Design and Implementation of a Smart Stick for Visually Challenged People

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Design and Implementation of a Smart Stick for Visually Challenged People

A Thesis submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology
In
Electrical Engineering

in
June 2021

to the department of
Electrical Engineering
of
National Institute of Technology, Rourkela

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We, the below signed, after checking the thesis mentioned above and the official record book of the students, hereby state our approval of the thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering at National Institute of Technology, Rourkela. We are satisfied with the volume, quality, correctness, and originality of the work.

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SUPERVISOR'S CERTIFICATE

This is to certify that the thesis entitled, '***Design and Implementation of a Smart Stick for Visually Challenged People***' submitted by *Hamvir Dev, Udeshya Dixit, Shivam Kumar Jha and Biswas Kashyap* in partial fulfillment of the requirements for the award of *Bachelor of Technology degree in* ***Electrical Engineering*** during 2017-2021 at the ***National Institute of Technology, Rourkela*** is an authentic work carried out by them under my supervision and guidance. Neither this thesis nor any part of it has been submitted for any degree or diploma to any institute or university in India or abroad.

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DECLARATION OF ORIGINALITY

We, Hamvir Dev, Udeshya Dixit, Shivam Kumar Jha and Biswas Kashyap, Roll Numbers 117EE0353, 117EE0354, 117EE0362 and 117EE0363 respectively, hereby declare that the presented thesis entitled 'Design and Implementation of a Smart Stick for Visually Challenged People' represents our original work carried out as a degree student of NIT Rourkela and, to the best of our knowledge, it comprises no material previously published or written by another person, nor any material presented for the award of any other degree or diploma of NIT Rourkela or any other institution. Works of other authors cited in this thesis have been duly acknowledged under the section "References". We have also submitted our original research records to the scrutiny committee for evaluation of our thesis.

We are fully aware that in the case of any non-compliance detected in the future, the Senate of NIT Rourkela may withdraw the degree awarded to us based on the present thesis.

June, 2021
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ACKNOWLEDGMENT

This project couldn't have been a success without meaningful contributions from several people directly or indirectly. We received timely suggestions, academic inputs and even emotional support throughout the project period.

We would like to express our sincere gratitude to our supervisor, Prof. K. Ratna Subhashini for believing in our abilities and enriching us with knowledge throughout our project work that crowned our efforts with success. Her constant guidance, positive approach to everything, and her zeal for giving back to the society through this project; has deeply encouraged us.

We would also like to thank all the people, faculty and non-teaching staff who have helped and inspired us during our project work at Department of Electrical Engineering of National Institute of Technology, Rourkela by extending their help and support as and when required. We also express our deepest gratitude to our parents, friends and all our loved ones. Our full dedication to the work would have not been possible without their blessings and moral support.

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ABSTRACT

The blind or visually impaired people have to face a lot of problems in their daily life. This includes several challenges from day-to-day activities to communicating with others. This makes them feel alienated from the society. In this paper we have proposed a system that may prove a boon to them. The system comprises of a smart stick that makes use of the power of modern technologies like sensors, actuators, Artificial Intelligence, etc. It will be equipped with various types of sensors like ultrasonic and fire sensors, microcontrollers like Arduino Nano and Raspberry Pi, several modules like camera module, Global Positioning System (GPS) and Global System for Mobile (GSM) communication modules.

Sensors sense the environment and Camera module keeps taking pictures of the surroundings. These are processed by Raspberry Pi according to the program fed to it, and then suitable instructions are sent to the user through vibrations, buzzer or audio playback. The GPS module receives the coordinates of the user's location, and the GSM module sends this information to the saved numbers allowing tracking of location by relatives and also by police in case some emergency situation occurs.

This project focusses on a system that is simple yet effective, user-friendly and has a good response rate so that user can take necessary steps in time to avoid an accident. This paper consists of the details of this proposed system and the simulation results of its different divisions. It further contains the analysis of the working prototype we have developed and how it stands on the expectations of all.

Keywords: Arduino Nano, Raspberry Pi, sensor, actuator, GPS, GSM

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
GPS	Global Positioning System
GSM	Global System for Mobile Communications
MWIR	Mid-Wave Infrared
TDMA	Time Division Multiple Access
API	Application Process Interface
YOLO	You Only Look Once
CNN	Convolutional Neural Network
R-CNN	Regions with Convolutional Neural Network
RPN	Region Proposal Network
RO	Region of Interest

CHAPTER 1

INTRODUCTION

Overview
Aim
Motivation
Outline of thesis

INTRODUCTION

In this chapter, overview of the smart stick is given. After getting the essence of its necessity, the aim and motivation behind the project is explained. Finally, the outline of thesis is mentioned

1. 1. Overview

According to a report of the World Health Organization (WHO), there are about 285 million visually impaired people globally. Out of them almost 40 million are blind [1]. In a modern world like ours, there are a lot of problems faced by these visually challenged people. This includes several challenges from day-to-day activities to communicating with others. They face difficulty in interacting with the environment or society due to their inability of making contact with the world using their visual sense organs unlike we normal people do. They have very limited physical movement because they can’t properly distinguish hurdles in their way or know how to react in some emergency situations. Though they can rely to some extent on hearing abilities but that seems too risky. For a long time, walking cane and helper dogs have also been of assistance to them. Still, considering a wider picture, many feel hopeless and lack confidence; they face difficulties in socializing and feel themselves cut from the mainstream. Even in a digitalized and modern world like ours, where science and technology are reaching new heights with each day, there is next to nothing that really helps these people to make their day-to-day routine easy.

1. 2. Aim

The main aim of the project is to use the power of modern technologies like sensors, AI, etc. to make a cost effective and convenient to carry smart stick for the visually impaired that would make their life a lot easier. The stick would sense the environment around and give appropriate instructions to the user to take necessary steps to avoid an accident. As such, they won’t feel reluctant interacting with environment and would see themselves socializing with others.

1. 3. Motivation

Though there are few solutions for the same purpose in market like UltraCanne, Isonic, Teletact, etc. but they possess notable disadvantages as mentioned in [2]. They can't detect hidden obstructions like downward stairs, holes etc. Ample training is necessary to help the user understand the feedback signals and to react to them in real time. This can be sometimes tiresome or even expensive [2]. Also, Information transmitted as cracking sound may be embarrassing for the blind person in public. Affordability is also an issue. Thus, our solution will be an alternative to the traditional canes as well as these existing solutions, providing faster response, reliability, affordability and a user -friendly experience.

1. 4. Outline of Thesis

Chapter 1 provides an overview of the smart stick. After getting the essence of its necessity, the aim and motivation behind the project is explained.

Chapter 2 enlists the functionalities we want to implement in our proposed system in the form of objectives of our project.

Chapter 3 infers a basic schema of the system along with the challenging areas involved in implementation of the project.

Chapter 4 explains the different divisions of the system, electrical equipment used for implementation and algorithms used.

Chapter 5 consists of the simulations done for different modules.

Chapter 6 shows the prototype of smart hand stick we made, and it's different responses in real time.

