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# Development of Object Recognition and Distance Measurement Device

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**ABSTRACT:** Visual impairment and situational awareness challenges affect millions of people worldwide, limiting their ability to perceive and interact with their environment independently. This paper presents an intelligent assistive device that combines real-time object recognition with distance measurement to provide auditory feedback about surrounding objects. The system utilizes a Raspberry Pi 4B as the central processing unit, integrated with a Raspberry Pi camera module for live video capture and an ultrasonic sensor for precise distance measurement. The camera feed is processed using the YOLO (You Only Look Once) deep learning algorithm trained on the COCO (Common Objects in Context) dataset, enabling real-time identification of 91 common object classes. When objects are detected, their names are converted to speech and delivered through earphones, providing immediate auditory feedback to the user. Simultaneously, the ultrasonic sensor measures the distance to objects and speaks out the measured value, giving users critical spatial awareness. This dual-modality approach creates a comprehensive environmental awareness system suitable for assisting visually impaired individuals, enhancing situational awareness in low-visibility environments, and serving as an educational platform for embedded AI applications.

**KEYWORDS:** Assistive technology, Distance measurement, Object recognition, Raspberry Pi, YOLO

## I. INTRODUCTION

The ability to perceive and understand one's environment is fundamental to independent living and safe navigation[1]. For visually impaired individuals, this capability is severely limited, creating challenges in mobility, safety, and quality of life[2]. According to the World Health Organization, approximately 2.2 billion people worldwide have some form of vision impairment, with 90% of the visually impaired population living in developing nations where access to assistive technology is limited[3]. Traditional assistive devices such as white canes and guide dogs provide valuable but limited information about the environment, offering tactile awareness only of immediately adjacent obstacles without identifying what those obstacles are or providing distance information[4]. This paper[5] addresses these limitations by developing an intelligent assistive device that combines computer vision with distance sensing to provide comprehensive environmental awareness through auditory feedback[5]. The system leverages the computational capabilities of the Raspberry Pi 4B—a credit-card sized computer powerful enough to run state-of-the-art deep learning models while maintaining low power consumption and portability[6]. A Raspberry Pi camera module captures live video feed, which is processed using the YOLOv8 object detection algorithm trained on the COCO dataset, enabling recognition of 80 common object classes including people, vehicles, furniture, and everyday items[7]. The addition of an ultrasonic distance sensor provides critical spatial information that pure visual recognition cannot offer[8]. While object detection identifies what is present, the ultrasonic sensor measures how far away it is—information essential for safe navigation and interaction[9]. When objects are detected, their names are converted to speech using text-to-speech technology and delivered through earphones, providing users with both identification and localization information[10]. Existing assistive systems primarily address either obstacle detection or object recognition in isolation, lacking seamless integration of both functionalities within a single portable, real-time embedded device. Vision-based solutions in prior literature predominantly depend on cloud computing infrastructure and high cost sensing hardware such as LiDAR or stereo camera arrays, resulting in increased system latency, elevated power consumption, and reduced affordability—particularly in resource-constrained settings prevalent across developing nations. Current devices also provide limited continuous environmental awareness and frequently lack an efficient real-time auditory feedback mechanism capable of simultaneously conveying both object identity and precise distance information in a cognitively manageable manner. In cluttered real-world environments, the absence of context-aware priority filtering further

diminishes the practical utility of such systems, contributing to auditory overload for visually impaired users. These deficiencies collectively underscore the need for an affordable, fully embedded, and real-time solution that integrates object recognition and distance measurement with intuitive, low-latency audio feedback—operable entirely on device without reliance on cloud infrastructure or costly specialized sensors. The system utilizes a Raspberry Pi 4B as the central processing unit, integrated with a Raspberry Pi camera module for live video capture and an ultrasonic sensor for precise distance measurement. The camera feed is processed using the YOLO (You Only Look Once) deep learning algorithm trained on the COCO (Common Objects in Context) dataset. When objects are detected, their names are converted to speech and delivered through earphones, providing immediate auditory feedback to the user. Simultaneously, the ultrasonic sensor measures the distance to objects and speaks out the measured value, giving users critical spatial awareness. The experimental results demonstrate reliable detection and distance measurement across all tested categories. The proposed system offers an affordable, portable, and fully embedded solution that advances accessibility and independence for visually impaired individuals without reliance on cloud infrastructure or high-cost specialized hardware.

