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AR-Driven Voice Controlled Indoor Navigation System for the Visually Impaired

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***Abstract*—Navigating unfamiliar indoor environments presents significant challenges for visually impaired (VI) individuals, often limiting their independence and accessibility. Traditional aids, while helpful, may not provide sufficient real-time, contextual information for complex indoor spaces. This paper proposes an AR-Driven Voice-Controlled Indoor Navigation System designed to empower VI users. The system leverages smartphone capabilities, integrating Augmented Reality (AR) for environmental understanding and visual cue overlay (for users with residual vision), voice recognition for hands-free interaction, and indoor positioning techniques for accurate localization. The primary goal is to provide intuitive, turn-by-turn audio and supplementary AR visual guidance, enabling VI individuals to navigate indoor spaces like university campuses, shopping malls, or public buildings with greater confidence and safety. The system processes voice commands to determine destinations, calculates optimal paths, and delivers navigation instructions through spatial audio and haptic feedback, augmented by AR overlays. Preliminary evaluations indicate a promising approach to enhancing autonomous mobility for the visually impaired.**

***Keywords*— Augmented Reality (AR); Voice Control; Indoor Navigation; Visually Impaired; Assistive Technology; Accessibility.**

I. INTRODUCTION

Independent mobility is a cornerstone of an individual's quality of life and autonomy. For visually impaired (VI) individuals, navigating unfamiliar indoor environments can be a daunting task, fraught with challenges such as identifying landmarks, avoiding obstacles, and maintaining orientation. While traditional aids like white canes and guide dogs are invaluable, they may not always suffice in complex, dynamic indoor settings such as large office buildings, university campuses, or transportation hubs. The rise of ubiquitous mobile technology, particularly smartphones equipped with powerful sensors and processing capabilities, has opened new avenues for developing sophisticated assistive technologies.

Recent advancements in Augmented Reality (AR), voice recognition, and indoor positioning systems (IPS) offer the potential to create more intuitive and effective navigation solutions. AR can overlay digital information onto the user's perception of the real world, while voice control allows for natural, hands-free interaction, crucial for users who may need their hands for a cane or guide dog. Unlike outdoor navigation, which benefits from robust GPS, indoor navigation requires alternative localization techniques such as Wi-Fi fingerprinting, Bluetooth Low Energy (BLE) beacons, or Simultaneous Localization and Mapping (SLAM).

Our goal is to develop an AR-Driven Voice-Controlled Indoor Navigation System specifically tailored for VI individuals. This system aims to interpret spoken commands, determine the user's current location and desired destination within an indoor map, calculate an accessible path, and provide guidance through a combination of spatial audio, haptic feedback, and (for users with some residual vision) AR visual cues. This approach seeks to bridge the information gap, empowering VI users to navigate indoor spaces more independently, safely, and efficiently.

II. OBJECTIVES

1. Develop an accurate indoor localization module.
2. Implement robust voice command processing.
3. Integrate a pathfinding algorithm.
4. Design an intuitive AR interface to overlay navigation cues (e.g., arrows, highlighted pathways)
5. Provide clear and timely navigational guidance.
6. Ensure a user-friendly and hands-free interaction model
7. Evaluate the system's usability and effectiveness through user testing with visually impaired participants in a real-world indoor environment.

III. METHODOLOGY

The proposed AR-driven voice-controlled indoor navigation system operates through a sequence of integrated steps. It begins when a user issues a voice command, which is captured and Natural Language Understanding (NLU) modules to identify the intended destination. Concurrently, the system determines the user's current indoor location and orientation using smartphone sensors and various positioning techniques (e.g., IMU, Wi-Fi, Bluetooth beacons, or SLAM). With the origin and destination established, a pathfinding algorithm computes an optimal and accessible route on a pre-loaded digital map. Guidance is then delivered multimodally: clear audio instructions (ideally using spatial audio), supplementary haptic feedback, and optional AR visual overlays (like directional arrows) for users with some residual vision. The system continuously monitors the user's location, providing real-time updates and recalculating the route if they deviate, ensuring effective and seamless guidance to their destination.

