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Smart Obstacle Detection Aid for Visually Impaired

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Abstract: *This project presents a real-time obstacle detection, classification, and safety aid system for visually challenged individuals using Raspberry Pi. An ultrasonic sensor senses obstacles, activating a camera to take the scene, which is then processed by a lightweight YOLO model to pinpoint and classify objects. The detected object label and its position (left, right, or center) are convert the output into speech to guide the user. Additionally, the system integrates face recognition using OpenCV to identify familiar individuals, enhancing personal safety and social interaction. Safety features include an accelerometer for fall detection, which automatically sends an email alert with GPS location to a caretaker, and a panic button for manual emergency assistance. A moisture sensor detects water-filled potholes, and an LDR determines day or night conditions for context-aware alerts. The system also incorporates a custom lightweight hack module for real-time optimization of notifications and recognition. This multifunctional system significantly enhances mobility, situational awareness, and personal safety for visually impaired users in real-world environments.*

Keywords: ultrasonic sensor

I. INTRODUCTION

Mobility and safety are key challenges encountered by individuals with low vision, especially in dynamic outdoor environments. Traditional aids such as canes or guide dogs provide limited information about the surrounding environment, making obstacle detection and navigation difficult. With the advancement of computer vision, artificial intelligence, and sensor technologies, it is now possible to develop intelligent systems that aid people with low vision in real-time.

This project focuses on building a multifunctional assistive system using Raspberry Pi that combines obstacle detection, object classification, face recognition, and safety alert mechanisms. An ultrasonic sensor first detects obstacles, prompting the camera to capture the scene. A lightweight YOLO based (You Only Look Once) model interprets the image to detect and classify objects, while the system conveys the output presented to the user via audio feedback, indicating the object's type and position (left, right, or center).

To further enhance safety, the system includes an accelerometer to detect falls and automatically send GPS-enabled email alerts to caretakers. A panic button allows manual emergency assistance. A moisture sensor detects water-filled potholes, and an LDR sensor distinguishes between day and night, allowing context-aware notifications. Additionally, face recognition using OpenCV identifies familiar people, and a lightweight hack module optimizes real-time processing and alerts.

This consolidated approach ensures that visually impaired users can navigate safely, interact socially, and respond to emergencies more effectively, providing a significant improvement over conventional assistive tool.

Proposed System Architecture

Admittedly, the human brain has a remarkable ability to perceive and understand a real-world scene, going through a very complex process at the level of neurons. This makes simulation a very difficult and complicated. Although, computers exceed most of the big data, human visual system emulation is still primitive and can only capture basic information from visual images such existing objects. Mainly the object detection is the key step in this system. As

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known, there are variety of sensors for that mission as Laser, radar, etc. [18], [19]. But using a camera it will serve the author's idea of having a low cost system for sighted individuals impairment community.

The main goal is to take this emulation to a next level and pursuing a whole learning process, which groups together the object sensing and tracking along with the risk classification related to all objects around the user, so as to give this assisting system the capability to :

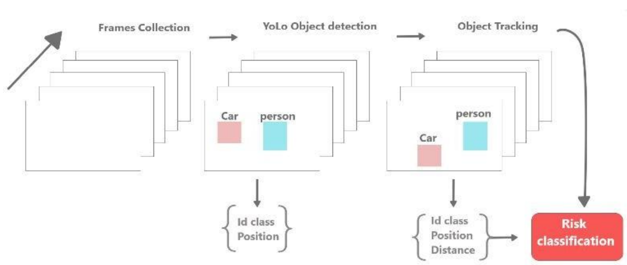
- Identify and distinguish between barriers ahead of the user's body from the ground to the heads.
- Provide the user details about the obstacle distance with essential direction instructions depending on a risk classification.
- Afford instructions to the individual about surroundings.
- Give the user an ability to create cognitive understanding of the surroundings to succeed self-orientation.

According to some measure, this blind assisting technology and using a wearing glasses. As shown in figure 3, the system integrated within glasses has different stages starting with a frame collecting stage, passing through the visual detection process phase. Detected objects are tracked in the next frames. An object is identified by its position, type and its distance to the user estimated using the DisNet technique. The information is leveraged to classify the risk related to this object. For the intended determines how far the user is from the hurdle and the obstacle is very important stage it become after detecting an object and knowing its direction. Below are the steps shown in figure 3:

1. Get frames in real-time from given source (smart glasses, camera).
2. Reading this dataset in our program.
3. Detecting the objects present in the images using YOLO.
4. Compare the extracted objects with the known dataset
5. Once the object is recognized its Location at the current frame is extracted.
6. The object will be tracked, while computing his risk on the user in the next frame tell it disappear.
7. Repeat 3 to 6 tell the end of the navigation

The system only begins to generate warnings of vulnerable targets in the proximities when the distance seperating the user from the obstacle and the obstacle is less than the thresholding value equal to 0.5 (thresholding-risk). If the distance between the object and the person is less than thresholding-risk, then the object is considered as a high risk obstacle, otherwise is classified as a negligible. Meanwhile the user would be informed just by the surrounding obstacle with high risks and their types, consequently the focus on the global environment where the user navigates would be reduced.