## II. METHODOLOGY

This section presents the system architecture and working principle of the proposed Object Recognition and Distance Measurement Device.

### A. System Architecture and Block Diagram

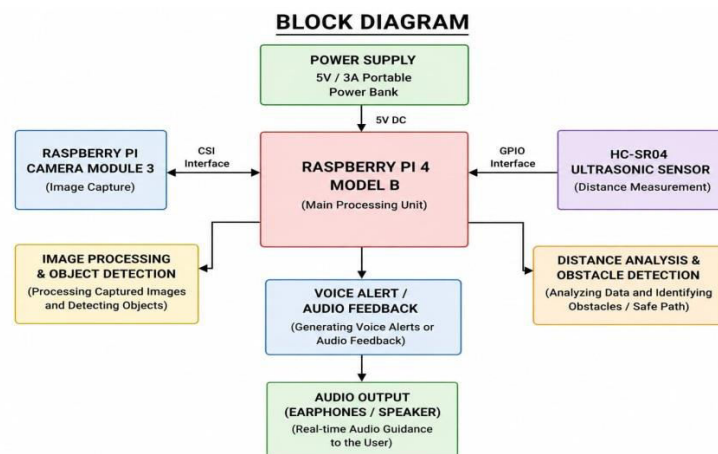


FIG.1. BLOCK DIAGRAM OF THE PROPOSED METHOD

The system architecture integrates four major subsystems operating concurrently under a multi-threaded Python application. The Object Recognition Subsystem employs the Raspberry Pi Camera Module V3 to capture continuous video at 640×480 resolution via the CSI interface, with each frame processed by the YOLOv8-nano model running locally for real-time inference. The Distance Measurement Subsystem uses the HC-SR04 ultrasonic sensor, physically aligned with the camera's central field of view, to deliver single-point distance measurements through time-of-flight calculation. The Auditory Feedback Subsystem employs the espeak text-to-speech engine to convert detected object labels and measured distances into natural spoken sentences delivered through earphones. The Software Integration Framework orchestrates all subsystems on Raspberry Pi OS (64-bit) within a dedicated virtual environment.

### B. Description

The description of the proposed system is based on real-time object recognition and distance measurement using Raspberry Pi technology. The Raspberry Pi camera continuously captures live video, and the YOLO algorithm processes the frames to detect surrounding objects such as persons, chairs, bottles, laptops, and other common items identified using the COCO dataset model. Simultaneously, the HC-SR04 ultrasonic sensor measures the distance between the user and the detected object by transmitting ultrasonic waves and receiving the reflected echo signal. The Raspberry Pi calculates distance using the travel time of the sound waves. The detected object name and measured

distance are then converted into speech using a text-to-speech module and provided through earphones, helping users understand their surroundings through real-time audio guidance.

