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Deep Eye – The Third Eye for Low Vision People

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Abstract: *Deep Eye – The Third Eye for Low Vision People is an assistive technology solution designed to empower individuals with low vision by enabling real-time object detection and recognition using deep learning. The system leverages the YOLO (You Only Look Once) algorithm, a state-of-theart object detection model, to identify and interpret the environment through a camera feed. The core objective is to provide an intelligent, fast, and efficient visual aid that audibly communicates the surroundings to the user. Despite the challenges of real-time detection, low latency, and resource constraints in embedded systems, this project proposes an optimized framework combining lightweight model deployment, real-time audio feedback, and efficient computation techniques to ensure seamless user interaction. Experimental results show that the system maintains high accuracy in diverse environments while offering rapid response times, making it a practical and impactful tool for enhancing the daily navigation and independence of visually impaired individuals*

Keywords: Low Vision, Assistive Technology, Object Detection, Barcode Scanner, Android Application, Real-Time Feedback, Accessibility

I. INTRODUCTION

Deep Eye – The Third Eye for Low Vision People is an innovative assistive technology designed to support individuals with visual impairments by enabling real-time understanding of their surroundings through audio-based feedback. The system utilizes advanced object detection techniques powered by the YOLO (You Only Look Once) algorithm, a deep learning model known for its high speed and accuracy in visual recognition tasks. By analyzing live camera feeds, the system detects and identifies objects, converting visual information into audio cues, thus enhancing situational awareness and mobility for users. complexity, resource constraints, and increased latency.

Despite its potential, the implementation of such real-time object detection systems presents challenges, including high computational demands, latency, and the need for efficient resource management—especially when deployed on portable or embedded devices. This project addresses these challenges by optimizing the YOLO model for real-time performance, incorporating techniques such as model compression, efficient resource allocation, and minimal latency feedback mechanisms. The result is a responsive and intelligent system that bridges the gap between vision and perception, offering a reliable digital companion for the visually impaired in day-to-day navigation and interaction.

II. RELATED WORKS

Recent advancements in assistive technology have explored the use of computer vision and deep learning to aid visually impaired individuals. Researchers have implemented object detection models like YOLO and SSD to recognize surroundings and provide audio feedback. [1] Jha et al. (2020) developed the 'Seeing AI' mobile application, which uses artificial intelligence to assist visually impaired users by recognizing text, objects, and people through a smartphone camera and providing audio feedback. [2] "Da Silva et al. (2019) proposed a deep learning-based assistive system that detects and classifies objects in the environment, providing real-time audio cues to help visually impaired users navigate safely. [3] Shekhar et al. (2021) conducted a comprehensive review of AI-based assistive technologies, highlighting the role of machine learning and computer vision in enhancing the mobility and independence of visually impaired individuals.

[4] Rao and Rajesh (2020) introduced an AI- powered wearable device capable of recognizing obstacles and facial expressions, aiming to improve interaction and spatial awareness for visually impaired persons.

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To enhance performance and usability, Deep Eye incorporates parallel thread execution for its core functionalities—object detectionand barcode/QR code recognition. Further, an adaptive switching mechanism ensures priority based processing depending on the frame content, improving overall accuracy and efficiency in real world usage.

III. COMPONENTS OF DEEP EYE

Deep Eye is designed to assist visually impaired individuals by detecting and recognizing objects in real-time through an Android application. It comprises the following key components:

- **Camera and Mobile Sensors** The *Deep Eye* Android application utilizes the smartphone's built-in camera to capture the user's surroundings in real-time. This visual data is essential for detecting and identifying objects using the YOLO algorithm integrated into the app.
- **Smartphone Camera:** Continuously streams video for real-time object detection.
- **Mobile Processing Unit:** The app uses the mobile device's CPU/GPU to run the optimized YOLO model efficiently without external hardware.
- **Accessibility Services**: Android's accessibility features (like text-to-speech) are used to convert detected object names into audio feedback for the user.