CHAPTER 2

OBJECTIVES

OBJECTIVES

In this chapter, the functionalities we want to implement in our proposed system are enlisted. These ranges from detection of obstacles, to getting images of the surroundings, to warn the user of the potential threats and even track him/her with a GPS module.

- To detect static obstacles in the way using sensors
- To detect water lying on the ground, potholes, pits and staircases.
- To warn the user about various obstacles and give directions via an earpiece in enough time for the user to act upon.
- To track user using a GPS module and save various locations in order to assist him/her reach the destination.
- To send a warning message in case of emergency using a GSM module.
- To get an image of the surroundings and obstacles in order to predict various things such as the surrounding is crowded or not.
- To detect objects in the image taken and then use the information to instruct the user.
- To predict the type of surface of the ground if it is smooth or rough.

CHAPTER 3

METHODOLOGY

Basic Schema
Challenges

METHODOLOGY

In this chapter, different components of the smart stick are enlisted and an overview of how they synchronize among themselves as a single unit, is explained.

3. 1. Basic Schema

The system is equipped with different types of sensors, camera module and Artificial Intelligence techniques. The brain of the system constitutes Raspberry pi and Arduino Nano where all the inputs are processed and decisions are made. There are different types of sensors such as ultrasonic sensors for detecting large and static obstacles, temperature sensor for sensing the surrounding conditions, etc. There are camera modules to take images of the surrounding for processing and for detecting moving obstacles such as vehicles. The images from camera are processed inside the raspberry pi and AI techniques are used for identifying different types of obstacles. The system has GPS module to locate the user and its destination and an audio playback module to guide the user via audio instructions. There is also a GSM module to send a message to saved mobile numbers when prompted by the user in cases of emergency.

3. 2. Challenges

The most challenging part of the system is to integrate the individual components into a single system and to process all the inputs to make a decision for the user in a very short time so that user will be able to act upon the situation in enough time to avoid any type of accident. Apart from that we also need to use minimum number of sensors and camera modules in order to reduce the costs and make the system more effective and faster as reducing the number of inputs will lead to faster processing but will affect the accuracy of the system. Hence the utilization of the equipment has to be done in such a manner that accuracy and speed of the system is maintained at the same time. Apart from these things we also need to make the system as user friendly as possible, such as instead of telling the user about obstacles in detail we can just give instructions to the user to avoid that obstacle.

CHAPTER 4

DESIGN OF SMART STICK

Arduino Nano with Sensors, GPS & GSM
Raspberry Pi with Camera Module

DESIGN OF SMART STICK

In this chapter, the complete design of smart stick is explained. It provides a detailed discussion on the different divisions of the system, the components used and the mathematical or analytical validation of the theories involved.

The system consists of two parts; one where Arduino Nano is used for taking inputs from various sensors, GPS and process the information for making decisions whereas the second part has Raspberry Pi with camera module which takes images of the surroundings and object detection techniques are used to make decisions. Overall rough idea of functioning of our proposed system is depicted in Fig.1

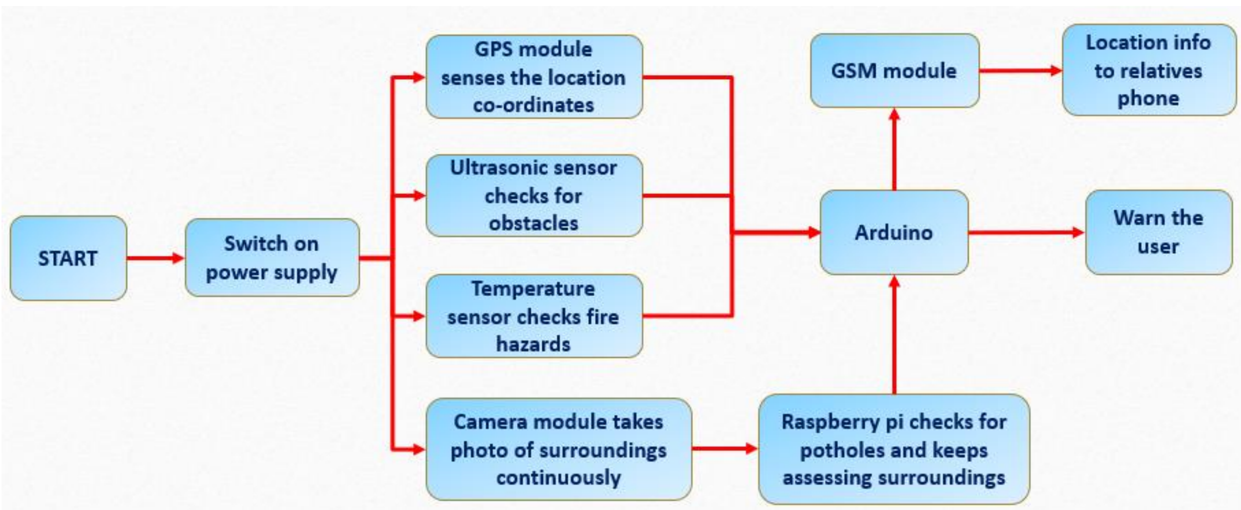


Figure 1: System Flow Chart

4. 1. Arduino Nano With Sensors, GPS & GSM

This part basically consists of 6 components: -

a) Temperature Sensor
b) Ultrasonic Sensor
c) Arduino Nano
d) Buzzer
e) GPS Module
f) GSM Module

4. 1. 1. Temperature Sensor:

It's basic use is to sense the temperature of the surroundings and then warn the user of any fire hazards nearby. Though we have used LM35 analog temperature sensor here, but we can also use thermistors or MWIR infrared cameras to detect fire and alarm the user. It has 3 terminals as can be seen in Fig.2. 2 for giving supply and ground; and third one is for taking output. It senses the temperature of surrounding and gives it as output in form of voltage that can be analog read using Arduino and converted back to temperature using appropriate formulae [3] . We can give it input from 4 to 20V. Generally, the temperature sensor sends back voltage that is directly proportional to the temperature sensed. For instance, LM35 uses 10 mv for each degree rise in centigrade [3]. So if we are using an Arduino to read this voltage (using AnalogRead( )) then, we will get some value between 0 to 1024 and we have to convert it back to voltage and then to temperature.

For simple LM35 the conversion formulae becomes: -

$$T = \left(\frac{x}{1024}\right) * V_{ref}/10$$

Where,

T = temperature in degree Celsius (℃)

x = the reading of Arduino through analog input pin.

V_{ref} = Reference voltage of Arduino in mV (5000mV)

Generally, LM35 works over a temperature range of -55 ℃ to 150 ℃. The 'x' in the equation is the difference of value between output pin and ground pin of LM35, but since gnd pin is connected solidly to ground we can take output pin as output.

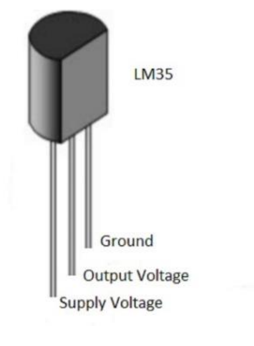


Figure 2: Pinout diagram of LM35 temperature sensor

4. 1. 2. Ultrasonic Sensor:

It's basic use is to sense any obstacle in front and warn the user about any near obstacle through a buzzer or speaker. For hardware implementation, we used HC – SR04 sensor. It has 4 terminals as can be seen in Fig.3. 2 are for supply and ground respectively. Third pin is trigger pin which is an input pin and has to be kept high for 10µs to initialize measurement by sending ultrasonic wave. The fourth pin is echo pin. It is an output pin and this pin becomes high until the sent wave is received back by the sensors. So, if we measure the time for which echo pin remains high then we can measure the distance of the obstacle from the sensors [3]. Its operating voltage is 5v.

