CHAPTER 1

INTRODUCTION

Indoor navigation has become increasingly critical, especially in complex environments such as malls, airports, and hospitals, where GPS signals are often unreliable or unavailable. For visually impaired individuals, navigating such spaces safely and independently poses a significant challenge. This project aims to develop an Augmented Reality (AR)-based Indoor Navigation System specifically designed to assist visually impaired users by providing real-time navigation, obstacle avoidance, and social awareness features.

The system uses object detection techniques to identify and alert users about nearby obstacles and offers continuous voice guidance to support safe movement indoors. A key feature of the system is its ability to recognize known individuals and inform the user of their presence, while also storing data about unknown persons for future interaction.

The literature survey highlights the effectiveness of cost-efficient AR-based navigation solutions that utilize smartphones, vision-based tracking, SLAM (Simultaneous Localization and Mapping), and marker-based navigation. Tools like Unity, ARKit make these systems accessible and scalable without the need for expensive hardware. By integrating Computer Vision, AR, and voice technology, this system offers an inclusive, affordable, and practical solution to indoor navigation, empowering visually impaired users to move safely and independently in enclosed environments.

1.1 Overview

With the increasing complexity of indoor environments such as shopping centers, hospitals, and transport hubs, the need for reliable navigation systems that work without GPS has become vital. Recent developments have focused on integrating technologies like Augmented Reality (AR), SLAM, QR code-based localization, and vision-based tracking to build smartphone-friendly indoor navigation tools.

These methods eliminate the need for costly infrastructure by using devices people already own. AR, in particular, enriches the user experience by overlaying navigational cues onto real-world views. Combined with real-time localization and semantic mapping, users receive intuitive, accessible guidance tailored to dynamic indoor settings. By leveraging tools like Unity, ARKit, developers can deliver low-cost, scalable systems that cater to diverse needs, including those of visually impaired users, significantly enhancing autonomy and spatial awareness in complex indoor spaces.

1.2 Purpose of Literature Survey

The literature survey aims to explore existing research and technologies related to indoor navigation and assistive systems for visually impaired individuals. By reviewing eight research papers, we identified key methods such as BIM, AR, and AI-based object detection that enhance navigation accuracy and user experience.

The survey helped highlight limitations in current systems, including dependence on external sensors, lack of real-time feedback, and minimal semantic data usage. It also guided the selection of effective methodologies like the IARA algorithm and YOLO-v3 for our proposed system. This understanding enables us to design a smartphone-based, cost-effective navigation system with improved path planning, object recognition, and audio guidance tailored to the needs of visually impaired users.

1.3 Scope and Limitations

The project aims to develop an AR-based indoor navigation system for visually impaired individuals using a smartphone. It provides real-time voice guidance, obstacle detection, and identification of known individuals to enhance indoor mobility and safety. The system prioritizes affordability and ease of use by relying on mobile devices without requiring expensive hardware. However, it has certain limitations, such as sensitivity to lighting conditions, dependence on camera quality, and the need for a clear view for accurate detection. In dynamic or crowded environments, performance may be affected due to obstructions. Additionally, users must handle the device properly, and voice guidance may not be effective in noisy surroundings.

CHAPTER 2

LITERATURE SURVEY

"ARGuide Pro: An AR-based Indoor Navigation" by Juile J., Surendar Chandrasekaran, Surya P.R. in 2024[1]

Problem Statement :

The paper addresses the challenge of navigating large and complex indoor spaces such as educational campuses, malls, and offices, where GPS is ineffective. Many visitors struggle with disorientation, leading to inefficiencies and poor user experience. The aim is to create a cost-effective, intuitive, and robust AR-based indoor navigation solution that utilizes smartphones and provides real-time visual guidance to users.

Methodology:

The proposed system leverages a combination of ARCore, Unity, and NavMesh technologies to construct a dynamic indoor navigation solution. The architecture is divided into two main modules:

- **AR-based Data Collection:** ARCore uses camera and motion sensor data to generate a real-time 3D model of the environment, capturing both static and dynamic elements. It applies Simultaneous Localization and Mapping (SLAM) for accurate user positioning.
- **AR-based Navigation:** NavMesh defines walkable surfaces and routes within the environment. Users view their navigation path through AR overlays on their mobile device screen, enhanced by visual markers and voice guidance. The navigation system also incorporates **Natural Language Processing (NLP)** for voice

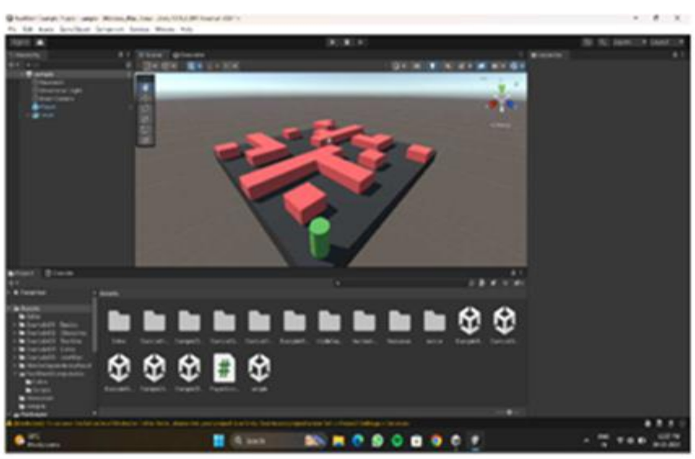


Fig 1.1:Virtual map using Navmesh

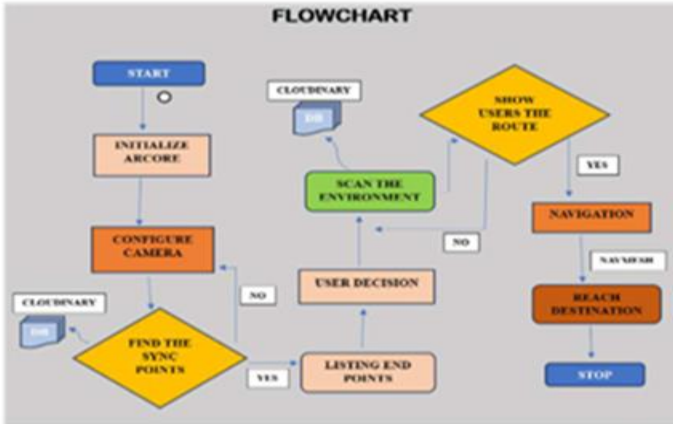


Fig 1.2:Flowchart of the application.

Supporting tools include:

- Unity NavMesh: Used to model the navigable environment.
- Android SDK: Enables application development and integration with ARCore.
- ARCore Spatial Mapping: Facilitates real-time tracking and environmental mapping.
- Hardware Specs: Smartphones or AR glasses with necessary sensors (camera, gyroscope, magnetometer, accelerometer); optional LiDAR for high-precision mapping.

Fig 1.3:Working of AR Core

Result and Analysis:

The project demonstrates a working prototype capable of mapping indoor environments and assisting users in real-time navigation with AR overlays and directional markers. The system detects the user’s movement via camera-based motion tracking and updates their position, refreshing AR path indicators accordingly. Though no quantitative accuracy metrics are detailed, the visual result shows smooth user interaction. Flowcharts and block diagrams of the navigation pipeline and AR response are included.

