

AI VISION AID: YOLO OBSTACLE DETECTION AND CLASSIFICATION

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Abstract: This work presents a real-time obstacle detection and classification system designed to assist visually impaired individuals using Raspberry Pi and YOLO object detection. An ultrasonic sensor first detects the presence of an obstacle, triggering the camera to capture the scene, which is then processed by a lightweight YOLO model to identify and classify the object. The detected object label along with its position (left, right, or center) is converted into speech to inform the user. Additional safety features include an accelerometer to detect falls, which automatically sends an email alert with GPS location to a caretaker, and a panic button for manual emergency assistance. A moisture sensor identifies water-filled potholes, and an LDR determines whether it is day or night, enabling context-aware alerts. This multifunctional system enhances mobility and personal safety for the visually impaired in real-world environments.

Keywords: Real-time obstacle detection, YOLO, Raspberry Pi, assistive navigation, ultrasonic sensor, fall detection, GPS alert, speech output.

I. INTRODUCTION

All Visually impaired individuals face numerous challenges when navigating through their surroundings, especially in unfamiliar or complex environments. While traditional mobility aids such as white canes or guide dogs offer some support, they lack the ability to dynamically inform users about specific obstacles or hazards in real-time. With the advancement of embedded systems and artificial intelligence, there is great potential to develop intelligent assistive technologies that significantly enhance the independence and safety of visually impaired persons. This project introduces a smart assistive device built around a Raspberry Pi that utilizes the YOLO (You Only Look Once) object detection algorithm for real-time obstacle classification. An ultrasonic sensor is

used to initially detect the presence of nearby obstacles, prompting the camera to capture images for processing. The YOLO model then identifies objects within the scene and determines their position left, right, or center. This information is converted into audio feedback, helping the user understand their environment and make informed movement decisions. In addition to object detection, the system is equipped with multiple sensors for added safety. A fall detection feature is implemented using an accelerometer, which can detect sudden changes in motion or orientation indicative of a fall.

When such an event is identified, the system automatically sends an emergency email to a pre-defined contact, including the user's GPS location. Similarly, a panic button is integrated into the device to allow the user to manually send an alert in case of emergency or distress. Environmental awareness is further enhanced through a moisture sensor and a light-dependent resistor (LDR). The moisture sensor detects water bodies or wet potholes on the ground, which may pose a slipping hazard. The LDR determines whether it is day or night, allowing the system to adapt its responses or trigger auxiliary features like a flashlight or buzzer during nighttime conditions. Overall, this project combines object detection, sensor integration, and real-time communication to provide a comprehensive navigation and safety solution for visually impaired users. By offering audio feedback, fall detection, and emergency alerting, the system aims to improve mobility, situational awareness, and user confidence, ultimately supporting independent and secure navigation in outdoor and indoor settings.

II. LITERATURE SURVEY

A literature review of a variety of publications that is necessary to understand the methods that have been employed in the past. This also discusses their importance and constraints. Each and every strategy is presented, and its drawbacks are examined.

Anurag Patil et al. [1] proposed a low-cost IoT-based navigation system for visually impaired individuals. Their system integrated ultrasonic, IR, gyroscopic, and accelerometer sensors with an ESP32 microcontroller and a vibration motor to deliver real-time obstacle detection and navigation support. They emphasized affordability and effectiveness to enhance user mobility.

Himanshu Singh et al. [2] introduced a smart assistance system that utilized ultrasonic sensors and buzzers for real-time obstacle detection and alerts. Their approach also incorporated web-based emergency support, focusing on user independence and safety through remote monitoring and IoT integration.

Deepa J et al. [3] examined SMART technologies for obstacle detection and navigation. Their system provided real-time audio feedback using various sensors to help users navigate both indoor and outdoor environments. The study underscored the role of modern technology in improving the mobility and safety of visually impaired individuals.

S. Mohan Kumar et al. [4] developed an indoor navigation solution using IoT and Bluetooth Low Energy (BLE). Unlike GPS, which is ineffective indoors, their system enabled accurate real-time positioning and navigation assistance

within buildings. The BLE-based system provided detailed support for independent indoor movement.

R. Arthi et al. [5] presented a prototype of assistive shoes equipped with ultrasonic sensors and an Arduino UNO for obstacle detection. The system provided real-time alerts to support safe navigation, emphasizing the benefits of wearable technology in improving mobility for the visually impaired.

