Real-Time Object Recognition with Voice Feedback for Visually Impaired Using Raspberry Pi

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Abstract - This paper presents a real-time object recognition system with voice feedback designed for visually impaired individuals using a Raspberry Pi platform. The system integrates computer vision, deep learning, Optical Character Recognition (OCR), and sensor-based technologies to provide environmental awareness and safety. A USB camera captures real-time images, which are processed using a YOLO-based object detection model. Detected objects are converted into speech output through a text-to-speech module. Additionally, an OCR module enables users to read printed text aloud. An ultrasonic sensor is used for obstacle detection, providing audio warnings when objects are nearby. The system also includes an emergency alert feature that sends the user's location via email using a GPS module. The proposed system is compact, cost-effective, and energy-efficient, making it suitable for portable assistive applications. Experimental results demonstrate that the system effectively improves independence, safety, and accessibility for visually impaired users.

Key Words: Object Recognition, Assistive Technology, Raspberry Pi, Computer Vision, Voice Feedback System.

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1. INTRODUCTION

Visual impairment significantly limits a person's ability to interact with their surroundings independently. Tasks such as object identification, reading printed text, and navigation become challenging without assistance. Traditional aids like white canes provide limited functionality and do not offer detailed environmental information.

Recent advancements in artificial intelligence, computer vision, and embedded systems have enabled the development of smart assistive technologies.This paper proposes a Raspberry Pi–based integrated system that combines real-time object detection, OCR-based text reading, obstacle detection, and emergency alert functionality. The system enhances user independence by providing real-time audio feedback about the environment.

2. LITERATURE SURVEY

Lourdes Santhosh S et al. [1] Proposed an object detection and identification system for visually impaired individuals using deep learning techniques, achieving reliable detection accuracy in controlled environments. R. Smith [2] introduced the Tesseract OCR engine, which enables efficient extraction of textual information from images and forms the basis for many assistive reading systems. Xinnan Leong and R. Kanesaraj Ramasamy [3] developed an obstacle detection system using ultrasonic sensors, demonstrating improved navigation safety for visually impaired users.

Redmon et al. [4] presented the YOLO (You Only Look Once) algorithm for real-time object detection, offering high speed and accuracy suitable for embedded systems. Howard et al. [5] introduced MobileNet, a lightweight convolutional neural network designed for resource-constrained devices like Raspberry Pi, enabling efficient deep learning applications.

Various researchers have explored Raspberry Pi-based assistive systems due to its low cost and compact size. Several studies [6] demonstrated integration of camera modules with image processing techniques to provide real-time environmental awareness. Other works [7] focused on combining OCR with text-to-speech systems to assist visually impaired users in reading printed content.

Recent advancements [8] have emphasized integrating multiple functionalities such as object detection, obstacle sensing, and emergency alert systems into a single platform. These systems improve usability but often face challenges related to processing speed and power limitations.

3. EXISTING SYSTEM

The existing systems for assisting visually impaired individuals primarily rely on separate technologies such as object detection, text recognition, and obstacle detection. Most designs use a camera-based approach combined with computer vision techniques to identify objects in the surroundings. These systems typically employ deep learning models such as YOLO for object detection, where images captured from a camera are processed frame-by-frame to recognize objects.

In addition, Optical Character Recognition (OCR) techniques are used to extract textual information from images. The recognized text is then converted into speech using text-to-speech engines, enabling users to access printed content. For navigation assistance, ultrasonic sensors are commonly used to detect nearby obstacles by measuring distance through echo signals.

In many existing implementations, these modules operate independently. Object detection systems focus only on identifying objects, while OCR systems are limited to text reading, and sensor-based systems provide only obstacle alerts. Some systems also include basic alert mechanisms but lack real-time integration of multiple functionalities.

- **Limitations:** Existing systems focus on solving only one specific problem; Lack of integration between object detection, OCR, and navigation systems; require high computational resources; Reduced usability due to separate module operation.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

4. PROPOSED SYSTEM

The proposed system is a smart assistive solution designed to support visually impaired individuals by providing real-time information about their surroundings through audio feedback. The system is built around a Raspberry Pi, which acts as the central processing unit, integrating multiple functionalities such as object recognition, text reading, obstacle detection, and emergency alert services. A camera continuously captures images from the environment, and these images are processed using computer vision and deep learning techniques to identify common objects. Once an object is detected, its name is converted into speech and delivered to the user through a speaker, enabling easy understanding without visual input. The Fig.1 shows the block diagram of proposed system.

In addition to object recognition, the system incorporates an Optical Character Recognition (OCR) module that allows users to read printed text. This feature is activated through a push button, upon which the system captures an image of the text, extracts the content, and converts it into audio output. To enhance user safety, an ultrasonic sensor is used to detect nearby obstacles by continuously measuring distance. If an object is detected within a predefined range, the system generates a voice alert, helping users navigate safely and avoid collisions in their environment.

Furthermore, the system includes an emergency alert mechanism to provide immediate assistance when required. By pressing a dedicated emergency button, the system retrieves the user's location using a GPS module and sends it to a predefined contact via email. The overall design is compact, portable, and cost-effective, making it suitable for real-world applications. By integrating multiple assistive features into a single platform, the proposed system significantly improves the independence, mobility, and safety of visually impaired individuals.

