SAFE STEPS FOR VISUALLY IMPAIRED

A COMMUNITY FOCUS PROJECT REPORT

216ECE4221

Submitted by

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In partial fulfillment for the award of the degree

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BACHELOR OF TECHNOLOGY

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Project Title	:	**SAFE STEP FOR VISUALLY IMPAIRED**
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Constraints	:	Power Efficiency
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Integrated Circuits Standard	:	Low-power MCU (Microcontroller) MIPI CSI (Camera Serial Interface) Voltage Regulation Standards (VRS)

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We hereby declare that this project **"Safe Steps For Visually Impaired"** is our genuine work and no part of it has been reproduced from any other works.

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ABSTRACT

This project, titled “Safe Steps for the Visually Impaired,” aims to design an assistive device that uses a camera module and advanced software to enhance mobility and safety for visually impaired individuals. The device combines embedded systems and computer vision to identify obstacles, detect changes in the walking path, and provide real-time feedback to the user. Equipped with a compact camera module, the system captures live video, which is then processed using image recognition algorithms to detect obstacles, steps, and other environmental hazards. This information is converted into auditory or vibrational alerts, allowing the user to navigate their surroundings safely and independently.

Key features of this device include high-speed processing for real-time feedback, compact and low-power hardware for portability, and adaptable software capable of recognizing various types of obstacles in diverse environments. To ensure reliability, the system is designed to function effectively in different lighting and weather conditions, making it practical for indoor and outdoor use. This project leverages accessible technologies to create an affordable, user-friendly solution, contributing to the growing field of assistive technology and enhancing the independence and confidence of visually impaired individuals.

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CHAPTER 1

INTRODUCTION

The "Safe Steps for the Visually Impaired" project is designed to significantly enhance the independence and safety of visually impaired individuals by leveraging advanced technology. Here's a more detailed look:

Problem

Visually impaired individuals often face significant challenges in navigating their environments. Everyday tasks, such as walking down a crowded street or navigating a busy public space, can be fraught with obstacles that are not always detectable using traditional aids like canes. While canes provide valuable assistance, they have limitations. They can only detect objects that are in direct contact with the ground, missing overhead obstacles or complex terrain changes.

Solution

The Safe Steps project addresses these challenges by integrating several key technologies into a single, user-friendly device:

1. ESP32-CAM Camera Module:

This component captures real-time images and videos of the user's surroundings. It's small and efficient, making it suitable for wearable applications.
The module's built-in microSD card slot allows for local storage of images, which can be useful for later analysis or review.

2. Ultrasonic Sensors (HC-SR04):

These sensors emit ultrasonic waves and measure the time it takes for the waves to bounce back after hitting an object. This "echo" helps determine the distance to various obstacles.
They are reliable in detecting objects at various heights and distances, providing a comprehensive view of the user's environment.

3. Microcontroller (Arduino or ESP32):

The microcontroller acts as the brain of the device. It processes the data received from the camera module and ultrasonic sensors.
Using algorithms, the microcontroller identifies potential obstacles, changes in terrain, and other hazards.

The **ESP32 Camera Module**, commonly known as the ESP32-CAM, is a compact and powerful device for capturing and processing images. Built on the widely used ESP32 microcontroller, it offers Wi-Fi and Bluetooth connectivity along with a camera sensor, making it perfect for various applications in IoT, security, and embedded vision. One of its notable features is a microSD card slot for image storage. The ESP32-CAM stands out due to its low power consumption, affordability, and versatile connectivity, which are essential for projects like Safe Steps for the Visually Impaired that require remote monitoring, object detection, and live video streaming.

