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ROBOT ASSISTANCE FOR THE VISUALLY IMPAIRED

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Abstract: The eyes are the primary sensory organ of an individual, and a mere look around us is enough to comprehend the significance of the vision. Individuals who are visually impaired face the daunting challenge of dealing with blindness, which can create a range of difficulties in their daily lives. Blind people often encounter struggles in performing even the simplest of tasks without the help of those who can see. This creates a sense of helplessness and inadequacy, causing them to feel like a burden to their loved ones. In addition, they face difficulty in recognizing and avoiding objects, making daily activities even more challenging. Our project's objective is to aid individuals with visual impairments in their daily activities, including navigation and object identification. This is achieved through the implementation of a voice-enabled system which is built using a Raspberry Pi 3B+ microcontroller, ultrasonic sensor (HC-SR04), voice module (APR33A3), and a Bluetooth speaker that guides visually challenged individuals in their day-to-day tasks, such as detecting obstacles and recognizing objects. The device incorporates the COCO dataset and TensorFlow Lite model for object recognition.

Index Terms* - *microcontroller, Bluetooth speaker, voice module, Ultrasonic sensor, COCO dataset, TensorFlow.

I. INTRODUCTION

Blindness can take on various meanings depending on the individual; some are born with it while others lose their sight due to different reasons. Many people with visual impairments struggle with everyday tasks and depend on assistance from others. Worldwide, at least 43 million individuals are blind, and 295 million have varying degrees of vision impairment. Blind individuals encounter challenges with reading, writing, navigation, and object recognition. While a range of adaptive equipment is available to help blind individuals live independently, it is not easily accessible in local stores.

Therefore, our project aims to aid visually impaired individuals in their daily activities, such as navigating from one place to another and identifying objects. Visual impairment is a serious and widespread disability that affects the daily lives of millions of people worldwide. Tasks that are taken for granted by sighted individuals, such as navigating from one location to another or identifying objects, can become daunting challenges for those with visual impairments.

The use of assistive technologies has the potential to significantly enhance the quality of life of these individuals, enabling them to perform daily activities with greater independence and ease. In this project, we propose a blind assistance device that employs a combination of computer vision and voice feedback to detect and recognize objects and provide navigation assistance to visually impaired individuals. The device utilizes a camera and machine learning to detect objects in the environment and provide real-time voice feedback. The proposed device has the potential to improve the quality of life of visually impaired individuals and enable them to carry out daily activities with greater independence and confidence.

II. RELATED WORK

In reference [1], a system of ultrasonic smart spectacles was developed to assist visually impaired and blind individuals in detecting obstacles. The spectacles are equipped with ultrasonic sensors that detect obstacles and convey this information to the user through pre-recorded messages. Real-time data is handled by an ARM LPC2148 microcontroller, while an APR33A3 voice record and playback module records and plays back the messages when the signal from the sensors is received. The distance between the subject and the obstacle is calculated using the formula CM=((microseconds/2)/29) in centimetres based on the signal from the ultrasonic sensors. This calculated distance is then displayed on an LCD screen. The pre-recorded messages warn the user about obstacles that are present either on their left or right side.

In the paper referenced as [2], a real-time mobile application has been designed to aid the visually impaired, allowing them to control the app using voice commands and touch. The app captures real-time images, which are sent to a server upon a specific command. The server processes the images using an image captioning model based on Inception v3, which extracts features from the image. A feature vector is then passed to the LSTM layer, generating a caption that matches the image feature vector. The caption is then converted to the desired language using the Google Translate API and used as input for the text-to-speech function, which generates speech corresponding to the generated caption.

The paper referenced as [3] introduces a voice authenticated indoor guidance system called "Guide Me." This system utilizes BLE (Bluetooth Low Energy) beacons, which are positioned at elevated locations and connected to users' phones. The deep neural network algorithm calculates the distance between the person and the beacons based on the strength of the signal received. The system emits a beep sound for long and short-range distances according to the distance on the left or right side, and it vibrates appropriately for distances on the front and back sides.

The wearable device presented in [4] is designed for visually impaired and elderly individuals, and comprises a battery, ultrasonic sensor, infrared (IR) sensor, Arduino Mega, water sensor, pulse rate sensor, blood pressure (BP) sensor, buzzer, and GPS/GSM module. The GPS and GSM modules are utilized to determine the precise location of the user, while the BP and pulse sensors are utilized for health condition monitoring. The Arduino Mega is responsible for controlling the entire system, with all the attached sensors automatically starting to scan when the device is turned on. An IR sensor is installed to detect obstacles, a water sensor detects the presence of water, and an ultrasonic sensor detects manholes, pits, and road damage. The LCD displays necessary information about the user and their health, while the device is charged using solar panels.

