Obstacle, Fire and Smoke Detector for Visually Impaired Person

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Abstract— In this work, we have developed a portable, versatile and simple simulated circuit model to help the blind person. The proposed model is able to detect the object upto twenty one meters distance with the view of 360 degree. The proposed model is able to classify the object using the You Only Look Once (YOLO) algorithm. The Common Object In Context (COCO) dataset is used for classification. The model is able to measure the distance of the object from the blind person using Sound Navigation & Ranging (SONAR) technique. The model is also able to detect the fire & smoke. The microcontroller is used to take the input from the different sensors, and to analyze the inputs as per the feeded algorithm inside the controller and subsequently to generate a desired output. The generated output in text form is transferred to the smartphone application via serial communication. Smartphone application is designed in such a way that it converts the text into the audio. Finally the audio output is delivered to blind person via smartphone speaker so that the blind person can hear about the things going around and can take the appropriate step in the journey.

Index Terms — YOLO Algorithm, COCO dataset, visually impaired, Serial communication, Flame & Gas sensor, SONAR, blind person.

I. INTRODUCTION

According to the world health organization (WHO) report of 2011, there are 253 Million people in the world who are visually impaired and facing multiple difficulties in their livelihood. Considering the same there are multiple products available in the market which helps a blind person to track the objects through different modes of detection.

There are many applications and devices in the field of helping the blind person and one of them is referred to in [1], where the narrator mobile application is developed using the mobile camera itself through machine learning algorithms and having access in one direction only.

Smart sticks are available to detect the obstacles and to warn the blind person. The work is referred to in [2] where an object detection model is developed on a smart stick having GPS and GSM facility. The disadvantage of smart sticks model is having unidirectional coverage only, rather it should be 360 degree coverage. The referred work in [2] is a narrator model based on the predefined commands and having no real time commands.

A Navigator Smart Cap is proposed in [3], where smart caps are developed having a camera on top of the cap covering the front side towards the blind person's journey. In this model the object is only classified without measuring the distance of the object from the user.

As referred in [4] a simple model is developed which classifies the objects using YOLO algorithm and then converts the text into audio form. This model is working at mobile application end instead of seperate focussed device.

In [5], a model helping blind person is developed in which a specific microcontroller is used i.e. Raspberry Pi which controls all the operations. Raspberry pi is a good choice of controlling unit when there is an inclusion of image data at the controller end.

A collision avoidance system model is developed in [8], where Raspberry Pi with camera module and ultrasonic sensor are used in object detection. The shape, color and distance of the object is also extracted. Collision avoidance systems should have an insight of more than one direction in order to avoid collision, while this model has a unidirectional view only.

A work is referred to in [10], where a model is developed consisting of a mobile application. The mobile application is able to detect the distance of the object using ultrasonic sensors and generates an alert after threshold level. Mobile application is also giving the alert after detection of drowsiness of the human while driving, through measuring the heart beat rate of the person.

An AI based pilot system is developed in [12], where the smart stick concept is represented with the features of source to destination walking instructions in audio format. This model has ultrasonic sensors in multi-directions but the camera is static to uni-direction only.

As per the best of our knowledge, blind people are able to know that there is an X object in front of them in audio format. In the available literature, there is less focus on fire & smoke detection, object distance measurement and identifying if the object is static or moving for the blind person.

In this proposed model, an object is detected in four directions using SONAR technology. Objects are classified using the YOLO algorithm, and COCO dataset is used for classification. The distance of the object from the blind person is also measured. Fire & Smoke around the blind person is also detected using physical sensors. Most significantly in this model, the blind person is able to have insight of 360 degree object detection, rather than having a view of the front side only.

II. MODEL STUDY

In the model, a combination of various electronic sensors & software algorithms are used to detect the object, fire & smoke, to measure the distance from the object and to classify the particular object.

The block diagram of the model is represented in Fig.1.