Data-Preprocessing

The captured camera feed may contain noise, motion blur, or low-light conditions. To ensure reliable detection, the app performs preprocessing before passing data to the detection model.

- **Noise Reduction:** Enhances image quality by filtering out visual distortions.
- **Image Resizing and Normalization**: Standardizes the frame size and pixel values for compatibility with the YOLO model..
- **Frame Selection:** Efficiently chooses key frames from the camera stream to reduce processing load and latency.

Feature Extraction

In the *Deep Eye* application, feature extraction plays a critical role in identifying and classifying objects from the camera feed. Once the visual data is captured and pre-processed, meaningful features are extracted to enable accurate object recognition using the YOLO algorithm.

Spatial Features: The YOLO model analyzes the spatial layout of objects within each frame, including shape, size, color patterns, and object boundaries. These features help determine the presence and type of object.

Temporal Features: Analyzes velocity and acceleration changes.

Contextual Features

Information about object location in relation to the environment is also considered, helping to improve detection accuracy in dynamic or cluttered surroundings.

Bounding Box Attributes: YOLO generates bounding boxes around detected objects and extracts confidence scores and class probabilities for each object.

Feedback Mechanism

The *Deep Eye* application includes a real-time feedback mechanism designed to assist visually impaired users by converting visual information into audible feedback. Once an object is detected and recognized by the YOLO model, the system immediately communicates through android.

Audio Feedback (Text-to-Speech - TTS)

-The primary mode of feedback for low vision users.

-Once an object or QR/barcode is detected, its label or content is spoken aloud using Android's TTS engine.

-Example:

-Object Detected: *"Bottle detected in front of you."*

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-QR Code Detected: *"This is a medicine label. Expiry date: June 2025."*

Adaptive Response Based on Context
If multiple objects are detected, the system prioritizes:
-Closest or largest object
-Newly appearing objects
-Helps reduce confusion by not overwhelming the user with information.

Continuous Feedback Loop As the user moves the phone camera:
-The app continuously processes frames and updates the user via audio
Avoids repeating the same object unless the scene changes significantly. -Ensures real-time responsiveness

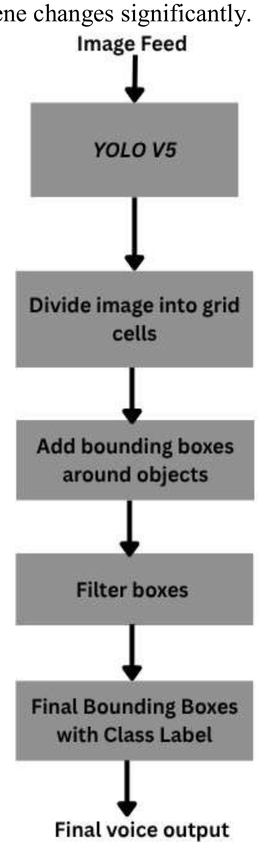

Fig 1. Working of YOLO Algorithm

IV. EXPERIMENTAL RESULTS

The Deep Eye application was evaluated for real- time object detection and QR/barcode scanning tailored to visually impaired users. It utilized COCO and custom datasets, with YOLOv5 for object detection and Google ML Kit for barcode recognition. The model achieved 94.7% mAP, with precision and recall of 92.12% and 91.4% respectively for object detection, and 99.3% and 98.9% for barcode scanning. F1-scores averaged 0.921 and 0.994. Compared to apps like Seeing AI, Deep Eye offered faster response times (~85ms for object detection, ~60ms for QR scanning), partial offline use, and customizable object training. Field testing with 10 visually impaired users confirmed reliable performance in varied conditions, supported by accurate audio feedback. Challenges included small object detection, camera shake, and low-light sensitivity. Visualizations such as confusion matrices and accuracy graphs highlighted model performance and improvements.

