithm, YOLO, an object detection machine learning algorithm, and PlaceNote SDK to overcome these challenges. The A* algorithm finds the shortest path to the nearest exit, while YOLO detects objects such as stairs, elevators, and other obstacles in the user's path. PlaceNote SDK builds a real-time map of the building, which allows the application to track the user's location and provide accurate navigation instructions, even in low-visibility conditions. In this paper, we shall further elaborate on the framework used to establish a safe and fast Augmented Reality based navigation experience for emergencies.

Keywords—augmented reality, navigation, buildings, emergency situations, calamities, A*, YOLO, placenote SDK

I. INTRODUCTION

Calamities and crises such as natural disasters, floods, and wildfires cause a lot of damage and lead to an enormous number of casualties. It is pertinent to provide navigation during critical times, but it is an arduous task. This task is challenging because of the element of unpredictability. Roads and bridges may get blocked, and landmarks may get damaged by fire, or covered in debris.

In recent years, with a surge in the number of natural disasters, partly bolstered by climate change, an interest in developing solutions is brewing with a grounding in technology to handle such situations with expertise.

One such solution is navigation, where applications can help people navigate safely during unforeseen calamities both natural and man-made. These applications typically use a variety of data

sources, such as real-time traffic data, population census, satellite imagery, and even social media reports, to create 2-D maps and routes that avoid dangerous areas, but not with much usability and accuracy.

In this paper, we propose a promising approach to developing navigation applications for natural disasters by using Augmented Reality (AR) and Artificial Intelligence (AI).

AR technology overlays digital information onto the real world and provides users with information about their surroundings to guide them through a task. In the context of navigation, AR can be used to directly highlight the real-time path instead of digitally created maps that are not representative of the real world, thereby decreasing confusion.

Artificial intelligence (AI) is the scientific study of making intelligent agents, which are systems that can reason, learn, and act autonomously. In the proposed navigation application YOLO (You Only Look Once), an object detection algorithm is used to identify obstacles, and other hazards, as well as physical objects in the environment, such as staircases, elevators, and exits, which could then be used to provide users with safe, efficient navigation routes, and real-time information about the disaster situation. In this manner, AI is used to generate the best possible route for the user, taking into account various factors, such as the type of disaster, the severity of damage, and the user's current position in relation to his/her external environment.

Further into the paper, the literature survey is presented in Section 2 based on some existing AR-based navigation applications. Section 3 delves into the proposed work. The results are discussed in Section 4, followed by Section 5 dealing with Performance Analysis. Finally, Section 6 provides a conclusion to our article.

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II. LITERATURE SURVEY

Alessandro et al. [1] in their paper combine activity-based instructions with sparse 3D localisation at selected info points in the building. The interface uses localization to accurately display arrows, signs, and highlighted landmarks. In complex environments, the proposed interface was easier to navigate, more appealing and engaging compared to map-based navigation interfaces. Users unfamiliar with the building will benefit from its more natural and intuitive instructions.

Prashant et al. [2] propose an indoor navigation application using augmented reality built in Unity 3D for complex buildings. The application uses PlaceNote SDK (Software Development Kit) for indoor positioning, Vuforia SDK for AR rendering and a cloud-based management system for building administrators to modify paths. The authors conducted technical evaluations in a hospital building which showed that the system could accurately track the user's location indoors and further found that the AR-based navigation interface was more effective than traditional maps.

Lu et al. in [3] present an AR navigation system for campuses using ARCore to provide users with real-time navigation visually to different places within the campus. To calculate the best route to the user's destination, the navigation algorithm uses a database of campus maps. The system displays the names of the buildings, classrooms, parking lots, hours of operation, the course schedule and even instructors.

Zeman et al. in [4] present an AR navigation system for first responders that provides real-time navigation in even smoke-filled or dark environments whilst tracking the location of victims and other first responders. The algorithm used calculates the best route for first responders to reach the victim and projects relevant instructions onto a wearable AR headset to provide a real-time view of surroundings, with overlays such as display arrows to point to the nearest exit and so on.

Depari et al. in [5] present a comprehensive system to manage factory and office evacuations. The Central Monitoring Unit (CMU) receives alerts about fire, smoke, etc. from environmental sensors and sends it to a user app via Wi-Fi which uses RSSI (Received Signal Strength Indicator) to locate distressed workers and calculate the best evacuation plan using CMU obstacle information.

III. PROPOSED WORK

The proposed AR-based indoor navigation utilises YOLO, Unity based Augmented Reality, A* algorithm and PlaceNote SDK all of which operate in tandem for quick and safe navigation in dire circumstances.

