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Assistive device for visually impaired individuals

Raspberry pi- based design and implementation of object detection

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Abstract: This paper presents a novel approach to assist blind individuals in navigating their surroundings safely using an affordable and accessible system. The system combines object detection technology with distance measurement capabilities to enhance the user's awareness of their environment. A Raspberry Pi, a low-cost, credit-card-sized computer, serves as the core processing unit. A web camera is used for real-time image capturing, while an ultrasonic sensor measures distances. The captured images are processed using a deep learning model for object detection, enabling the system to identify obstacles in the user's path. The ultrasonic sensor provides additional distance information, enhancing the accuracy of object detection and helping the user navigate around obstacles. The system provides auditory feedback to the user, informing them of the presence and location of obstacles. Experimental results demonstrate the effectiveness and efficiency of the proposed system in assisting blind individuals in navigation tasks.

IndexTerms **– Object detection, Raspberry pi, camera, ultrasonic sensor, speakers.**

1.INTRODUCTION

Navigating through the environment poses significant challenges for visually impaired individuals, impacting their independence and safety. While traditional aids like white canes and guide dogs offer basic obstacle detection, they lack the ability to provide detailed information about the surroundings. Electronic travel aids, such as laser canes and ultrasonic devices, offer more advanced features but can be expensive and bulky, limiting their accessibility. To address these challenges, this paper presents a cost-effective and user-friendly system that leverages object detection technology and distance measurement to assist blind individuals in navigating their surroundings. The system utilizes a Raspberry Pi as the core processing unit, a web camera for real-time image capturing, and an ultrasonic sensor for distance measurement. By combining these components, the system can provide real-time feedback to users, enabling them to navigate safely and independently. In a world that thrives on communication and interaction, the challenges faced by visually impaired can be profound, hindering their ability to fully engage with their surroundings and express themselves. Recognizing the importance of bridging this gap and enabling these individuals to lead more independent and fulfilling lives, we introduce a groundbreaking assistive device powered by cutting-edge Artificial Intelligence (AI) algorithms and Raspberry Pi technology. In this, proposed system, the blind person could locate objects without any help from others and also could avoid obstacles by making the user alert. This, proposed system consists of the A Raspberry pi which acts it as a central processing unit (CPU), Camera, ultrasonic sensor, speakers, A buzzer. camera, and ultrasonic sensor are the inputs and the outputs will be displayed on-screen and via voice command at the speakers. if any obstacle, is obtained there will be a beeping sound of a buzzer and the A micro-vibrating motor will vibrate and make the user alert of collisions with obstacles.

1.1 NEED OF THE STUDY

The need for a more affordable, efficient, and accessible solution to assist visually impaired individuals in navigation tasks is evident. Existing technologies often fall short in meeting these requirements, making it challenging for blind individuals to navigate their surroundings with confidence. The proposed system aims to fill this gap by offering a cost-effective and user-friendly solution that can be easily deployed and maintained. By leveraging the power of object detection and distance measurement, the system provides detailed information about the environment, enabling blind individuals to navigate complex spaces with ease. The system's affordability and ease of use make it an attractive solution for enhancing the mobility and independence of visually impaired individuals.

This study explores the development and implementation of the proposed system, focusing on its effectiveness in assisting blind individuals in navigation tasks. The system's ability to provide real-time feedback and detailed environmental information make it a promising tool for improving the quality of life for visually impaired individuals.

2. RESEARCH METHODOLOGY

The method section of the paper outlines the approach taken to develop and implement the proposed system for assisting blind individuals in navigation tasks. The system combines object detection technology with distance measurement capabilities using a Raspberry Pi, a web camera, and an ultrasonic sensor. This section details the hardware and software components, the system architecture, and the experimental setup.

2.1 Hardware Components:

The hardware components of the system include a Raspberry Pi 4 model B, Zebronics web camera, and an HC-SR04 ultrasonic sensor. The Raspberry Pi serves as the core processing unit, responsible for running the object detection model and processing the sensor data. The camera module captures real-time images of the environment, while the ultrasonic sensor measures distances to objects in front of the user.