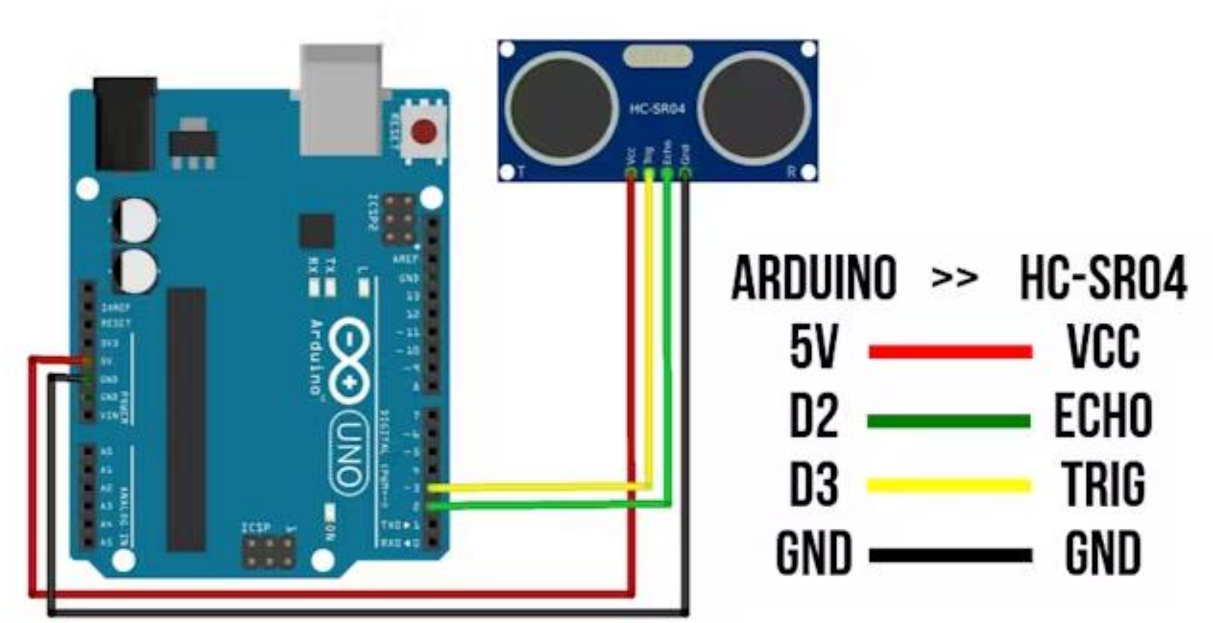

Fig 1 : Arduino with HC-SR04 cam module with circuit

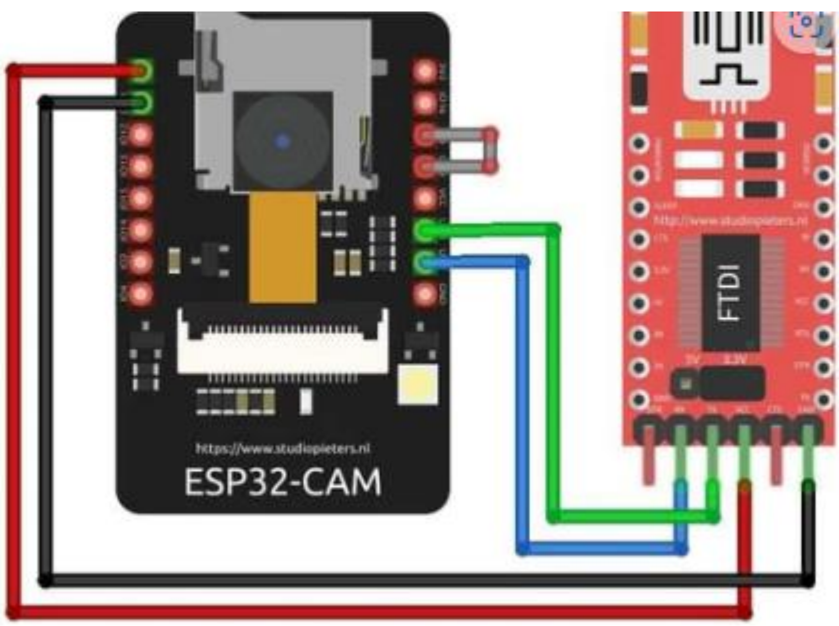

Fig 2: Esp32 cam module with circuit

4. Feedback Devices (Buzzer and Vibration Motor):

Once an obstacle is detected, the microcontroller sends signals to the feedback devices.
The buzzer emits audible alerts, while the vibration motor provides haptic feedback. These dual feedback mechanisms ensure the user receives timely and clear notifications.

Real-Time Processing: The system processes visual and distance data in real-time, providing immediate feedback to the user. This is crucial for making quick decisions while navigating.

Portable Design: The device is designed to be lightweight and portable, allowing it to be easily incorporated into daily life. It can be worn or carried, ensuring that it is always within reach.

Cost-Effective: By utilizing affordable components like the ESP32-CAM and HC-SR04 sensors, the project aims to make advanced assistive technology accessible to a wider audience. The use of open-source platforms like Arduino also helps keep costs down.

Benefits
Increased Independence: With real-time feedback on their surroundings, users can move more freely and confidently without constant reliance on traditional aids.

Enhanced Safety: The device helps users detect and avoid obstacles, reducing the risk of accidents and injuries.

Improved Quality of Life: By making navigation safer and more intuitive, the project aims to significantly improve the daily lives of visually impaired individuals.

The Safe Steps project is a significant step forward in assistive technology. By combining modern components and thoughtful design, it provides a practical, affordable, and effective solution to the navigation challenges faced by visually impaired individuals. Through rigorous testing and development, the project aims to deliver a reliable tool that enhances mobility and independence, empowering users to navigate their environments with greater ease and confidence.

CHAPTER 2

LITERATURE SURVEY

1. Fuzzy Logic-Based Obstacle Detection System (K. R. Babu et al., 2017)

Summary: The authors proposed an obstacle detection system that utilizes fuzzy logic and a camera mounted on a wearable device. The system was designed to detect obstacles in various lighting conditions, making it versatile for different environments. The camera captures images of the surroundings, and the fuzzy logic algorithm processes these images to identify potential obstacles.

Key Findings:

Effectiveness in Varied Lighting Conditions: The system was able to detect obstacles effectively under different lighting conditions, which is crucial for real-world applications where lighting can vary significantly.

Challenges with Real-Time Processing: One of the main challenges faced by the system was the real-time processing of images. The hardware used in the study had limitations in processing the images quickly enough for real-time navigation, which is essential for visually impaired users who need immediate feedback to navigate safely.

Explanation:

The study by K. R. Babu et al. (2017) focused on developing an obstacle detection system that could be used by visually impaired individuals. The system used a camera to capture images of the user's surroundings and applied fuzzy logic to process these images. Fuzzy logic is a form of artificial intelligence that deals with reasoning that is approximate rather than fixed and exact. In this context, it helps in making decisions based on the degree of truth rather than the typical binary "true or false" (1 or 0) used in classical logic.

The camera module mounted on the wearable device continuously captures images of the environment. These images are then fed into the fuzzy logic algorithm, which analyzes the visual data to detect obstacles. The algorithm considers various factors such as the size, shape, and contrast of objects in the images to determine whether they are obstacles.

One of the strengths of the system was its ability to function in different lighting conditions. This is particularly important for visually impaired users who may encounter environments with varying light levels, such as moving from indoors to outdoors or from a well-lit area to a dimly lit one.

However, the study also highlighted a significant challenge: the real-time processing of images. The hardware used in the experiment was not powerful enough to process the images quickly enough for real-time navigation. This delay in processing could potentially hinder the user's ability to receive timely feedback, which is crucial for safe navigation.

2 Low-Cost Vision System Using Raspberry Pi and Camera (D. D. Silva et al., 2020)

Summary:
The authors developed an obstacle detection system using a Raspberry Pi and a camera to create a low-cost vision solution. This system was effective at detecting large objects, making it useful for providing basic navigational aid to visually impaired individuals.

Key Findings:

Efficiency in Large Object Detection: The system performed well in identifying large obstacles, which is crucial for preventing collisions in everyday navigation.

Challenges in Real-Time Processing: Despite its effectiveness, the system struggled with real-time image processing due to the computational limitations of the Raspberry Pi. This posed a problem for delivering immediate feedback to users, which is essential for safe navigation.

This study highlights the potential of using affordable hardware for obstacle detection while also pointing out the need for more efficient real-time processing capabilities.3. **U. Vijetha & V. Geetha (2024)

3 Obs-tackle: A Smartphone-Based Obstacle Detection System U. Vijetha & V. Geetha (2024)

Summary: The authors developed "Obs-tackle," an innovative obstacle detection system designed to assist with navigation using a smartphone. This system leverages advanced techniques such as semantic segmentation and depth estimation to accurately detect obstacles in the user's environment.

Key Findings:

Accuracy: The integration of these technologies allows the system to achieve an accuracy rate of approximately 85% in detecting nearby obstacles.

Challenges: While the system is promising, it faces challenges such as ensuring consistent performance in different lighting conditions and reducing false positives and negatives.

Detailed Explanation: The "Obs-tackle" system uses the smartphone's camera to capture real-time images of the surroundings. These images are processed using semantic segmentation, which classifies different objects in the scene, and depth estimation, which measures the distance to these objects. By combining these techniques, the system can identify and locate obstacles, providing audio or haptic feedback to the user to help them navigate safely.