Priyanka Bhosle et al. [6] proposed a smart navigation solution incorporating an ESP32 microcontroller, radar and ultrasonic sensors, GPS, and Bluetooth. The system converted obstacle data into audio signals and provided Bluetooth-based audio navigation, offering a comprehensive and user friendly experience. 4 AI Vision Aid: YOLO Obstacle Detection and Classification.

Nikhi S. Patankar et al. [7] introduced an intelligent IoT- based smart stick combining image sensing and AI for obstacle detection. The device utilized cameras and AI algorithms to provide auditory and tactile feedback, with GPS integration enhancing mobility. Their work showcased a sophisticated and intelligent assistive navigation solution.

J. Wang et al. [8] investigated smart glasses-based navigation, highlighting a cane system using ultrasonic sensors and haptic feedback. While effective for basic obstacle detection, the authors noted that haptic-only feedback might be insufficient in complex environments, suggesting the need for audio guidance.

A. Gupta et al. [9] developed a wearable ultrasonic system providing feedback via vibration motors. Their study emphasized the effectiveness of wearable devices for spatial awareness but pointed out the lack of GPS integration as a limitation for comprehensive navigation.

G. C. Y. Chan et al. [10] designed a smart cane using haptic signals for obstacle detection. Though effective for simple navigation tasks, they acknowledged the need for multimodal feedback systems—including audio—to handle complex navigation scenarios more effectively.

J. M. Reinhardt [11] created a navigation system that combined GPS and GSM for real-time location tracking. While it demonstrated the feasibility of mobile network-based guidance, the lack of integrated obstacle detection reduced its utility in dynamic environments.

III. PROPOSED SYSTEM ARCHITECTURE

Methodology The proposed system is developed using a Raspberry Pi as the central processing unit, which integrates various sensors and modules to support real-time obstacle detection, classification, and user assistance. The process begins with the ultrasonic sensor, which constantly monitors the user's path. When it detects an obstacle within a predefined distance, it triggers the Pi camera to capture a live video frame. This frame is then passed to the YOLO (You Only

Look Once) object detection algorithm, which classifies the obstacle in real time with high accuracy and speed. Once an obstacle is detected and classified, the system determines its relative position left, center, or right based on its bounding box coordinates within the camera frame. This information, along with the label of the object (e.g., "car," "person," "pole"), is converted into speech using

a text-to-speech (TTS) engine. The audio is then played through a speaker or earphones, informing the visually impaired user about the obstacle and its direction. This real-time feedback mechanism allows the user to make quick and safe navigation decisions. To ensure user safety in unexpected scenarios, the system incorporates an accelerometer (e.g., MPU6050) to monitor the user's movement.

If the accelerometer detects a sudden change in orientation or motion that matches fall patterns, it automatically triggers an emergency protocol. The Raspberry Pi then collects GPS data using a GPS module and sends an alert email with the user's location to a predefined contact. Additionally, a physical panic button is included, allowing the user to send an emergency email manually if they feel unsafe or need help. Environmental awareness is further improved through the use of a moisture sensor and a light-dependent resistor (LDR). The moisture sensor is placed near the ground level to detect water bodies or potholes containing water, which can be dangerous for visually impaired users. When water is detected, an audio warning is issued. Meanwhile, the LDR continuously monitors ambient light conditions. If it detects low-light environments, indicating nighttime, the system can adjust its operation accordingly for instance, increasing the volume of alerts or activating a flashlight or buzzer if necessary. All the components and processes are programmed in Python, running on Raspberry Pi OS. The system operates in a continuous loop, where sensor data is constantly monitored, and object detection is performed dynamically based on input from the ultrasonic sensor. The integration of sensors diagram with intelligent decision-making ensures that the device functions as a comprehensive assistive tool. This layered methodology not only provides obstacle III.

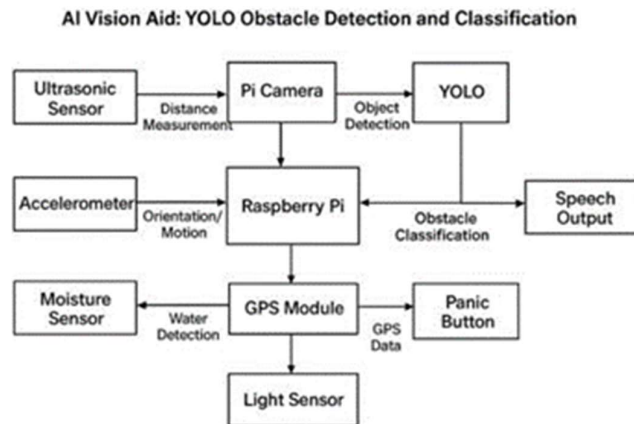


Fig.1 AI Vision Aid Block Diagram

III. HARDWARE REQUIREMENT

1. Raspberry Pi

It is a series of small single-board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, because of its low cost, modularity, and open design. It is typically used by

computer and electronic hobbyists, due to its adoption of the HDMI and USB standards