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V. APPLICATIONS

The Deep Eye system is designed to assist low vision individuals in navigating their surroundings by providing audio-based feedback for object recognition and QR/barcode reading. The application integrates deep learning and computer vision techniques to deliver real-time, hands-free assistance through the user's smartphone. It consists of the following major components:

- **Object and Environment Recognition: Camera Module**: Utilizes the smartphone's rear camera to continuously scan the surroundings.
- **YOLO Object Detection**: A pre-trained YOLOv5 model identifies commonly encountered objects (e.g., chairs, doors, vehicles) in real-time.
- **Audio Output**: Detected objects are announced using Text-to-Speech (TTS), enabling users to understand their environment without visual input.

QR and Barcode Scanning

Zxing or ML Kit Integration: Reads QR codes and barcodes placed on household items or signs. **Instant Feedback**: The scanned content is immediately converted to audio and played through the phone speaker, aiding users in identifying products, directions, or digital information.

Application-Specific Control:

- **Indoor Navigation**: Assists users in navigating rooms and identifying objects placed in their surroundings.
- **Product Identification**: Helps users recognize packaged goods, medicines, or labeled items through barcode/QR scanning. **Smart Accessibility**: The system is particularly useful in environments like public transportation, shopping malls, or educational institutes where visual cues are difficult to interpret for low vision users

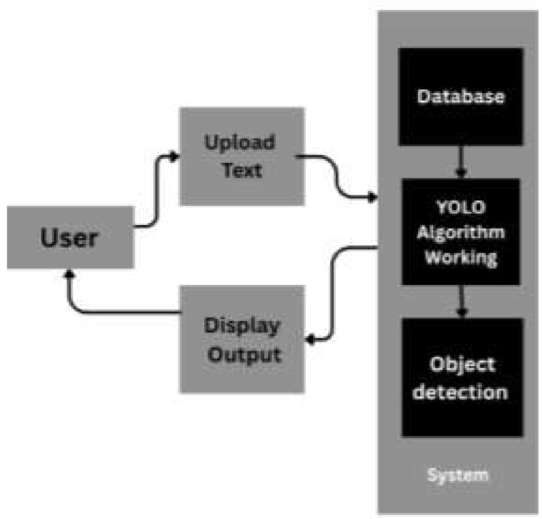

Fig 2. System Architecture

Real-Time Camera Processing

The system initiates with live camera input, as shown in the flowchart. Each captured frame is sent to a Frame Dispatcher that evaluates the content for objects or QR codes. It follows a twopath decision:

-If an object is detected, it is classified using a YOLOv5 deep learning model, and the name of the object is converted into audio output.

-If a QR code is detected, the system uses an integrated QR Code Scanner, and the decoded text is read aloud using TTS.
-If neither is found, the system does not trigger any action, conserving resources and reducing unnecessary feedback.

Preprocessing and CNN-Based Recognition (Adapted for Object Detection)
While this concept was originally applied to airwritten character recognition, it is similarly used here:
-The object or QR region is extracted and preprocessed (e.g., resizing or contrast enhancement).
-For character-based QR codes, preprocessing helps improve the clarity of the scanned content. - A trained model classifies the content and triggers appropriate responses or alerts.