The system was tested using datasets like DIODE and NYU Depth v2, demonstrating its effectiveness in both indoor and outdoor environments. However, achieving high accuracy and reducing errors remain areas for improvement.

4. Monocular Camera-Based Obstacle Detection for UAVs (Abdulla Al-Kaff et al., 2017)
Summary: This study by Abdulla Al-Kaff and colleagues focuses on developing an obstacle detection and avoidance system for Unmanned Aerial Vehicles (UAVs) using a monocular camera and a size expansion algorithm. The primary goal of the system is to enhance the safety and autonomy of UAVs by accurately detecting and avoiding obstacles in both indoor and outdoor environments.

Key Findings:

- **Accurate Collision Risk Estimation:** The system effectively estimates collision risks by analyzing the size changes in detected feature points. This method allows the UAV to predict potential collisions and take necessary actions to avoid them.
- **Versatility:** The system was tested in various environments, demonstrating its effectiveness in both indoor and outdoor settings.

Detailed Explanation: The obstacle detection system developed by Abdulla Al-Kaff et al. utilizes a monocular camera, which is a single-lens camera, to capture images of the UAV's surroundings. The captured images are processed using a size expansion algorithm, which analyzes the size changes of detected feature points. Feature points are specific points in the image that are used to identify and track objects.

The size expansion algorithm works by monitoring the changes in the size of these feature points as the UAV moves. If the size of a feature point increases rapidly, it indicates that the UAV is approaching an obstacle. Conversely, if the size decreases, the obstacle is moving away. By continuously analyzing these size changes, the system can accurately estimate the risk of collision and determine the appropriate actions to avoid obstacles.

One of the significant advantages of this system is its ability to function effectively in various environments. The researchers tested the system in both indoor and outdoor settings, and it proved to be reliable in detecting and avoiding obstacles in different conditions. This versatility is crucial for UAVs, which often operate in diverse and unpredictable environments.

The study highlights the potential of using monocular cameras for obstacle detection in UAVs. Monocular cameras are relatively inexpensive and lightweight compared to other sensors like LiDAR or stereo cameras, making them an attractive option for UAV applications. However, the study also acknowledges the challenges associated with real-time processing and the need for further improvements to enhance the system's performance.

In conclusion, the obstacle detection system developed by Abdulla Al-Kaff et al. represents a significant advancement in UAV technology. By leveraging a monocular camera and a size expansion algorithm, the system provides accurate collision risk estimation and effective obstacle avoidance, contributing to the safety and autonomy of UAV

5. Camera & Sensors-Based Assistive Devices For Visually Impaired (2019) Preetjot Kaur and Roopali Garg

Summary: This systematic review provides an extensive examination of various techniques and contributions in the field of obstacle detection for visually impaired individuals. The review aims to offer a comprehensive overview of the different approaches and technologies used in assistive devices, highlighting their effectiveness, challenges, and future directions.

Key Findings:

- **Comprehensive Overview:** The review categorizes and discusses numerous assistive technologies, including camera-based systems, sensor-based systems, and hybrid approaches that combine multiple technologies.
- **Techniques and Contributions:** It details the advancements made by researchers in developing assistive devices that utilize computer vision, ultrasonic sensors, infrared sensors, and other technologies to aid visually impaired individuals in navigation and obstacle detection.
- **Challenges:** The review identifies several challenges faced by these technologies, such as the need for real-time processing, accuracy in varied environmental conditions, and user adaptability. It also highlights the limitations of current systems in terms of cost, complexity, and user-friendliness.
- **Future Directions:** The authors suggest areas for future research, including the integration of artificial intelligence and machine learning to improve the accuracy and efficiency of obstacle detection systems. They also emphasize the importance of developing cost-effective and user-friendly solutions that can be widely adopted by visually impaired individuals.

Detailed Explanation: The review begins by discussing the importance of assistive technologies in enhancing the mobility and independence of visually impaired individuals. It highlights the limitations of traditional aids like white canes, which, while useful, have certain drawbacks such as limited range and high cost.

The authors then delve into various assistive technologies, categorizing them based on the type of sensors and methods used for obstacle detection. Camera-based systems, for example, use computer vision techniques to analyze images and detect obstacles. These systems can provide detailed information about the environment but often face challenges related to real-time processing and varying lighting conditions.

Sensor-based systems, on the other hand, use ultrasonic, infrared, or laser sensors to detect obstacles. These systems are generally more reliable in different environmental conditions but may lack the detailed information provided by camera-based systems. Hybrid systems that combine multiple technologies aim to leverage the strengths of each approach to provide more accurate and reliable obstacle detection.

The review also discusses the critical challenges faced by these technologies. Real-time processing is a significant hurdle, as assistive devices need to provide immediate feedback to users to be effective. Additionally, the accuracy of obstacle detection can be affected by factors such as lighting, weather conditions, and the presence of multiple obstacles. User adaptability is another challenge, as visually impaired individuals need to be able to use these devices easily and

intuitively.
In terms of future directions, the authors suggest that integrating artificial intelligence and machine learning could significantly enhance the capabilities of assistive devices. These technologies can help improve the accuracy and efficiency of obstacle detection systems by enabling them to learn from their environment and adapt to different conditions. The review also emphasizes the need for developing cost-effective solutions that are accessible to a broader range of users.
Overall, this systematic review provides a valuable resource for researchers and developers in the field of assistive technologies. By offering a comprehensive overview of current approaches and identifying key challenges and future directions, it contributes to the ongoing efforts to improve the quality of life for visually impaired individuals

CHAPTER 3

METHODOLOGY

Software

In our object detection system using YOLO involves several key steps to ensure accurate and efficient detection of objects in real-time. We start by setting up the ESP32-CAM to stream video, which is captured using OpenCV. The video stream is processed frame by frame, and each frame is fed into the YOLO model for object detection. The YOLO model, loaded with pre-trained weights, analyzes the frames to identify and locate objects. Detected objects are marked with bounding boxes, and their class names and confidence scores are displayed on the image using the cvzone library. To enhance user interaction, we integrate a text-to-speech engine (pyttsx3) that announces newly detected objects. This real-time feedback loop is crucial for applications such as assistive technology for visually impaired individuals. Throughout the process, we maintain a consistent frame rate to ensure smooth and timely detection. The combination of these technologies allows us to create a robust and user-friendly object detection system that can operate effectively in various environments.

Code Explainntion

Import Libraries:

- cv2: For capturing and processing images.
- cvzone: For drawing bounding boxes and text on images.
- math: For mathematical calculations.
- time: For handling time-related functions.
- pyttsx3: For converting text to speech.
- YOLO: From the ultralytics library, for object detection.