Simply,

$$D = S * T/2$$

D = distance

S = speed of sound

T = time taken for wave to return back, called as Time of Flight (TOF)

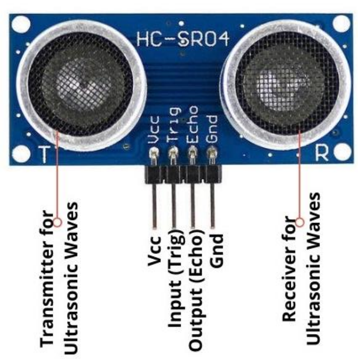


Figure 3: Pinout diagram of ultrasonic sensor

In Arduino, we have a "pulseIn" function that measures the time T for which echo pin remains high and thus we can find distance from the above formulae. If this distance is less than a certain threshold then we can warn the user. Other than time of flight (TOF), detection using ultrasonic sensor also depends on Beam size [2]. Obstacle size and the amount of reflected wave are closely related to each other. Obstacles that have dimensions greater than the beam size, all of the sound waves will be reflected to receiver. In case of obstacles having size small as compared to the beam size, one part of the ultrasonic sound wave will be reflected to the receiver and the rest will be lost. This is shown in Fig.4. Here, we propose to use 2 sensors facing front, one at the upper position & one at lower position in order to detect both small and large obstacles. We may use an extra sensor for covering wider angle and allowing detection on sideways too. In our design it is powered from 5V output pin of Arduino Nano.

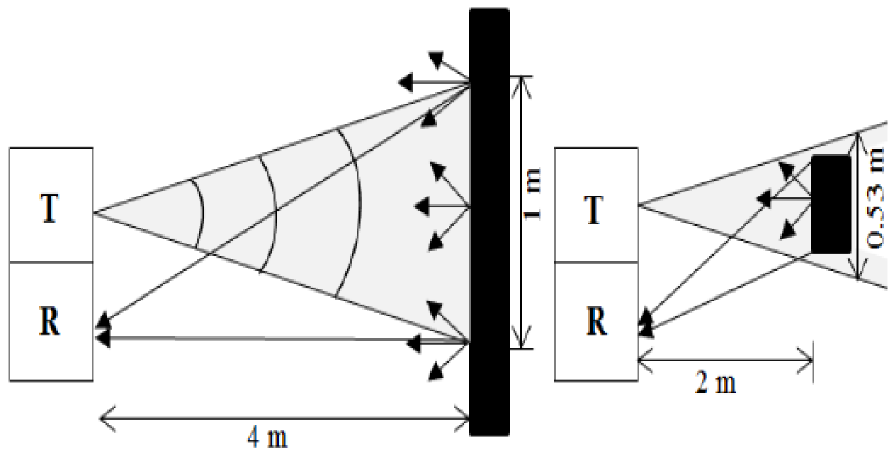


Figure 4: Large and small obstacle detection by ultrasonic sensor [2]

4. 1. 3. Arduino Nano:

This is the brain of our electronics division. It decides what and which type of hazard is there and whether to alarm the user or not. Its operating voltage is 5V and thus, we can give input in the range of 7 – 21v. It has 8 analog input pins and 14 digital pins that can be used as input or output. Atmega328 microcontroller is used here. It's crystal oscillator is of 16MHz frequency. It supports Serial and I²C protocol communication. Memories are embedded in it for different purposes. It's small size offers us flexibility. It is used extensively in areas like automation, robotics, control system.

Figure 5: Arduino Nano

It is interfaced with ultrasonic sensor, temperature sensor and GPS module. It takes analog input from temperature sensor using an analog input pin and calculates the temperature of the surroundings from it. It then decides if the temperature is hazardous or not [4]. Similarly, it calculates the time for which the echo pin of ultrasonic sensor remains high, which is attached to one of the digital pins on Arduino Nano, and calculates the distance of the user from the obstacle and if the obstacle is nearer enough then it warns the user about the obstacle. It receives the location coordinates of the user in panic situations and directs the GSM module to send this information to the phone numbers of relatives or police so that they can track him/her.

Even the raspberry pi (for object detection using AI techniques) can be interfaced to this Arduino so that without having 2 outputs in our system we will have one output and it will be through this Arduino or the other way round. But we must take care about not overloading this Arduino, so we must give supply to the sensors, in such case, through another battery using buck converter.

4. 1. 4. Buzzer:

It is an audio signaling device that generates sound in the range 1 kHz to 7 kHz. The sound of buzzer can be heard even in the noisiest of the environment. It can be used to signal the blind people of any impending danger. It can be attached to ear so that the blind people will be able to hear it properly. Mainly there are two types of buzzers piezoelectric and electromagnetic. In our circuit whenever there is a need to inform the blind person about any danger it is done using buzzer. A piezoelectric buzzer operates on the principle of piezoelectric effect. It has a piezoelectric element and a metal disc that are held together with an adhesive. The piezoceramic disc (made of piezoelectric material) has electrodes attached to it which produces vibration when current flows through it and this vibration produces sound. Electromagnetic buzzer contains oscillator, solenoid, and magnet. When the power supply is switched ON, the current generated by the oscillator passes through the solenoid coil which generates magnetic field. The vibration diaphragm continually vibrates under the interaction of solenoid coil and magnet and thus produce sound.

4. 1. 5. GPS Module:

GPS is a satellite-based navigation system made up of at least 24 satellites. It can work universally in any climatic conditions. These satellites circle the Earth twice a day in a precise orbit. GPS devices decode and compute the precise location of the satellite with the help of signals and orbital parameters transmitted by them. GPS receivers use this information and trilateration to calculate a user's exact location. To calculate the dimensions: latitude and longitude, the receiver should be locked on to the signal of at least 3 satellites [5]. With 4 or more satellites in view, the receiver can determine all the dimensions: latitude, longitude and altitude. Generally, a GPS receiver tracks 8 or more than that number of satellites, but it depends upon the time of day and where it is present on the earth [5].

A GPS signal contains 3 different types of information: Pseudorandom code, Ephemeris data and Almanac data. Pseudorandom code helps in identification of transmitting satellite. Ephemeris data helps in determining the satellite's position. Almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day and shows the orbital information for that satellite and every other satellite in the system.

Now, the GPS module is used to determine the location of a person or object on which it is attached. It can help the blind person to reach his/her destination or can give the location of the blind person to the family members in case he/she is lost or has come across some emergency situation. Tracking becomes much more convenient. This module generally consists of 4 pins as shown in Fig.6. One is Vcc (input voltage), second is for gnd (ground) and two other pins are Tx and Rx for transmission and receiving respectively. It is connected with Arduino and continues to send latitude and longitude of the blind person continuously. It communicates with the Arduino serially. There will be a switch that controls the OFF and ON of GPS module. So, when the blind person thinks that he is lost, feels some sort of danger, faces difficulties in unfamiliar environments or suddenly have some health issues; he can press the switch so that the GPS module will send the location of the person to Arduino which further, with the help of GSM module, can send the location information to the saved numbers.