Conclusion:

- **Advantages:** Low hardware cost, effective use of AR for real-time direction, scalability for various settings such as educational campuses and commercial buildings, and integration with voice-based interaction for accessibility.
- **Disadvantages:** The model faces screen jitter and instability during user motion, especially at turns; initial setup may require environmental scanning and calibration.
- **Gap / Future Work:** Future enhancements include incorporating GPS for semi-outdoor usage, adding educational modules using AR for immersive learning, deploying dynamic content for events, and improving tracking algorithms to reduce visual jitter and increase reliability.

"A BIM and AR-based Indoor Navigation System for Pedestrians on Smartphones" by Wensheng Zhang, Yanjing Li, Pengcheng Li, Zhenan Feng in 2024[2]

Problem Statement :

The paper addresses the challenges in indoor navigation systems, particularly in complex buildings like shopping centers and airports where GPS signals are not accessible. Traditional methods for indoor localization are costly, and existing path planning techniques lack semantic information, reducing practical usability. The aim is to develop a cost-effective and user-friendly navigation system for pedestrians using smartphones.

Methodology:

The proposed system integrates Building Information Modeling (BIM) and Augmented Reality (AR) for navigation.

- A 3D indoor space model is mapped to a 2D grid using triangular prism-based spatial division.
- AR nodes are strategically installed to aid in visual positioning through smartphone cameras, using camera calibration and marker-based tracking.
- The Indoor Augmented Reality Navigation Algorithm (IARA) is introduced for path optimization, considering multiple factors like AR node usage, distance, and visibility.
- Tools used include Revit for BIM data and Android SDK for AR development.
- The test environment was a subway station area modeled in 3D and simulated in 2D grids with installed AR nodes.

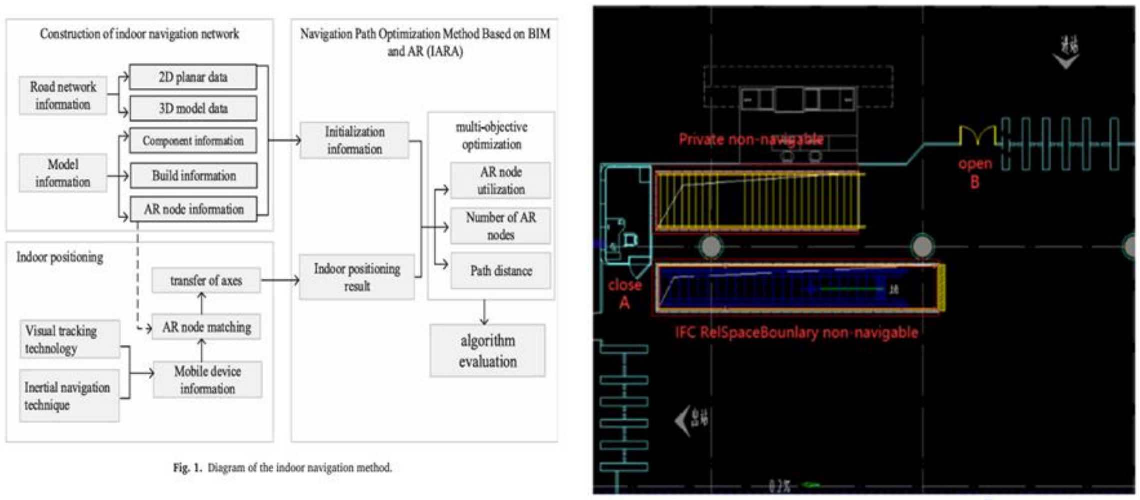


Fig 2.1:Diagram of the indoor navigation method

Result and Analysis:

The IARA algorithm was compared with a standard SPA (Shortest Path Algorithm).

- IARA Results (Avg. of 3 test cases): Distance ≈ 184m, AR Nodes ≈ 7, Utilization ≈ 50%
- SPA Results: Distance ≈ 143m, AR Nodes ≈ 3, Utilization ≈ 25%
- The IARA paths, while slightly longer, offered higher AR node usage and better usability.
- Graphs and tables illustrated improved semantic interaction and user orientation.

Table 6
Comparison of navigation path results.

	Algorithm	Distance/m	Number of AR nodes	Node utilization/%
1	IARA	173	6	43
	SPA	142	3	25
2	IARA	193	8	58
	SPA	152	4	28
3	IARA	186	7	48
	SPA	136	3	21

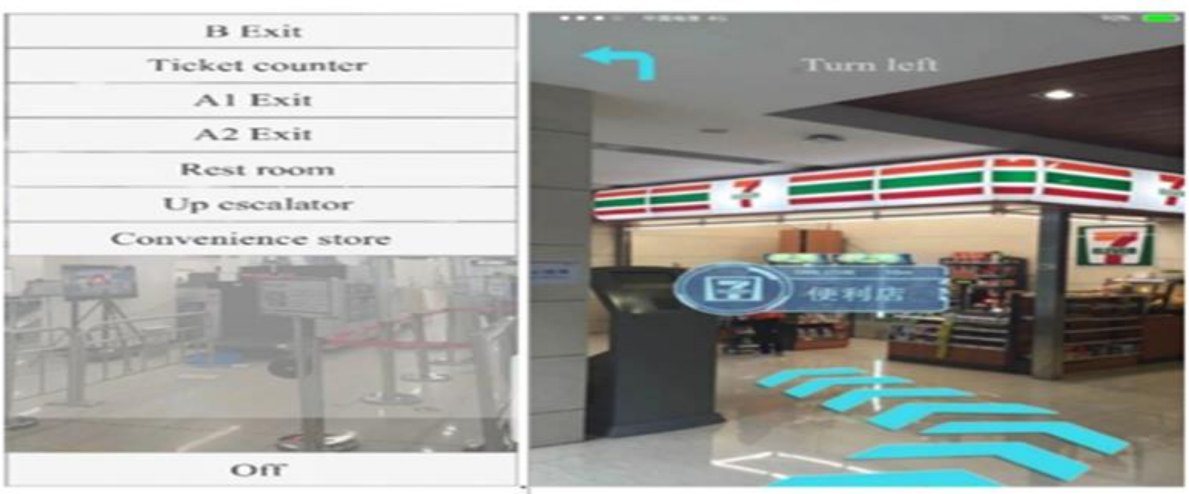


Table 2.2:AR navigation interface

Conclusion:

- Advantages: Provides high-precision, intuitive indoor navigation using only smartphones; reduces hardware cost; integrates spatial semantics for better user experience.
- Disadvantages: AR node installation and calibration require manual setup; high initial modeling effort in BIM.
- Gap / Future Work: System needs optimization for dynamic environments and scalability across multiple buildings. Future enhancements could focus on real-time AR node generation and autonomous BIM updates.

"A visual aid system using image processing and deep learning with audio haptic feedback," by R. G. Baldovino, J. M. Panganiban, R. G. Velasco, J. G. Mendoza, and G. D. Fajardo, in 2024[3].

Problem Statement:

Blind and visually impaired (BVI) individuals face difficulty in navigating unfamiliar environments independently. Traditional navigation aids often require hand-held or wearable devices that may be bulky or inconvenient. This study proposes a system using image processing and deep learning with audio and haptic feedback to provide real-time, hands-free assistance via CCTV-based monitoring.

Methodology

- The system is designed around three main modules: input, analysis, and feedback.

  1. Data Input: A CCTV camera provides a live feed of the environment.

  2. Deep Learning Analysis: A YOLO-based custom object detection model trained on a custom dataset (humans, chairs, tables) recognizes objects.