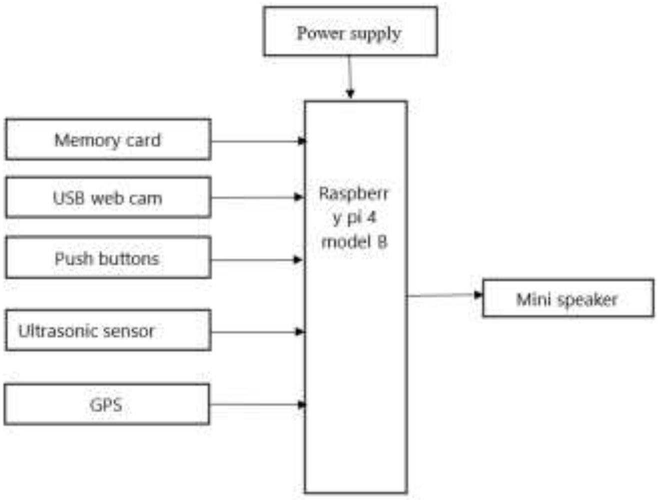

Fig.1: Block Diagram of Raspberry Pi–Based Object Recognition and Assistive System for Visually Impaired Users

5. IMPLEMENTATION AND RESULTS

The Fig.2 shows the complete hardware setup of the proposed smart assistive system designed for visually impaired users. The system is centered around the Raspberry Pi 4 Model B, which processes data from connected components. A USB camera is used for object detection and OCR operations, while the ultrasonic sensor helps in detecting nearby obstacles and ensures user safety. A GPS module is integrated to send location details via email during emergencies when the alert button is pressed. The audio output is provided through speakers, enabling voice feedback for detected objects and recognized text. This setup demonstrates a compact and cost-effective solution for real-time assistance and navigation.

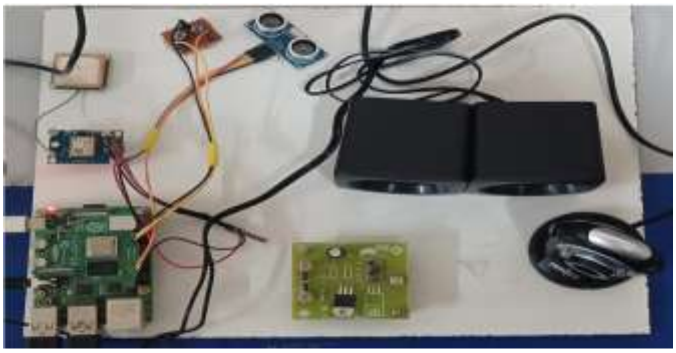

Fig.2: Hardware set up of proposed system

The system was successfully implemented on a Raspberry Pi platform. The results demonstrate that the proposed system effectively assists visually impaired users by providing real-time environmental awareness. The object detection module successfully identifies common objects as shown in Fig.3 using camera input and delivers accurate voice feedback, enabling users to understand their surroundings. The OCR feature also performs well by extracting printed text from images and converting it into speech, allowing users to access written information easily.

Additionally, the ultrasonic sensor enhances safety by detecting nearby obstacles and providing timely audio warnings. The emergency alert feature reliably sends the user's location via email as shown in Fig.4. Overall, the system shows efficient performance by integrating multiple functionalities, making it a practical and reliable assistive solution despite minor limitations due to environmental conditions.

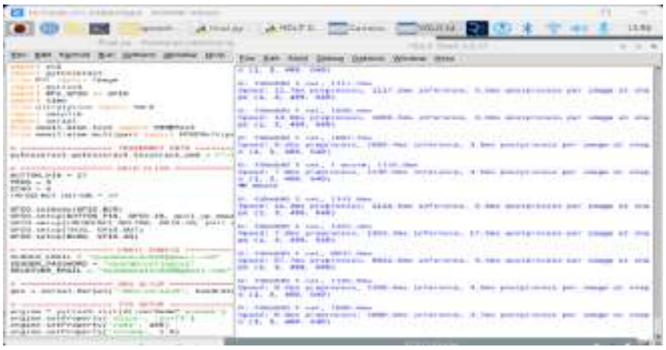

Fig.3: Object identification and returning the object name

Fig.4: Emergency Alert Email Containing GPS Location

6. DISCUSSION

The proposed system effectively integrates object recognition, OCR, obstacle detection, and emergency alert features into a single assistive device using a Raspberry Pi. It improves independence and environmental awareness for visually impaired users by providing real-time voice feedback.

However, the system's performance may be affected by lighting conditions, image quality, and hardware limitations. Despite these challenges, it remains a cost-effective and practical solution. Future improvements can enhance accuracy, expand features, and further improve user safety and usability.

7. CONCLUSION

The proposed system successfully demonstrates a smart and integrated assistive solution for visually impaired individuals by combining object recognition, text reading, obstacle detection, and emergency alert features into a single platform. By using a Raspberry Pi and low-cost components, the system provides real-time audio feedback, enabling users to understand their surroundings and perform daily activities more independently.

The system enhances safety through obstacle detection and emergency alert functionality, while also improving accessibility to printed information using OCR. Overall, the solution is compact, affordable, and practical for real-world use, contributing to increased independence, mobility, and quality of life for visually impaired users.

ACKNOWLEDGEMENT

The authors sincerely thank Mr. V. Bharath Kumar (Assistant Professor, ECE, PBR VITS Kavali) for his guidance, Dr. R. Sravanthi (Professor & HoD, ECE) for providing facilities, and Dr. V. Anil Kumar (Principal, PBR VITS Kavali) for the academic environment that enabled this work.

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