To build the application, there are three plausible methods. First, the placement of sensors in strategic points but this is not feasible on a global scale and it breaches privacy protocols. Second, RSSI Wi-Fi Fingerprinting that uses signal strength to determine the device's indoor location, but it is affected by inference, additionally iOS does not grant access to sensitive information like the MAC (Media Access Control) Address.

The final most prudent option is to create a floor map of the layout of the building by scanning the rooms with the device camera and constructing a 3D model of the rooms.

Mainstream options like ARCore pose notable limitations. ARCore uses Cloud Anchors which are stored for merely 24 hours which befits an AR Multiplayer game but the ephemeral nature of the data storage system does not yield itself to an AR based Navigation system. The time constraint indicates there will be no retention of maps over a prolonged passage of time.

On the other hand, our augmented reality based indoor navigation methodology uses PlaceNote SDK, A* algorithm, and YOLO algorithm. The following Figure 1 illustrates the same.

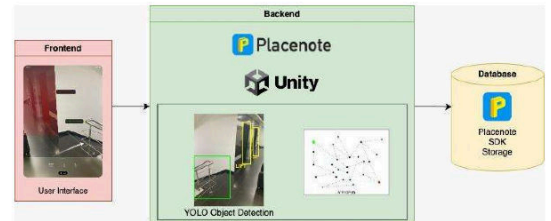


Fig. 1. System Architecture

PlaceNote SDK maps and stores spatial data for future retrieval. If the building were to collapse, debris may lie in places and a mere floor plan is insufficient.

The machine learning model YOLO enhanced the field of computer vision and object detection. Here, YOLO is harnessed to identify obstructions in real-time situations. For instance, it will identify debris which was not there before.

Subsequently, the objects assessed by YOLO are allotted danger values which are supplied to the A* algorithm. It then determines the suitable path and may redirect the user accordingly. The workflow of the application shall be detailed in the forthcoming passages in vein of Figure 2, where the diagrammatic representation of the workflow is illustrated.

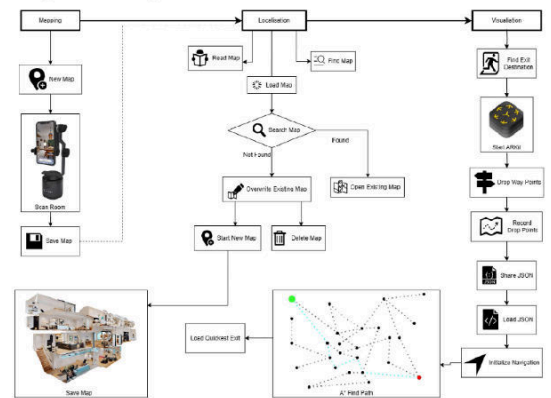


Fig. 2. Work Flow

A. Mapping

The predicament with most navigation applications is the requirement of a pre-existing map model of the building. This is preloaded into Unity after which AR navigational features are programmed with relation to the structure and architecture of the

building. This demands preparatory work for each map model and location.

In contrast, this AR based navigation system truly follows AR principles and employs a CreateMaps method in C# which allows the user to scan the area, chart out the layout of the building and plot Path Finding Anchors. Thus mapping the individual objects and blueprint of the rooms.

Users can experience true AR based Navigation as PlaceNote SDK is utilised to store these map models. It integrates ARKit with its cloud based storage and stores up to 50 maps for 50 users for free. PlaceNote SDK API (Application Programming Interface) requires a valid licence. An API key has been procured from the official source.

The rooms and passageways are scanned with the device camera. Consequently, the software simulates a 3D model of the layout of premises for augmented navigational assistance using the cross-platform solution PlaceNote SDK.

The mapped data is serialised, uploaded and stored within PlaceNote Database for future reference as a dictionary in a JSON (JavaScript Object Notation) file. Each place possesses an ID, time it was created and the GPS location i.e., the altitude, latitude and longitude. Metadata such as type and position as well as dimensions of the rooms and the building are also retained within the PlaceNote SDK Cloud Storage database.

B. Localisation

Localisation is the detection of the location of a device with respect to its environment. It comprises of numerous aspects namely Position tracking, Orientation, tracking, Map alignment, Obstacle detection, Wayfinding and AR Overlays. Navigation in emergency situations requires robust localisation and adaptability due to changing unforeseen circumstances.

Position tracking pinpoints the device location like GPS (Global Positioning System). This project adopts the usage of Waypoints or cloud anchors. They are dropped along like bread crumbs, visually represented by golden orbs using augmented reality techniques. Path-finding waypoints are recorded and define a walkable path.