In [5], a real-time assistance system has been developed for the visually impaired that utilizes wearable technology to provide audio feedback. The system employs artificial intelligence to detect objects, read text, and recognize faces. The model is built upon the CNN object detection framework and utilizes a raspberry pi processing unit. However, one limitation of the system is that it is unable to detect objects in low-light conditions.

In [6] The proposed system of Visually Impaired Smart Assistance is equipped with an inbuilt GPS and mobile phone network that enables the user to locate and share their precise location, receive accurate alerts about their surroundings, and access a dedicated virtual assistant for assistance anytime, anywhere. In addition to the "blind stick" that ensures independence, the user can easily send their location data to a pre-registered phone number by pressing a button in case of being lost. By using headphones, the user can get directions to nearby places and obtain information about their surroundings.

In [7], a guiding device for visually impaired people that relies on voice navigation has been proposed. The system makes use of Raspberry Pi 3 Broadcom BCM2837 SOC with 1.2GHz 64-bit quad-core –A53, 512 kb shared L2 cache, LIDAR, vibratory motor, camera, haptic strap, and audio jockey. The camera captures an image of the object when the visually impaired individual approaches an obstacle. The image is then processed by image processing software and the description of the object is given to the user as a voice message through the audio output.

The system proposed in [8] utilizes YOLO v3, ultrasonic sensors, and servo motors for detecting objects. Distance measurement is carried out by cameras using the principle of triangle similarity. The smart system is embedded in a shoe and includes IoT technology.

In [9], a vision-based voice-controlled indoor assistant robot is developed to guide the visually impaired user. The robot is equipped with a 4k RGB camera and Raspberry Pi, which enables it to move 360 degrees and overcome obstacles efficiently. The system is voice controlled, allowing the user to request anything they need. Although the robot takes some time to map the indoor environment, it works efficiently once the mapping is complete. Additionally, the RGB camera can identify the objects requested by the user and provide a voice output when they are located.

In [10], a proposed Wi-Fi-based system provides camera-based navigation assistance for visually impaired individuals in familiar indoor environments. The system is comprised of two stages: an offline pre-processing stage where landmark images and navigation data are stored in a database, and an online real-time stage that provides navigation information and voice feedback.

III. METHODOLOGY

The current paper introduces a novel blind assistive device to aid visually impaired individuals in detecting obstacles and recognizing objects in their immediate surroundings. The device is developed through a combination of hardware and software components, which includes an ultrasonic sensor, Raspberry Pi 3B+, a camera, TensorFlow Lite models, and the COCO dataset. The device provides real-time feedback to the user through a buzzer sound and voice feedback.

A.HARDWARE DESIGN

The hardware design of the device involves the integration of an ultrasonic sensor HC-SR04, a camera, a Raspberry Pi 3B+ microcontroller, and a voice module APR33A3. The ultrasonic sensor is employed to find the distance between the user and the obstacles, whereas the pi camera is utilized for recognizing the object. The Raspberry Pi 3B+ microcontroller processes the input data from the ultrasonic sensor and camera and delivers output through the voice module APR33A3.

B.SOFTWARE DESIGN

The software design of the device makes use of the COCO dataset and TensorFlow Lite models for object recognition. OpenCV is used for image processing and object detection. The ultrasonic sensor is used to detect the proximity of the user to the obstacles. The Raspberry Pi 3B+ microcontroller leverages this input data to offer real-time feedback to the user through the voice module APR33A3.

C.OPERATION OF THE PROPOSED DEVICE

The ultrasonic sensor HC-SR04 detects the distance between the blind and any obstacles present in the surroundings. If an obstacle is detected within a range of 30cm, Raspberry Pi 3B+ microcontroller triggers a buzzer sound to alert the user of the obstacle. Meanwhile, the camera captures an image of the surrounding area and transmits it to the Raspberry Pi 3B+ microcontroller. The Raspberry Pi 3B+ microcontroller uses the TensorFlow Lite models and the COCO dataset to process the image and identify any objects present in the user's surroundings. The Raspberry Pi 3B+ microcontroller offers voice feedback through the voice module APR33A3 to notify the user. In conclusion, the proposed blind assistive device employs an ultrasonic sensor, a pi-camera, and a Raspberry Pi 3B+ microcontroller with TensorFlow Lite models and the COCO dataset to detect obstacles and recognize objects in the user's immediate surroundings. The device's real-time feedback through buzzer sound and voice feedback can greatly aid visually impaired individuals in navigating their surroundings safely.