Gas sensor: The MQ-02 variant of the Gas sensor is used in the model which is able to detect the LPG, alcohol, methane, butane, smoke etc. This sensor has the capability of producing digital output directly in case gas is detected. The digital output of this sensor is directly given to the microcontroller to process it and to generate the output accordingly. Detection concentration scope of this sensor may vary from 200ppm to 5000ppm depending upon the type of gas it is detecting.

Flame sensor: This sensor is used in the model to detect the fire. It basically detects the illumination level of the flame having wavelengths ranging from 760 nm to 1100 nm.

Ultrasonic sensor is used in the model to detect the object and to measure the distance of the object from the blind person. This sensor basically works on the principle of SONAR. The sensor calculates the distance by conversion of time duration to wavelength considering the velocity of the sound as constant. The range of a generic ultrasonic sensor may vary from 3 meters to 21 meters depending upon the frequency of the sound wave generated at the transmitter end of the ultrasonic sensor. The distance d The object from the ultrasonic sensor is calculated by equation (1).

$$d = (v * t) / 2 \tag{1}$$

Where, d is the distance of the object from the ultrasonic sensor, t is the time elapsed by the sound wave in reaching to the object after transmission and coming back to the receiver and, v is the velocity of the sound wave.

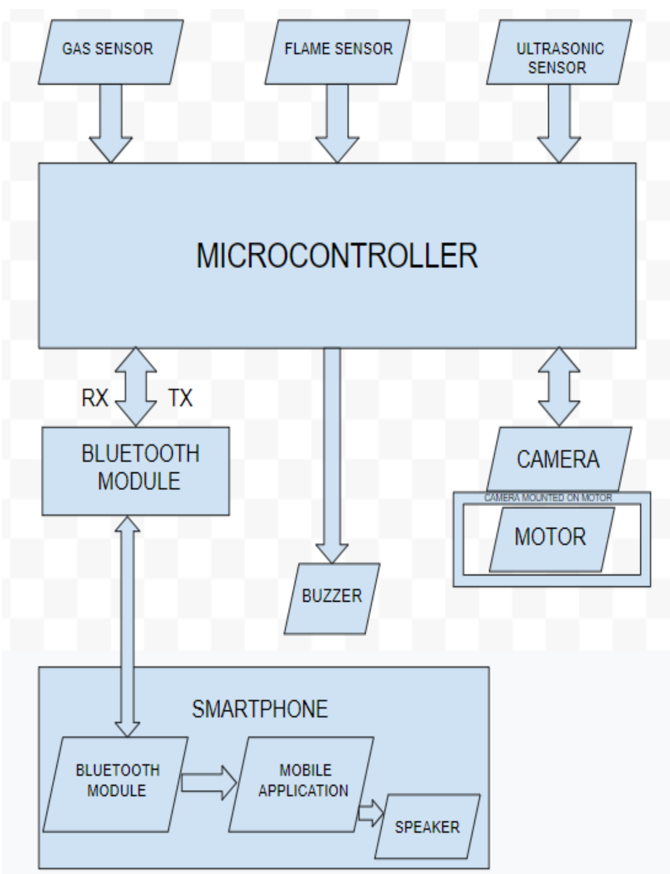


Fig.1 - Block diagram of model

Camera is used in the model to capture an image in the referenced direction it is facing. It captures the image only when it is triggered by the microcontroller. Microcontroller processes the image through a machine learning algorithm YOLO to classify the object.

Motor is used in the model to move the camera in four directions using 360 degree rotation so that the camera can capture the images of four directions.

Microcontroller is used in the model as the dominant part which takes the input from different sensors and further processes them to generate the supposed output using the algorithm programmed inside the memory of the microcontroller. After generating the output in the text form, the controller passes it to the module of serial communication.

Bluetooth Module is used in the model to work as a transmitter which transmits the text output generated by the controller to the receiver which is a smartphone.

