Original Article

Efficient Multi-Object Identification and Guiding System for Visually Impaired

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Abstract

Blind or visually impaired people can experience the surroundings through sound. Navigation based on audio is much helpful. Based on this principle a prototype with deep learning techniques is developed. Sensor based IoT system finds the presence of the objects and recognition is done through CSPDarknet-53 along with SPP and PANet for feature extraction and fusion. In addition to this it provides audio output in multilingual language. The system is designed to provide good accuracy and low latency in recognizing the objects and audio output in local language. Apart from this, it also provides the distance of the object from the user. The system is designed to recognize even a moving object with good accuracy.

Keywords: Raspberry Pi, Pi Camera, Ultrasonic Sensors, Feature Extraction, CSPDarknet-53, SPP and PANet.

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Introduction

Visual Impairment is disabling autonomous mobility of an individual. It is found that 285 million in worldwide and 20 million in India are visually impaired. No single existing techniques have all features such as recognizing indoor and outdoor objects, moving objects, distance between object and user, finding multi objects simultaneously, portability, less latency, and low cost. This paper presents a prototype having all the above mentioned features. In addition to this it also guides the visually impaired to navigate independently with audio in local language of their convenience.

Implementation

This section gives a detailed description of implementation of Object recognition and Navigation System of that is proposed in this paper.

1. Components

A brief overview of various components used to build the proposed prototype is given as follows:

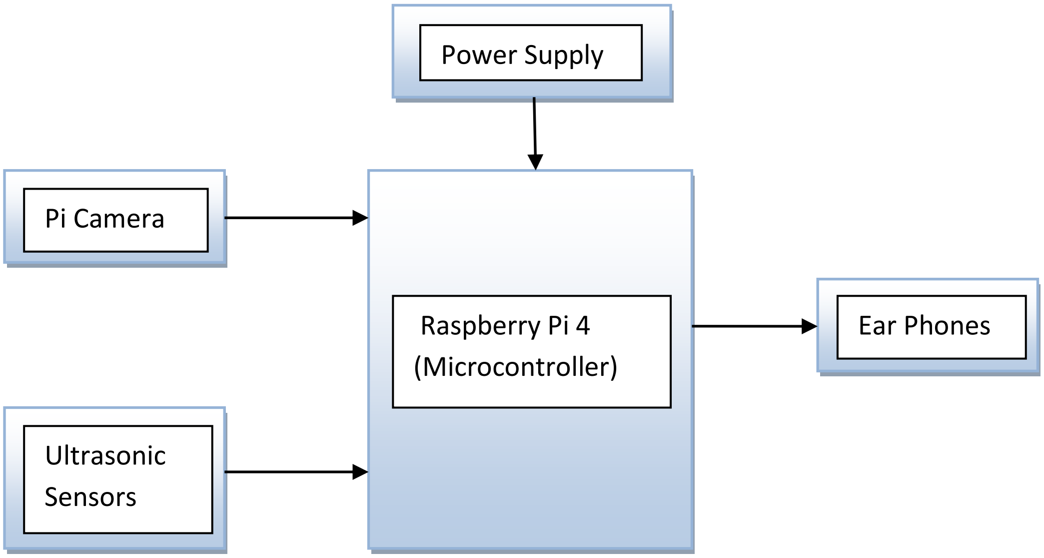

Fig. 1. Block diagram of Object recognition and Navigation System

Raspberry Pi 4

Raspberry Pi 4 is a small sized Wi-Fi enabled microcontroller with Quad core Cortex-A72 (64-bit) @ 1.5GHz, 4GB RAM, and 28 I/O pins configuration is used to perform processing and automation activities.

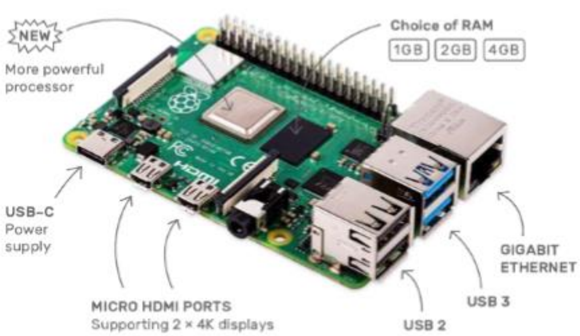

Fig. 2. Raspberry Pi 4

Pi Camera

It is a custom design module for Raspberry Pi, and has 5 mega pixel resolution camera in still capture mode and up to 1080p at 30 frames per second in video capture mode.

Fig.3. Pi Camera

Ultrasonic sensor

It transmits transmit ultrasonic waves into free space and reflected waves are captured to detect the object. Theoretically, they can be used to detect the objects located upto 450cm distance and practically upto 80cm. The HC-SR04 distance sensor is the most commonly used ultrasonic sensor for measuring distance from an object [19].

Fig. 4 HC-SR04 Utrasonic Sensor

2. Configuring

Setting Up of the Hardware System

- The Raspberry Pi needs an Operating System called NOOBS which is installed in SD memory card and inserted on the bottom of the controller.
- Pi camera is connected to the CSI port to capture video frames in real time.
- The utrasonic sensor consists of 4 pins VCC, GND, Trigger and Echo. Raspberry Pi works with 3.3V but Utrasonic sensor require 5V. Hence, a converter is used for compatibility. Through Trigger pin is used to transmit Ultra sound signals and Echo pin will capture the reflected waves from the object.
- The Ear phones are connected to the microcontroller to provide audio output.

