A Review of AI-Powered Tools to Help People With Visual Impairments

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***Abstract*—In this paper, we introduce ECHOEYES - a computer vision- based assistive device for the blind. The system fuses computer vision for object and scene recognition, Optical Character Recognition for text identification and presents real-time, context aware auditory feedback using Natural Language Processing. Although several tools such as Envision AI, Google Lookout, and Microsoft Seeing AI exist, they typically focus on limited capabilities such as text reading or object detection. ECHOEYES addresses this gap by offering a low-cost, multi-capability platform that combines navigation assistance, text reading, currency identification, familiar-face recognition, and emergency communication in one system. The device is lightweight, low-power, and cost-effective, making it accessible to a wider population. This paper outlines the system architecture, highlights research gaps in existing tools, and discusses how ECHOEYES can evolve into a comprehensive assistive technology for visually impaired individuals.**

Keywords—AI, Device, Visually impaired, Assistive technology, Computer vision, NLP

I. INTRODUCTION

Visually impaired individuals face persistent obstacles in performing routine activities, such as navigating unfamiliar spaces, identifying objects, reading printed text, or recognizing people. Traditional tools, such as canes and guide dogs help with basic obstacle detection but cannot provide deeper contextual information. Existing AI-based apps such as Envision AI, Google Lookout, and Microsoft Seeing AI offer valuable features but often suffer from limitations such as a focus on single capabilities, lack of emergency support, or dependence on internet connectivity.

To bridge these gaps, ECHOEYES leverages artificial intelligence and mobile technology to provide an integrated, hands-free cognitive assistant. The system converts visual information into meaningful audio explanations and offers multiple assistive functions traditionally spread across different applications. This integration directly addresses research gaps such as lack of multi-feature platforms, limited real-time emergency assistance, and lack of affordable and offline-capable solutions.

II. LITERATURE REVIEW

A. Research Papers

The study introduces **ARIANNA**, a hybrid navigation system designed to improve mobility for visually impaired people in both indoor and outdoor environment. The system presents an advanced alternative to traditional mobility aids by leveraging the widespread accessibility of smartphones. It uses the phone camera and a combination of advanced computer vision and sensor fusion techniques to detect specially marked paths on the ground. The core functionality of the system relies on two primary computer vision methods: **geometry-based path detection** [1] using the Canny edge and Hough transform algorithms to pinpoint the location of the paths, and **color-based filtering** with the HSV model to focus on the distinct color of the markers. To ensure high accuracy, data from inertial sensors, such as accelerometers and gyroscopes is fused with the visual information using an **Extended Kalman Filter**, which intelligently combines the two data streams to reduce estimation errors. The final output is delivered to the user in real time through clear and intuitive vibration cues, providing a hands-free, self-contained, and effective guidance system for the visually impaired.

Another proposed system provides an assistive solution to help visually impaired individuals navigate challenging and dynamic outdoor environments. It leverages the ubiquity and affordability of smartphones and uses the built-in camera to perform real-time object detection. At its core, the YOLOv3 algorithm [2] is employed for its balance of speed and accuracy. The system processes a continuous stream of video captured by the camera, analyzing each frame to identify objects from the vast COCO dataset. Once an object is detected, a bounding box is drawn around it, and Non-Maximum Suppression is applied to retain only the most confident and accurate detections. The identified object labels are then converted into spoken words using a Text-to-Speech (TTS) module, which delivers audio feedback to the user through headphones or speakers. This real-time feedback enhances mobility, making daily navigation safer and more

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easier.The OpenCV library was used for image preprocessing and handling.

An AI-driven assistive system is presented that goes beyond basic obstacle detection to provide a more comprehensive understanding of the user's surroundings. The design is built around a Raspberry Pi and integrates a camera and sensors to enable real-time object detection, facial recognition, and color identification. Unlike many modern solutions, the device is capable of operating offline, ensuring functionality without reliance on an internet connection or external servers. The core technologies include the Haar Cascade algorithm for object and face detection, and the LBPH (Local Binary Patterns Histogram) algorithm for face recognition, which analyzes local texture patterns to identify known individuals. Implementation is carried out using Python in combination with the OpenCV library [3] for image processing. For user feedback, the system delivers alerts through sound or vibration. A notable feature is the integration of a SIM card and GPS module, enabling the user's location to be shared with family members in emergencies, thereby adding an essential safety layer. Overall, the approach offers a smart, interactive, and self-contained device that provides blind users with a richer and safer understanding of their environment.