Mobile bluetooth is used in the model to receive the actual text information from the model via Bluetooth and the information is processed by the designed mobile application.

Mobile Application is designed to convert the text format output information into audio format and deliver it to smartphone speakers.

Machine learning algorithm YOLO, and COCO data set is used to process the captured image by camera and classifies the captured image using COCO dataset. The classified object is further used by the microcontroller unit in reference to the generation of supposed output.

The YOLO algorithm employs convolutional neural networks (CNN) to detect the objects in real-time. You look only once (YOLO), which actually means that the algorithm makes predictions in a single run.

The speed of detection in the YOLO algorithm is quite good, which makes this algorithm useful for low end processing units. It has minimal background errors, and has an accuracy of 90%. Learning capabilities of the YOLO algorithm are excellent in practical terms.

The YOLO algorithm actually uses three techniques i.e. residual blocks, bounding box and intersection over union (IOU). In residual blocks technique, it divides the image into grids while in the bounding box it highlights the objects through an outline.

Fig.2 - Object classification sample

In Fig.2, the highlighted outline is the predicted box and it is compared with the actual bounding box. In comparison, if the predicted box is an intersection of the bounded box then it shows the results.

III. MODEL ARCHITECTURE

The flow chart of the proposed model is shown in Fig. 3. The gas sensor & flame sensor are used to detect the fire & smoke respectively in the surrounding and produce the output HIGH if gas or fire is detected and LOW otherwise. The combinational output of gas sensor and flame sensor resulted in the following four cases:

Case1-Gas Detection: In the case when Gas sensor output is HIGH and Flame sensor output is LOW, the audio output at mobile application results in "Attention There is Smoke or Gas".

Case2-Fire Detection: In the case when Gas sensor output is LOW and Flame sensor output is HIGH, the audio output at mobile application results in "Attention There is Fire".

Case3-Gas & Fire Detection: In the case when Gas sensor output is HIGH and Flame sensor output is also HIGH, the audio output at mobile application results in "Attention There is Smoke or Gas & Fire".

Case4-Object Detection: In the case when Gas sensor output is LOW and the flame sensor output is also LOW, the microcontroller enables the ultrasonic sensor and detects the object. Only if an object is detected within the range of five feets from the ultrasonic sensor, it enables the camera and