  3. Feedback Mechanism: When proximity ($\leq$0.3 m) to an object is detected, the system triggers audio (via Python's winsound) and haptic feedback (via a vibration motor connected through pyFirmata).

Technologies Used:

- YOLO object detection
- Roboflow for data augmentation
- Albumentations (alternative data augmentation library)
- Jupyter Lab for model training
- Django for the web interface

- Bird's-eye view transformation for spatial estimation.

Implementation Highlights:

- Dataset of 390 images across 3 classes was augmented to 1080 images.
- Models trained with 20, 50, and 100 epochs; best results observed at 50 epochs.
- Achieved mean average precision (mAP) of 0.92.
- Used perspective transformation for accurate spatial positioning and proximity estimation.
- Proximity breaches (overlap between proximity circles) trigger feedback alerts.

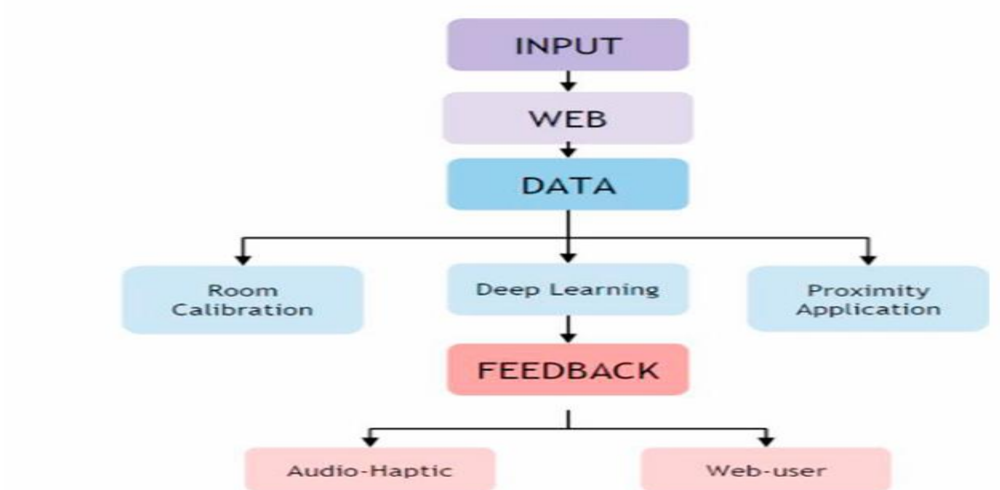


Fig. 3.1: Conceptual framework of the study

Results and Discussion:

- The system was tested in a controlled indoor environment with a webcam mounted at a specific height and angle.
- Audio and haptic alerts were successfully triggered when users approached objects.
- Detection dropped near image edges or for objects too close to or far from the camera.
- A web application ("Project MATA") was implemented for real-time monitoring and visualization.

Conclusion:

The study demonstrated the feasibility of an efficient, low-cost navigation aid system for BVIs using deep learning and audio-haptic feedback. The system allows hands-free interaction and accurate real-time object detection with proximity alerts.

Advantages:

- High accuracy (mAP 0.92)
- No need for hand-held devices
- Custom dataset and augmentation increase model robustness
- Web-based monitoring for caregivers

Limitations and Future Work:

- Detection lags (5s delay in feedback)

- Difficulty detecting objects near frame edges
- Potential improvement using multi-camera setups and depth sensors
- Recommendations include better hardware, optimized algorithms, and dedicated haptic drivers
- Let me know if you’d like this converted into .docx, included in a comparison with other papers, or formatted for a research review.

“Recognizing Distant Faces” by Izzat N. Jarudi, Ainsley Braun, Marin Vogelsang, Lukas Vogelsang, Sharon Gilad-Gutnick, Xavier Boix Bosch, Walter V. Dixon III, Pawan Sinha in 2023[4]

Problem Statement:

The study focuses on a crucial yet under-explored challenge in facial recognition—identifying familiar faces from long distances. Most previous research has concentrated on close-range, high-resolution face recognition, whereas in real-world situations like airports or streets, individuals often need to recognize people at greater distances. At such ranges, traditional internal facial features (eyes, nose, mouth) lose detail due to image degradation, raising questions about which cues actually support recognition. This work investigates how recognition performance varies with distance and the relative importance of internal versus external facial features.

Methodology:

The researchers conducted two human experiments and a set of computational experiments using CNNs.

Human Experiments:

- Experiment 1: Used Gaussian blur as a proxy for viewing distance. Participants identified celebrities based on different facial configurations: only internal features (arranged or spatially intact), only external features, and full faces. Recognition was measured across increasing blur levels.
- Experiment 2: Directly manipulated viewing distance. Participants viewed faces mounted on a movable cart and responded when they recognized the person. This helped map recognition performance to physical distance.

Computational Experiments:

- A convolutional neural network (AlexNet) was trained on full-face images from the FaceScrub dataset and tested on internal-only, external-only, and combined features.
- Additional controls included using average faces to fill missing regions and simulating side-by-side presentations of features.

Tools:

- Adobe Photoshop for stimulus editing
- AlexNet CNN architecture
- FaceScrub dataset
- Grad-CAM for feature activation visualization

Test Environment:

- Participants from MIT with normal or corrected-to-normal vision
- Testing room with a 25-foot track to simulate distance

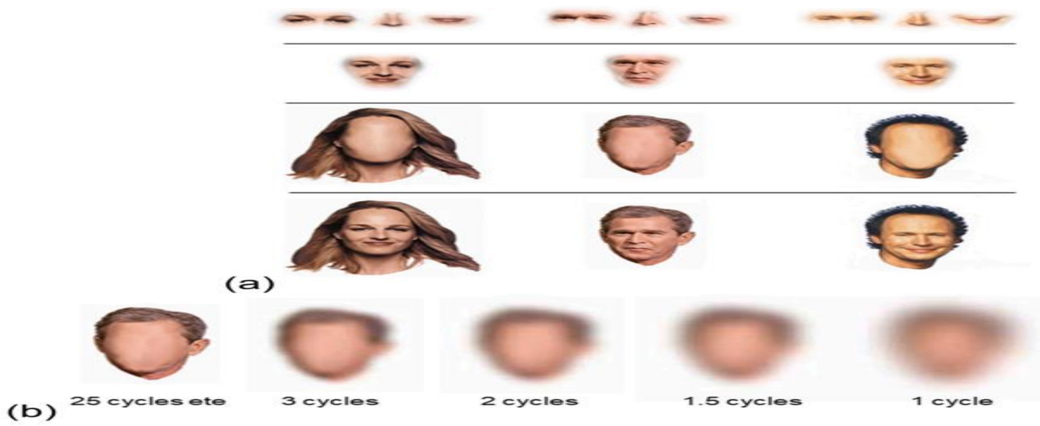
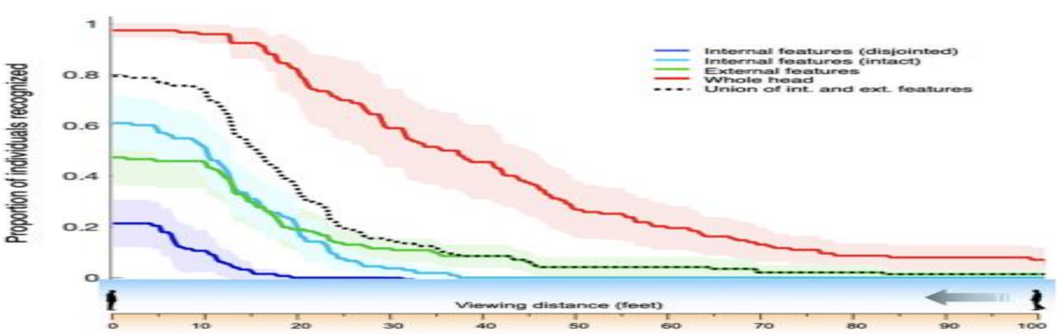


Fig. 4.1: **Face stimuli variations, blur levels, and recognition performance across conditions.**

Result and Analysis:

Human Results:

- Full faces were consistently recognized better than internal or external features alone.
- Recognition at longer distances relied heavily on the spatial relationship between internal and external features.
- The union of internal and external feature performance was still significantly less than full-face performance, indicating a synergistic effect.
- Inverted face recognition dropped, confirming the reliance on spatial configuration (face inversion effect).



