Vision Enhanced: Empowering Visually Impaired with Smart Sense Technology

Prof (Dr.)Indu Prabha Singh
Department if Electronics and Communication Engineering
Shri Ramswaroop Memorial College of Engineering and Management, Lucknow, India
Dr A.P.J. Abdul Kalam Technical University, India
indu.ec@srmcem.ac.in

Abhishek Shukla
Department of Electronics abd Communication Engineering
Shri Ramswaroop Memorial College of Engineering and Management, Lucknow, India
Dr A.P.J. Abdul Kalam Technical University, India
shuklaabhi7777@gmail.com

Preet Dixit
Department of Electronics and Communication Engineering
Shri Ramswaroop Memorial College of Engineering and Management, Lucknow, India
Dr A.P.J. Abdul Kalam Technical University, India
preetrashi62@gmail.com

***Abstract*— People who are blind or visually impaired often encounter challenges when navigating streets and might not be aware of surrounding landmarks. To move from one location to another, they may need assistance such as a cane, guide dog, or human aid. This paper is based on the designing of integrated assistive devices for visually impaired people. It consists of the integration of two devices smart navigating helmet and a stick based on object detection. The novelty of this paper is that we are processing the data of both devices and then providing a better navigation solution. (*Abstract*)**

Keywords- YOLO, MQTT, Ultrasonic Sensor, Raspberry Pi 4, Image Processing (key words)

I. INTRODUCTION

In today's rapidly evolving technological landscape, the quest for inclusivity and accessibility remains paramount. According to the World Health Organization (WHO), Globally, at present 2.2 billion people have vision impairment, of whom at least 1 billion can be corrected or yet to be addressed and the rest are completely blind. Hence, they need assistance for their daily work [1]. Humans rely on their vision to perceive approximately 80% of the information about their environment. Ensuring mobility is one of the significant challenges faced by visually impaired people. Consequently, living in this world poses significant challenges for individuals with visual impairments.

II. RELATED WORKS

There are different mobility Aid that was introduced to assist VIPs (visually impaired people). One of them is "Reliable Ultrasonic Obstacle Recognition for Outdoor Blind Navigation.", to make VIPs independent while navigating in familiar and unfamiliar outdoor spaces and to acquire useful long-term Orientation and Mobility (O&M) skills [2]. Another device for VIPs are “Multi-Feature Smart Blind Stick” which seeks to build up a cutting-edge solution for folks with visual disabilities. This Project is an amalgamation of advanced technology and the necessity of blind people to give them a better and more efficient means of moving independently [3]. Another study is about “Smart Assistive Devices for Visually Impaired People”, which is a wearable Helmet to alert and assist about surrounding obstacles and objects to VIPs through earphones [4]. The next study is about. "Smart walking stick - an electronic approach to assist visually disabled persons," which is designed for abating disabilities of blindness by constructing a microcontroller-based automated hardware that can corroborate a blind to detect obstacles in front of him/her instantly. The hardware consists of a microcontroller incorporated with ping sonar sensor, proximity sensor, wet detector, a micro-pager motor and additional equipment [6]. For the software study, we analyzed a paper which is based on the "Voice-controlled smart assistive device for visually impaired individuals." which is an Android mobile Application (app) that assists people with visual impairments in currency recognition and general object detection such as mobile phones, laptops, chair, water bottle, vehicles, persons, book, door, watch etc. more quickly and accurately [7].So this paper is a solution of all these studies of papers and analysis to make an integrated assistive device which is a Helmet and Stick for VIPs to assist them in their surroundings and let them be alert about the obstacles and objects.

III. PROPOSED SOLUTION

The proposed system comprises a Raspberry Pi 4 microprocessor along with various components including Ultrasonic Sensors, Accelerometer, Camera, Node MCU, and GPS Module.

The Ultrasonic Sensor, mounted on a stick, detects obstacles below knee length. The Camera captures frames for object detection and recognition by the Raspberry Pi. The microprocessor processes this data and outputs audio cues for the user, which can be transmitted to external devices like earphones.

The Accelerometer detects changes in helmet acceleration, facilitating fall detection. The GPS Module provides the person's coordinates, enabling real-time location tracking by loved ones. Node MCU, functioning as an IoT client, relays data from the ultrasonic sensors to the Raspberry Pi, enhancing system connectivity and efficiency.