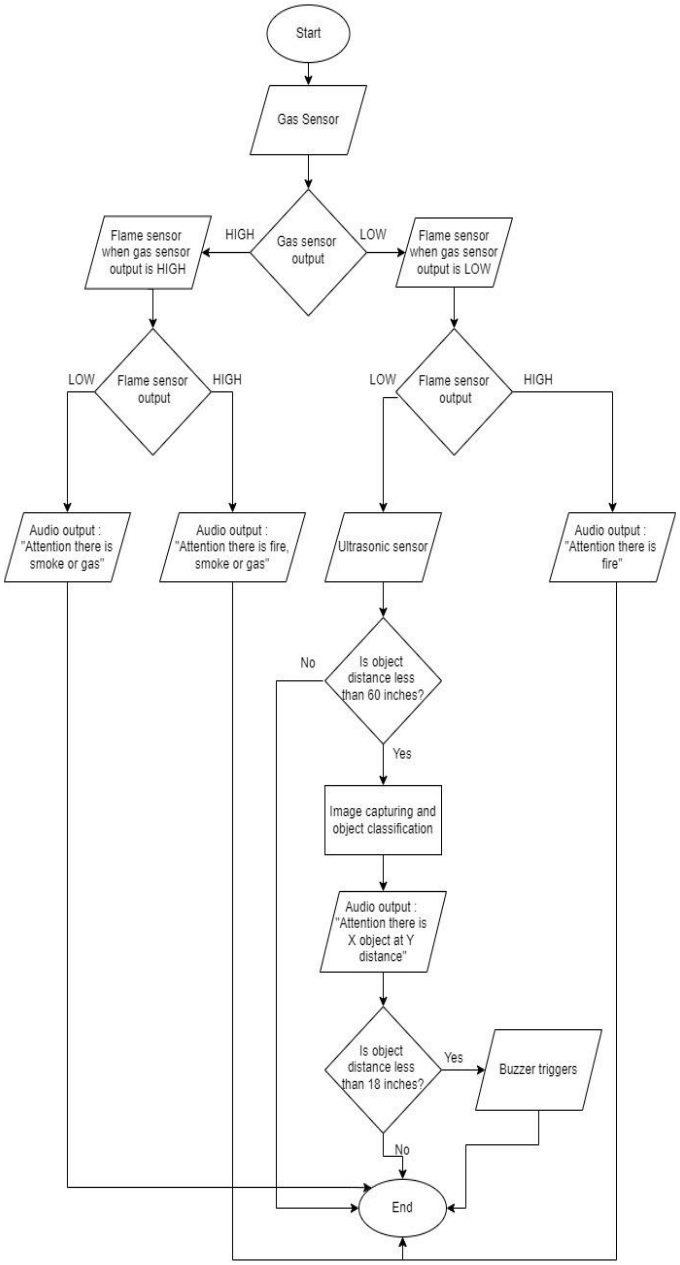


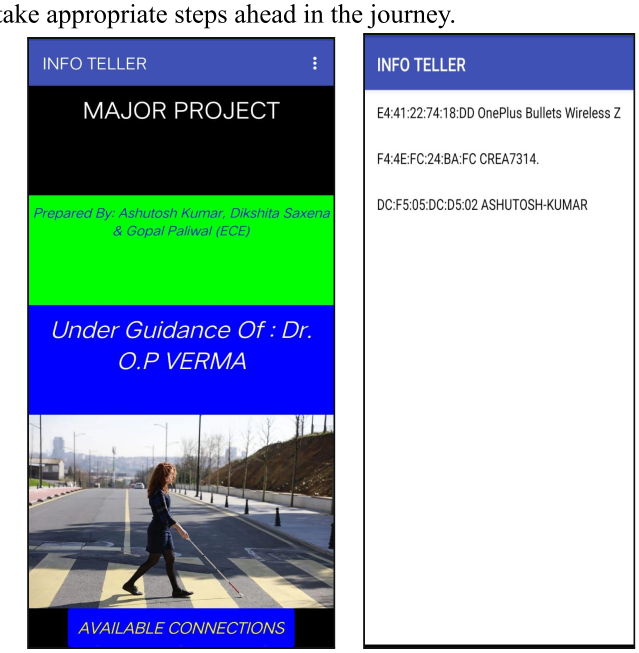
Fig.3 - Control flow Diagram

classifies the object using the YOLO algorithm. If an object is detected at a distance of more than five feets, Case4 simply ends the process. If the object is in the range of five feets, it divides the output into two following special cases:

Special case 1: If the output is detected in the range from one and half feets to five feets, the audio output at mobile application results in “There is X object at Y distance”. Here X and Y are the real time variables.

Special case 2: If the output is detected within one and half feets, the audio output at mobile application results in “There is X object at Y distance”. In addition to the mobile application audio message warning, the buzzer also triggers this time at the controlling unit end to warn the blind person.

The pictorial representation of the designed mobile application is shown in Fig.4-a and Fig.4-b. The mobile application makes a connection with the model bluetooth module. It converts the text message received from the model into an audio message. Finally it delivers the audio to the smartphone speaker so that blind person can hear about the things going around and can take appropriate steps ahead in the journey.



(a) (b)

Fig.4 - Android application, (a) Layout, (b) Available connections

IV. SIMULATION RESULTS

The model has been simulated on a virtual platform for all the key workings of object classification, fire and smoke detection. In the virtual simulation, toggle switch is used to generate the digital outputs of Gas sensor & Flame sensor. A variable resistor is used to vary the distance in an ultrasonic sensor virtually.