The connections of the hardware components to the raspberry pi are as follows, the web camera is connected to the USB cable to USB-A port, ultrasonic sensor is connected to VCC to Pin 4, Trig to Pin 38, Echo to Pin 40, GND to Pin 6, where speaker is to Aux connectivity to 3.3mm Audio and composite output port USB powered to System.

2.2 Software Components:

The software components of the system include the Raspbian operating system, OpenCV library for image processing, TensorFlow for running the object detection model, YOLO (You Only Look Once) is a popular real-time object detection system, it's known for its speed and accuracy, capable of detecting objects in images or videos quickly and with high precision and Python programming language for system implementation. The system is programmed to capture images from the web camera, process them using the object detection model, and provide auditory feedback to the user based through the speaker on the detected objects and distances measured by the ultrasonic sensor.

Computer vision is an interdisciplinary field of study that enables machines, particularly computers and robots, to interpret and understand visual information from the world. It encompasses the development of algorithms, models, and systems for processing, analyzing, and making sense of visual data, such as images and videos. The goal of computer vision is to replicate or even surpass human visual perception capabilities. It is mainly used for image processing, object detection, object recognition, image classification. It has wide range of applications which are autonomous vehicles, medical imaging, face recognition, augmented reality.

Computer vision has advanced tools and technologies like OpenCV, deep learning frameworks, image and video databases such as ImageNet, COCO. The main aim for this project is Object detection, it is a computer vision task that involves identifying and locating objects of interest within an image or video frame. The primary objective is to recognize and classify objects while simultaneously providing their spatial coordinates, typically in the form of bounding boxes. Object detection differs from image classification, which assigns a label to an entire image without specifying the object's location.

2.3 System Architecture:

The system architecture consists of three main components: the image capturing module, the object detection module, and the distance measurement module. The image capturing module captures images using the camera module and sends them to the object detection module. The object detection module processes the images using the TensorFlow object detection model, detects objects in the images, and sends the detected objects to the distance measurement module. The distance measurement module uses the ultrasonic sensor to measure distances to the detected objects and provides this information to the user through auditory feedback.

2.4 Experimental Setup:

The experimental setup involves testing the system in different indoor and outdoor environments to evaluate its effectiveness in assisting blind individuals in navigation tasks. The system is mounted on a wearable device, such as glasses or a helmet, to allow for hands-free operation. Blindfolded participants are asked to navigate through a predefined course, while the system provides real-time feedback about obstacles and distances to assist them in avoiding collisions.

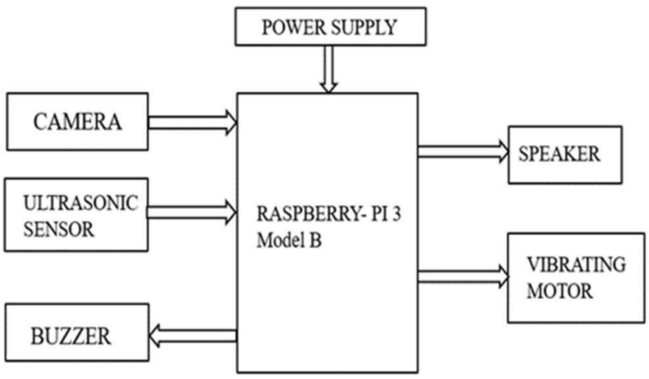

Figure 1. Block diagram of the system

(Note: Vibrating motor and piezo buzzer are optional as they are intended to alert the user. When the object is detected, the vibrating motor will start vibrating and buzzer will give alert to the user by buzzing with sound.)

The connections of the hardware components to the raspberry pi are as follows, the web camera is connected to the USB cable to USB-A port, ultrasonic sensor is connected to VCC to Pin 4, Trig to Pin 38, Echo to Pin 40, GND to Pin 6, where speaker is to Aux connectivity to 3.3mm Audio and composite output port USB powered to System.