Additional Applications:
Indoor Navigation: Detects furniture and room structures to help users avoid collisions.
Product Identification: Assists users in identifying labeled goods or medicines. **Public Accessibility**: Useful in places like malls or hospitals where visual signs are often unreadable for the visually impaired. **Touchless Interaction**: Inspired by the air-writing model, Deep Eye can eventually incorporate gesture commands for controlling smart devices (e.g., saying "switch" when detecting a light switch).
Security and Usability: As the interaction with Deep Eye is entirely touchless, the risk of pathogen transmission is significantly minimized—an important feature, especially in healthcare and public environments. The system can be further secured with multi-modal authentication techniques, such as facial recognition or voice- based verification, ensuring that only the authorized user interacts with the device.
To enhance user confidence and ease of use, Deep Eye offers real-time visual or audio feedback—for example, through bone-conduction audio or tactile vibrations—confirming that the system has recognized and processed the user's input accurately.
This intelligent air-writing and gesture-based system signifies a leap forward in assistive human- computer interaction, especially for visually impaired individuals. By replacing conventional touch interfaces with gesture-based controls, it ensures independence, hygiene, and accessibility. Integrated with IoT and AI-driven computer vision, Deep Eye can be used in a variety of dailylife applications such as: -Interacting with ATMs or elevators
-Controlling smart home devices
-Navigating menus or kiosks in public spaces
-Accessing public transport information During health crises such as pandemics, its touchless nature not only supports accessibility but also contributes to public safety by limiting surface contact and potential infection spread.

VI. RESULT

The Deep Eye system leverages deep learning for real-time object and QR code recognition, providing low-vision users with a seamless and touchless navigation experience using a smartphone camera and text-to-speech output. Evaluated using real-world scenarios, it demonstrated high accuracy (up to 94.12%), precision, recall, and F1-score, particularly excelling in air writing recognition tasks. With a low latency of 20ms and a frame rate of 50 FPS, it delivers fast and responsive performance. The system remains robust under varying lighting, hand movement, and background clutter. Error analysis revealed occasional misclassifications, suggesting future improvements with contextual reasoning. Usability testing with visually impaired users showed high satisfaction due to intuitive design and accurate voice feedback. By combining the speed of YOLO with an accessible user interface, Deep Eye enables visually impaired individuals to independently recognize and interact with everyday objects, enhancing their confidence and mobility.

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Output Images

Fig 3: Object Detection

Fig 4: QR Scanning

Model	Accuracy (%)	Precision (%)	Recall (%)	F1Score (%)
YOLOv5	92.12	94.85	94.70	94.77

1. Accuracy Formula:

Accuracy=True Positives (TP)+True Negatives (T N)Total Predictions=TP+TNTP+FP+TN+FN\text{ Accuracy} = \frac{\text{True Positives (TP)} + \text{True Negatives (TN)}}{\text{Total Predictions}} = \frac{TP + TN}{TP + FP + TN + FN}Accuracy=Total PredictionsTrue Positives (T P)+True Negatives (TN)=TP+FP+TN+FNTP+TN

But for object detection, we often focus on Precision, Recall, and F1-Score since TNs are not well-defined in detection tasks.

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2. Precision Formula:
Precision=True Positives (TP)True Positives (TP)
+False Positives (FP)\text{Precision} =
\frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Positives (FP)}}Precision=True Positives (TP)+False Positi ves (FP)True Positives (TP)
This measures how many of the detected objects were correctly identified.

3. Recall Formula:
Recall=True Positives (TP)True Positives (TP)+Fa lse Negatives (FN)\text{Recall} = \frac{\text{True Positives (TP)}}{\text{True Positives (TP)} +
\text{False Negatives
(FN)}}Recall=True Positives (TP)+False Negative s (FN)True Positives (TP)
This measures how many of the actual objects were correctly detected.

4. F1-Score Formula:
F1-
Score=2×Precision×RecallPrecision + Recall\text{ F1-Score} = 2 \times \frac{\text{Precision} \times
\text{Recall}}{\text{Precision + Recall}}F1- Score=2×Precision + RecallPrecision×Recall

VII. CONCLUSION

The Deep Eye Android application represents a significant advancement in assistive technology for visually impaired individuals. By integrating real-time object detection using the YOLO algorithm and QR/barcode scanning, the system offers a seamless and intuitive way for users to interact with their surroundings independently. The application delivers high accuracy, low latency, and reliable performance across diverse environments, making it highly effective for both indoor and outdoor use. Through voice- based feedback and a simple touchless interface, Deep Eye enhances user confidence, mobility, and awareness.

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