Map Alignment refers to placing the user's live location in tangent to the 3D virtual map model that was developed in the previous stage. This is a vital step as it bridges the gap between the tangible physical environment and the digital map.

Augmented Reality elements are overlaid on the screen over the physical environment as seen from the camera. Alerts and additional directional information, including the location of wildfires, flood zones, and other hazardous areas thus providing the ultimate Augmented Reality experience.

Accurate localisation permits seamless integration of AR and the real world. Here the digital augmented reality elements and map models are integrated with the physical world using a camera whilst keeping track of the real time position.

Therefore, localisation is crucial for AR Navigation in emergency situations for users to stay aware of their surroundings, avoid hazards, find the quickest and safest way to their destination, coordinate with first responders and other

personnel, and get real-time information about the location of victims, and assess the damage caused.

C. Path Finding

Once the augmented reality elements have been integrated into the application, it must direct the user to the safest and quickest exit. To achieve this, the A* pathfinding algorithm is employed in two different ways.

YOLO object detection model identifies objects in the environment and assigns danger values that represent the level of danger an object poses, higher values indicate greater harm. For example, fire has a greater danger value than debris.

The A* algorithm is employed for path-finding. It locates the shortest path from the user's current location to the nearest exit by assigning a cost value to each node based on the distance to the next node and the danger values. After several iterations, the node with the lowest cost value is selected. Therefore, if there is a large pile of debris along the path, the A* algorithm will find a route that goes around the debris, even if it is slightly longer.

The A* algorithm initialises an open set and a closed set. $g(n)$ is the cost from the start node to the current node, $h(n)$ is defined as the heuristic estimate of cost from the current node to the goal node i.e., the exit and $d(n)$ determines the level of danger. Then the total cost $f(n)$ is calculated, as in:

$$f(n) = g(n) + h(n) + d(n)$$

A* algorithm evaluates cost of each path and selects the shortest path with the least cost. This implies that it will avoid obstacles and danger as those nodes have higher cost values.

This would be implemented as illustrated in the following contextual scenario.

1) *Context*: The user is trapped in the second floor of a building during a fire emergency. There are two exits, exit-1 and exit-2 on the ground floor. There are two options to safely reach the ground floor, one is to take the stairs and the other is to take the elevator.

2) *Implementation*: The user is 10 metres away from the nearest emergency exit – 'exit-1', and 20 metres from 'exit-2'. The available paths to the exit are:

a) *Path 1*: 10 metres long via exit-1, passing through the fire.

b) *Path 2*: 20 metres long via exit-2, while avoiding the fire, but taking the elevator.

c) *Path 3*: 25 metres long via exit-2, while avoiding both the fire and the elevator.

3) *Calculation*: The A* algorithm would calculate the total cost $f(n)$ for each path with the following constraints: User is at $g(n) = 0$; $d(n)$ for Fire = 100; $d(n)$ for Elevator = 50

a) *Path 1*:

$$d(n) = 100 \text{ (flames)}$$

$$h(n) = 10 \text{ metres (to exit - 1)}$$

$$f(n) = g(n) + h(n) + d(n) = 0 + 10 \text{ metres} + 100 = 110 \text{ metres}$$

b) Path 2:

$$\begin{aligned} d(n) &= 50 \text{ (elevator)} \\ h(n) &= 20 \text{ metres (to exit - 2)} \\ f(n) &= g(n) + h(n) + d(n) = 0 + 20 \text{ metres} + 50 \\ &= 70 \text{ metres} \end{aligned}$$

c) Path 3:

$$\begin{aligned} d(n) &= 0 \text{ (no danger)} \\ h(n) &= 25 \text{ metres (to exit - 2 via the staircase)} \\ f(n) &= g(n) + h(n) + d(n) = 0 + 25 \text{ metres} + 0 \\ &= 25 \text{ metres} \end{aligned}$$

Since Path 3 has the lowest total cost $f(n)$, the A* algorithm would select Path 3 as the safest path to the exit.

This example illustrates how a modified A* algorithm determines the safest path to the goal node in the AR disaster response application during calamities and crises.

D. Proposed modifications to A* algorithm

The proposed algorithm will always select the path that minimises the user's exposure to danger.

Step 1: Mapping

- 1.1 Scan the areas to be localised with the device camera such as entrances, common areas, and staircases and save it in a JSON file.

Step 2: Server Integration

- 2.1 Setup and obtain a licence key for PlaceNote.
- 2.2 Upload the map file to the PlaceNote SDK cloud database.

Step 3: Unity Implementation

- 3.1 Import the PlaceNote SDK into a Unity project.