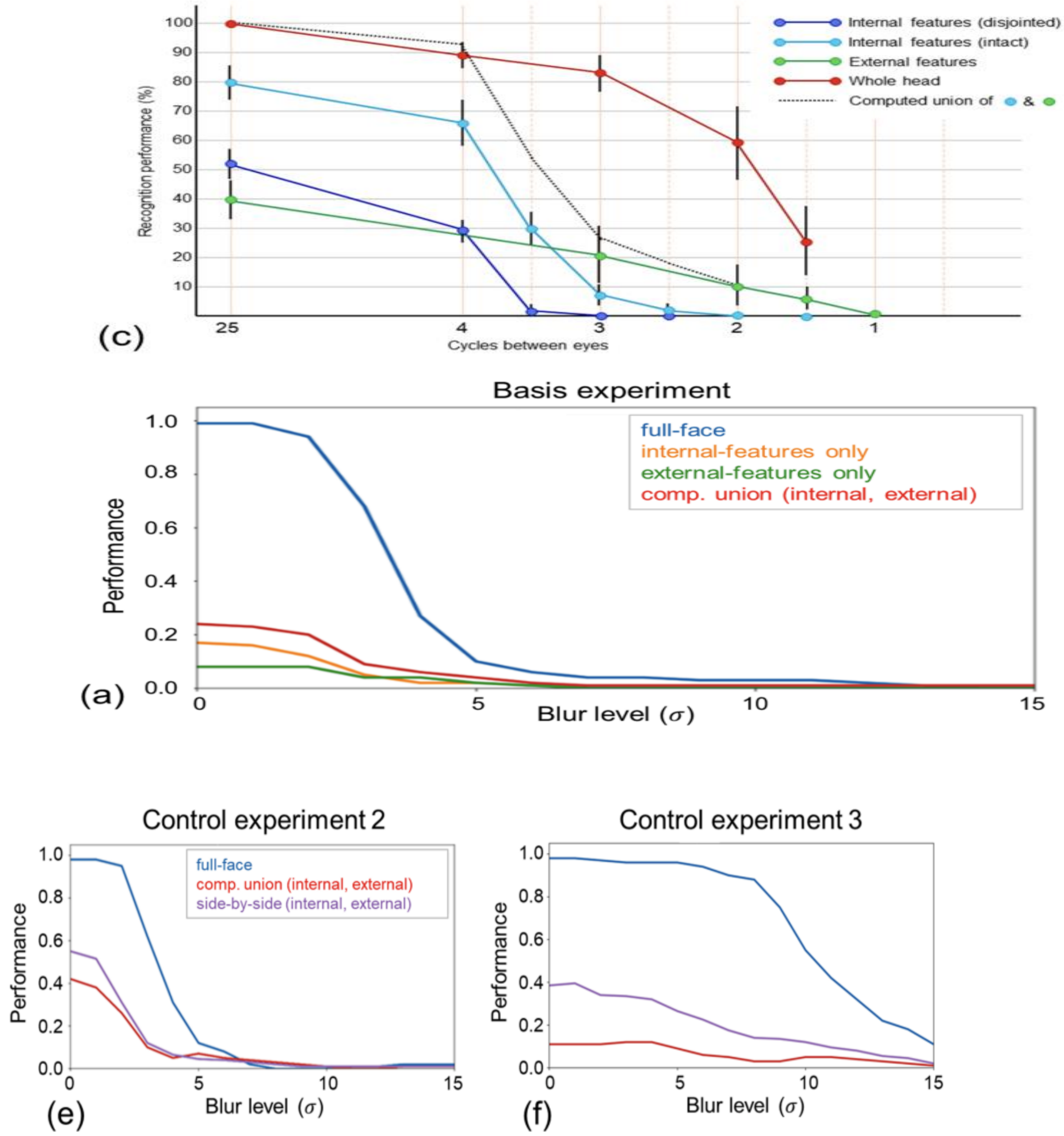


Fig 4.2:**Classification results using different face feature combinations and training conditions**.

Computational Results:

- CNNs performed significantly worse on isolated feature sets than on full-face images.
- CNN performance improved slightly when trained on blurred images but still lagged behind human synergy.
- Grad-CAM showed internal features dominating decision-making at close blur levels and more holistic activation at higher blurs.

Conclusion:

Advantages:

- Demonstrates that face recognition at a distance is not merely a function of internal feature clarity.

- Highlights the importance of spatial relationships between facial components.

Offers insights into improving artificial face recognition systems for real-world conditions.

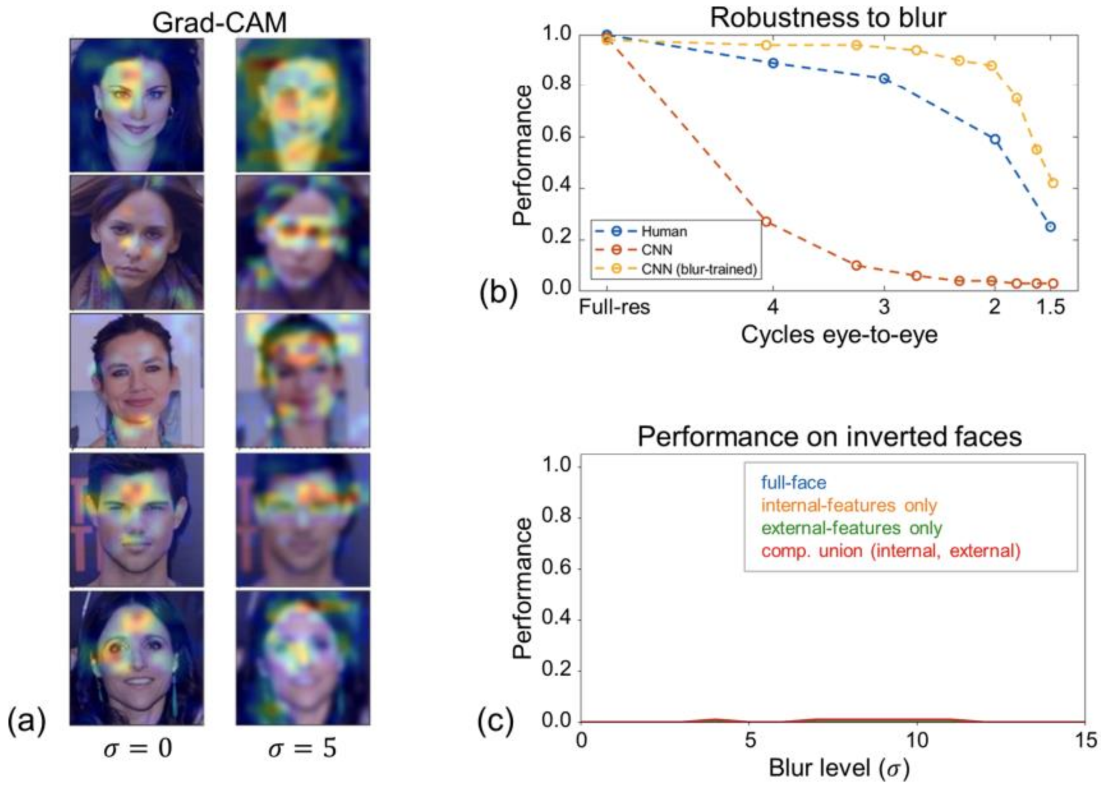


Fig 4.3: key regions for classification, blur effects, and CNN performance on inverted faces.