Visually impaired individuals face significant challenges in achieving independent mobility due to inaccessible infrastructure, the absence of real-time transit information, and limited awareness of obstacles in their surroundings. While traditional tools such as white canes or guide dogs offer basic support, they lack the capability to provide intelligent guidance. To overcome these limitations, a mobile application powered by Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) has been developed to make mobility safer, smarter, and more accessible. The system is designed to determine the user's location, guide them with voice commands, detect obstacles, and provide access to emergency support when required. Developed for Android devices, the application uses voice-based interaction to eliminate the need for screen navigation, incorporating the Google Speech API for speech recognition and Text-to-Speech (TTS) [4] for delivering responses. A smart stick equipped with ultrasonic and infrared (IR) sensors, along with vibration motors, connects to the app via IoT modules such as NodeMCU, transmitting real-time sensor data through Firebase. GPS integration enhances navigation by providing voice-guided directions, while an emergency calling feature ensures that family members can be contacted instantly if the user feels unsafe. By combining multiple technologies into a unified system, the solution delivers continuous support from the environment, the device, and the user's trusted network, ultimately enhancing independence, safety, and quality of life for visually impaired individuals.

An AI-based mobile assistant has been developed to enhance the independence and quality of life for visually impaired individuals by supporting daily activities through a smartphone application that integrates artificial intelligence, voice commands, text recognition, and chatbot interaction. Unlike traditional assistive devices, the system provides an interactive platform that enables users to make phone or video calls, send messages, recognize text in documents, and identify nearby objects through voice guidance. Designed as an Android application, the solution is built around user-centered design principles and employs Natural Language Processing (NLP) [5] to understand and respond to voice commands, implemented with libraries such as NLTK, SpaCy, and Hugging Face Transformers. Speech recognition is achieved using algorithms like Hidden Markov Models (HMM) and Convolutional Neural Networks (CNN), while Text-to-Speech (TTS) and Speech-to-Text (STT) modules convert between spoken and written language through neural network models. Dialog management is handled using rule-based systems or reinforcement learning to provide contextually appropriate responses, with a knowledge graph incorporated to store and relate information for personalized support. The application is capable of reading printed text, detecting objects, and executing commands such as making calls, sending texts, or interacting via chatbot, thereby ensuring a real-time, voice-driven, hands-free experience. Overall, the system offers a smart, interactive, and accessible tool that empowers visually impaired users to navigate their environment more confidently and independently.

RESEARCH PAPER	SHORT EXPLANATION	ADVANTAGES	DISADVANTAGES
An Indoor and Outdoor Navigation System for Visually Impaired People	Proposes a smartphone-based navigation system using computer vision and inertial sensors to guide users along predefined paths in both indoor and outdoor environments.	1. Enables both indoor and outdoor navigation using one device. 2. Operates in real-time with no need for external servers or GPS.	1. Needs pre-installed visual guides (colored tapes or markers). 2. Performance can drop in poor lighting or visually cluttered environments.
Object Detection System for Visually Impaired Persons Using Smartphone	Develops a real-time YOLOv3-based object detection app that identifies objects through a smartphone camera and provides instant audio feedback.	1. Uses existing smartphone features — no extra hardware needed. 2. Faster object detection with YOLOv3 compared to other models.	1. May struggle with low-light conditions or occluded objects. 2. Dependent on pre-trained dataset (limited object categories).
Empowering the Blind: AI-Assisted Solutions	Reviews AI-based technologies like OCR, object detection, and wearable devices designed to assist blind individuals in reading, navigation, and environmental awareness.	1. Face and object recognition improves situational awareness. 2. Color detection helps understand surroundings (e.g., road vs. non-road).	1. Performance may drop in low-light or complex visual environments. 2. Requires initial training (face/object datasets).
Enhancing Mobility for the Visually Impaired with AI and IoT-Enabled Mobile Applications	Suggests an AI and IoT-integrated mobile platform for providing real-time navigation, transit updates, and safety features to visually impaired commuters.	1. Hands-free voice interaction for ease of use. 2. Obstacle detection using ultrasonic and IR sensors.	1. Requires internet for real-time location and Firebase data sync. 2.May struggle in noisy environments for speech recognition.
AI Assistant for Visually Impaired People	Introduces a mobile AI assistant with speech recognition, object detection, and text reading features to improve accessibility and independence for visually impaired users.	1. Combines multiple assistive features like object recognition, text reading, and voice commands in a single application. 2. Incorporates a voice-driven interface for ease of use by visually impaired users.	1. Requires a smartphone with a good-quality camera and microphone for optimal performance. 2. Some features may need a stable internet connection, limiting use in offline scenarios.

Table 1. Significant Insights From The Literature

III. PROPOSED SYSTEM

The proposed system, ECHOEYES, is designed as a comprehensive mobile-based assistive platform that integrates multiple AI-powered features often found separately in existing tools. Unlike other applications that specialize in single functions, ECHOEYES combines YOLO-based object detection, Dlib-based familiar face identification, CNN-based currency recognition, and OCR-based text-to-speech conversion.