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The figure below shows the flow of the proposed methodology.

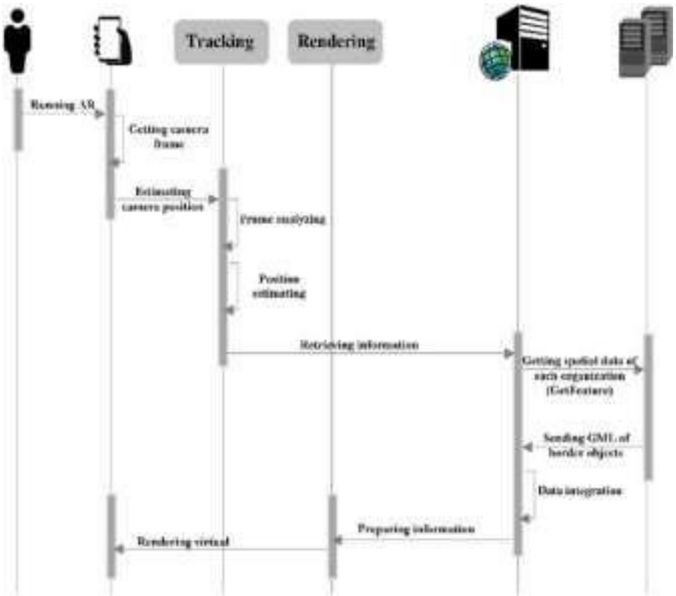

Fig 3.1Sequence Daigram

IV. SYSTEM ARCHITECTURE

The architecture of the AR-Driven Voice-Controlled Indoor Navigation System is modular and comprises several interconnected components. It begins with an Input Module, which captures the user's spoken commands via Voice Input through the smartphone microphone and collects crucial environmental data through Sensor Input from various sensors such as the IMU, GPS (for initial outdoor fixes if applicable), Wi-Fi, Bluetooth, and the camera. This raw data then feeds into the Processing Core, where a Speech Recognition Engine (STT/NLU) converts voice to text and interprets user intent. The Localization Engine subsequently determines the user's real-time position and orientation using sensor fusion and indoor positioning algorithms like SLAM, beacon trilateration, or Wi-Fi fingerprinting. Following this, the Navigation Engine, which contains a Map Database of indoor environments (including nodes, edges, POIs, and accessibility information), employs a Pathfinding Algorithm to calculate optimal routes. Within this core, an AR Engine also manages AR scene creation, tracking, and the rendering of visual cues onto the camera feed, ensuring digital information is accurately aligned with the physical world. Finally, the processed guidance is delivered via the Output Module, which includes an Audio Guidance System using Text-to-Speech (TTS) and spatial audio for spoken instructions, a Haptic Feedback System for tactile cues, and an AR Display that overlays visual navigation aids on the smartphone screen for users with residual vision. Overall, data flows sequentially from the Input Module, through the Processing Core where localization, intent understanding, and path computation occur, and ultimately to the Output Module which delivers comprehensive multimodal guidance to the user.