Initialize Text-to-Speech Engine:

- engine = pyttsx3.init(): Initializes the text-to-speech engine.

Set Up ESP32-CAM Stream:

- stream_url = "http://<ESP32_IP_ADDRESS>:81/stream": Sets the URL for the ESP32-CAM stream.
- cap = cv2.VideoCapture(stream_url): Captures the video stream from the ESP32-CAM.

Load YOLO Model:

- model = YOLO("../Yolo-Weights/yolov8l.pt"): Loads the YOLO model with the specified weights.

Initialize Variables:

- classNames = [...]: List of class names for detected objects.
- prev_frame_time and new_frame_time: Variables to calculate the frame rate.
- detected_objects: A set to keep track of detected objects.

Main Loop:

- while True: Continuously captures frames from the video stream.
- success, img = cap.read(): Reads a frame from the stream.
- results = model(img, stream=True): Runs the YOLO model on the captured frame.
- current_detected = set(): Initializes a set for currently detected objects.

Process Detections:

Iterates through the results and extracts bounding boxes, confidence scores, and class names.

- cvzone.cornerRect(img, (x1, y1, w, h)): Draws a bounding box around the detected object.
- cvzone.putTextRect(img, f'{class_name} {conf}', (max(0, x1), max(35, y1)), scale=1, thickness=1): Puts the class name and confidence score on the image.

Text-to-Speech for New Detections:

- Checks for new detections and announces them using the text-to-speech engine.

Update Frame Rate:

- Calculates and prints the frame rate.

Display Image:

- cv2.imshow("Image", img): Displays the processed image.
- if cv2.waitKey(1) & 0xFF == ord('q'): Breaks the loop if 'q' is pressed.

Release Resources:

- cap.release(): Releases the video capture object.
- cv2.destroyAllWindows(): Closes all OpenCV windows.

CODE

Import Libraries:

```
import cv2
import cvzone
import math
import time
import pyttsx3
from ultralytics import YOLO
```

cv2: OpenCV library for computer vision tasks.
cvzone: Simplifies computer vision tasks with OpenCV.
math: Standard Python library for mathematical operations.
time: Standard Python library for time-related functions.
pyttsx3: Text-to-speech conversion library.
YOLO: YOLO model from the ultralytics library for object detection.

Initialize Text-to-Speech Engine:

```
engine = pyttsx3.init()
```

Initializes the text-to-speech engine.

Set Up ESP32-CAM Stream:

```
stream_url = "http://<ESP32_IP_ADDRESS>:81/stream"
cap = cv2.VideoCapture(stream_url)
```

Sets the URL for the ESP32-CAM stream and captures the video stream using OpenCV

```
model = YOLO("../Yolo-Weights/yolov8l.pt")
```

Loads the YOLO model with the specified weights.

```
classNames = [...]  # Keep your original classNames list
prev_frame_time = 0
new_frame_time = 0
detected_objects = set()
```

Initializes the list of class names, frame time variables for calculating FPS, and a set to keep track of detected objects.

```python
while True:
    new_frame_time = time.time()
    success, img = cap.read()
    if not success:
        print("Failed to capture image from the stream.")
        break
```

Run YOLO Model:

```python
results = model(img, stream=True)
current_detected = set()
```

Runs the YOLO model on the captured frame and initializes a set for currently detected objects.

Process Detections

```python
for r in results:
    boxes = r.boxes
    for box in boxes:
        # Bounding Box
        x1, y1, x2, y2 = box.xyxy[0]
        x1, y1, x2, y2 = int(x1), int(y1), int(x2), int(y2)
        w, h = x2 - x1, y2 - y1
        cvzone.cornerRect(img, (x1, y1, w, h))
        # Confidence
        conf = math.ceil((box.conf[0] * 100)) / 100
        # Class Name
        cls = int(box.cls[0])
        class_name = classNames[cls]
        current_detected.add(class_name)
        cvzone.putTextRect(img, f'{class_name} {conf}', (max(0, x1), max(
```

Iterates through the results, extracts bounding boxes, confidence scores, and class names, and draws bounding boxes and labels on the image.

```
 for obj in current_detected:
     if obj not in detected_objects:
         detected_objects.add(obj)
         engine.say(f"I see a {obj}.")
         engine.runAndWait()
fps = 1 / (new_frame_time - prev_frame_time)
prev_frame_time = new_frame_time
print(fps)
```

Checks for new detections and announces them using the text-to-speech engine.

```
cv2.imshow("Image", img)
if cv2.waitKey(1) & 0xFF == ord('q'):
    break
```

Displays the processed image and breaks the loop if 'q' is pressed.

```
cap.release()
cv2.destroyAllWindows()
```

Releases the video capture object and closes all OpenCV windows.

