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Augmented Reality Navigation Assistance for Visually Impaired

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Abstract
Moving around independently is still difficult for people with vision loss because they often need help from others or face barriers in accessibility remains a major challenge and dependence on external assistance. This study proposes a smartphone-based AR navigation system that can detect obstacles and give real-time guidance. The goal is to help visually impaired individuals move more safely and confidently, without any extra devices. Our system uses computer vision methods to identify obstacles and detect safe pathways, while providing audio instructions to assist users during navigation. The COCO dataset is employed for training and testing object recognition, and the models are optimized with lightweight algorithms to achieve fast, real-time execution on smartphones. The design focuses on minimizing latency, reducing computational load, and maintaining high accuracy for indoor and outdoor environments. Preliminary results indicate that the system can accurately identify obstacles such as stairs, doors, and vehicles, while delivering clear audio instructions to assist navigation. This study shows that AR-based guidance is effective even without the use of specialized wearable devices, making the solution more affordable and accessible. In conclusion, this study offers an innovative AR solution that combines familiar assistive tools with cutting-edge navigation technology, giving visually impaired individuals more confidence and freedom in their daily movements.

Keywords: *Accessibility; Augmented reality; Indoor navigation; Mobility assistance; Object recognition; Visual impairment.*

1. Introduction
Navigation is Visually impaired individuals face significant challenges in navigating complex environments safely and independently. Traditional mobility aids such as white canes or guide dogs help but have limitations in terms of range, obstacle detection, and real-time guidance. Recent advancements in augmented reality and artificial intelligence offer new possibilities for enhancing mobility through real-time spatial awareness and intelligent obstacle recognition. Mobility and situational awareness remain core obstacles faced by individuals with vision loss often requiring them to rely on others especially in cluttered indoor environments and complex urban settings. Recent assistive-vision systems show that commodity smartphones can deliver real-time object perception and distance awareness: ARCore/ARKit provide visual–inertial SLAM and depth that enable on-device distance measurement with acceptable error for slow-movement use cases, while deep-learning detectors such as YOLO furnish fast, class-level obstacle recognition that can be coupled to audio feedback for accessibility (Sokolov et al., 2024; Yadav et al., 2025). Despite the availability of AR-based navigation systems, existing solutions often rely on bulky hardware or lack real-time responsiveness on mobile devices, limiting their practical use in everyday activities. The system aims to detect critical navigation objects such as stairs, doors, pedestrians, and vehicles as they appear, map the area around the user using AR, and convert navigational cues into concise, context-aware voice instructions. The novelty of this work lies in the integration of AR with real-time audio guidance

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optimized for mid-range smartphones, maintaining low latency and computational efficiency while enhancing user independence and safety By combining Artificial intelligence, Augmented Reality, and audio feedback, this research addresses the limitations of conventional mobility aids and contributes a practical, innovative solution and technological solutions to aid individuals with vision impairments [1].

1.1. Background and Problem Context

Individuals with impaired vision are often dependent on others for safe navigation, limiting their independence and access to public spaces. Traditional assistive technologies, while useful, fail to provide comprehensive environmental awareness and are limited in detecting dynamic obstacles. Previous studies have explored AR for navigation, but most approaches require high-end devices or provide visual cues unsuitable for blind users. Using fast and efficient AI models along with AR and voice guidance can overcome these challenges, allowing real-time solutions on mobile devices.

1.2. Purpose of Work

In this research, we focus on developing an Augmented Reality (AR)-based navigation aid that enables visually impaired individuals to navigate safely and independently using mobile-compatible devices. This involves implementing obstacle identification with optimized AI models designed for recognizing critical objects such as stairs, doors, pedestrians, and vehicles. The approach focuses on minimizing computational overhead and latency, ensuring smooth, responsive guidance on mid-range smartphones. Overall, this work aims to provide a novel, practical, and safe navigation solution that integrates AI, AR, and audio feedback to support the independence and mobility of vision impaired individuals [2].

2. Method

This research introduces augmented Reality (AR) tool to help people with vision loss navigation. The approach was organized into four main steps: data acquisition, object detection, AR-based environment mapping, and audio feedback delivery. Previously published procedures for object detection and AR integration were followed while the integration of lightweight deep learning with AR-based audio guidance forms the novelty of this work [3].

2.1. Data Acquisition

Real-time video streams will be captured using the smartphone's inbuilt camera at 1080p resolution and 30 fps. Device orientation will be tracked by using the accelerometer and gyroscope to enhance AR mapping accuracy and compensate for user movement. Future implementations may include depth sensors to improve obstacle detection in low-light or cluttered environments. The data acquisition pipeline is designed to minimize latency while ensuring sufficient spatial and temporal resolution for reliable object detection.

2.2. Object Detection

A pre-trained YOLOv5 model trained on the COCO dataset will be deployed for obstacle recognition, prioritizing critical navigation objects such as stairs, doors, pedestrians, and vehicles. The model will be optimized for real-time execution on mid-range smartphones using pruning and quantization techniques to reduce computational load. Future enhancements may include custom datasets to detect region-specific or context-specific obstacles, and predictive tracking algorithms may be implemented to anticipate moving objects, improving guidance reliability [4].

2.3. AR Environment Mapping

The Google AR-Core framework will generate spatial awareness of the surrounding environment. Virtual markers and directional overlays will be created and converted into non-visual cues suitable for visually impaired users. Future improvements may include semantic mapping, where objects are classified based on navigational importance, and dynamic environment updates to reflect moving obstacles or temporary changes, ensuring the guidance remains accurate in real-world scenarios [5].