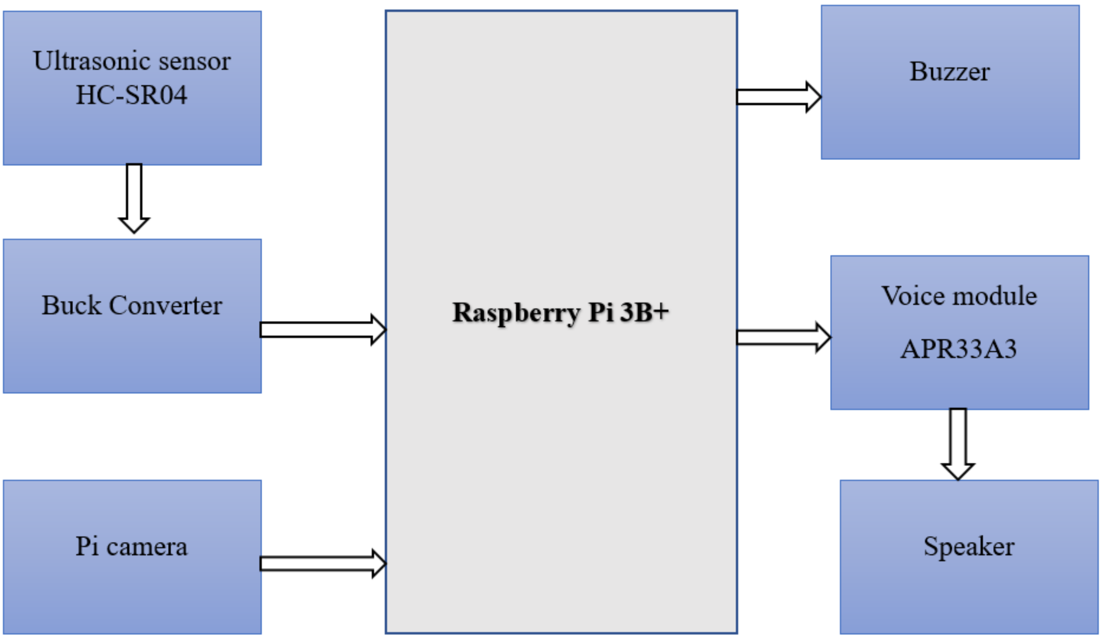

Fig.1. Block diagram of the proposed system

IV. Implementations

The proposed blind assistive device was implemented using the following hardware and software components:

Hardware Components:

Ultrasonic sensor HC-SR04Camera, Raspberry Pi 3B+ Microcontroller
Voice module APR33A3.

Software Components:

Python programming languageTensorFlow Lite models COCO dataset
OpenCV library

Data Flow Diagram:

