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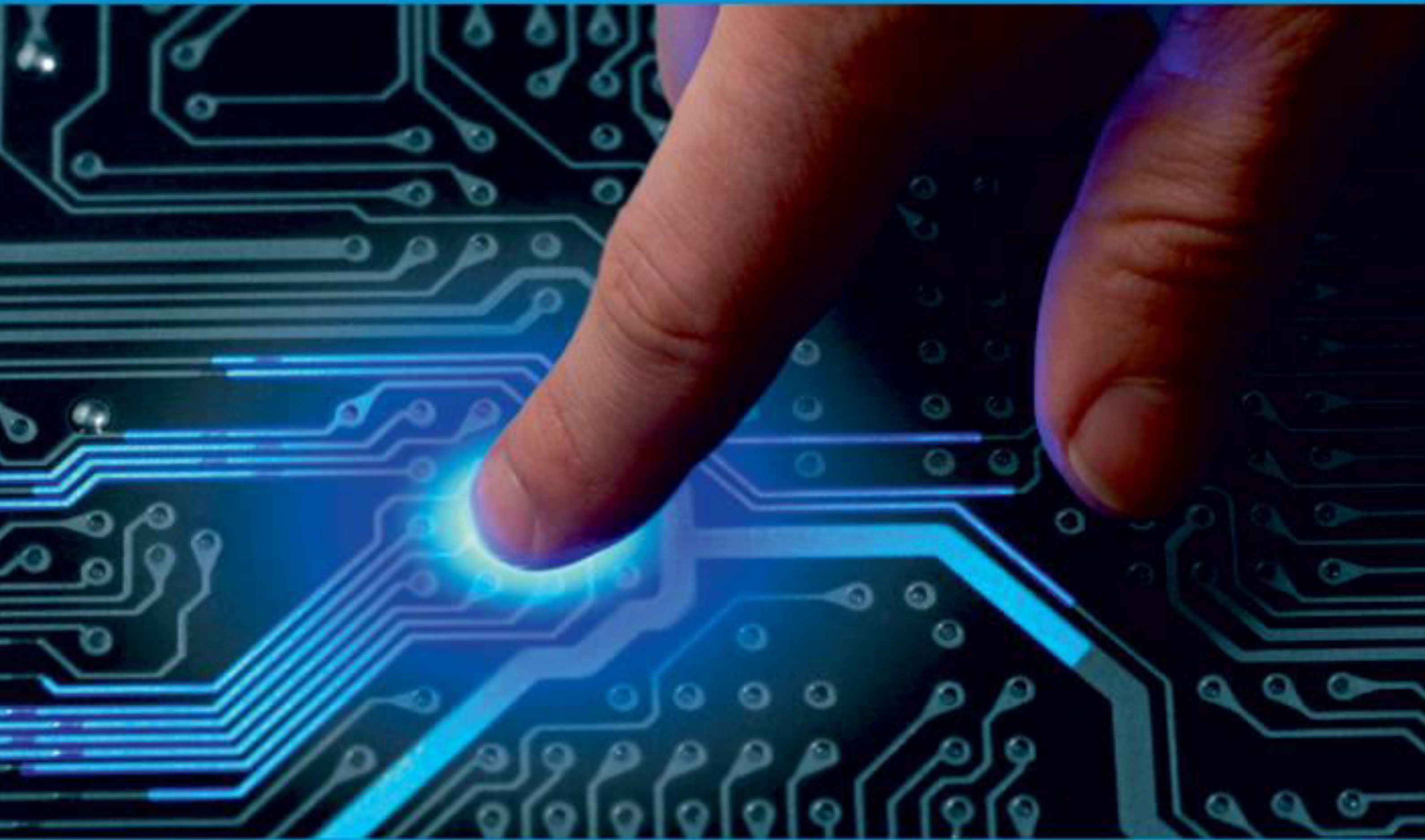

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Smart Glasses Designed for People with Visual Impairments

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ABSTRACT: This paper presents the design and development of smart glasses aimed at assisting people with visual impairments. The system integrates multiple sensor technologies, including ultrasonic and infrared (IR) sensors, along with a camera, all powered by a Raspberry Pi 3 Model B. The glasses help users by detecting obstacles in real-time and converting printed text into speech for easier reading. The combination of various sensor technologies allows for an efficient and cost-effective solution to improve mobility and access to information for visually impaired individuals. Simulated results demonstrate the system's ability to perform well in both obstacle detection and text reading tasks, showing promise as a comprehensive assistive device.