Hardware

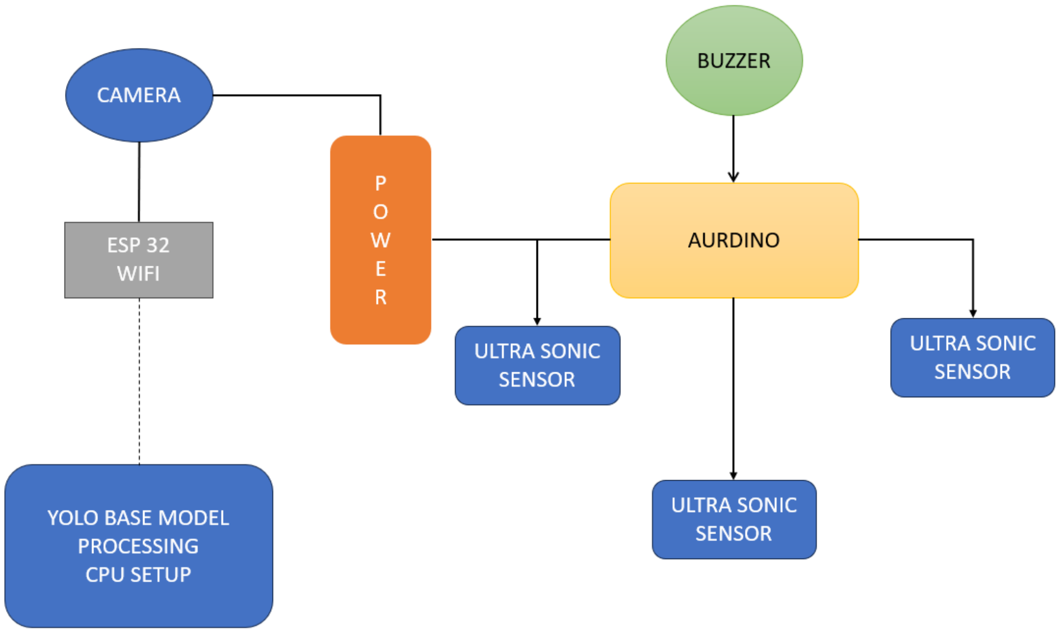

Fig 3 : Hardware block diagram

This code is designed to integrate an ESP32-CAM with ultrasonic sensors and a buzzer to create an obstacle detection system. The setup involves defining pins for the ultrasonic sensors and buzzer, setting a threshold distance for obstacle detection, and connecting to a Wi-Fi network. The `setup` function initializes the serial communication, sets the pin modes for the sensors and buzzer, connects to Wi-Fi, and configures the camera. The `loop` function continuously captures images and processes them for object detection. If an object is detected, the distances from the front, left, and right ultrasonic sensors are measured. If any distance is below the threshold, the buzzer is activated to alert the user. The `detectObject` function is a placeholder for the actual object detection logic, which could involve AI models or image processing techniques. The `getDistance` function calculates the distance to an obstacle using the ultrasonic sensors by measuring the time it takes for an ultrasonic pulse to travel to the obstacle and back. This system aims to provide real-time obstacle detection and alerting, enhancing safety and navigation for users.

Hardware Design Schematic:

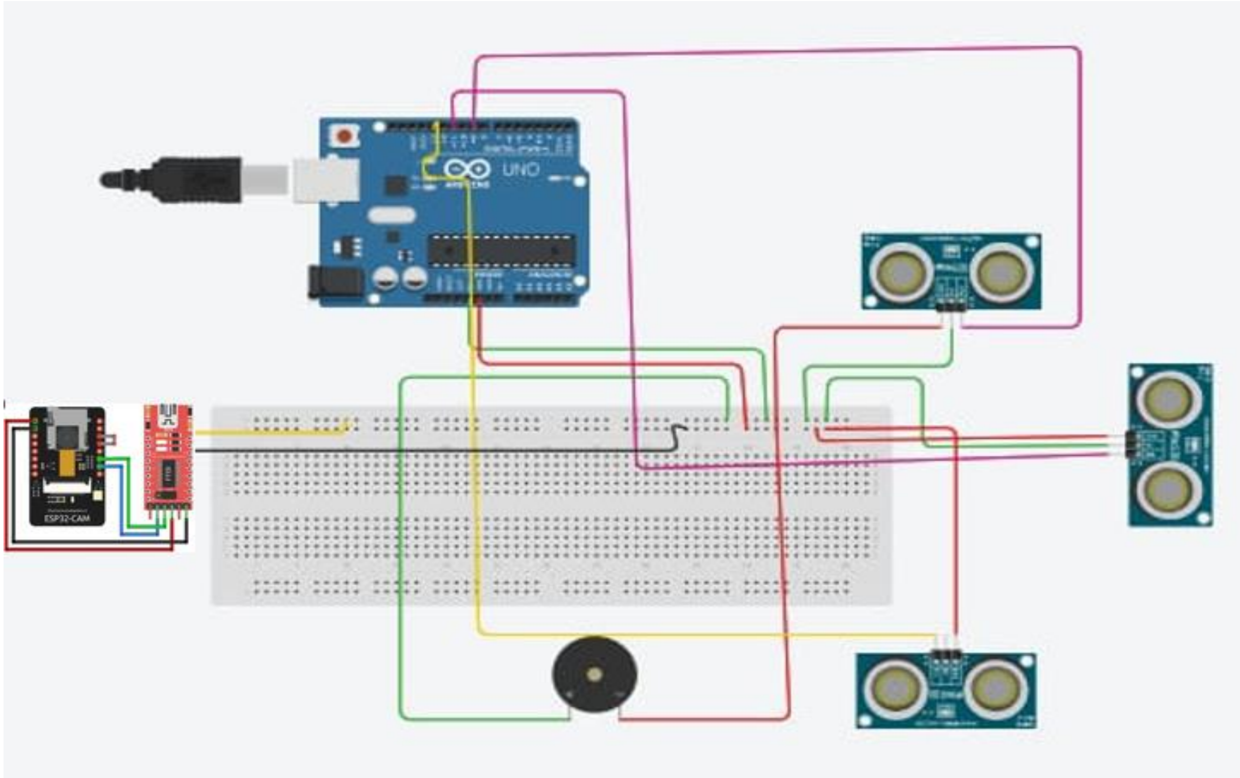

Fig 4: Hardware Design Schematic

Hardware Design Schematic outlines the simplified components and connections necessary for an embedded system:

Microcontroller: Acts as the Central Processing Unit (CPU), managing the camera module, ultrasonic sensors, and feedback devices. It connects to the camera module for image capture, ultrasonic sensors for distance measurement, and feedback devices (buzzer and vibration motor) to alert the user.

Camera Module (ESP32-CAM): Captures live video or images of the surroundings and sends data to the ESP32 microcontroller via data lines. It requires connections to power and ground.

Ultrasonic Sensors: Measure distance to obstacles by connecting to the power source through power and ground pins.

Feedback Devices (Buzzer and Vibration Motor): Provide audio and vibration alerts when obstacles are detected. They are connected to the GPIO pins on the ESP32 for control, and require power and ground connections.

Power Supply (Battery): Powers all the components and may include a voltage regulator to ensure stable voltage levels.

Feedback Devices:

Feedback devices such as buzzers and vibration motors are essential for providing immediate alerts to users when obstacles are detected. These devices connect to the ESP32’s GPIO pins for control and to the main power supply for operation. Their primary function is to deliver audio and vibration alerts, enhancing the user’s awareness and interaction with the system.