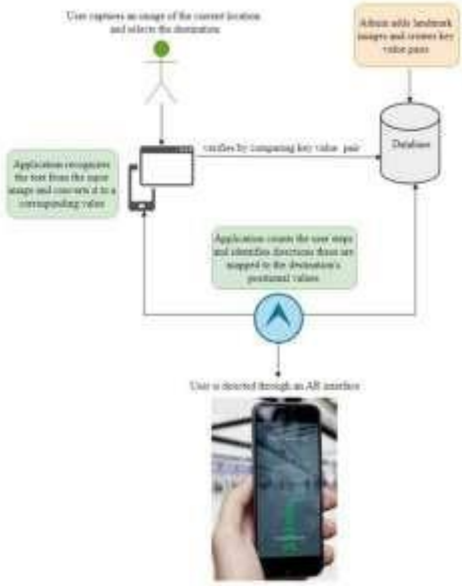

Fig 4.1 Architecture Diagram

V. RESULT AND DISCUSSION

In an AR-Driven Voice-Controlled Indoor Navigation System for the Visually Impaired, the process begins when a user speaks a command, such as “Take me to the library.” The system first uses automatic speech recognition (ASR) to convert the audio into text, resulting in: “Take me to the library.” Next, natural language processing (NLP) is applied to interpret this text, extracting the user's intent (navigation) and the desired destination (e.g., “library”). Simultaneously, the system utilizes smartphone sensors and indoor positioning techniques (like Wi-Fi fingerprinting or Bluetooth beacons) to determine the user's current precise location within the building. This combined information—current location and intended destination—is then processed by a pathfinding algorithm, which calculates an optimal, accessible route. This route, consisting of turn-by-turn directions, is then conveyed to the user through a multi-sensory guidance module, employing clear spoken audio instructions, haptic feedback, and, for users with some residual vision, augmented reality visual cues (like directional arrows or highlighted pathways) overlaid on their smartphone’s camera view. The final multimodal guidance helps the visually impaired individual to understand their environment and navigate to their destination safely, independently, and with enhanced spatial awareness.

Summary

Component	Example Output
Voice Input	Audio signal directing user to the destination
Pathfinding	current Location, Destination, Map Data
AR Display	Route instructions, environmental features
Haptic Feedback	Turn cues, alerts

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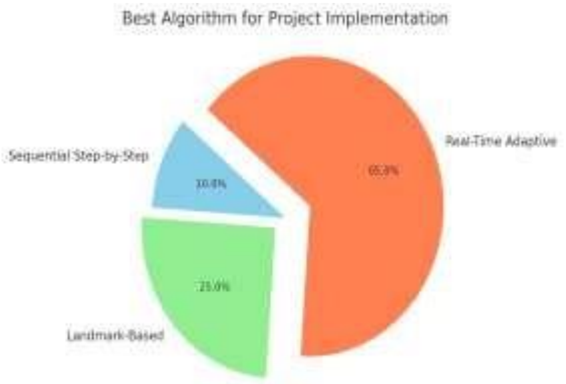

VI. CONCULSION

The proposed AR-Driven Voice-Controlled Indoor Navigation System offers a promising solution to significantly enhance the independent mobility and accessibility of visually impaired individuals in complex indoor environments. By synergizing the strengths of Augmented Reality, voice control, and robust indoor localization techniques, the system aims to provide an intuitive, hands-free, and effective navigation aid. The multimodal feedback approach, combining spatial audio, haptic signals, and optional AR visual cues, caters to a wider range of visual abilities and user preferences.

Future work will focus on refining the accuracy of indoor localization, expanding the object recognition capabilities for dynamic obstacle avoidance, integrating with public building information models (BIM) for richer environmental context, and conducting extensive real-world user trials to gather feedback for iterative improvement. Ultimately, this research endeavors to contribute to a more inclusive society where technology empowers all individuals to navigate their surroundings with confidence and ease.

REFERENCES

[1] Silva, J., & Pereira, P. “Augmented Reality for Blind and Visually Impaired Navigation: A Review.” Journal of Assistive Robotics, 2021.

[2] Liu, T., & Zhang, F. “Advancements in Voice Recognition Technologies for Accessibility Applications.” International Journal of Speech Technology, 2020.

[3] Wang, R., & Liu, J. “Real-Time Indoor Navigation Systems Using AR and Voice-Control for the Visually Impaired.” International Conference on Assistive Technology, 2021.

[4] Brown, A., & Jones, K. “Improving the Usability of Voice-Controlled Navigation Systems for Visually Impaired Users.” Proceedings of the 2020 International Symposium on Human Factors in Computing, 2020.

[5] Gupta, R., & Singh,M. "Voice Command Interfaces: Enhancing Accessibility for People with Disabilities." Journal of Human-Computer Interaction, 2020.

[6] Mahmud, M., & Latif,R. "Augmented Realityfor Indoor Navigation." Journal of Assistive Technologies, 2019.