The selected models (YOLO, CNN, Dlib, Tesseract OCR) are widely used, robust, and suitable for on-device or hybrid processing. While real-time performance cannot be fully evaluated until implementation, these models are appropriate choices for building a reliable assistive platform.

Additionally, the system addresses research gaps by introducing an instant emergency support module, enabling audio/video calls with trusted companions and real-time location sharing—features missing in Envision AI, Lookout, and Seeing AI.

The architecture includes three roles: blind user, companion, and administrator, allowing user assistance, safety monitoring, and system management. Voice-driven interaction ensures accessibility without reliance on visual controls. By unifying essential assistive features into a single low-cost mobile application, ECHOEYES enhances independence and addresses shortcomings found in existing solutions.

A. System Architecture

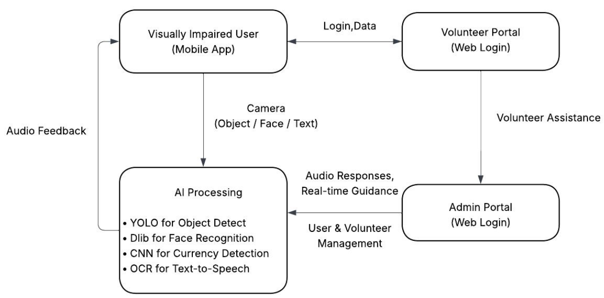

Fig. 1. Architecture Diagram

B. Flow Chart

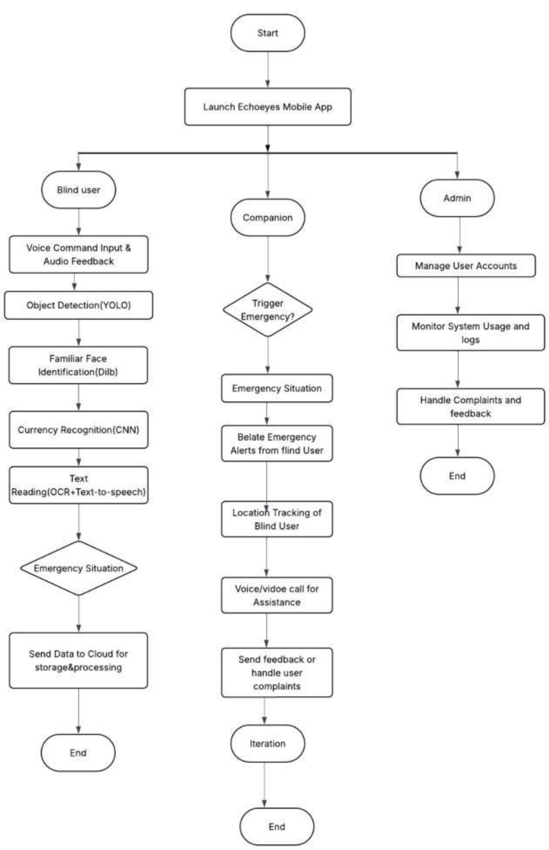

Fig. 2. Flowchart Diagram

IV. COMPARISON WITH EXISTING AI TOOLS

Feature	EchoEyes	Envision AL	Seeing AI	Lookout
Object Detection	Yes	Yes	Yes	Yes
Face recognition	Yes	No	Yes	No
Currency Detection	Yes	Yes	No	Yes
Emergency Module	Yes	No	No	No
All-In-One Integration	Yes	No	No	No
Uses Only Smartphone	Yes	Yes	Yes	Yes

V. CONCLUSION

The development of **EchoEyes**, an AI-powered assistive system for visually impaired individuals, demonstrates how artificial intelligence, computer vision, and cloud-enabled services can be combined to create an inclusive solution that enhances independence and safety. Unlike traditional assistive tools that are limited to navigation or text reading, EchoEyes integrates multiple features such as **object detection, face recognition, currency identification, and text-to-speech OCR**, while also providing **real-time volunteer assistance** and **administrative support** through dedicated web portals.

The system's architecture, which combines on-device processing for speed with cloud-based AI for scalability, ensures that users can receive reliable and context-aware feedback in real time. Additionally, the inclusion of a volunteer portal bridges the gap between AI-driven support and human empathy, offering users an added layer of security during emergencies or complex scenarios. The admin portal further strengthens the ecosystem by managing users, volunteers, and overall system performance, ensuring long-term sustainability and trust.

Through this project, we demonstrate that affordable and user-friendly AI systems can be designed to meet real-world accessibility challenges. This positions the system as a scalable, adaptable, and socially impactful innovation that contributes meaningfully to the field of assistive technology.

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