KEYWORDS: Visually impaired, Text recognition, Raspberry Pi, Python

I. INTRODUCTION

Visual impairments affect a significant portion of the global population, with over 12 million people in India alone suffering from blindness, according to the National Programme for Control of Blindness (NPCB). Individuals with visual impairments face challenges in mobility, reading printed text, and interacting with their surroundings. While several assistive technologies have been developed to aid in either obstacle detection or reading, there remains a need for a device that can integrate these functionalities into a single, user-friendly system. The **Smart Glasses** project addresses this gap by combining ultrasonic sensors, IR sensors, a camera, and the Raspberry Pi 3 Model B to provide a portable, affordable, and effective solution for individuals with visual impairments. The system is designed to offer both real-time obstacle detection and text-to-speech conversion, making it a versatile tool for improving the daily lives of users

II. RELATED WORK

A range of assistive technologies for the visually impaired have been developed, primarily focusing on either obstacle detection or reading assistance. Devices like the **Sunu Band** employ ultrasonic sensors to detect obstacles and provide haptic feedback, allowing users to navigate their environments [1]. Similarly, the **Smart Cane** integrates sensors to detect objects in the user's path, though it is limited to providing feedback at ground level [2]. On the reading assistance front, camera-based systems such as **OrCam My Eye** use Optical Character Recognition (OCR) to capture printed text and convert it into speech [3]. However, such systems are often expensive and focus solely on reading, without addressing mobility challenges. Other devices, like Microsoft's **Seeing AI** app, use AI to describe objects and scenes, but these are typically smartphone-based rather than integrated into wearable systems [4]. This paper proposes a system that combines both obstacle detection and reading functionalities into a pair of smart glasses, offering an affordable and efficient solution for visually impaired users.

III. PROPOSED ALGORITHM

A. *Design Considerations:*

The design of the smart glasses involves several key aspects:

- **Sensor Selection**: Ultrasonic sensors are used for long-range obstacle detection, while IR sensors are employed for short-range, precise detection of nearby objects. A camera is used for text recognition
- **Processing Unit**: The Raspberry Pi 3 Model B was chosen as the main processing unit for its cost-effectiveness and ability to handle real-time data from multiple sensors.

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- **User Interface**: The system provides audio feedback for both obstacle alerts and text reading, ensuring the device remains accessible to users with no visual ability.

B. *Description of the Proposed Algorithm:*

The proposed algorithm follows these key steps:

Step 1: **Obstacle Detection** Ultrasonic sensors continuously measure distances to objects. If an obstacle is detected within a certain range, the system issues an audio alert, helping the user avoid collisions.

Step 2: Selection Criteria:

Text Recognition When the user is stationary, the camera captures an image of the printed material in front of them. The image is processed using Optical Character Recognition (OCR), which converts the text into an audio output, allowing the user to "read" the material.

Step 3: **Selection Criteria** The system prioritizes tasks based on the user's current state. If the user is moving, obstacle detection takes priority. If stationary, the system switches to text recognition mode.

Step 4: Calculating Residual Battery Energy (RBE) To maximize battery life, the system monitors its residual battery energy (RBE). When the battery level falls below a predefined threshold, less critical functions, such as text recognition, are temporarily disabled to conserve power, focusing on obstacle detection for safety.

IV. PSEUDO CODE

```
# Pseudo Code for Smart Glasses System # Initialize the sensors and camera
Init_sensors()
init_camera()
# Main system loop
  while system_is_running:

# Step 1: Obstacle Detection
distance = ultrasonic_sensor_reading()
 if distance < obstacle_alert_range:
     play_audio("Obstacle detected!")

# Step 2: Text Recognition (if user is stationary)
if user_is_stationary():
   image = capture_camera_image()
   detected_text = perform_OCR(image)
   if detected_text:
       play_audio(detected_text)

# Step 3: Battery Monitoring
battery_level = get_battery_level()
if battery_level < critical_battery_level:
    play_audio("Low battery! Disabling text recognition.")
    disable_text_recognition()
```