Fig.2 Raspberry Pi

2. Pi Camera:

It is used to capture image of the crops. It is directly connected to raspberry pi model. There are two ways to Raspberry pi is a small size module like a small computer. The image captured by camera is sent to the raspberry pi. Using tensor flow, the image is processed and detected by the raspberry pi.



Fig.3 Pi Camera

3. Ultrasonic sensor



Fig.4 Ultrasonic sensor

An ultrasonic sensor is a device that gauges distance using ultrasonic waves, functioning based on the principle of echolocation, akin to how bats navigate. The sensor generates a high-frequency sound wave, typically around 40 kHz, from a transmitter. This wave propagates through the air and is reflected to the sensor when it strikes an object. The sensor's receiver captures the reflected wave. By measuring the duration, it takes for the sound wave to travel to the object and return, the sensor calculates the distance to the object. The distance is computed using the formula: $\text{distance} = (\text{time period} \times \text{sound speed}) / 2$, with the speed of sound in air being approximately 343 meters per second.

4. Accelerometer:



Fig.5 Accelerometer

With I2C and SPI interfaces, the ADXL345 is a compact, low-power, full 3-axis MEMS accelerometer module. The ADXL345 board has an on-board level shifter and 3.3V voltage regulator, which makes interacting with 5V microcontrollers like the Arduino easy.

5. GPS Module:



Fig. 6 GPS Module

The NEO-6MV2 is the name of the GPS (Global Position System) module that is used in satellites for navigation. All that the module does is find its location on Earth and output the latitude and longitude of that position. It is part of a series of standalone GPS receivers that have the potent u-blox 6 position engine. These versatile and reasonably priced receivers have a large selection of connecting options and are compact (16 x 12.2 x 2.4 mm). NEO-6 modules' small design, power, and memory options make them ideal for battery-operated cell phones with extremely strict financial and spatial constraints. Because of its creative design, the NEO-6MV2 can perform remarkably effectively in even the most challenging navigational conditions.

6. Buzzer:

Auditory signalling devices, such as beepers and buzzers, can be categorized as mechanical, piezoelectric, or electromechanical. These devices are primarily utilized to convert electrical signals into sound. They typically operate on direct current (DC) voltage and are commonly integrated into a range of devices, including computers, printers, alarm clocks, timers, and similar equipment. Depending on their design, they can produce a variety of sounds, such as alarms, melodies, bells, and sirens.

The operational mechanism of a buzzer relies on generating pressure differentials when a voltage is applied across a piezoelectric material. Piezo crystals between two conductors make up a piezo type. These crystals push one conductor via their intrinsic property and drag the other conductor through it if a potential difference is applied to them. Thus, a sharp audio signal will be produced by this ongoing motion.



Fig 7. Buzzer

7. LDR Sensor:

LDR sensor module is a low-cost digital sensor as well as analog sensor module, which is capable to measure and detect light intensity. This sensor also is known as the Photoresistor sensor. This sensor has an onboard LDR(Light Dependent Resistor), that helps it to detect light. This sensor module comes with 4 terminals. Where the “DO” pin is a digital output pin and the “AO” pin is an analog output pin. The output of the module goes high in the absence of light and it becomes low in the presence of light. The sensitivity of the sensor can be adjusted using the on board potentiometer

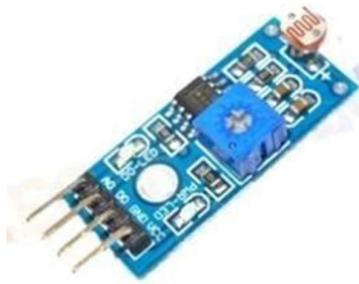


Fig. 8 LED Sensor

8. Soil Moisture Sensor:

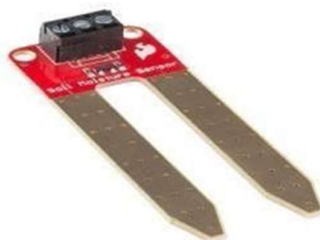


Fig 9. Soil Moisture Sensor

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

IV. RESULTS

The implemented system successfully detects obstacles in real time using the YOLO algorithm and accurately classifies them with corresponding directional feedback (left, center, or right), which is conveyed to the visually impaired user through speech output. The ultrasonic sensor reliably triggers the camera for object detection, while the accelerometer effectively identifies fall incidents and initiates automatic email alerts with GPS location. The panic button also functions as intended, allowing manual emergency alerts. The moisture sensor accurately detects the presence of water-filled potholes, and the LDR effectively distinguishes between day and night conditions. Overall, the system demonstrates robust performance in enhancing navigation, situational awareness, and safety for visually impaired individuals in various environments