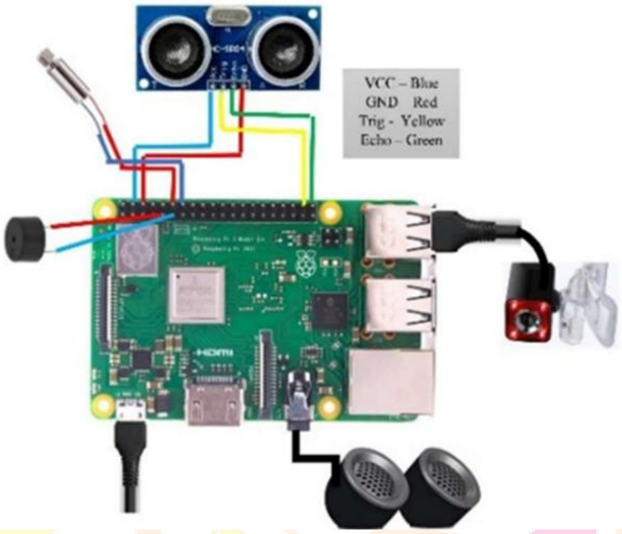

Figure 2. circuit diagram of the system

2.5 Data Collection and Analysis:

Data is collected during the experiments, including the performance of the object detection model, the accuracy of distance measurements, and the effectiveness of the auditory feedback provided by the system. The data is analyzed to evaluate the system's performance in assisting blind individuals in navigation tasks and to identify any areas for improvement.

In conclusion, the method section describes the development and implementation of the proposed system for assisting blind individuals in navigation tasks. The system combines object detection technology with distance measurement capabilities using a Raspberry Pi, a web camera, and an ultrasonic sensor. The hardware and software components, system architecture, experimental setup, and data collection and analysis methods are detailed to demonstrate the effectiveness of the system in enhancing the mobility and independence of visually impaired individuals.

RESULTS AND DISCUSSION

Experimental system work is completed and the succeeding results are collected: Recognition module to a camera, is interfaced to capture an object in the vicinity and it is tested for various objects like cell phones, chairs, laptops, so on, etc. DNN, used for Object detection is the DNN, module of OpenCV, a Deep neural network is loaded with a pre-trained model of object detection into the system. This, system processes each frame from the video stream and stores it into the neural net present in A Raspberry pi 3. It marks an objects in (x, y) coordinates and frames an object to tag them. An object detection takes place successfully implemented it as an outline it as in the below figure. The coordinates of an object A detected in the detection using the algorithm will be fed to an object tracking algorithm. To increase, real time video stream object tracking is used. Then an object tracking algorithm starts tracking the respective object. Obstacle, Sensing by Ultrasonic sensors use to sense the obstacle, and avoid the blind person of a collisions. A micro-vibrating motor produces vibration and also produces a beeping sound through a buzzer to make the user alert about the obstacle