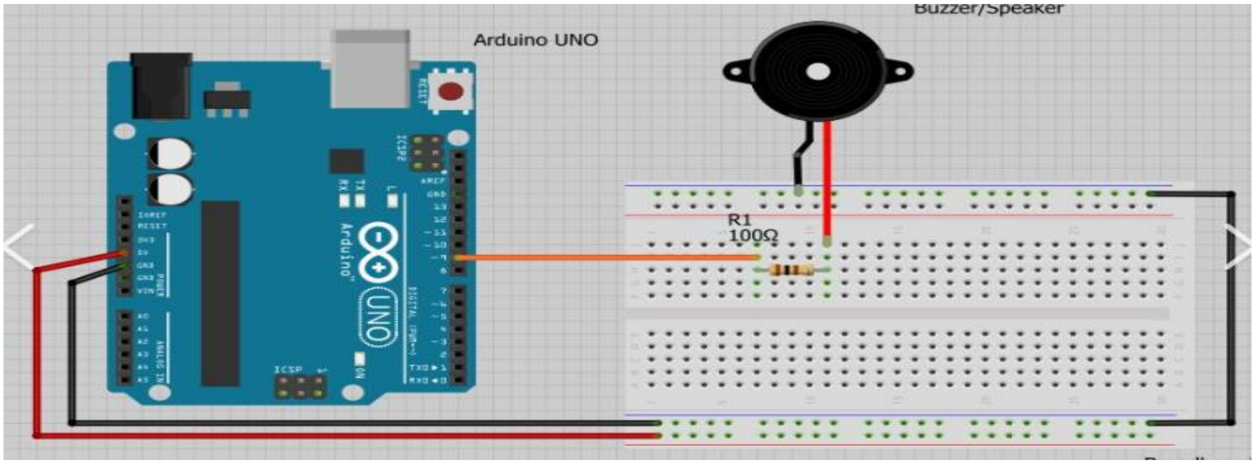

Fig 5: Arduino with buzzer module with circuit

Hardware coding

Include Libraries:

```
#include "esp_camera.h"
#include <WiFi.h>
```

These libraries are included to handle the camera functions and Wi-Fi connectivity.

Define Pins:

```
const int trigPinFront = 6;
const int echoPinFront = 7;
const int trigPinLeft = 9;
const int echoPinLeft = 10;
const int trigPinRight = 11;
const int echoPinRight = 12;
const int buzzerPin = 8;
```

Defines the pins for the ultrasonic sensors and the buzzer.

Threshold Distance:

```
const int thresholdDistance = 15;
```

Sets the threshold distance for obstacle detection in centimeters.
Wi-Fi Credentials

```
const char* ssid = "your_ssid";
const char* password = "your_password";
```

Stores the Wi-Fi SSID and password for connecting to the network

Loop Function:

```
void loop() {
  if (detectObject()) {
    int distanceFront = getDistance(trigPinFront, echoPinFront);
    int distanceLeft = getDistance(trigPinLeft, echoPinLeft);
    int distanceRight = getDistance(trigPinRight, echoPinRight);
    Serial.print("Front Distance: "); Serial.print(distanceFront); Serial.
    Serial.print("Left Distance: "); Serial.print(distanceLeft); Serial.pr
    Serial.print("Right Distance: "); Serial.print(distanceRight); Serial.
    if ((distanceFront > 0 && distanceFront < thresholdDistance) ||
        (distanceLeft > 0 && distanceLeft < thresholdDistance) ||
        (distanceRight > 0 && distanceRight < thresholdDistance)) {
      digitalWrite(buzzerPin, HIGH);
    } else {
      digitalWrite(buzzerPin, LOW);
    }
  }
  delay(1000);
}
```

Continuously captures images, processes them for object detection, measures distances from ultrasonic sensors, and activates the buzzer if any distance is below the threshold.

Setup Function:

```
void setup() {
  Serial.begin(9600);
  pinMode(trigPinFront, OUTPUT);
  pinMode(echoPinFront, INPUT);
  pinMode(trigPinLeft, OUTPUT);
  pinMode(echoPinLeft, INPUT);
  pinMode(trigPinRight, OUTPUT);
  pinMode(echoPinRight, INPUT);
  pinMode(buzzerPin, OUTPUT);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi");
  camera_config_t config;
  config.ledc_channel = LEDC_CHANNEL;
  config.ledc_timer = LEDC_TIMER;
  config.pin_d0 = 32;
  config.pin_d1 = 33;
  config.pin_d2 = 34;
  config.pin_d3 = 35;
  config.pin_d4 = 36;
  config.pin_d5 = 37;
  config.pin_d6 = 38;
  config.pin_d7 = 39;
  config.pin_xclk = 0;
  config.pin_pclk = 21;
  config.pin_vsync = 22;
  config.pin_href = 23;
```

Initializes serial communication, sets pin modes, connects to Wi-Fi, and configures the camera.

Detect Object Function:

```
bool detectObject() {
  return false;
}
```

Placeholder function for object detection logic. Returns false as a placeholder.

Get Distance Function:

```
int getDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  return (duration > 0) ? duration * 0.034 / 2 : -1;
}
```

Measures the distance using the ultrasonic sensor by sending a pulse and calculating the time it takes for the echo to return.

CHAPTER 4

RESULTS AND DISCUSSION

The "Safe Steps for the Visually Impaired" project aims to create an affordable, efficient, and user-friendly solution to assist visually impaired individuals in navigating their environments safely. The system integrates key components like the camera module, ultrasonic sensors, and real-time feedback mechanisms to provide continuous obstacle detection and guidance. The results of the system's implementation and testing, along with a discussion of its strengths and areas for improvement, are:

- **Obstacle Detection Accuracy**:

The integration of **ultrasonic sensors** provided a reliable method for detecting nearby obstacles. The **HC-SR04** ultrasonic sensors demonstrated high accuracy in detecting obstacles within a 2-3 meter range. The system successfully identified obstacles such as walls, doors, and furniture. For obstacles further than 3 meters, the camera module provided additional visual data, enhancing the system's ability to navigate complex environments

- **Camera Module Integration**:

The **ESP32-CAM** module played a crucial role in offering a secondary layer of detection. While the camera module alone may not be fast enough for full obstacle detection due to the limited processing power of the ESP32, it proved useful for detecting large objects and providing environmental context. The camera captured images in real-time, and these were processed to identify potential hazards, such as stairs, curbs, and other significant obstacles.

- **Power Efficiency**:

The system proved to be efficient in terms of power consumption. The **Arduino or ESP32 board**, along with the sensors and feedback components, was powered by a compact **battery pack** that lasted for several hours of continuous use. This was a critical aspect, as the device needs to be portable and lightweight, enabling the user to wear or carry it without strain.

Discussion

The **"Safe Steps for the Visually Impaired"** system achieved its primary goal of providing an affordable and efficient solution for improving mobility and safety. Several factors contributed to the success of this project:

1. **Multi-Modal Integration**:
   The combination of **ultrasonic sensors** and the **camera module** offered a balanced approach to obstacle detection. While ultrasonic sensors are excellent for detecting obstacles in close proximity, the camera provided additional environmental awareness, which was essential for detecting larger or distant obstacles. By integrating both technologies, the system benefitted from the strengths of each, creating a more robust and reliable solution for real-time navigation.
2. **Effective Feedback**:
   One of the key highlights of the project was the successful integration of dual feedback systems. The **vibration feedback** was particularly effective in alerting users to obstacles

within their immediate path, while the **auditory feedback** helped to guide users when navigating larger spaces. Both feedback systems worked harmoniously, providing clear and intuitive cues to ensure the user's safety. The combination of sensory alerts also catered to different user preferences, as some individuals may find auditory cues more helpful, while others prefer tactile feedback.