### C. Proposed Workflow

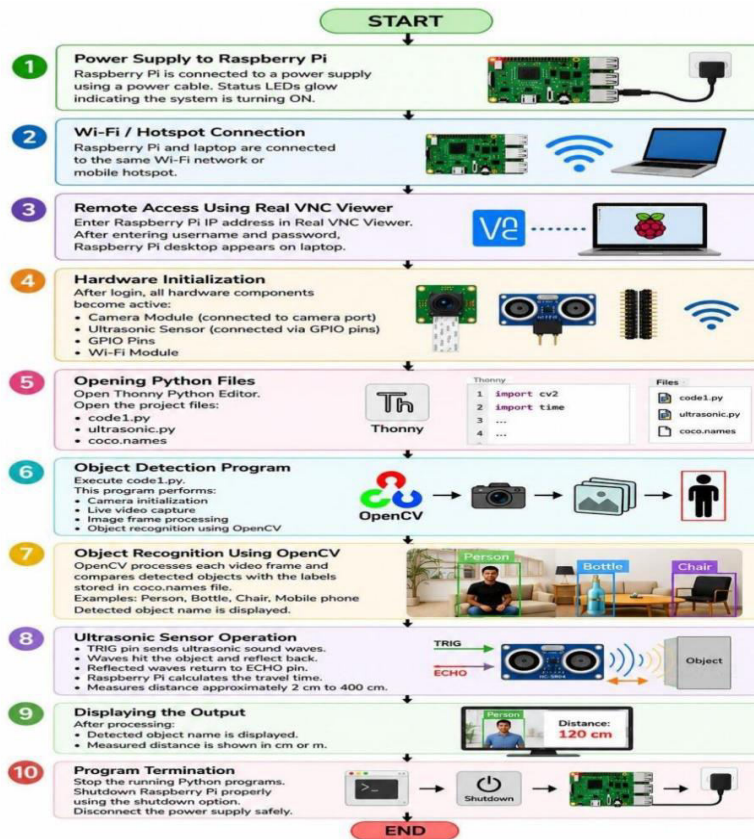


FIG.2. FLOWCHART OF THE PROPOSED SYSTEM FOR REAL-TIME OBJECT RECOGNITION AND DISTANCE MEASUREMENT USING RASPBERRY PI

As depicted in Fig. 2, the system initiates by supplying power to the Raspberry Pi and establishing a Wi-Fi/VNC network connection. Following boot-up, the camera module and HC-SR04 ultrasonic sensor are initialized through the GPIO and CSI interfaces respectively. The Python program is then executed to commence concurrent object detection and distance measurement. The Raspberry Pi camera continuously captures live video frames; OpenCV with YOLO processes each image to detect surrounding objects, while the ultrasonic sensor simultaneously measures the distance of nearby objects. The Raspberry Pi processes both data streams and delivers the combined output as spoken audio to the user.

### III. RESULTS AND DISCUSSION

#### A. Experimental Setup

The experimental setup was developed using a Raspberry Pi 4B board, an HC-SR04 ultrasonic sensor, a Raspberry Pi Camera Module V3, and standard electronic interfacing components, as shown in Fig. 3. The Raspberry Pi acts as the central controller and performs all processing operations. The system was evaluated for detection accuracy and distance measurement performance across eight common object categories at four representative distance ranges.



FIG.3.EXPERIMENTAL SETUP OF THE OBJECT RECOGNITION AND DISTANCE MEASUREMENT DEVICE

**B. Object Detection Results**

The system was experimentally validated by testing detection of 8 common object categories at four distance ranges: very near, near, medium, and maximum. Table I summarizes the experimental results obtained from the proposed system.

TABLE I. OBJECT DETECTION RESULTS AT VARIOUS DISTANCES

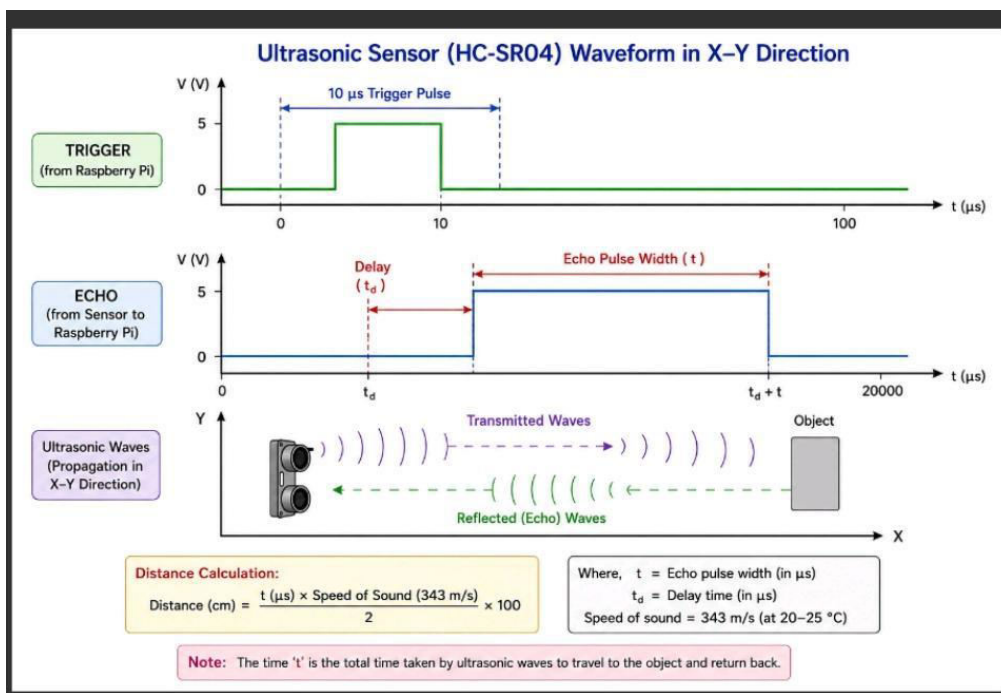
Sl. No	Object Detected	Very Near	Near	Medium	Maximum Measured Distance	Result
1	Person	0.5 m	1.5 m	3 m	4 m	Detected
2	Chair	0.3 m	1 m	2 m	4 m	Detected
3	Bottle	0.2 m	0.8 m	1.5 m	3 m	Detected
4	Laptop	0.3 m	1 m	2 m	3 m	Detected
5	Door	0.8 m	2 m	3 m	4 m	Detected
6	Table	0.5 m	1.5 m	2.5 m	4 m	Detected
7	Bicycle	0.7 m	2 m	3 m	4 m	Detected
8	Car	1 m	2.5 m	3.5 m	4 m	Detected