To make it work perfectly fine with Arduino, we have to download a "*tinygps*" library in the Arduino and work with it. If we are using pins other than Rx and Tx, then we also have to use "*Softwareserial*" library. It's work is to give the latitude and longitude of the location when required or more specifically when the button is pressed.

Figure 6: Pinout diagram of NEO-6M GPS Chip (on Left) and External antenna (on right)

4. 1. 6. GSM Module:

GSM is a widely used mobile communication system in the world that is used for transmitting mobile data and voice services. This technology utilizes the time division multiple access (TDMA) technique for communication purposes. A GSM first digitizes the data and after reduction, finally sends it down through a channel with two different streams of client data, each in its own particular time slot. This digital system has the ability to carry 64 kbps to 120 Mbps of data rates.

Now, here we have used GSM module to transfer message to a mobile number using Arduino. If the blind person feels himself lost or faces some panic situation, he can press a button to send the message of his location using GPS module to his relatives using GSM module. It is a wireless modem that sends and receives data using radio waves. There are different kinds of GSM modules available in the market. Generally used is "*Simcom SIM900*". The board has provisions for attaching mic and speaker. But these types of provisions vary with different types of modules. GSM module's Rx and Tx pin are connected to PWM pins of Arduino and using "*Softwareserial*" library we can communicate with the GSM module. Communication with the GSM module follows certain steps and after following those steps we can send the data we want to send to GSM which further forwards it to the mobile number we have given.

Figure 7: SIM900a GSM Module

4. 2. Raspberry Pi with Camera Module

We are using Raspberry Pi due to its ability to handle advanced applications like Object Detection [5]. An image of the surroundings is taken by the camera periodically, which is then processed in the Raspberry Pi. The Object Detection model gives the information about various objects present in the surrounding as output which is then conveyed to the user using audio playback so that the user can take appropriate action. Here we are using Tensorflow Object Detection API for the given task. This API contains a pre-trained YOLO model and is very effective in detecting various classes of objects.

4. 2. 1. Object Detection:

Object detection is a computer vision technique that works to identify and locate objects within an image or video. Specifically, object detection draws bounding boxes around these detected objects, which allow us to locate where said objects are in (or how they move through) a given scene or frame [7]. It is different from image recognition in the sense that image recognition only performs labelling of an image as shown in Fig.8 & Fig.9. Here in Fig.8, given the image identifying that a dog is present in it will be termed as image recognition whereas telling where the dog is present in the given image (in terms of pixel coordinates) will be termed as Object Detection. Hence, we can say that object detection provides more information than image recognition. Also, when there are a number of objects present in the given image, recognition does not work but using object detection we can locate the different objects present in the image and then perform classification to recognize those objects. Earlier various image processing techniques were used to detect different objects present in an image and it was a process that involved various steps and was very cumbersome with not so good accuracy. Nowadays with the advent of deep neural networks like CNNs object detection can be done in mere one or two steps and is highly accurate.

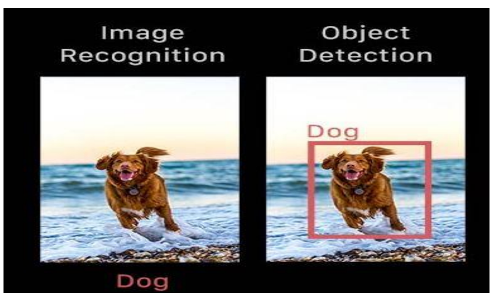


Figure 8: Image recognition and Object Detection [7]

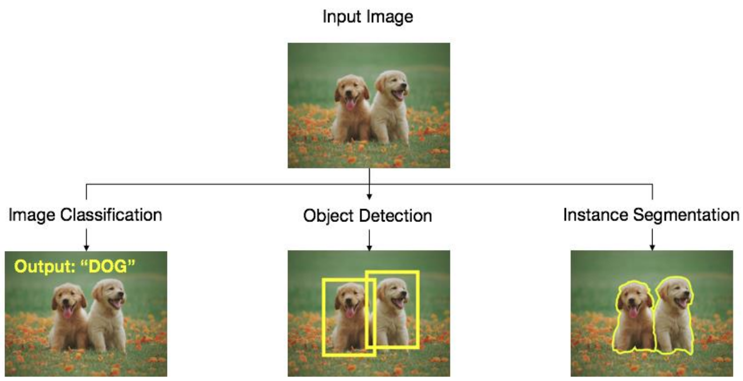


Figure 9: Different Image Processing tasks [7]

Hence broadly speaking, object detection can be broken down into machine learning-based approaches and deep learning-based approaches. In more traditional ML-based approaches, computer vision techniques are used to look at various features of an image, such as the color histogram or edges, to identify groups of pixels that may belong to an object. These features are then fed into a regression model that predicts the location of the object along with its label. On the other hand, deep learning-based approaches employ convolutional neural networks (CNNs) to perform end-to-end, unsupervised object detection, in which features don't need to be defined and extracted separately hence making object detection using deep neural networks more efficient as well as accurate [7].

Object Detection is being extensively used in various domains to solve different problems. Some applications of Object Detection are: -

- Crowd counting
- Self-driving cars
- Video surveillance
- Face detection
- Licence Plate Detection
- Anomaly Detection

- Medical Object Detection (e.g., Liver Lesion Detection)
- Vehicle Detection

There are various CNN based models available for Object Detection with their own pros and cons. Mainly these can be divided into two, those who perform object detection in a single step (e.g. YOLO) and those who perform object detection in two steps (e.g. Faster RCNN).

To understand how object detection works we are going to discuss about two models one which performs detection in a single step (YOLO) and the other which performs detection in two steps (Faster RCNN): -

1. YOLO
2. Faster RCNN

4. 2. 2. YOLO (You Only Look Once)

YOLO is one of the fastest algorithms for Object Detection. Although it is little bit less accurate, it is perfect for real time object detection where faster results are needed. There are different versions of this model each improving on the previous in terms of accuracy or speed. YOLO v2 (YOLO9000) was the fastest and one of the most accurate models of its time but soon it was outperformed by other models like SSD in terms of accuracy. YOLO v3 traded speed to achieve higher accuracy by using a more complex architecture. Here we discuss YOLO v3.

YOLO v3 uses a variant of Darknet, which originally has 53 layered network trained on the Imagenet Dataset. For the task of detection, 53 more layers are added to it, giving us a 106 layer fully convolutional underlying architecture for YOLO v3. This increase in complexity of the architecture results in higher accuracy but at the cost of slower processing speed. The architecture of the YOLO v3 is shown in Fig. 10 on next page.