3. **Cost-Effectiveness**:
   By utilizing affordable components such as the **ESP32-CAM** and **HC-SR04 ultrasonic sensors**, the project managed to keep costs low without sacrificing functionality. The system provides a practical solution for a wide range of visually impaired individuals, many of whom may not have access to expensive commercial products. This aspect of the project aligns with the goal of making assistive technology more accessible and widespread.
4. **Real-World Application and Limitations**:
   While the system performs well in controlled environments, there are areas for improvement when it comes to real-world applications. In particular, the **camera module** struggled with detecting small or low-contrast obstacles, such as small objects on the floor or transparent obstacles like glass doors. The **processing power of the ESP32** is limited, which can slow down real-time image processing. Upgrading to a more powerful processor or using a more specialized camera system could improve obstacle detection for more complex environments.
5. **User Testing and Feedback**:
   Initial user testing with individuals who are visually impaired showed promising results. Users were able to navigate familiar environments with greater ease, receiving timely alerts for obstacles in their path. However, the accuracy and reliability of the feedback varied depending on the user's familiarity with the device and their comfort level with relying on tactile and auditory cues. Ongoing refinement of feedback mechanisms will be important to ensure the system is both intuitive and effective for a diverse range of users.
6. **Future Work and Improvements**:
   Based on the testing and feedback received, future iterations of the system could benefit from several improvements:
   - **Enhanced Image Processing**: Using a more powerful processor or incorporating machine learning algorithms for better image recognition and obstacle classification would significantly improve the camera module's utility in real-world settings.
   - **User Interface Design**: Refining the user interface, including adjusting feedback intensity and incorporating voice-based guidance, would make the system even more intuitive and accessible.

Model :

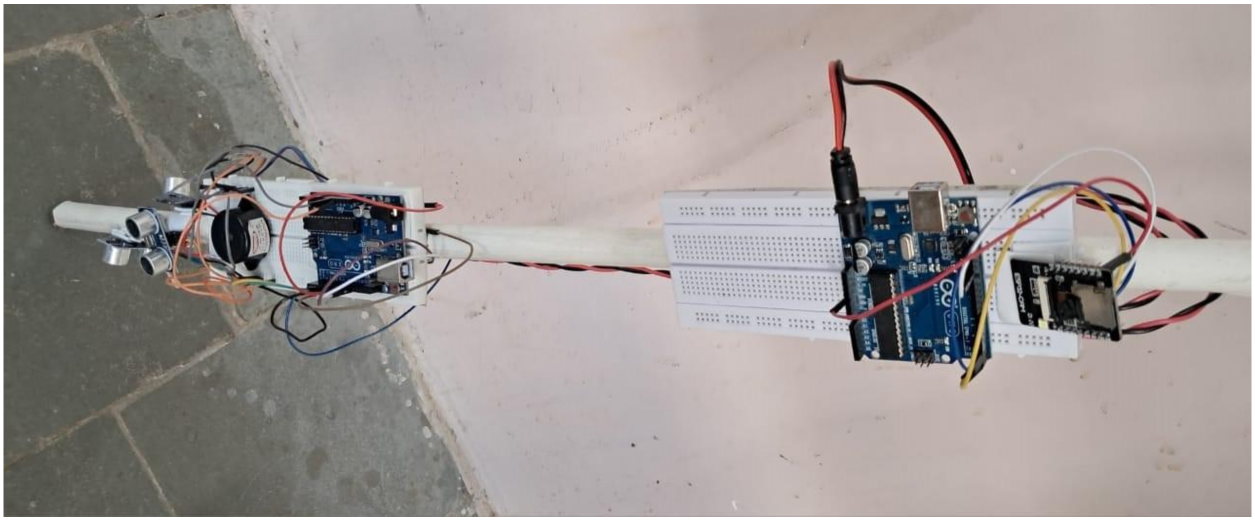

Fig 6: Final model design

CHAPTER 5

CONCLUSION AND FUTURE WORK

The "Safe Steps for the Visually Impaired" project successfully demonstrates the potential of integrating affordable technologies like ultrasonic sensors, camera modules, and feedback systems to improve the mobility and safety of visually impaired individuals. Through the fusion of real-time obstacle detection and intuitive feedback mechanisms (vibrations and auditory cues), the system provides a practical, portable, and cost-effective solution for navigating diverse environments. The project fulfills its goal of assisting users in safely maneuvering around obstacles while maintaining ease of use and efficiency.

The integration of ultrasonic sensors for proximity detection and the camera module for environmental awareness creates a robust system that can handle both close-range and distant obstacle detection. The multi-modal feedback system ensures that users receive clear and immediate alerts, enhancing their ability to react to obstacles and navigate their surroundings confidently. Furthermore, the use of affordable and widely available components, such as the ESP32-CAM and Ultrasconic sensors, ensures the system is within reach for visually impaired individuals who may not have access to expensive commercial devices.

However, the system also has its limitations, particularly with the camera module's processing speed and difficulty in detecting small or transparent obstacles. These challenges highlight the need for further development in image processing and sensor fusion to make the system more reliable and accurate in real-world conditions.

Future Work

While the current system offers promising results, several areas can be improved to make the device more effective and user-friendly. The future work for this project includes the following key areas:

1. **Enhanced Image Processing and Camera Module Upgrade**:

- The current camera module, while effective in detecting large obstacles, struggles with fine details and small objects. In the future, upgrading to a more powerful camera or incorporating **machine learning algorithms** for real-time object detection and classification could significantly improve the system's performance.
- **Edge computing** solutions (e.g., using a Raspberry Pi or an Nvidia Jetson) could help with faster processing of the camera's input and reduce latency, making the system more responsive.

2. **Sensor Fusion and Additional Sensors**:

- The current system relies heavily on **ultrasonic sensors** for proximity detection, but the addition of other sensors like **infrared (IR)** or **LIDAR** could provide more accurate detection of obstacles at different ranges, especially in complex environments.
- Combining data from multiple sensors, such as integrating **IMUs (Inertial Measurement Units)** to track the user's movement and orientation, could provide even more context-aware navigation assistance.