Virtual simulation of MQ-02 Gas sensor is shown in Fig.5., representing the Case1-Gas Detection of model architecture.

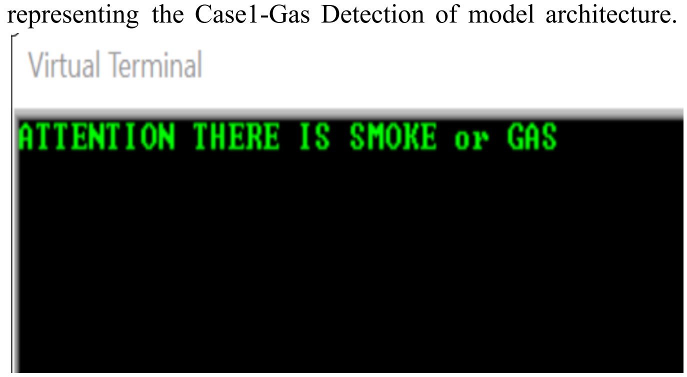


Fig. 5 - Case 1-Gas Detection

Virtual simulation of flame sensor is shown in Fig.6., representing the Case2-Fire Detection of model architecture.

Fig. 6 - Case 2-Fire Detection

Virtual simulation of Flame and Gas sensor is shown in Fig.7., representing the Case3-Gas & Fire Detection.

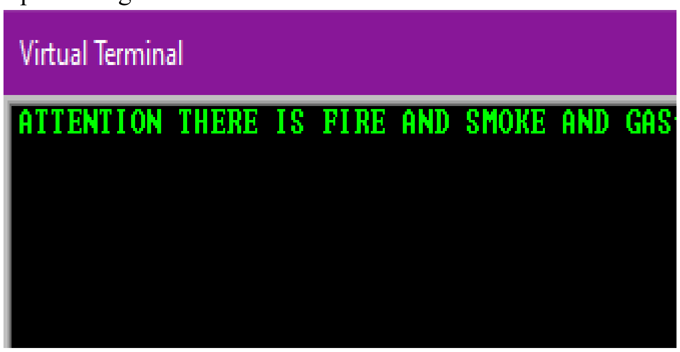


Fig. 7 - Case 3-Gas & Fire Detection

Virtual simulation of SONAR technology of ultrasonic sensors is shown in Fig.8., representing the Case4-Object Detection.

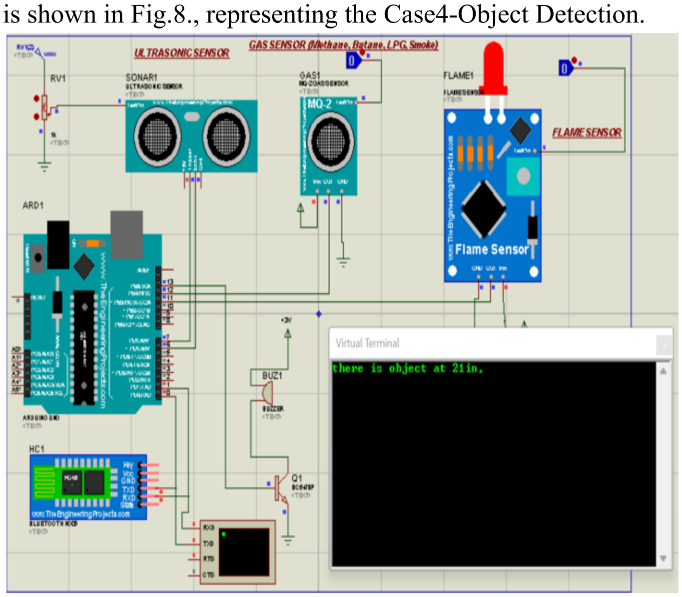


Fig. 8 - Case 4-Object Detection

Virtual simulation of object classification of the model using YOLO algorithm for COCO data set is shown in Fig.9.