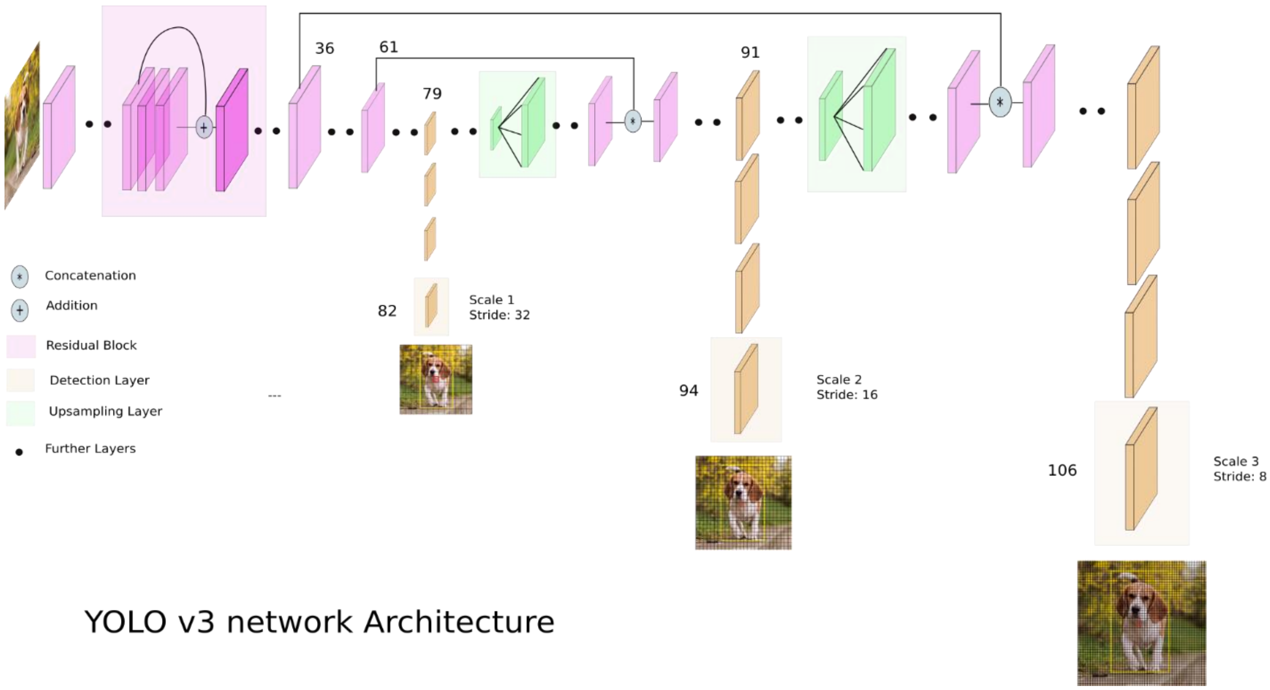


Figure 10: YOLO v3 architecture [8]

The newer architecture boasts of residual skip connections, and up-sampling. The most salient feature of v3 is that it makes detections at three different scales. YOLO is a fully convolutional network and its eventual output is generated by applying a 1 x 1 kernel on a feature map [6]. In YOLO v3, the detection is done by applying 1 x 1 detection kernels on feature maps of three different sizes at three different places in the network. [8]

The shape of the detection kernel is 1 x 1 x (B x (5 + C)). Here B is the number of bounding boxes a cell on the feature map can predict, "5" is for the 4 bounding box attributes and one object confidence, and C is the number of classes.

In YOLO v3 trained on COCO, B = 3 and C = 80, so the kernel size is 1 x 1 x 255. The feature map produced by this kernel has identical height and width of the previous feature map, and has detection attributes along the depth as described in Fig. 11 on next page [8].

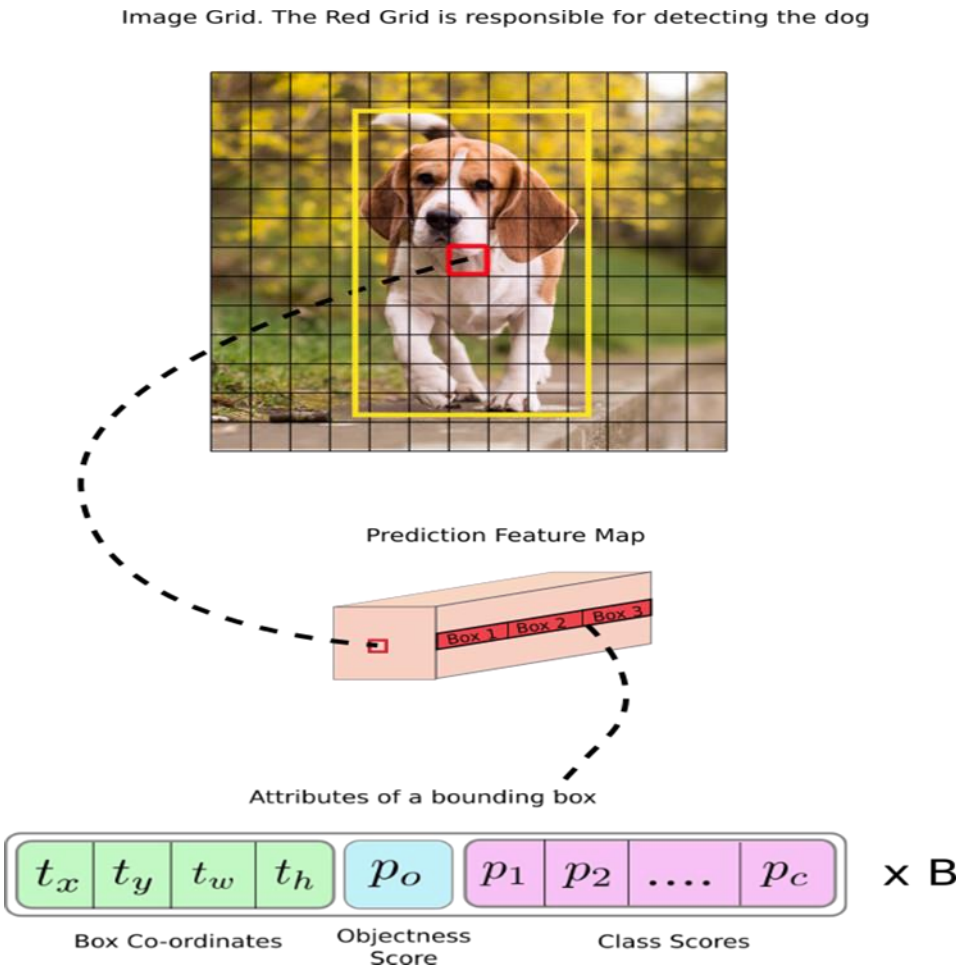


Figure 11: Detection by YOLO v3 [9]

Assuming the input size to be 416×416, YOLO v3 makes prediction at three scales, which are precisely given by down-sampling the dimensions of the input image by 32, 16 and 8 respectively. The first detection is made by the 82nd layer. For the first 81 layers, the image is down sampled by the network, such that the 81st layer has a stride of 32 [6]. If we have an image of 416 x 416, the resultant feature map would be of size 13 x 13. One detection is made here using the 1 x 1 detection kernel, giving us a detection feature map of 13 x 13 x 255 [8].