The experimental results demonstrate reliable detection and distance measurement across all tested categories. For the person as an object, the ultrasonic sensor detects it and generates an audio voice output indicating that the detected object is a person, located at distances of 0.5 m, 1.5 m, and 3 m from the reference position. The maximum identification range achieved for person detection is 4 m. If the chair as an object, the system successfully detects it at very near, near, and medium ranges of 0.3 m, 1.0 m, and 2 m respectively, with a maximum identification range of 4 m. The audio feedback accurately announces the chair's identity and its distance from the user. For the bottle as an object, detection is achieved at 0.2 m, 0.8 m, and 1.5 m across the three primary distance ranges. The maximum identification range for bottle detection is 3 m, reflecting the relatively smaller acoustic cross-section of this object class. If the laptop as an object, the system detects it successfully at 0.3 m, 1.0 m, and 2 m, with a maximum identification range of 3 m. The audio output correctly identifies the laptop and communicates its spatial position to the user. For the door as an object, owing to its larger physical profile, detection is reliable at 0.8 m, 2.0 m, and 3 m, with the maximum identification range extending to 4 m. The system provides accurate audio guidance regarding the door's presence and distance. If the table as an object, the system detects it at 0.5 m, 1.5 m, and 2.5 m across the three primary ranges, achieving a maximum identification range of 4 m. The audio output correctly identifies the laptop and communicates its spatial position to the user. For the bicycle as an object, detection is performed successfully at 0.7 m, 2.0 m, and 3 m,

with a maximum identification range of 4 m. This demonstrates the system's ability to reliably identify larger moving objects in both indoor and outdoor environments. The audio output correctly identifies the laptop and communicates its spatial position to the user. For the car as an object, detection is achieved at distances of 1.0 m, 2.5 m, and 3.5 m, reaching a maximum identification range of 4 m. The audio output correctly identifies the laptop and communicates its spatial position to the user.

**C. Sensor Waveform Analysis**

Fig. 4 illustrates the HC-SR04 ultrasonic sensor timing waveform. The Raspberry Pi sends a 10 μs trigger pulse to the sensor, activating the ultrasonic transmitter. The sensor emits ultrasonic waves toward the object; upon reflection, the ECHO pin remains HIGH for a duration equal to the total travel time of the ultrasonic waves. Using this echo time and the speed of sound (343 m/s), distance is calculated accurately.



**FIG.4. HC-SR04 ULTRASONIC SENSOR WAVEFORM SHOWING TRIGGER PULSE, ECHO PULSE WIDTH, AND DISTANCE CALCULATION TIMING**

**IV. CONCLUSION**

This paper presented an intelligent Object Recognition and Distance Measurement Device integrating Raspberry Pi 4 Model B, YOLOv8 object detection, and the HC-SR04 ultrasonic sensor. The system successfully performs real-time object detection, distance measurement, and audio-based feedback, enabling users to comprehensively understand their surroundings. Experimental validation confirmed reliable detection across eight object categories at multiple distance ranges in both indoor and outdoor environments. The proposed system offers an affordable, portable, and fully embedded solution that advances accessibility and independence for visually impaired individuals without reliance on cloud infrastructure or high-cost specialized hardware. Future enhancements include integration of Time-of-Flight (ToF) and thermal camera modules for improved distance accuracy and low-visibility performance. GPS-based voice-guided navigation may be incorporated to extend outdoor usability and assist in safe wayfinding. Upgrading the processing platform to Raspberry Pi 5 and employing advanced AI models will increase inference speed and detection accuracy. Additionally, IoT connectivity, mobile application support, and emergency alert systems are envisaged to further enhance real-world reliability and user accessibility.

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