Disadvantages

- CNNs still fall short in matching human-like recognition robustness.
- Experimental limitations include a lab-based distance simulation and a focus on already-familiar.faces.

Gap/Future Work:

- Develop real-world, ecologically valid datasets simulating distant recognition.
- Improve machine learning models by incorporating developmental and spatial configuration training.
- Investigate the role of temporal dynamics and recognition timing.

"Indoor navigation using augmented reality for mobile application," by R. M. S, A. M. R, and K. R. M in 2023[5].

Problem Statement:

The paper focuses on the limitations of GPS in indoor environments such as malls, universities, airports, and complex buildings, where it fails to provide accurate navigation. This often causes confusion and time loss for users trying to find destinations indoors. The goal is to develop a smartphone-based, cost-efficient AR indoor navigation system that eliminates the need for manual guidance and enhances user independence and experience.

Methodology:

The system is built using ARCore, Flutter, and Firebase, enabling real-time AR navigation on Android and iOS devices. It is designed as a markerless AR solution that detects the user's position using the smartphone camera and sensors, and overlays directional guidance using virtual arrows.

The architecture comprises:

- Front-End: Built with Flutter, handling user interface and interactions.
- Middleware: Uses Firebase to store and retrieve geolocation coordinates.
- Back-End:ARCore SDK processes motion tracking, environment mapping, and 3D object rendering.

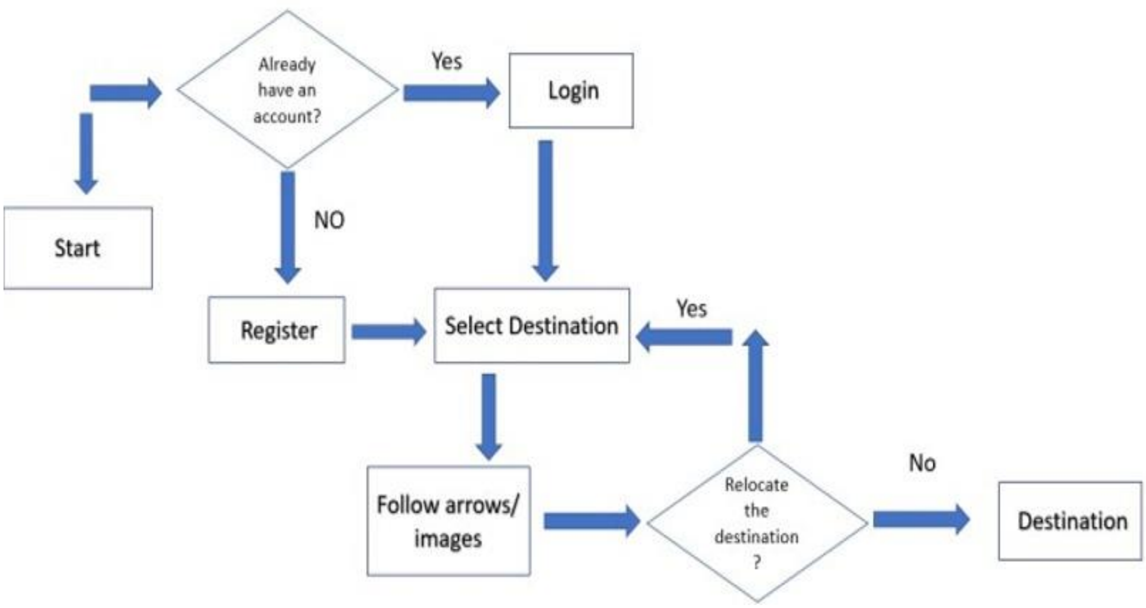


Fig 5.1: Flowchart

Tools & Technologies:

- ARCore (Android)/ARKit (iOS): For spatial mapping and motion tracking.
- Flutter:For building the cross-platform mobile app.
- Firebase:Backend for storing paths and location data.

Result and Analysis:

A working mobile prototype was developed that successfully tracks user location indoors and overlays directional AR markers in real-time. The system supports destination search, QR-based location identification, and dynamic arrow guidance. The effectiveness is validated through smooth transitions, responsive marker rendering, and user testing, though no quantitative metrics are provided.

Conclusion:

Advantages:

- Intuitive AR navigation without physical markers.
- Efficient indoor guidance using smartphones.
- User-friendly interface with dynamic location updates.
- QR code scanning support for route initiation.

Disadvantages:

- Limited support on low-end devices.
- Heavy battery and RAM usage with AR features.
- Dependency on high-speed internet.
- ARCore incompatibility on some devices.

Gap / Future Work:

- Integration with outdoor navigation for hybrid scenarios.
- Optimization for resource consumption (battery, RAM).
- Security enhancements to prevent misuse of indoor infrastructure data.
- Exploring more lightweight AR SDK alternatives to Unity for better performance.

"A Low Cost Indoor Navigation System using Augmented Reality," by R. Goud, N. Paatil, M. Patil, H. Khadakar, and S. Koparde, in 2022[6].

Problem Statement:

The paper addresses the challenge of indoor navigation in large structures such as malls, airports, museums, and hospitals, where GPS fails due to signal unavailability. Traditional indoor navigation solutions are often expensive and complex. The proposed solution focuses on developing a "cost-effective AR-based indoor navigation system" that uses virtual markers and real-time live feeds from smartphones to provide indoor localization and directional assistance. The system aims to avoid the use of GPS, complex ML models, or AI, making it accessible for everyday users.

Methodology:

The proposed system combines augmented reality, SLAM, and image recognition with a smartphone-based interface. The architecture involves placing virtual anchors at designated indoor locations, which are persistent and reusable by any user through the app.

Key Components:

- User Input: Users scan the environment using a smartphone camera.
- Localization:Location is identified via real-time AR analysis of the environment (SLAM).

- Path Planning:A* algorithm computes the optimal path to the selected destination.
- Navigation:AR arrows guide users in real-time using Unity and AR SDKs.
- Database:Stores user information, virtual anchor points, and destination paths.