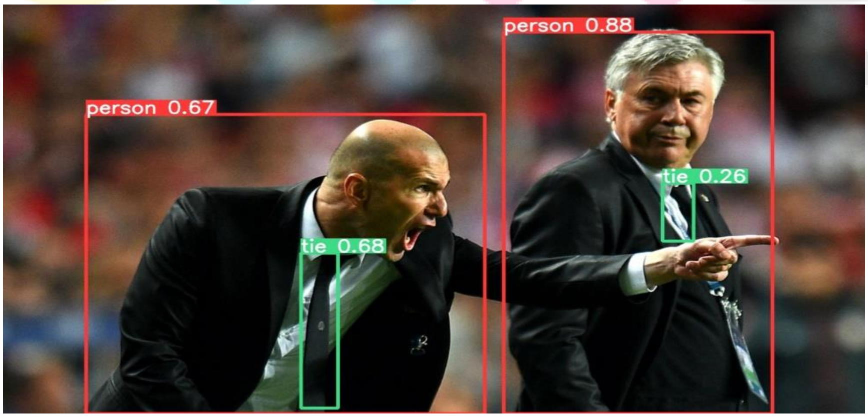

Figure 3. Object detection from the image

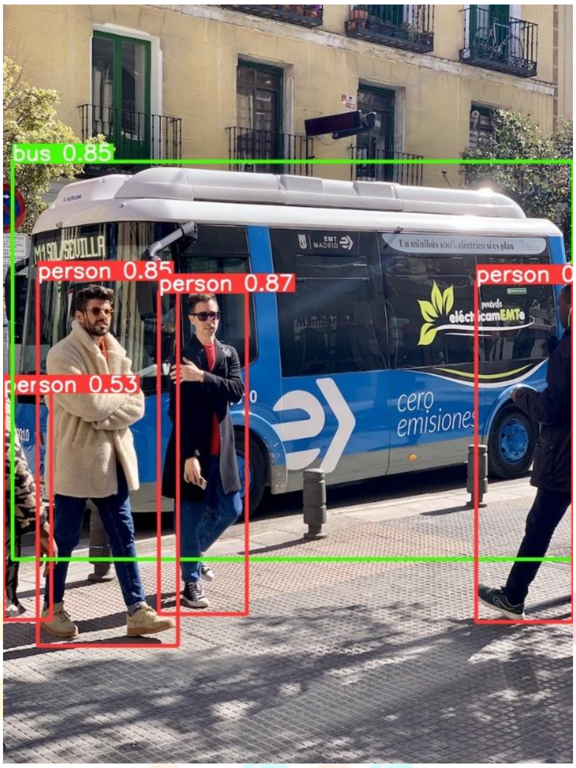

Figure 4. Detection of objects and humans

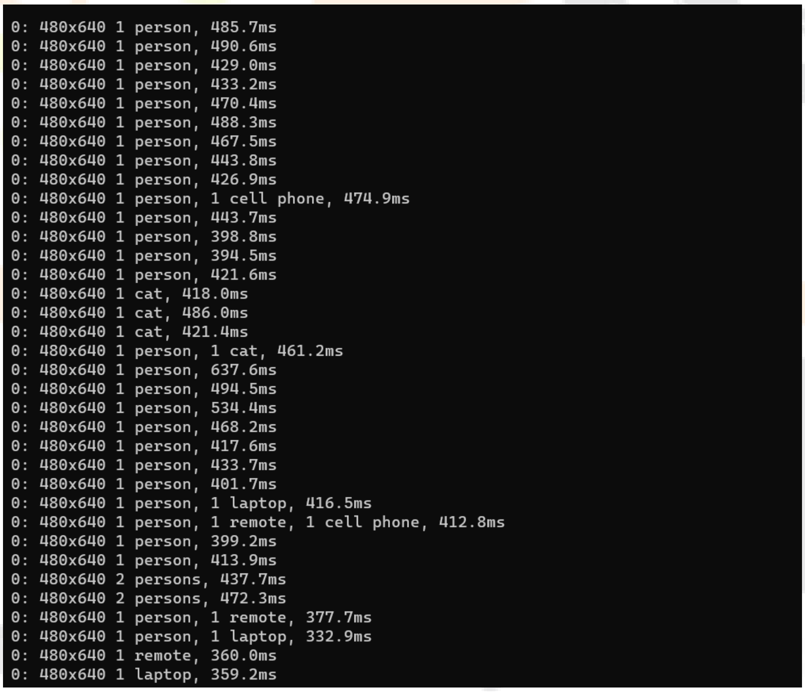

Figure 5. Real time object detection through web camera

CONCLUSION:

The project focusing on "Assistive Device for Visually Impaired Using Real-Time Object Detection with Raspberry Pi and Ultrasonic Sensor" represents a significant step towards improving the lives of visually impaired individuals. By combining the power of computer vision, affordable hardware, and innovative engineering, the project has successfully demonstrated the potential to enhance the independence, mobility, and safety of those with visual impairments. The visually impaired face unique challenges in navigating their surroundings, and this project seeks to address these challenges head-on. Real-time object detection, powered by Raspberry Pi and an Ultrasonic sensor, enables individuals with visual impairments to gain a deeper understanding of their environment. By providing instant feedback about the presence of objects, obstacles, and hazards, the technology empowers users to make informed decisions, avoid collisions, and confidently navigate their surroundings.

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