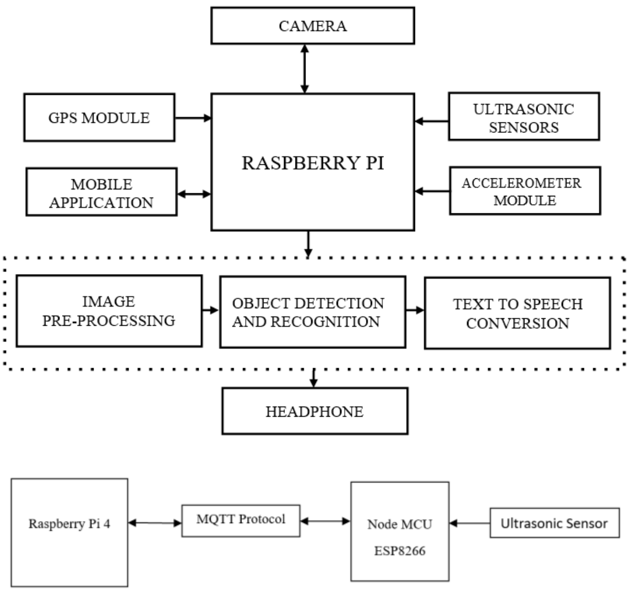

Fig. 1 Block Diagram

IV. SYSTEM INFORMATION

A. Hardware Requirements

1) *Raspberry Pi:* The Raspberry Pi 4B+ is a powerful single-board computer renowned for its versatility and affordability. It features a Broadcom BCM2711 processor with quad-core Cortex-A72 cores running at 1.5GHz, and options for 2GB, 4GB, or 8GB LPDDR4 RAM. Connectivity includes dual-band Wi-Fi, Gigabit Ethernet, Bluetooth 5.0, and multiple USB ports (2x USB 3.0, 2x USB 2.0). It supports 4Kp60 resolution via dual micro-HDMI ports, with a CSI camera port, DSI display port, and 40-pin GPIO header for expansion. Its compact form factor and low power consumption make it ideal for various applications, from educational projects to home automation.

Fig. 2 Raspberry Pi 4B+

2) *NodeMCU:* ESP32 is a powerful microcontroller featuring dual-core processing, Wi-Fi, and Bluetooth connectivity. It offers ample GPIO pins for interfacing with sensors and actuators, making it ideal for IoT projects. Its versatility, low power consufmption, and affordability have made it a popular choice for developers in various applications, from home automation to industrial IoT.

Fig. 3 NodeMCU

3) *Ultrasonic Sensor:* The HC-SR04 Ultrasonic Sensor is a popular module for measuring distance. It emits ultrasonic waves and calculates distance by measuring the time taken for the waves to bounce back.

Fig. 4 Ultrasonic Sensor

4) *Pi Camera:* The Pi camera is a compact module designed for Raspberry Pi, enabling high-quality image and video capture for diverse applications.
5) *Accelerometer:* Accelerometers can detect sudden changes in acceleration, like those that occur during a fall. When programmed appropriately, they can trigger alerts or actions for fall detection applications, such as in wearable devices or elder care systems.
6) *Headphones:* It is used to alert the person through auditory output.

B. Software Requirements

1) *Python:* Python is a high-level, interpreted language that was created in 1991 and is extensively utilized in many different fields, including automation, data research, web development, and AI. Preferred for its ease of use, vast library, and compatibility with multiple platforms, it frequently integrates with Django, Flask, NumPy, pandas, TensorFlow, PyTorch, and OpenCV, among other frameworks and tools.
2) *Raspbian Stretch:* A version of the Raspbian operating system called Raspbian Stretch was developed specifically for use with the well-known single-board computer Raspberry Pi. It was taken from the Debian Linux distribution. Stretch is a software distribution that was first released in August 2017 and was replaced by Raspbian Buster in June 2019. It comes with updated development tools, an enhanced desktop environment with new visual elements and performance enhancements, improved security features like firewall capabilities and App Armor integration, expanded hardware support, and additional software packages like the Thonny Python IDE, Sense HAT emulator, and Chromium web browser.

C. Algorithms:

YOLO Algorithm: In computer vision, YOLO (You Only Look Once) is a well-liked object detection algorithm. The primary contribution of YOLO is its real-time object identification capability, which makes it appropriate for uses in augmented reality, driverless cars, and video surveillance.

YOLO predicts object positions and classifications in an image using a single neural network. It accomplishes this by creating a grid out of the image and using each cell to forecast the existence and characteristics of objects. A sizable dataset of annotated photos is used to train the network, and convolutional, pooling, and fully connected layers are used to provide predictions.

The loss function utilized in training the YOLO network encompasses multiple components aimed at penalizing discrepancies in predicted bounding boxes, class probabilities, and confidence scores. Its main constituents are as follows:

1. *Localization loss:* Penalizes inaccuracies in predicted bounding boxes by calculating the sum of mean squared errors between predicted (x, y, w, h) values and true values.
2. *Confidence loss:* Penalizes inaccuracies in confidence scores by computing the sum of mean squared errors between predicted and true confidence scores.
3. *Classification loss:* Penalizes errors in predicted class probabilities through cross-entropy loss computation between predicted probabilities and true class labels.