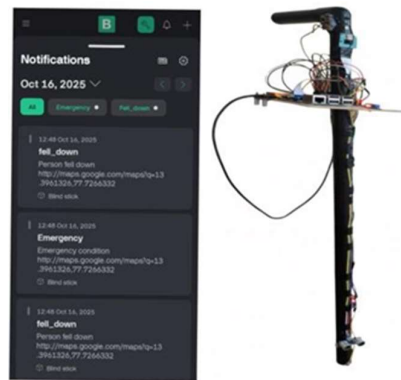


Fig 10. Result

Fig. 10 Illustrates the real-time emergency reporting capability of the proposed Smart Blind Stick system using the Blynk IoT platform. The Blynk mobile application displays multiple alerts generated by the device, including fall detection and emergency condition notifications. Each alert record includes the timestamp, event type, and a Google Maps hyperlink containing the detected GPS coordinates of the user's location, thereby enabling immediate tracking and response. The source device label is identified as "Blind Stick." The hardware prototype of the developed smart cane is shown in Fig. 2. The system incorporates a Raspberry Pi controller interfaced with multiple embedded modules, including ultrasonic sensors for obstacle detection, a fall detection unit, an emergency trigger switch, GPS for geolocation acquisition, and wireless connectivity for cloud communication. When a critical event such as a fall is detected, the system

automatically transmits a warning to the caregiver through the Blynk app along with precise geolocation data. This functionality supports remote monitoring and rapid assistance during hazardous situations. Overall, these results demonstrate the successful implementation of intelligent sensing, event classification, and cloud-based emergency notification in real time, validating the feasibility of the system for assisting visually impaired individuals.

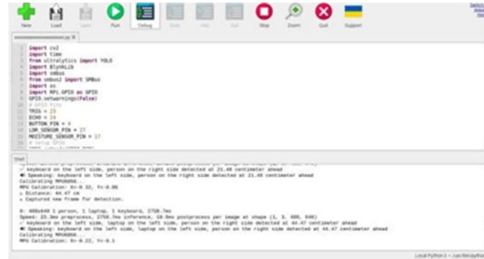


Fig. 11 Audio Speech Output

The real-time console and speech-based output generated by the proposed Smart Blind Stick system. The system continuously captures live video frames and performs object detection using the YOLO model. The speech output announces the detected objects and their approximate distance from the user; for example, the message “keyboard on the left side, person on the right side detected at 21.48 centimeters ahead” indicates that the objects are successfully localized with directional guidance. The response time includes image preprocessing, inference, and post-processing, as shown by timestamps in the output log. In addition, the system calibrates the MPU-6050 motion sensor to monitor body tilt variations. When abnormal orientation is detected, the system interprets it as a possible fall condition. If a fall is detected, the system automatically generates a spoken warning such as “person may have fallen”, and triggers an emergency alert through the Blynk cloud interface. The alert log includes date, time, and GPS location, enabling caregivers to identify the incident in real time.

Furthermore, the system distinguishes between day and night conditions using the LDR sensor. During nighttime, the device activates additional support—such as audio warnings or illumination—to assist the user. Emergency push-button activation also produces both speech-based alerts and cloud notifications containing time, date, and location details.

These observations confirm that the proposed system successfully integrates object detection, distance estimation, fall identification, time-based sensing, and emergency message generation, thus enhancing user safety under diverse environment.

V. CONCLUSION

The developed real-time obstacle detection and classification system provides an effective and intelligent solution for assisting visually impaired individuals in navigating their surroundings safely. By integrating Raspberry Pi with YOLO-based object detection, various sensors, GPS, and audio feedback, the system offers accurate obstacle identification, directional guidance, fall detection, emergency alerting, and environmental awareness. The successful implementation and testing of the system confirm its ability to enhance user independence, safety, and confidence in both indoor and outdoor settings. This project demonstrates the potential of combining AI and IoT technologies to create practical assistive tools for people with visual impairments.

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