The use of YOLO based object detection in the proposed system is reliable even though that YOLO classifier was used in its original form trained with COCO dataset [17], without retraining with the images from the test field. The result of object detection and distance estimation in a dynamic environment (moving car and moving object-obstacle) show that achieving distance estimation is not satisfactory in spite of considering that objects not fully bounded with the region of interest and also changed within the stream video owing to the tracking method, however this part needed an improvement along with the risk estimation in the event of colliding boxes.



SOFTWARE REQUIREMENTS

Python Language:

- Python is a powerful, easy-to-learn software technologies used for developing web applications, data science, AI, and more.
- It emphasizes readability and simplicity, making coding faster and more efficient.

Thonny IDE:

- Thonny IDE is a beginner-friendly Python editor designed to make learning and debugging simple.
- It provides a clean interface with built-in features like a debugger and variable inspector for easy understanding.

Raspberry pi OS:

- Raspberry Pi is a small, affordable computer used for learning programming and building electronic projects.
- It supports various operating systems and can control hardware like sensors, motors, and cameras.

Blynk App

- Blynk is a platform that allows you to control IoT devices through a smartphone app.
- It helps create custom dashboards to monitor and manage hardware like Arduino and Raspberry Pi easily.

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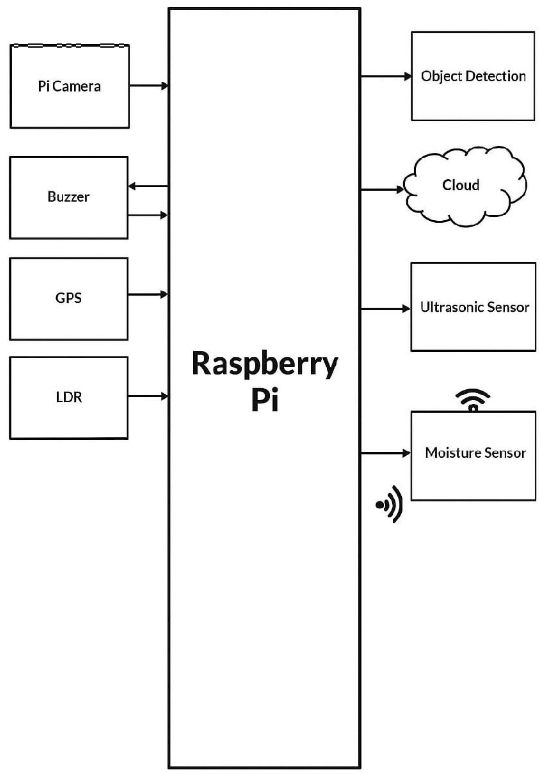
Proposed system Block Diagram



WORKING

Input components:

- **Ultrasonic Sensor:** Measures the distance to nearby obstacles using sound waves.
- **Accelerometer:** Detects movement, orientation, or sudden falls of the device.
- **LDR (Light Dependent Resistor):** Detects the light intensity in the environment.
- **Moisture Sensor:** Checks for wet surfaces or rain conditions.
- **Switch:** Used to power on/off or trigger the system manually.
- **GPS Module:** Provides real-time location data of the user.

Processing Unit (Raspberry Pi):

- Acts as the **central controller**.
- Processes camera input using **YOLO (You Only Look Once)** for object detection and classification.
- Integrates sensor data to analyze the environment in real-time.
- Uses Python scripts (written and tested in **Thonny IDE**) for all computations and decision-making.

Output Components:

- **Buzzer:** Produces alert sounds when an obstacle or hazard is detected.
- **Earphone:** Gives voice feedback or audio alerts to the visually impaired user.

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- **Blynk App:** Displays live sensor readings and notifications on a smartphone via Wi-Fi.
- **Cloud:** Stores and syncs data for remote monitoring and analysis.

Overall Functioning:

- When the system is turned on, the Raspberry Pi acquires data from all sensors and the Pi Camera.
- The camera detects and classifies objects; ultrasonic sensors measure their distance.
- Based on this, the Raspberry Pi alerts the user through buzzer sounds or voice feedback.
- Simultaneously, data is uploaded to the **Blynk App** and **Cloud**, allowing monitoring through the internet..

II. CONCLUSION

The developed system successfully integrates real-time obstacle detection, object classification, face recognition, and emergency alert mechanisms to assist visually impaired individuals. Using a Raspberry Pi, YOLO object detection, OpenCV-based face recognition, and multiple sensors, the system provides audio guidance, fall detection with GPS-enabled alerts, and environmental awareness through moisture and LDR sensors. The inclusion of a panic button

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