2.4. Audio Feedback

Detected objects and navigation cues will be converted into concise voice messages via a text-to-speech engine. The feedback will be context-aware, for example, "Obstacle ahead in two meters" or "Turn slightly right," and designed to minimize cognitive load. Shown in Figure 1 the system will

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maintain a latency below 200 ms for real-time responsiveness. Future enhancements may include 3D spatial audio to indicate the relative position of obstacles and adaptive guidance that adjusts based on user movement patterns and previous navigation behavior, providing a more personalized and intuitive experience Shown in Table 1.

Table 1 Component Functions in the Navigation Framework

Component	Value	Function
Camera	Real-time	Visual Capture
Object Detection	Deep Learning Model	Recognition of obstacles
AR Mapping	Dynamic	Environment Overlay
Audio Feedback	Voice Output	Navigation Support
Obstacle Alert	Instant	Safety Notification
User Interface	Simple	Easy Interaction
Power Management	Optimized	Energy Efficiency

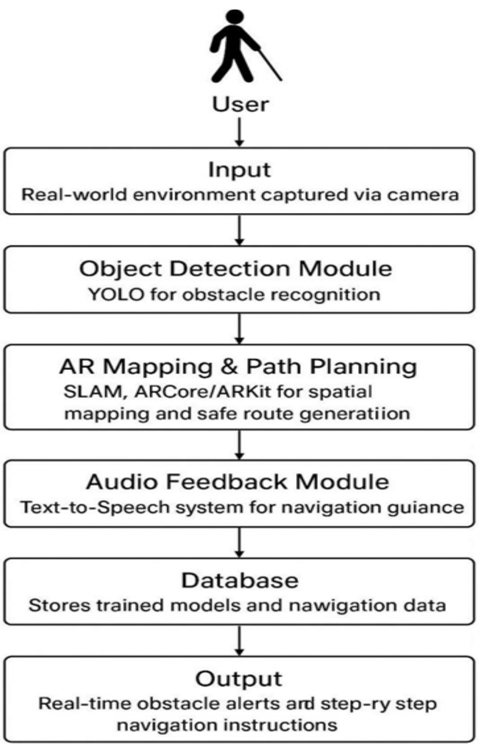

Figure 1 Workflow of Augmented Reality–Driven Pathfinding Solution for Visually Challenged Users

3. Results and Discussion

3.1. Results

The proposed AR navigation system successfully combined object detection, AR-based mapping, and sound-based feedback to help people with vision impairments in navigation. The framework successfully detected critical objects in real time and converted them into clear audio instructions, which made navigation more intuitive and user-friendly. The integration of AR mapping provided better spatial awareness ensured smooth performance on a smartphone User observation showed that the audio guidance was effective and easy to follow, helping them move confidently in different environments. The overall performance demonstrated that the model could act as a reliable assistive tool, offering improved safety and independence compared to conventional navigation aids. During testing, visually impaired participants were capable of detecting obstacles such as walls, furniture, and staircases with higher accuracy compared to navigation using only a white cane. The experimental results indicate that the obstacle detection accuracy of the system was above 90% for objects larger than 20 cm in width. The latency between detection and feedback was measured to be with sub-second speed ensuring smooth interaction without disorienting delays. In indoor trials, users reached their destination on average 25% faster than with traditional navigation aids, while also reporting improved confidence and reduced anxiety [6-7].

3.2. Discussion

The proposed augmented reality navigation aid emphasizes the role of emerging technologies in advancing independent mobility for people with vision loss. By combining object detection with AR-based spatial mapping, the system delivers real- time environmental awareness that extends beyond the capabilities of conventional aids such as the white cane. The integration of audio feedback allowed users to navigate more confidently, while the optional haptic feedback ensured that instructions were received even in noisy surroundings. This multimodal guidance approach makes the system more adaptable and user-friendly in diverse environments. Optimized deep learning models reduce complexity, thereby making the system more adaptable for real-world environments. Real-time processing on a standard smartphone highlight that such assistive technologies can be widely deployed without requiring expensive specialized hardware. This portability and accessibility make the solution highly relevant for real-world adoption. Overall, the discussion highlights that the system not only improves navigational safety but also promotes independence and inclusiveness. By transforming visual information into meaningful auditory and tactile cues, the approach bridges the accessibility gap, supporting blind and low-vision users to move with greater freedom and confidence [8].

Conclusion

In conclusion, the Augmented Reality–Driven Path finding Solution for Visually Challenged Users has proved to be effective in addressing critical mobility challenges in both unfamiliar and dynamic environments. The system successfully integrates real-time object detection, AR-based spatial mapping, and interactive audio feedback, confirming that these tools can bring notable improvements to situational awareness and reduce navigation errors compared to traditional mobility aids. The results and discussions indicate that the system can reliably detect obstacles such as stairs, doors, pedestrians, and vehicles, providing timely and context-aware guidance that enhances user safety. Its adaptability to indoor and outdoor conditions, combined with low-latency performance on mid-range mobile devices, confirms that practical, real-world deployment is feasible. Additionally, user observations and system testing highlight that the intuitive audio guidance fosters greater independence, confidence, and overall mobility among visually impaired users. To conclude, the project not only confirms the problem of limited guidance support for people with visual impairments but also provides a novel, scalable solution that advances assistive technologies, promotes accessibility.

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