V. SYSTEM IMPLEMENTATION

The solution is implemented into following moules which are independent of each other, these modules are described below:

A. Object detection and audio output module

In computer vision, the object detection and audio output module is concerned with identifying objects in an image or video frame to produce corresponding audible signals or feedback. Two major components are typical of this system:

Object Detection: This component utilizes computer vision algorithm YOLO (You Only Look Once) to detect and localize objects within an image or video. It's searching for objects, their bounding box and corresponding class labels.

Audio Output: The system will convert the information into sound feedback as soon as objects have been identified. This feedback may take different forms, e.g. a synthesized speech that announces the object name, spatialized sounds to indicate objects' positions or special soundings associated with certain class of objects.

B. Obstacle detection module

In order to detect obstacles in the vicinity of a device or system, an obstacle detection module using an ultrasonic sensor uses ultrasonic waves. The ultrasonic wave is emitted and the time taken for the waves to reflect back when they hit an obstacle shall be measured by this sensor. The distance to the obstacle is determined as a result of calculating the time difference between emission and reception.

C. Emergency alert system

In order to identify sudden, abnormal movements indicative of a fall, fall detection using an accelerometer requires monitoring of acceleration changes. The accelerometer sensor is usually placed in a clothing device, such as the helmet.

Baseline measurement: The system shall first establish the baseline by continuously monitoring the movement of the wearer during normal activities. Monitoring: The accelerometer continuously tracks acceleration on various axes, such as x, y, z and analyses motion patterns. Threshold detection: Based on known characteristics of falls, thresholds for acceleration changes are set by the system. The measured acceleration is indicative of a possible fall event if it exceeds these thresholds.

The system activates an alert mechanism when a fall is detected. This means that caregivers can be notified through a mobile phone application.

D. MQTT broker server

An MQTT broker server is a central hub in an IoT network that facilitates communication between devices. It receives messages published by NodeMCU and routes those messages to Raspberry Pi. In essence, in order to ensure effective and reliable communication within the network, a MQTT broker server is acting as an intermediary.

VI. CONCLUSION AND FUTURE WORK

There are a number of potential applications for the assistive device developed in this project and future scope. In order to enhance the functionality of this device, it is possible to optimise its performance. usability and can be integrated into various systems to create a comprehensive solution In the case of individuals with visual impairment.

The object recognition system is one area where improvements could be made to the device. While the The existing system is correct, training the YOLO could further improve it. The algorithm for a larger and more diverse set of data. The algorithm may be able to recognize this The device is more useful in different settings because it has a wider range of objects.

The user interface of the device is another area where it can be improved. While the current system of sound output is efficient, it can be improved by adding additional elements. A text to speech system that can provide more detailed information on the detected objects. In addition, speech output can be produced in a variety of languages. You can configure it according to the user's location.

By integrating other notifications, the emergency alert system can also be improved. channels, such as SMS or phone calls, to ensure that the user's family or caretakers Get the alert as soon as possible. Adding other sensors, for example heart rate. Sensors and blood pressure monitors may also provide additional information to the user health and well-being.

REFERENCES

[1] World Health Organization,2024 "*Global data of visually impaired*." at: [www.who.int/blindness/publications/globaldata/en].

[2] Meliones A, Filios C, Llorente J. Reliable Ultrasonic Obstacle Recognition for Outdoor Blind Navigation. *Technologies*. 2022; 10(3):54. https://doi.org/10.3390/technologies10030054

[3] N. Loganathan, K. Lakshmi, N. Chandrasekaran, S. R. Cibisakaravarthi, R. H. Priyanga and K. H. Varthini, "Smart Stick for Blind People," 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2020, pp. 65-67, doi: 10.1109/ICACCS48705.2020.9074374.

[4] I. P. Singh, A. Misra, A. Maurya and A. Verma, "Technical Review of Smart Assistive Devices for Visually Impaired People," 2023 4th International Conference for Emerging Technology (INCET), Belgaum, India, 2023, pp. 1-12, doi: 10.1109/INCET57972.2023.10170619.

[5] Alzubaidi, L., Zhang, J., Humaidi, A.J. *et al.* Review of deep learning: concepts, CNN architectures, challenges, applications, future directions. *J Big Data* **8**, 53 (2021). https://doi.org/10.1186/s40537-021-00444-8

[6] Mahmud, Mohammad Hazzaz & Saha, R & Islam, Sayemul. (2013). Smart walking stick-an electronic approach to assist visually disabled persons. International Journal of Scientific and Engineering Research.

[7] J. -R. Rizzo, Y. Pan, T. Hudson, E. K. Wong and Yi Fang, "Sensor fusion for ecologically valid obstacle identification: Building a comprehensive assistive technology platform for the visually impaired," 2017 7th International Conference on Modeling, Simulation, and Applied Optimization (ICMSAO), Sharjah, United Arab Emirates, 2017, pp. 1-5, doi: 10.1109/ICMSAO.2017.7934891.