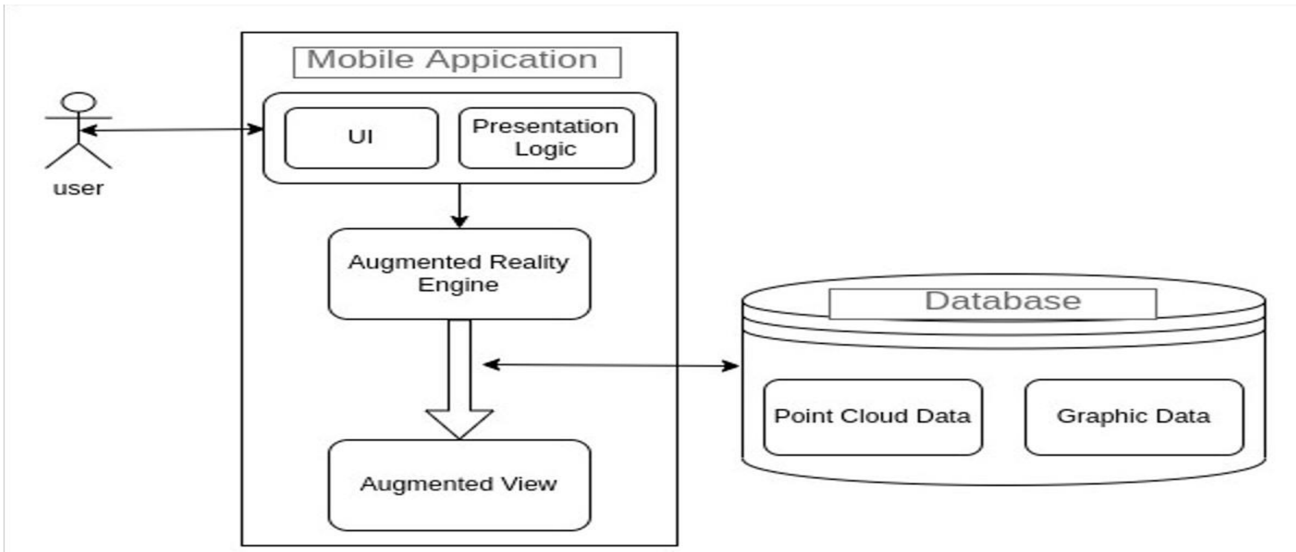


Fig 6.1: Architecture diagram

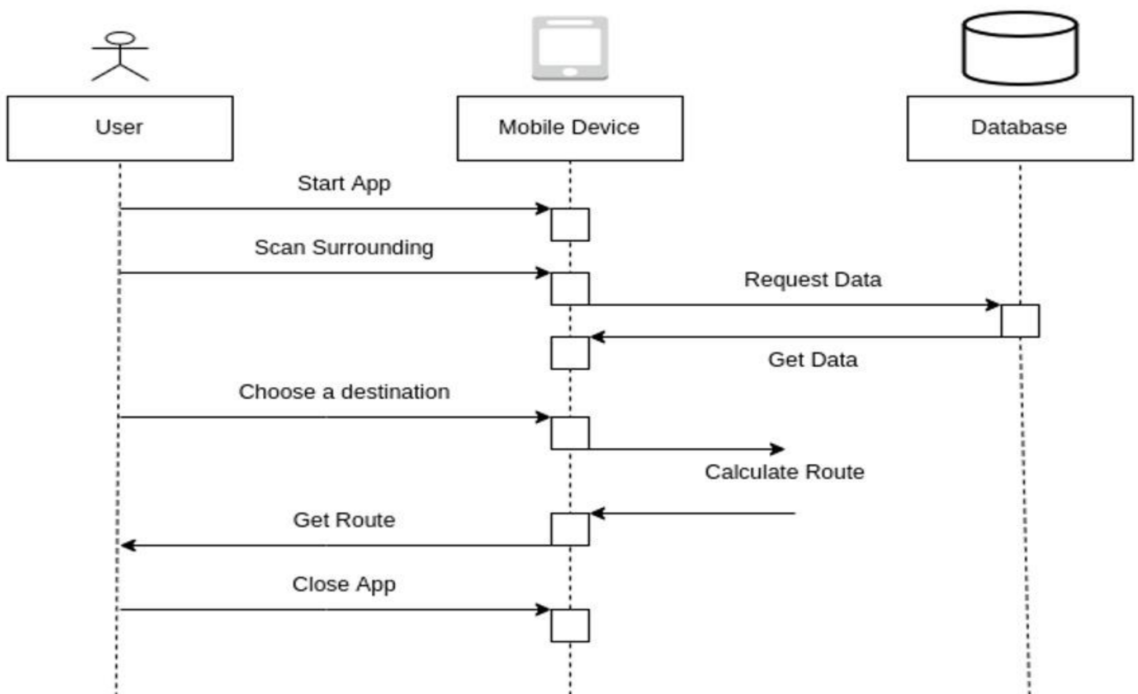


Fig 6.2: Sequence diagram

Technologies Used:

- Unity 3D
- AR SDKs (like ARCore)
- Vuforia SDK (for marker-based tracking)

- Firebase (for backend data and authentication)
- A* Algorithm (for pathfinding)
- SLAM (Simultaneous Localization and Mapping)

Result and Analysis:

The prototype was successfully tested to perform indoor localization and AR-guided navigation. The system uses virtual AR arrows to indicate direction and notifies users upon reaching their destination. Visual diagrams demonstrate modules such as localization, navigation, and destination confirmation. The system avoids the pitfalls of GPS indoors and provides a visually intuitive experience.

Fig 6.3: Navigation and Localisation

Conclusion:

Advantages:

- Eliminates the need for expensive hardware or GPS.
- Real-time AR experience using only smartphones.
- Supports persistent and reusable virtual markers.
- Potential integration with health apps (e.g., Aarogya Setu) for contact tracing.
- Enhances accessibility for differently-abled users.
- Offers scope for gamification and user interaction improvements.

Disadvantages:

- Performance may vary with low-end phones or poor lighting.
- AR and SLAM technologies may face limitations with repetitive structures.

- Some reliance on internet connectivity and camera capabilities.

Gap / Future Work:

- Gamification for better engagement.
- Integration of object detection for obstacle avoidance.
- Use of warning prompts for indoor features like elevators and stairs.
- Cross-platform deployment with web integration.
- Enhancement through photorealistic AR and AI-driven personalization.

"Indoor Navigation System Using Augmented Reality" by S. C. J., S. Dileep, S. C. S., and L. E. Sunny in 2021[7].

Problem Statement:

The paper addresses the inability of GPS to provide accurate positioning inside buildings like malls, airports, or hospitals due to signal obstruction. The authors propose an augmented reality (AR)-based indoor navigation system that overcomes these limitations using camera-based SLAM (Simultaneous Localization and Mapping), QR codes for location identification, and path visualization through AR arrows. The goal is to create an affordable and interactive indoor guidance solution using just a smartphone.

Methodology:

The system architecture consists of four key modules:

1. ARCore-Based Localization – Uses SLAM to detect the user's position without GPS or additional hardware.
2. QR-Code Repositioning – QR codes are placed at fixed indoor points to help users set start positions or re-localize while moving.
3. Unity NavMesh Navigation – Enables defining walkable paths and obstacle avoidance in the building using Unity game objects.
4. AR Path Display – Arrows rendered in AR guide users along the computed path.