Step 4: Waypoint Dropping

- 4.1 Scan the environment and drop waypoints along the desired path using the breadcrumb path creation.

Step 5: YOLO Object Detection

- 5.1 Use YOLO to identify objects in the environment.
- 5.2 Assign danger values objects based on threat level.

Step 6: A* Pathfinding

- 6.1 Use A* pathfinding algorithm to find the shortest and safest path from the user's location to the exit.
- 6.2 The danger values $d(n)$ detected by YOLO are added to the cost values of the nodes.

Step 7: User Interface

- 7.1 Display the path on the screen using AR elements, such as directional arrows and waypoints.
- 7.2 Display alerts to the user about nearby hazards.
- 7.3 Provide emergency contact information within the application.

Additional Steps

Pre-requirement: Training the YOLO Model

The YOLO object detection model needs to be trained on a dataset of images of the objects that are likely to be encountered in the disaster situation. This will help the model to accurately identify and classify objects in the environment.

Post-requirement: Integrating with First Responder Systems

The AR navigation app could be integrated with first responder systems to provide real-time information about the location of victims and hazards. This would help first responders to respond more quickly and effectively to disaster situations.

IV. RESULTS AND DISCUSSION

A. Results

The proposed AR-based navigation methodology has a number of advantages over traditional navigation systems. The proposed AR-based navigation methodology has a number of advantages over traditional navigation systems. First, it is able to provide real-time information about the environment to make informed decisions in emergency situations. Second, it provides wayfinding assistance. Third, it is easy to use as the user needs to only follow the path that is superimposed onto their screen view of the real world.

The proposed mechanism has the potential to save lives, reduce damage in emergency situations and can be used by first responders and civilians alike.

B. Discussion

Screenshots of the application are presented here, with relevant explanations.

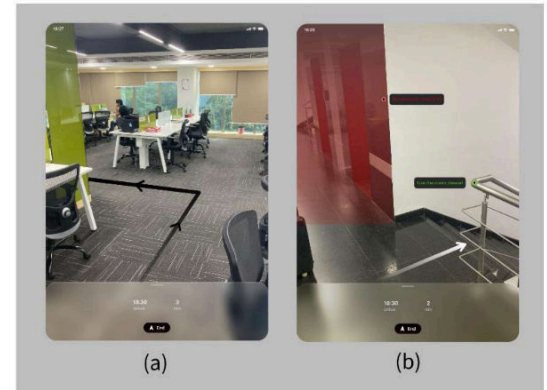


Fig. 3. Screenshot (a) & Screenshot (b)

Screenshot (a) in Figure 3 depicts a standard office. In the user study phase, a simulation was conducted in which the fire alarm was triggered. Upon hearing it, the user opened the application at once and selected the 'Fire Emergency' option among the listed calamities. This figure represents the beginning of the navigation $g(n)=0$. The application then chooses the most appropriate modus operandi for the selected scenario. In the instance of a fire, the ideal safety protocol is to find the safest and the quickest exit and leave in a systematic, organised manner by leveraging Deep Learning, Artificial Intelligence and Augmented Reality.

The black arrows on the carpet in Screenshot (a) directed towards the exit of the room are AR overlays onto the real world as markers for navigation and wayfinding. The AR elements are

overlaid to work in tandem with the A* pathfinding algorithm. Therefore, the user is directed out of the building as per standard fire safety protocols.

Screenshot (b) in Figure 3 portrays the corridor outside the office room. In the passageway, the camera scans the area and this real time data is supplied to the YOLO deep learning model. It proceeds to label the visual data and detects the elevators and staircase using a blend of computer vision and machine learning. Once the surroundings have been identified and labelled, each physical object is attributed a danger value $d(n)$ based on the threat analysed.

In the given scenario, YOLO identifies the elevator and assigns a higher danger value $d(n)$ to this node, whilst it captures the staircase and allocates a lower danger to it. Based on the aforementioned factors, weighted values i.e., costs are calculated by the modified A* algorithm.

The pragmatic approach is to cut the supply of electricity to the building to prevent electrical fires. As a precautionary measure elevator must be avoided to refrain from overloading the circuits. In recent times, most fire alarms automatically shut down the power supply although generators might still be in operation. Therefore, visual cues in the application dissuade the user from entering the elevator as the power might be cut off whilst the user is still inside.

Additionally, AR based textual cues such as “DO NOT USE THE LIFT!” appear on screen to further illustrate the safer routes with green overlays present to ensure that the user only takes the stairs. The guided route is represented in the form of an arrow superimposed near the stairs. The entire region of the lift in the corridor is covered in a red haze to indicate a ‘NO GO’ zone. Thus, the danger is averted complying with international UI/UX norms.