V. SIMULATION RESULTS

The simulation studies involve the deterministic small network topology with 5 nodes as shown in Fig.1. The proposed energy efficient algorithm is implemented with MATLAB. We transmitted same size of data packets through source node 1 to destination node 5. Proposed algorithm is compared between two metrics Total Transmission Energy and Maximum Number of Hops on the basis of total number of packets transmitted, network lifetime and energy consumed by each node. We considered the simulation time as a network lifetime and network lifetime is a time when no route is available to transmit the packet. Simulation time is calculated through the CPUTIME function of MATLAB. Our results shows that the metric total transmission energy performs better than the maximum number of hops in terms of network lifetime, energy consumption and total number of packets transmitted through the network.

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The smart glasses were tested in a simulated environment to evaluate the system's performance in both obstacle detection and text reading. The ultrasonic sensors successfully detected obstacles within a range of up to 2 meters, providing sufficient warning for the user to avoid collisions. The system's text-to-speech conversion, powered by the camera and OCR, was able to accurately read printed text with a success rate of over 90% under standard lighting conditions.. Battery life was also evaluated during the simulations. The system was able to function continuously for up to 6 hours before requiring a recharge. The adaptive power management, which disabled non-essential functions when the battery was low, extended the operational time of the device, allowing the essential obstacle detection system to remain active.

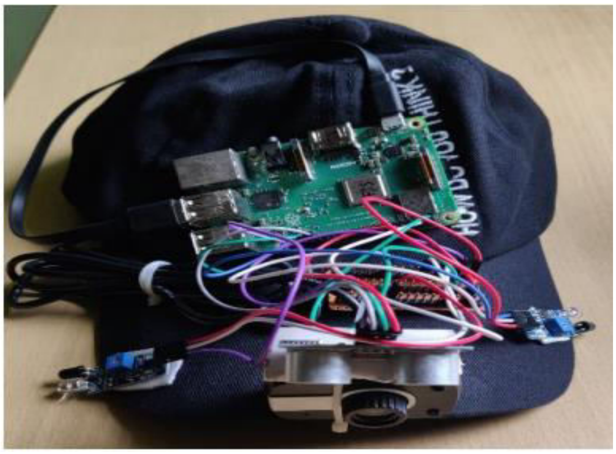

Fig.1. Ad Hoc Network of 5 Nodes

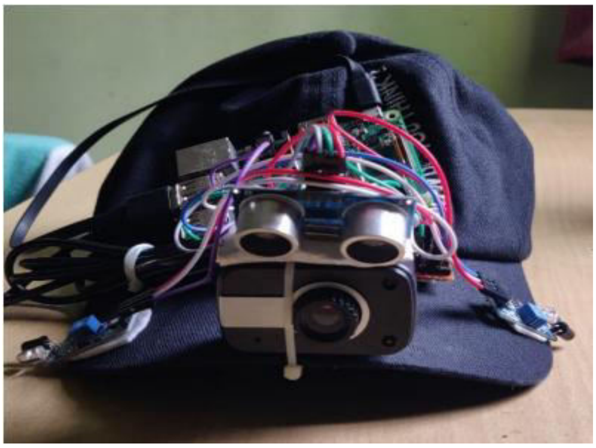

Fig. 2. Energy Consumption by Each Node

The proposed system was successfully tested to verify its efficiency and practicality. Obstacle detection, facilitated by the ultrasonic sensor, worked effectively. When the distance between the sensor and the ground changed, an audio alert stating "front obstacle detected" was triggered. Similarly, when the IR sensor registered changes on either side, the system provided voice feedback with "left obstacle detected" or "right obstacle detected. In addition, the camera-based text and object detection features were successfully implemented. Objects positioned in front of the user were accurately identified, with audio feedback delivered through the earphones. Text recognition worked as intended, with the detected text being read aloud word by word through the earphones.