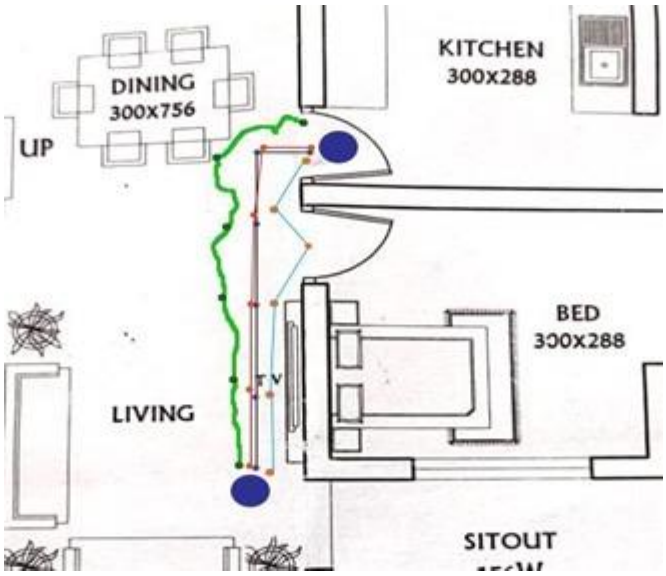


Fig 7.1: Path from living room to kitchen

Workflow:

- User scans a QR code at the starting location.
- The app retrieves location data and allows destination selection.
- The A-star algorithm calculates the shortest path.
- AR arrows are displayed along the route, updating dynamically as the user moves.
- The app also includes a minimap showing user position and path.

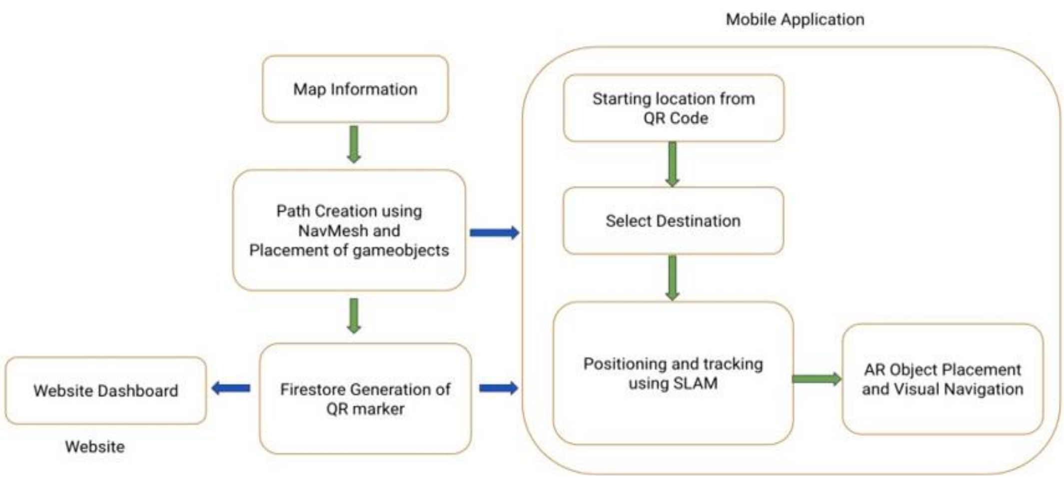


Fig 7.2:Architecture

Tools and Technologies:

- ARCore for SLAM-based localization
- Unity and NavMesh for rendering navigation environment and pathfinding
- QR codes for initial positioning and re-localization
- A-star pathfinding algorithm for computing optimal routes
- HTML, CSS, and JavaScript for the web dashboard where admins manage building layouts

Result and Analysis:

- The mobile application successfully enabled real-time AR navigation inside buildings.
- The system achieved higher accuracy using AR SLAM (variation approximately 0.08 meters) compared to marker-based (0.8 meters) and GPS (0.85 meters) methods.
- Navigation performance was evaluated using a path from a living room to a kitchen, and the SLAM-based approach showed the most accurate tracking.
- The solution also supports 2D map views for accessibility and fallback.

Conclusion:

Advantages:

- Accurate localization without external hardware
- Cost-effective: works on smartphones with ARCore support
- Interactive AR visuals improve user experience
- Scalable and adaptable for various buildings
- Web dashboard for easy admin management of locations and QR markers

Disadvantages:

- Requires Android 8.1 or higher with ARCore support
- AR object stability can vary based on lighting and camera alignment
- Continuous camera usage may impact battery life
- Position recalibration may be needed if QR markers are missed

Gap and Future Work:

- Handle dynamic obstacles in real-time path planning
- Improve AR object stability and rendering
- Extend to iOS devices using ARKit
- Integrate more accessibility features for visually impaired users
- Enhance web dashboard with analytics and real-time user tracking.

"Efficient Multi-Object Detection and Smart Navigation Using Artificial Intelligence for Visually Impaired People" by Rakesh Chandra Joshi, Saumya Yadav, Malay Kishore Dutta, Carlos M. Travieso-Gonzalez in 2020[8]

Problem Statement:

Visually impaired individuals face constant challenges in navigating and interacting with their surroundings due to a lack of reliable, real-time assistive technologies. Traditional aids like canes, guide dogs, or GPS devices often fall short in object recognition or complex navigation tasks. This research proposes an AI-based, real-time system combining deep learning with sensor technologies to provide both obstacle avoidance and intelligent object recognition with auditory feedback, enhancing spatial awareness for the visually impaired.

Methodology:

System Design:

- The proposed framework integrates a deep learning object detection model (YOLO-v3) with a DSP processor, a camera, and ultrasonic distance sensors.

Data Collection & Annotation:

- A custom dataset relevant to the needs of visually impaired people was created from various sources.
- Images were manually annotated using LabelImg, ensuring high-quality bounding boxes.
- Augmentation techniques like rotation, flipping, contrast changes, and noise addition were applied to increase dataset variability.

Model Training:

- YOLO-v3 with Darknet-53 backbone was trained on the augmented dataset.
- Both transfer learning and direct training approaches were evaluated.
- The model achieved an accuracy of 95.19% for detection and 99.69% for recognition.

Optimized Output Communication:

- A speech/audio module was added to translate detected object labels into sound.
- Object counter logic was implemented to minimize redundant audio playback (e.g., saying "3 persons" instead of "person" three times).
- Limits were set on the number of object categories read aloud to ensure timely frame processing.

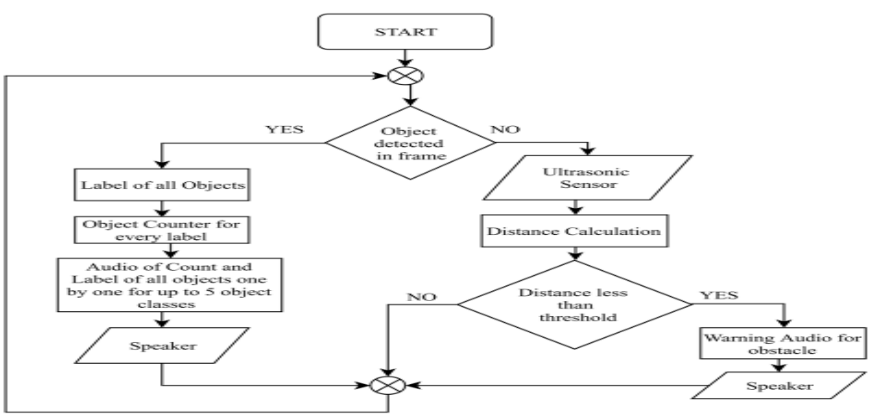


Fig 8.1: Information Optimization and Object–Obstacle.