Then, the feature map from layer 79 is subjected to a few convolutional layers before being up sampled by 2x to dimensions of 26 x 26. This feature map is then depth concatenated with the feature map from layer 61. Then the combined feature maps are again subjected to a few 1 x 1 convolutional layers to fuse the features from the earlier layer (61). Then, the second detection is made by the 94th layer, yielding a detection feature map of 26 x 26 x 255 [8].

A similar procedure is followed again, where the feature map from layer 91 is subjected to few convolutional layers before being depth concatenated with a feature map from layer 36. Like before, a few 1 x 1 convolutional layers follow to fuse the information from the previous layer (36). We make the final of the 3 at 106th layer, yielding feature map of size 52 x 52 x 255 [8].

Detections at different layers helps addressing the issue of detecting small objects, a frequent complaint with YOLO v2. The up-sampled layers concatenated with the previous layers help preserve the fine-grained features which help in detecting small objects. The 13 x 13 layer is responsible for detecting large objects, whereas the 52 x 52 layer detects the smaller objects, with the 26 x 26 layer detecting medium objects [8].

4. 2. 3. Faster R-CNN

Faster RCNN is a two-stage detector i.e., it performs object detection in two stages: - Region Proposal and Detection on Proposed Regions. Hence, it is composed of two modules. The first module is a deep fully convolutional network called as Region Proposal Network (RPN) that proposes regions, and the second module is the Fast R-CNN detector that uses the proposed regions to make detections. The entire system is a single, unified network for object detection as shown in Fig. 12 [10].

Both the Region Proposal Network and the Fast R-CNN detector use the same backbone hence there is weight sharing making the model more time efficient. The input image is first passed through the shared backbone (generally VGG-16 is used as the shared backbone for Faster R-CNN) which gives a feature map as output which is much smaller in size as compared to the input image but has a larger depth. The backbone feature map is then passed through a classification network which gives probabilities whether each point in the backbone feature map contains an object or not i.e., it gives the proposed regions that may contain objects. The backbone feature map is passed through a ROI pooling layer followed by a regression network in a sister branch which gives the regression coefficients for each of the anchors for every point in the backbone feature map. These coefficients are then used to improve the coordinates of the anchors that contain objects (predicted by the RPN). In this way Faster R-CNN works as a two-stage detector which gives region proposals in the first stage and then in the second stage it gives the coordinates of the bounding boxes that contain objects [10].

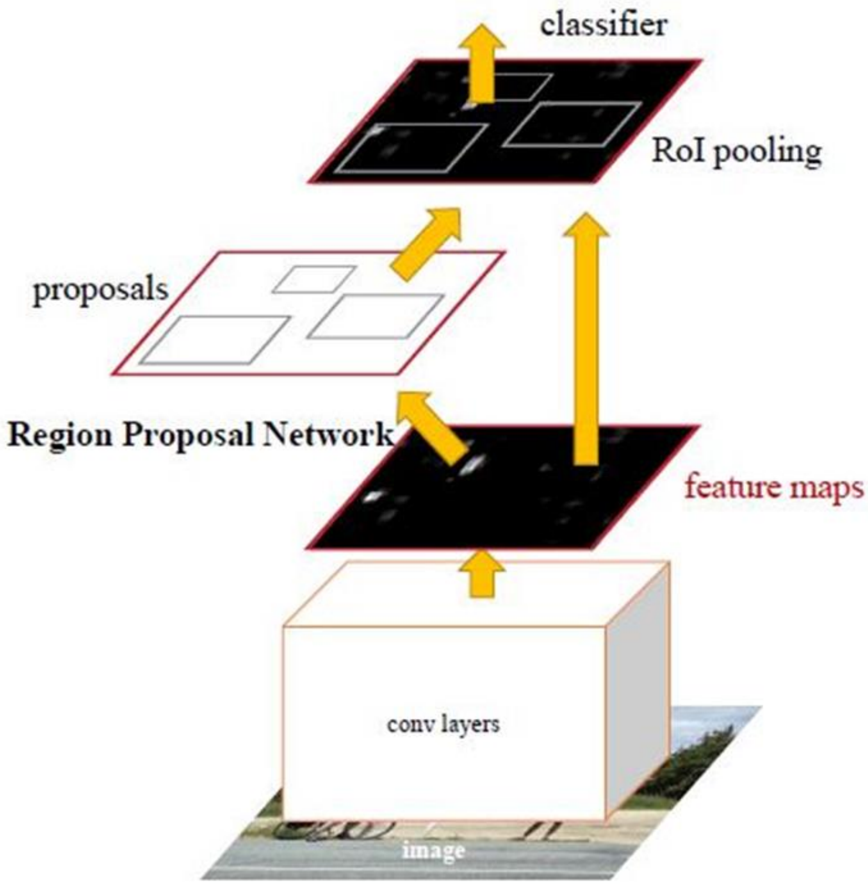


Figure: 12 Faster R-CNN architecture [10]

Doing the region proposal and detection separately makes the Faster R-CNN model highly accurate but at the cost of processing speed. Faster R-CNN is much slower as compared to Single Stage Detectors like YOLO but is highly accurate. The slow speed of this model makes it unsuitable to be used for real time detection on low-end devices. In our project we are using Raspberry Pi and also require fast real time object detection hence for this purpose the Faster R-CNN model is not suitable. Hence, we are using the TensorFlow Object Detection API which uses a Single Stage Detector for Object Detection and is fast enough to suit the needs of our project. Here we are using a pre-trained model but using TensorFlow Object Detection API we can train a custom object detection model which suits the requirements of the project better.

4. 2. 4. Why Object Detection?

Using various sensors, we can get various information about the surroundings such as if there is an obstacle present or not. But we cannot tell what type of obstacle is present in particular. Using Object Detection, we can get the information about different objects and obstacles that are present in the surrounding. This information can then be used to help the user in moving around with much ease.

CHAPTER 5

SIMULATIONS

Temperature Sensor
Ultrasonic Sensor
GPS & GMS

SIMULATIONS

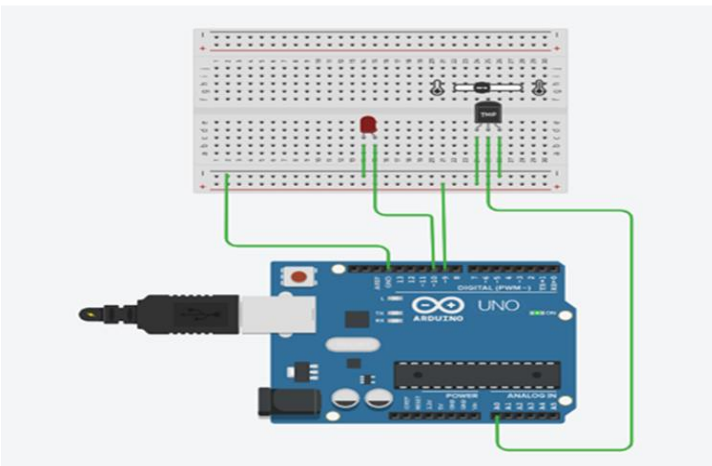
In this chapter, different simulations are shown which were done for different modules. TinkerCAD and Proteus 8 Professional software have been used.