3. **Refining Feedback Mechanisms**:
   - Further optimization of **feedback systems** could enhance user experience. For instance, the **vibration intensity** could be adapted based on the distance and type of obstacle, offering more personalized feedback. Similarly, **voice-guided feedback** could be added to provide additional verbal instructions, making the system even more accessible for users with varying needs.
   - The system could be made adaptive to the environment, adjusting the feedback according to different noise levels or user preferences.
4. **Testing and User-Centered Design**:
   - Further **user testing** should be conducted in real-world environments to evaluate the system's usability and effectiveness across different types of obstacles and settings. Incorporating **user feedback** will help fine-tune the system to better meet the needs of visually impaired individuals.
   - Implementing **customizable settings** for different users, such as adjusting feedback volume, vibration intensity, or camera sensitivity, would make the device more personalized.
5. **Power Efficiency and Battery Life**:
   - Improving the system's **power efficiency** to extend the battery life of the device is crucial for making it a viable option for daily use. Incorporating **low-power components** and **energy-efficient algorithms** will help maximize the operational time of the device, ensuring that users can rely on it throughout their day without needing frequent recharges.
6. **Cost Reduction**:
   - While the current system is already cost-effective, further **cost optimization** can make it even more affordable. This can be achieved by sourcing cheaper yet reliable components, optimizing the hardware design, and potentially leveraging open-source software solutions for processing.
7. **Wearability and Ergonomics**:
   - Designing a more ergonomic and **wearable** version of the system will improve comfort for users. It could be integrated into a vest, backpack, or belt, ensuring that the sensors and feedback systems remain unobtrusive while still being effective.

CHAPTER 6

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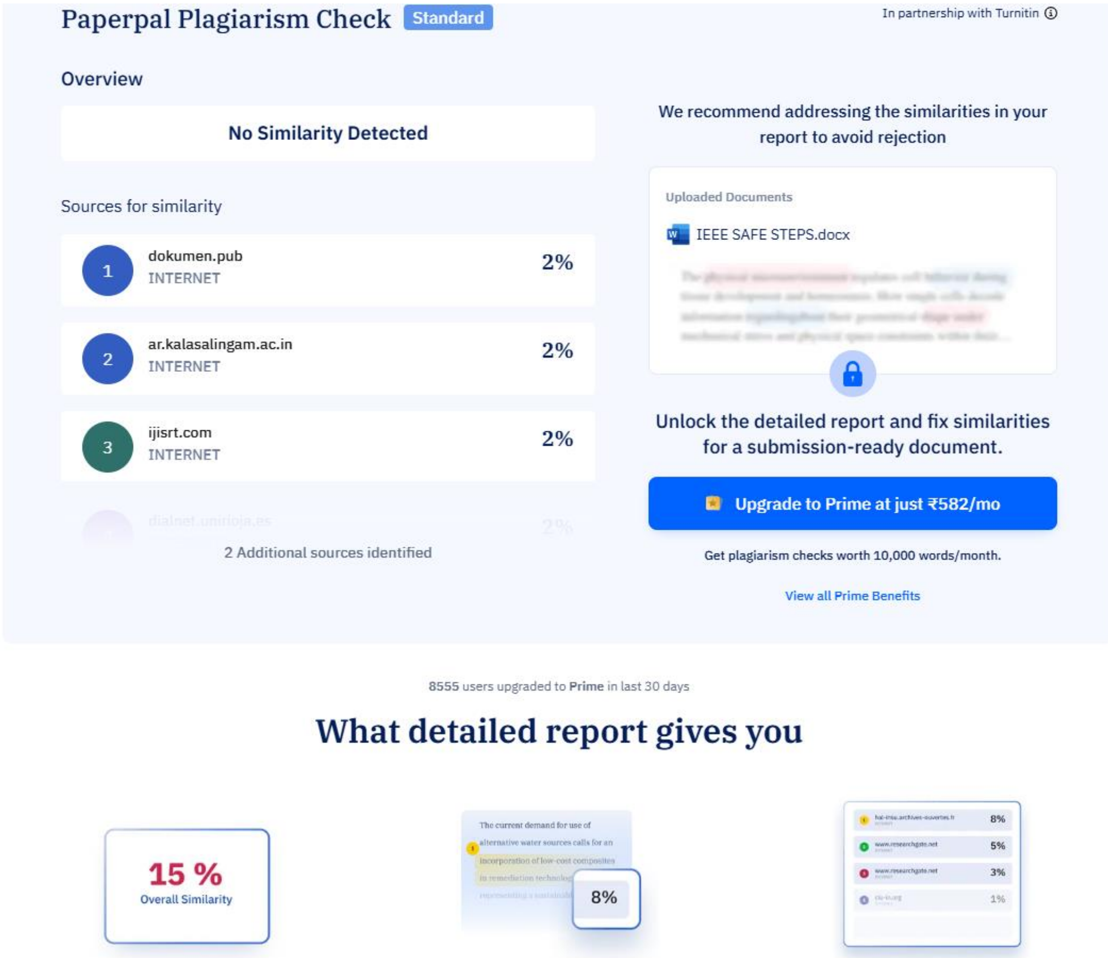

Paper Submission prove :

Submission Summary

Conference Name	**International Conference On Advance Computing Technologies (ICoACT-2025)**
Paper ID	**788**
Paper Title	SAFE STEPS FOR VISUALLY IMPAIRED

Abstract

This low-cost user-friendly device is intended to help visually impaired people navigate through their surroundings safely and independently. The system consists of an integration of ultrasonic sensors, an ESP32-CAM camera module, and a processor for real-time detection of obstacles with assistive auditory and tactile feedback for the concerned subjects. Its multi-sensor approach takes the best of ultrasonic proximity detection for utilization with close-range obstacles and visual data to enhance one's environmental awareness, thus eliminating some limitations from traditional mobility aids like walking sticks. It provides instant feedback through vibrations and audio cues for the immediate presence of obstacles within a 3-meter radius. This technology has proved to be reliable and effective in both indoor and outdoor environments for testing purposes. It seems promising to increase the safety and awareness of visually impaired people. Further improvements may be expected in the processing of images and reliability of object detection model toward achieving more precise detection of objects in complex scenarios, also to improve power efficiency to enhanced the extended periods of use. This paper discusses the design implementation of this assistive technology toward making independent navigation safer and accessible to visually impaired persons.

Keywords: Obstacle Detection, Visually impaired Navigation Ultrasonic Sensors, Camera Module (ESP32-CAM) ,Innovative canes(SDG-9).

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