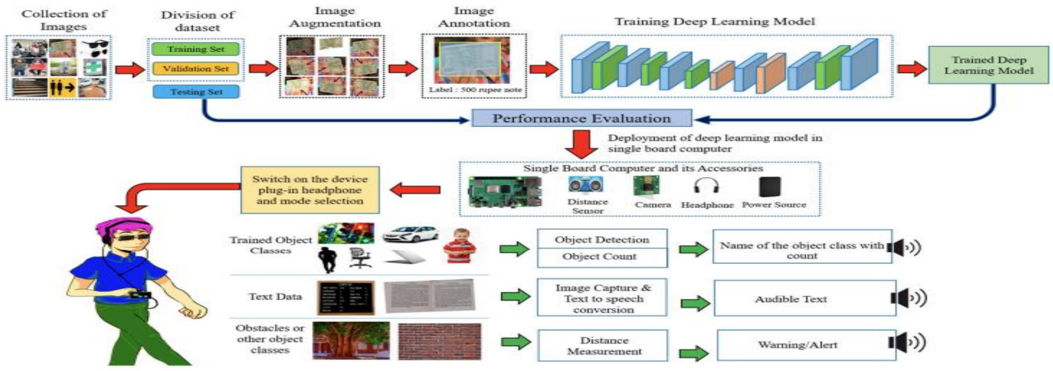


Fig 8.2: Block Diagram for proposed methodology.

Result and Analysis:

- A custom test set of 650 images per class was used, augmented 10× for robust validation.
- A live video stream was tested for real-time performance.
- Object detection and recognition accuracies were recorded at 95.19% and 99.69% respectively.
- The system demonstrated reliable performance across indoor and outdoor environments.

Table 2. Performance analysis of proposed model on most relevant objects.

Objects	Total Testing Images	Correctly Detected	Detection Accuracy (%)	Correctly Recognized	Recognition Accuracy (%)
Person	150	148	98.67	148	100.00
Car	150	146	97.33	145	99.32
Bus	150	144	96.00	144	100.00
Truck	150	143	95.33	141	98.60
Chair	150	147	98.00	146	99.32
TV	150	140	93.33	140	100.00
Bottle	150	148	98.67	148	100.00
Dog	150	145	96.67	144	99.31
Fire hydrant	150	146	97.33	146	100.00
Stop Sign	150	149	99.33	147	98.66
Socket	150	143	95.33	143	100.00
Pothole	150	129	86.00	128	99.22
Pharmacy	150	141	94.00	139	98.58
Stairs	150	139	92.67	139	100.00
Washroom	150	145	96.67	145	100.00
Wrist Watch	150	140	93.33	139	99.29
Eye glasses	150	141	94.00	141	100.00
Cylinder	150	131	87.33	131	100.00
10 ₹ Note	150	141	94.00	141	100.00
20 ₹ Note	150	148	98.67	148	100.00
50 ₹ Note	150	143	95.33	143	100.00
100 ₹ Note	150	140	93.33	140	100.00
200 ₹ Note	150	144	96.00	144	100.00
500 ₹ Note	150	140	93.33	140	100.00
2000 ₹ Note	150	149	99.33	149	100.00
Average			**95.19%**		**99.69%**

Table 8.3: Performance analysis of proposed model on objects.

Hardware Used:

- Training: Intel i9, NVIDIA Tesla K80 (12 GB VRAM)
- Deployment: 64-bit DSP board (Quad-core, 1.5 GHz, 4GB RAM), 8MP fixed focus camera.

Conclusion:

Advantages:

- Real-time object recognition and navigation support with high accuracy
- Audio-based guidance with intelligent time optimization
- Adaptable modes for indoor, outdoor, and text-reading situations

Disadvantages:

- Limitation to three object categories per frame in auditory feedback.
- Requires high initial training and annotation effort

Gap / Future Work:

- Expand the system to recognize more complex scenes
- Integrate face recognition and OCR for personalized assistance
- Minimize processing latency further with more lightweight models

Chapter 3

PROBLEM STATEMENT

Visually impaired individuals face serious challenges navigating indoor spaces independently. Common mobility aids like white canes or guide dogs have limitations, especially in unfamiliar, dynamic, or crowded environments. These challenges often result in accidents, restricted autonomy, and limited social engagement. Additionally, visually impaired users find it difficult to recognize people around them, leading to reduced confidence in social settings.

This project addresses these real-world issues by developing an **Augmented Reality (AR) based Indoor Navigation System** combined with **Object Detection** and **Facial Recognition**. The system provides voice-guided navigation, warns users about obstacles, and identifies nearby known individuals. This solution significantly enhances safety, independence, and social interaction, making it a powerful tool for fostering inclusion and empowerment.

OBJECTIVES:

- **To provide safe indoor navigation through real-time voice guidance:** The system uses AR and computer vision to map the surroundings and create a virtual path. It guides users with continuous voice instructions and alerts them of any obstacles in their path, ensuring safety during indoor movement.
- **To enable identification of known individuals using facial recognition:** The system detects faces in real time and informs users when familiar people are nearby, promoting confident and natural social interaction.
- **To store and manage unknown face data for future recognition:** When the system detects unfamiliar faces, it saves their data for future reference, helping users build familiarity and improving long-term interaction.

Chapter 4

WORK TO BE DONE

- **Indoor Navigation with Immersal SDK**
  The app will integrate the Immersal SDK to enable AR-based indoor navigation. Mapped locations will be uploaded to the Immersal Cloud to generate Map IDs. These maps will guide users through virtual arrows overlaid on the camera using React Native, with navigation paths defined by NavMesh or preset waypoints.
- **Voice Guidance Using TTS**
  Real-time navigation instructions will be delivered using react-native-tts. As users move, the app will announce directions like “Turn right” or “Walk forward 10 meters,” ensuring hands-free, audio-based guidance for visually impaired users.
- **Object Detection**
  The app will detect obstacles using models like YOLOv5 or MobileNet, running via TensorFlow Lite. Live camera input will identify objects (e.g., chairs, walls), and users will be alerted through voice feedback to avoid collisions.
- **Face Recognition**
  The system will recognize known individuals using FaceNet or ML Kit, and announce their identity and distance. If the face is unknown, the app can prompt the user to save it for future recognition using SQLite or Firebase.
- **Haptic Feedback (Optional)**
  For noisy environments, vibration patterns using react-native-haptic-feedback will alert users—single buzz for left, double for right, and long buzz for obstacles.

Chapter 5

CONCLUSION

This project presents a smart and inclusive solution for assisting visually impaired individuals in navigating indoor environments safely and independently. By integrating technologies such as Augmented Reality through the Immersal SDK, real-time object detection using YOLOv5, and facial recognition via FaceNet, the system enhances spatial awareness and social interaction for users. Developed as a mobile application using React Native, the solution ensures accessibility, portability, and cross-platform compatibility.

The use of real-time voice guidance through text-to-speech and optional haptic feedback ensures that users receive clear, timely instructions without relying on visual elements. Obstacle alerts, face identification, and the ability to store unknown individuals for future recognition further add to the system's practicality and adaptability in daily use.

Overall, the project combines computer vision, artificial intelligence, and mobile development to address real-world challenges faced by the visually impaired. It promotes independence, safety, and social inclusion, aligning with the goal of building assistive technologies that make environments more accessible. The modular design also allows for future enhancements such as emergency alerts, voice-command navigation, or expanded indoor mapping. This system thus represents a meaningful step toward creating smarter, human-centered indoor navigation solutions.

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