3. Algorithm for Object Recognition

- The COCO dataset is chosen.
- YOLOv5 object detection algorithm is trained by of COCO dataset.
- The model is tested by capturing the real time stationary or moving image through Pi camera. It recognizes the objects from the live video.
- The distance is calculated from the camera to an object in live video and displayed as label.
- Recognized object and distance are given in text form, which are converted into audio using pyttsx3 text to speech converter.

EXPERIMENTAL RESULTS

A prototype is designed using Raspberry Pi4 with help of Pi camera and Sensors for visually impaired for independent navigation. YOLOv5 algorithm is used for detecting the objects and measuring the distance between the user and the object. In YOLOv5, the model is designed using three modules i.e. Backbone Network, Neck, Head. In Backbone module, from an input image we extract key features using CSPDarknet-53. After extracting key features go to neck module in this module feature fusion network PANet and Spatial Pyramid Pooling (SPP) are used for scaling and identification of objects in different sizes and shapes. The next step is Head in this it performs Dense Prediction this module is the final step for object detection where it gives bounding boxes and detect the object and distance. YOLOv5 outputs three feature maps of different scales to predict the bounding box position information, corresponding category, and confidence of the target along with distance.

The indoor and outdoor objects are recognized as follows:

Fig. 5. Outdoor Object detection with confidence and distance in inches

Fig. 6. Indoor object detection with different orientation

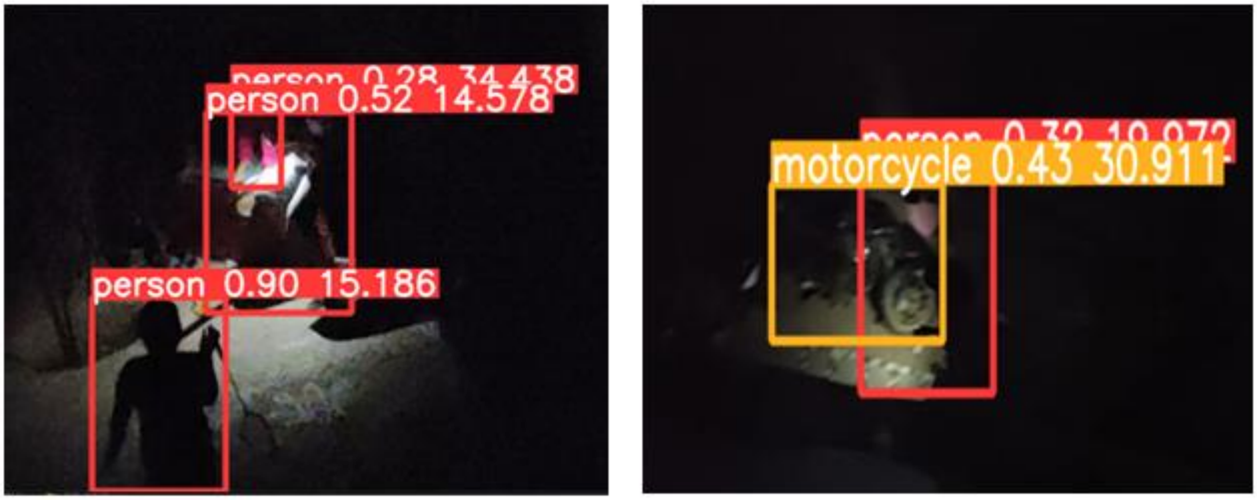

Fig. 7. Object Recognition in poor lighting Conditions

The prototype proposed in this paper also recognizes indoor and outdoor objects with orientations and under poor lighting conditions with high accuracy. The performance is studied based on F1- score, precision and Recall using the following three equations [17] [18].

F1score = 2 * (precision * recall) /(precision + recall) -----(1)

Precision = True Positive /(True Positive + False Positive) -----(2)

Recall =True Positive /(True Positive + False Negative) -----(3)

The prototype is also tested with YOLOv4 and results are compared with YOLOv5. The obtained results are as follows:

Table 1. YOLOv4 vs YOLO v5

	YOLOV4	YOLOV5
Neural Network Type	Fully Convolution	Fully convolution
Backbone Feature Extractor	CSPDarknet53	CSPDarknet53
Neck	SSP and PANet	PANet
Head	YOLO Layer	YOLO Layer
Precision	0.69	0.707
Recall	0.57	0.611
F1 Score	0.607	0.655
Dataset	MS COCO Dataset	COCO Dataset
Objects	121,408 images	330k images
Accuracy	93%	95%
Delay	11secs	7secs

The Table 1 shows that YOLOv5 performance is superior to YOLOv4.

Conclusion and Future Work

By using YOLOv5 different outdoor and indoor objects are recognized and send through voice as output along with distance from the object with an accuracy 95% and delay 7 sec. The performance of YOLOv4 and YOLOv5 algorithms is compared. It is found that YOLOv5 is better in detecting and recognizing the objects than YOLOv4 in terms of accuracy and delay. This system is giving audio output in English language only. In future, we would like to extend it for other languages for user convenience.

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