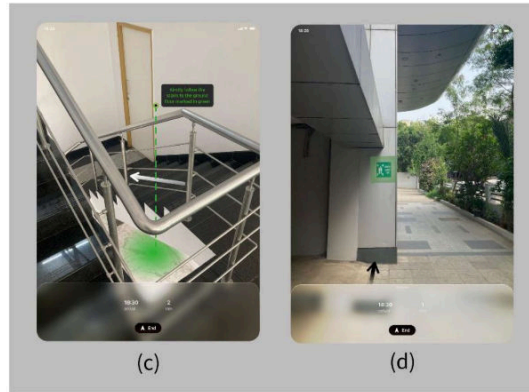


Fig. 4. Screenshot (c) & Screenshot (d)

Screenshot (c) in Figure 4 showcases the penultimate flight of stairs. The application successfully detects the ground floor as the user approaches it. The identified region is marked in green with arrows to direct the user to the desired location. It is further reinforced with an additional textual cue, “Kindly follow the stairs to the ground floor marked in green.” Screenshot (d) in

Figure 4 shows the user exiting the building from the nearest exit as directed by the application.

On exiting the building, the application detects an assembly point. As illustrated in Screenshot (d) of Figure 4, it highlights this region in green and superimposes navigational arrows onto the ground. The application informs them that they have arrived at an emergency assembly point and asks them to wait until authorities arrive, as seen in Figure 5.



Fig. 5. Snapshot-c

The application possesses an exclusive feature that permits architects, building managers, and registered stakeholders to upload a comprehensive list of the designated emergency assembly points. In the simulation, the emergency assembly locations were registered in the database, which enabled the application to determine the estimated time of approximately 3 minutes. This crucial factor enhances emergency preparedness and guided response within the building.

V. PERFORMANCE ANALYSIS

The proposed AR-based navigation application was tested in a simulated emergency scenario and a user study to determine the user-friendliness of the UI/UX as well as evaluate its potency in times of need.

a) Simulated emergency scenario: A simulated emergency scenario was constructed to evaluate the performance of the application in a realistic setting. The scenario involved an emergency fire drill in an office building. The application led the user to safety.

b) User study: A user study was conducted to evaluate the usability of the application. The user study involved 20 participants, who were segregated into two groups A & B. Group A was required to escape an expansive office building by themselves. Group B members were instructed to follow the AR application. Figure 6 represents a side-by-side comparison of Group A and Group B using two graphs.

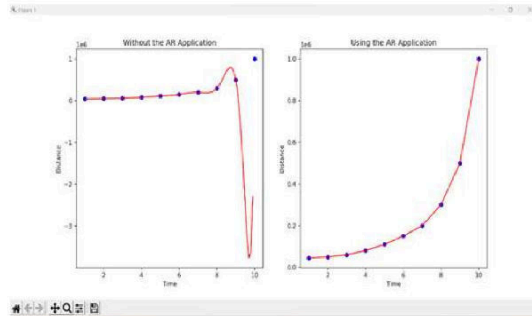


Fig. 6. Comparative Analysis

In Figure 6, a side-by-side comparison of the two groups A & B has been represented graphically. Here, Time is measured along the x-axis and Distance is measured along the y-axis. $y=1$ represents the exit as the distance is covered while $y=0$ is the starting point. Negative numbers imply that the user is either lost or walking in the wrong direction away from the exit.

Group A started at $y=0$, but eventually lost their way. This is visible in the graph where the curve dips below $y=-3$.

Group B began at $y=0$, and were directed to the safest, and shortest exit. All of them found the exit and were able to navigate to safety.

The results of our evaluation show that the AR-based navigation application is a viable solution for emergency situations. The application is able to find the safest and quickest path to the exit, even in complex and dangerous environments. This application is user-friendly, informative and effective as is demonstrated by the results of the user study. It provides an unparalleled user experience by integrating Machine Learning

concepts with Augmented Reality. Thus breaking the barriers between reality and the virtual world.

VI. CONCLUSION

This study has developed an augmented reality based navigation application for indoor environments with PlaceNote SDK, YOLO Object detection model and A* Algorithm with weighted modified costs. Safety is the primary principle. Future enhancements will include the YOLO model being further trained in more complex environments. This ensures that it tackles any sudden complications that may arise in emergency situations. The application will also incorporate a wider range of calamities and crises in addition to the existing choices.

This endeavour seeks to enhance the augmented reality experience, and transcend the horizons of the physical realm by expanding the definition of the known.

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CHAPTER 6

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