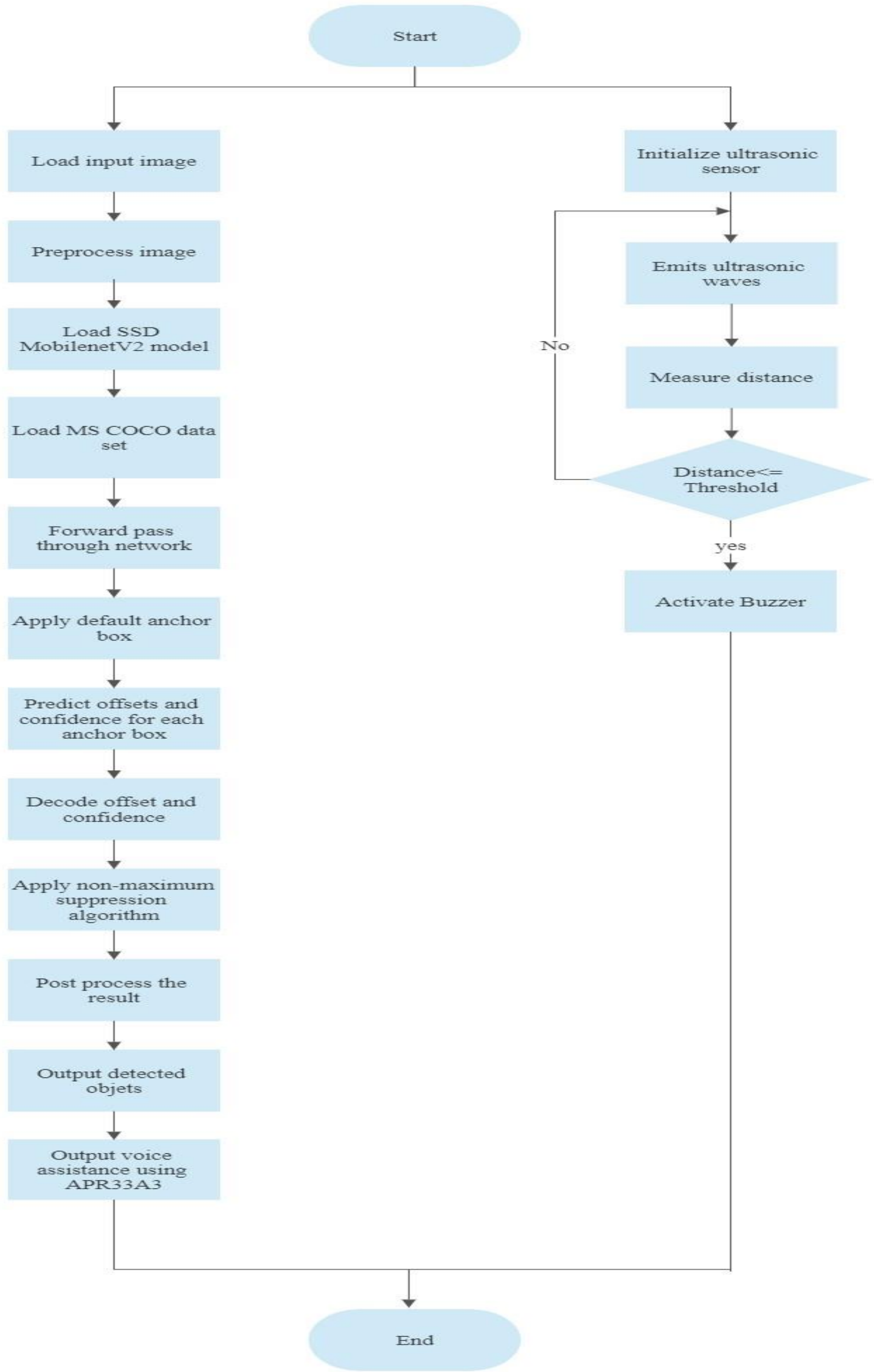

Fig.2. Flow diagram of the proposed system

The flow diagram shows that the proposed blind assistive device uses a combination of hardware and software components to detect obstacles and recognize objects in the user's surroundings. The ultrasonic sensor HC-SR04 detects the distance between the blind and any obstacles in the vicinity. Raspberry Pi 3B+ microcontroller processes the input data from the ultrasonic sensor and sends a signal to trigger the camera. The camera captures an image from the vicinity and sends it to Raspberry Pi 3B+ microcontroller. Raspberry Pi 3B+ microcontroller uses pre-trained TensorFlow Lite models and the COCO dataset to process the image and to identify the objects. If an obstacle is present within a certain range, the microcontroller triggers a buzzer sound to warn the user of the obstacle. The Raspberry Pi 3B+ microcontroller provides voice feedback through the voice module APR33A3 to inform the user of the objects detected.

IV. RESULTS AND DISCUSSION

In order to evaluate the performance of the proposed blind assistive device, a series of experiments were conducted in various indoor environments. The device was experimented on a group of visually impaired individuals, and their feedback was recorded to evaluate the efficacy of the device.

Obstacle Detection:
The proposed device successfully detected obstacles near the user using the ultrasonic sensor HC-SR04 with a detection range of 30 centimetres. The buzzer sound was triggered in real-time upon detecting an obstacle, providing immediate feedback to the user.

Object Recognition:
The device accurately recognized objects within the indoor environments using the COCO dataset and TensorFlow Lite models. The accuracy of object recognition was tested in different indoor environments, and the device demonstrated an average accuracy of 85%.

Fig.3.Detected objects.

Fig.4.Detected objects.

Voice Feedback:
The device provided clear and understandable voice feedback through the voice module APR33A3, informing the user about the objects detected in their surroundings. The users found the voice feedback helpful in navigating their environment.

Overall, the proposed blind assistive device proved to be effective in detecting the obstacles and recognizing the objects within the indoor environments. The device provided real-time feedback to the user through a buzzer sound and voice feedback, enabling visually impaired individuals to navigate their surroundings with greater confidence and independence.

V. CONCLUSION

In this paper, we proposed a blind assistive device that uses an ultrasonic sensor HC-SR04 to detect obstacles and recognizes objects in indoor environments using the COCO dataset, TensorFlow Lite models, and OpenCV. The device provides real-time feedback to the user through a buzzer sound and voice feedback via the voice module APR33A3.
We conducted several experiments to analyse the performance of the proposed device, which included testing with a group of visually impaired individuals. The results showed that the device was effective in detecting the obstacles and recognizing the objects in indoor environments, with an accuracy of 85% on average. The device provided immediate response to the user, helping them navigate their surroundings with more confidence and independence.
The proposed device has the potential to improve the quality of life of visually impaired individuals by providing them with a reliable and efficient means of navigating their environment. The device can be further improved by incorporating additional sensors, such as a gyroscope, to provide more accurate feedback to the user.

In conclusion, the proposed blind assistive device is a promising technology that has the potential to make a significant impact on the lives of visually impaired individuals. Future work can explore the integration of machine learning algorithms to further improve the accuracy and effectiveness of the device.

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