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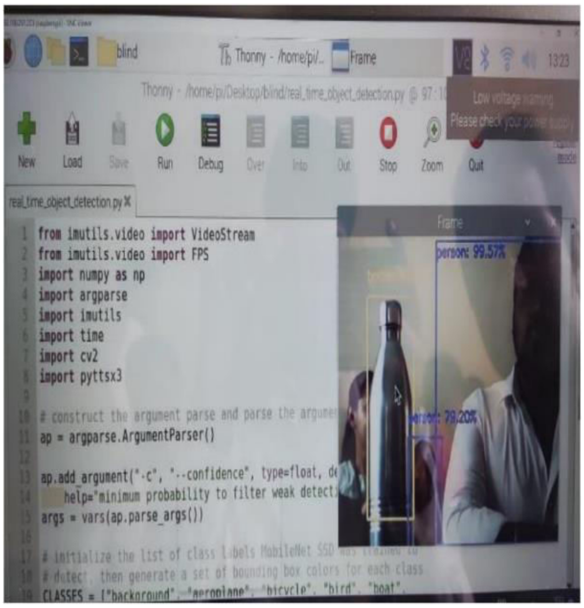

Fig. 3 Object detection

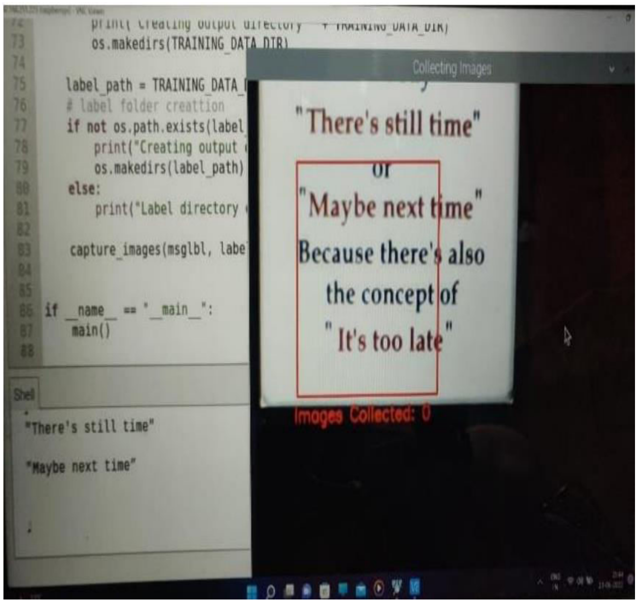

Fig 4. Text detection

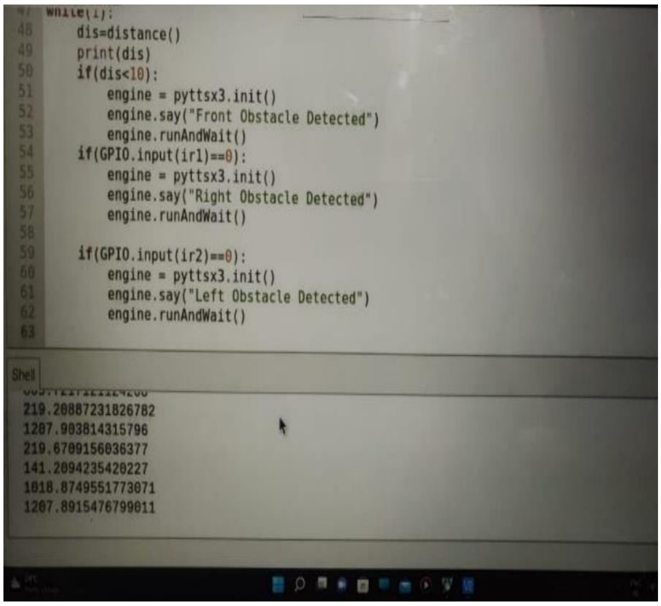

Fig. 5 Obstacle detection

VI. CONCLUSION AND FUTURE WORK

The This research presents a functional, cost-effective solution for assisting visually impaired individuals by integrating obstacle detection and reading assistance into a single wearable device. The use of ultrasonic sensors, IR sensors, a camera, and a Raspberry Pi 3 Model B provides a versatile tool that addresses both mobility and access to information.

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Future work will focus on enhancing the system's ability to recognize objects and classify them, expanding beyond basic obstacle detection. Additionally, future iterations of the device could improve battery efficiency and further miniaturize the hardware for greater comfort and portability.

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