V. CONCLUSION

In this work, we have proposed a model to help the visually impaired person. In this model object detection, classification and ranging is achieved using the SONAR technology & YOLO algorithm. Fire & smoke detection is also integrated with the model using physical sensors. The model simulation is not bounded for a single direction only, it is giving the insight of four directions. In the proposed model, smartphone receive the warnings in text form for the detection of fire, smoke & object via serial communication from the model. Smartphone application is converting the text form warnings into audio warnings for ease to the blind person.

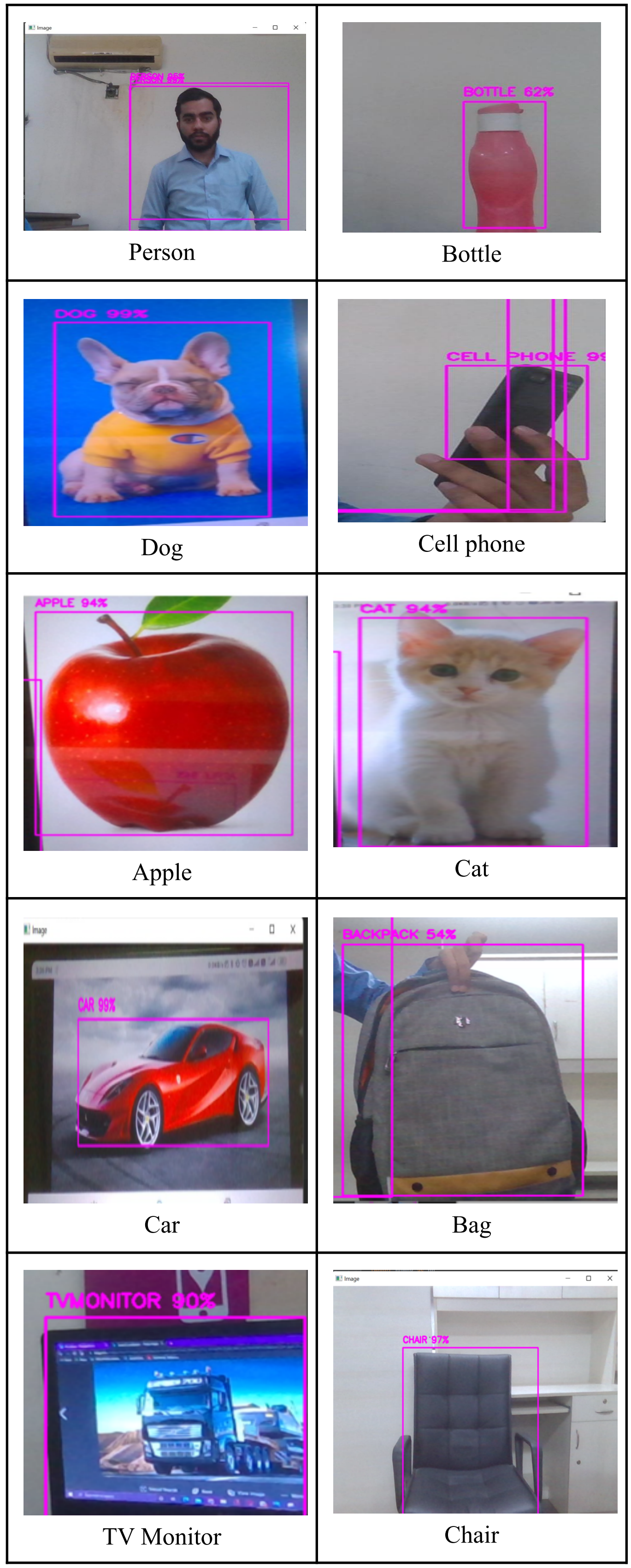


Fig.9 - Object Classification through YOLO

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