*We have used *TinkerCAD* for simulations of sensors and check whether they give the desired outputs. The platform provides the facility of powering the virtual Arduino board and all other components through USB Cable. Practically, we just feed the program to Arduino through USB and have separate battery banks for powering up the entire circuitry.

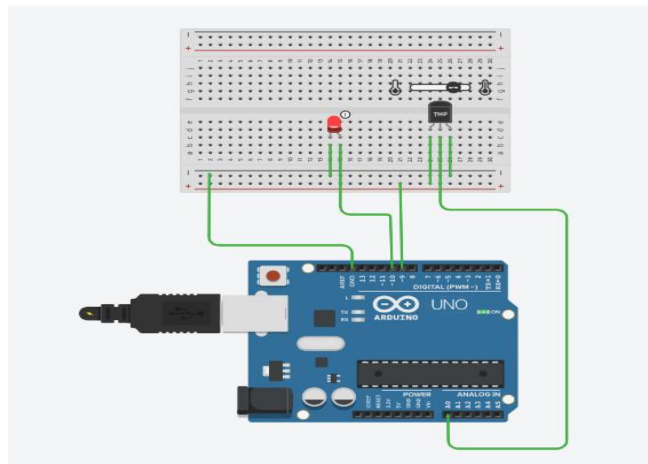
*Simulations for GPS & GSM have been done on *Proteus 8 Professional*. This software doesn't have the Arduino, GPS or GSM libraries pre-installed. So, one needs to download them separately from the internet and then add the libraries to the software manually. Arduino library can be found on it's official website but for GPS & GSM, we used the libraries built by TheEngineeringProjects.com website for simulation purposes. Though the GPS or GSM modules practically comes with several pins and sub-components, the website offers an integrated versions of these modules in the libraries. Only two pins are accessible to us: - one being the transmission pin and other the receiving pin.

GPS transmits location coordinates to Arduino and then Arduino transmits it back to GSM through some pin. GSM module receives the instructions serially on it's receiving terminal and then transmits them to the virtual monitor for displaying the message. Practically, this virtual monitor will be the cell phones, numbers of which are already saved in the GSM. The simulations are presented in a way that once the circuitry powers ON, GPS keeps accessing User's location and continuously sends data to Arduino. In real scenario, flexibility of operating it only when required can also be given. When the blind person feels some sort of difficulty, he will switch on a button available near the hand-grip of the stick, which will power on the GPS and GSM. GPS then locates the person and sends the coordinates to the relatives helping them to track him/her easily. It's also possible to integrate this GPS & GSM combination with camera module in such a way that along with the location coordinates, images of the surroundings taken by camera are also sent to the relatives through GSM. As such, one can have a better picture of the area where the blind person has got stuck.

5. 1. Temperature Sensor



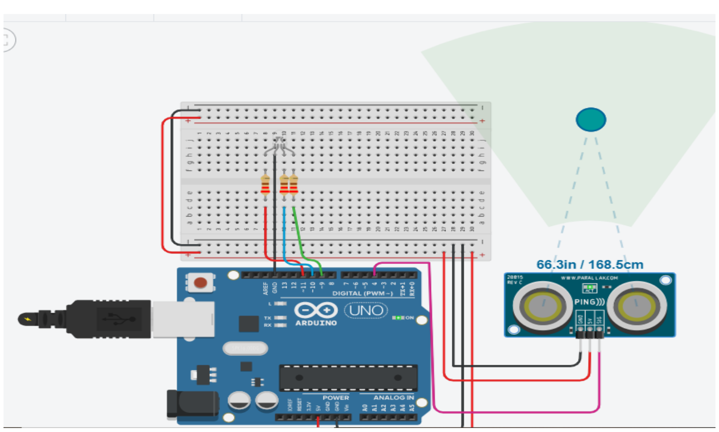
(a)



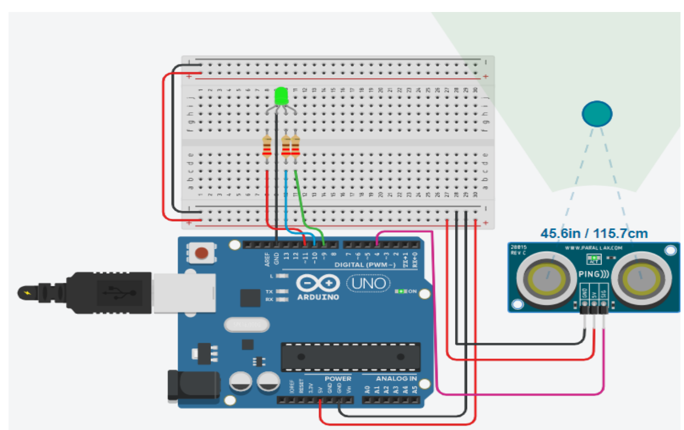
(b)

Figure 13: For Temperature Sensor, (a) circuit at normal temperature (b) circuit when temperature is above 50°C. Here Led (output) glows

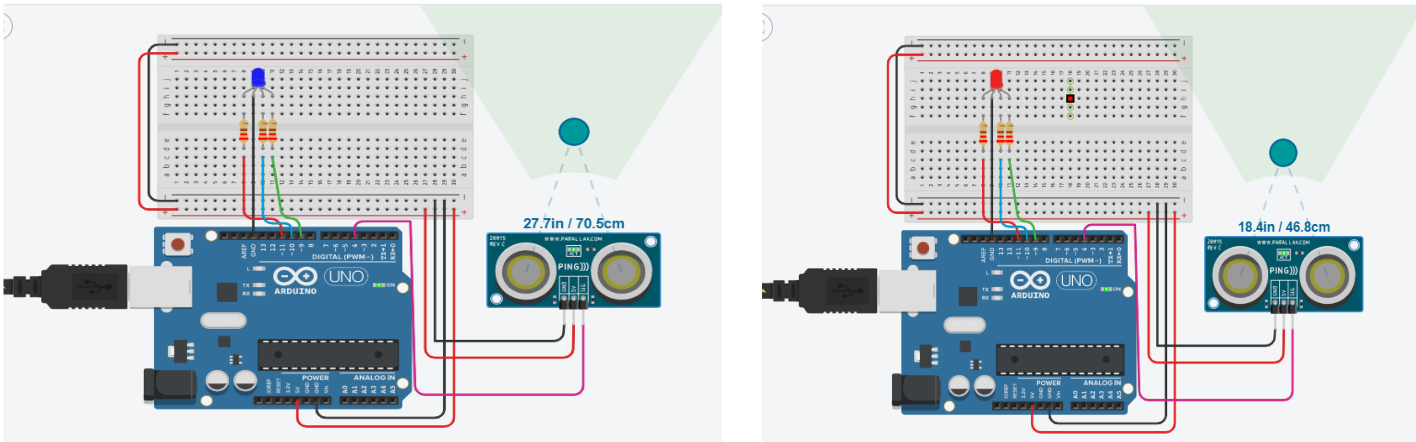
5. 2. Ultrasonic Sensor



(a)



(b)



(c) (d)

Figure:14- For Ultrasonic Sensor, (a) LED doesn't glow when obstacle is sufficiently far (b) Obstacle within 1.2m, less intensity output (green LED) (c) Obstacle within 80cms, more intensity output (blue LED) (d) Obstacle within 50cms, highest intensity output (red LED)

5. 3. GPS & GSM

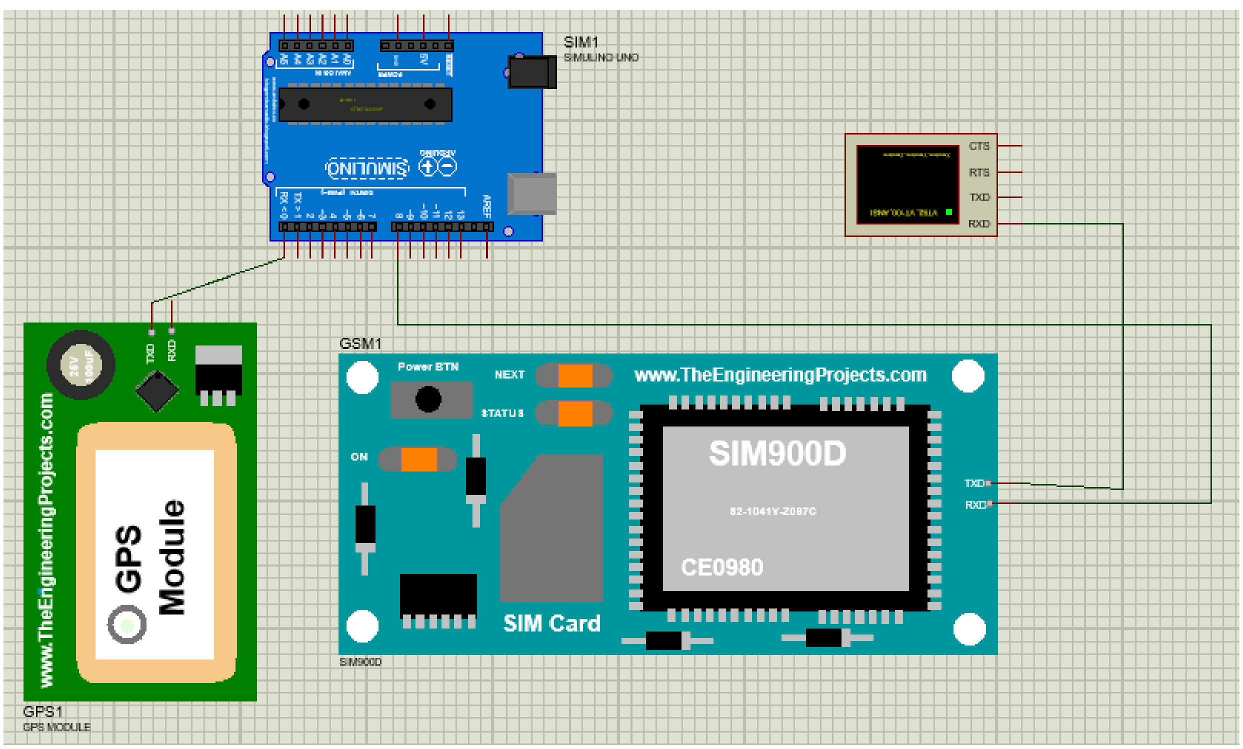


Figure 15: Simulation of GPS & GSM on Proteus

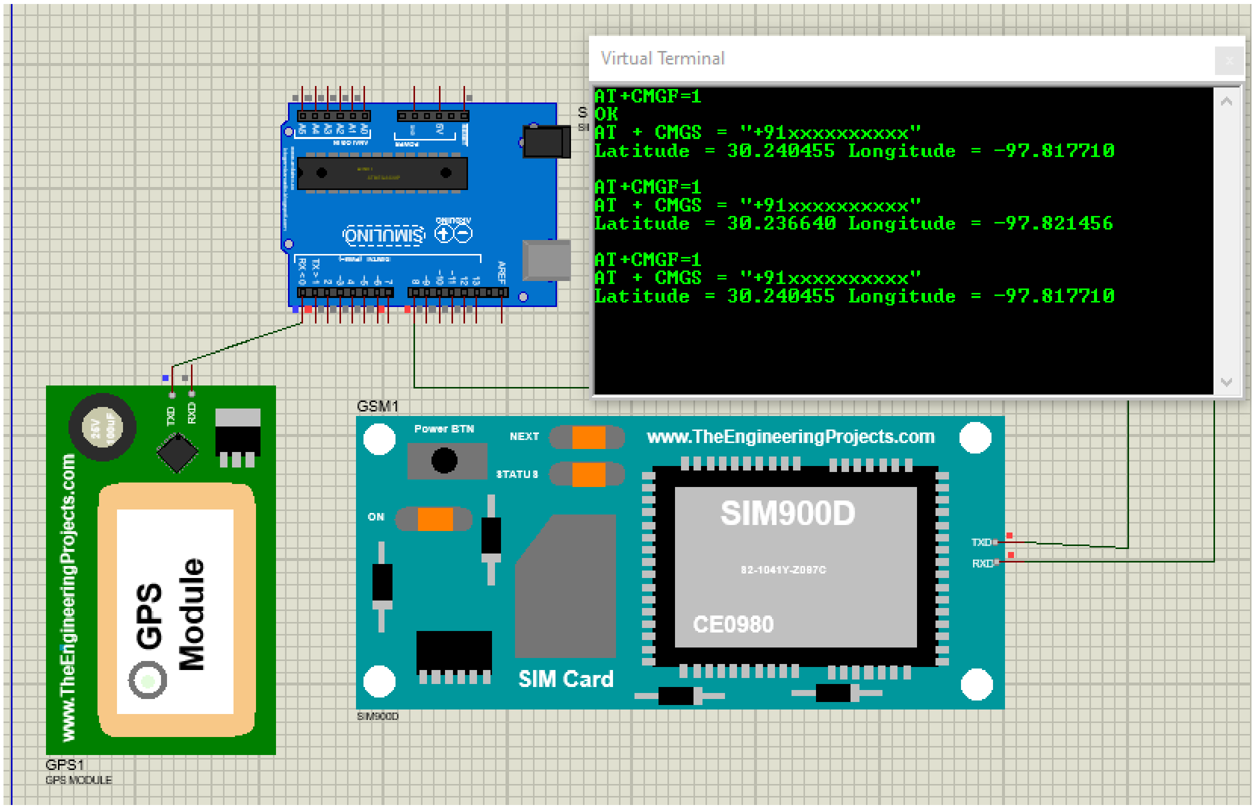


Figure 16: Output on the Virtual Terminal

CHAPTER 6

RESULTS & CONCLUSION

Prototype
Real time Obstacle Detection
Real Time Object Detection
Conclusion & Future Scope

RESULTS & CONCLUSION

In this chapter, the prototype of smart stick is shown. Along with real time detection of fire and obstacles encountered; real time object detection's results are also shown.

6. 1. Prototype

We have developed a prototype of smart stick and tested it's performance for different hurdles. It's labelled figure is shown in Fig.17 and the responses are shown in next sub-sections.

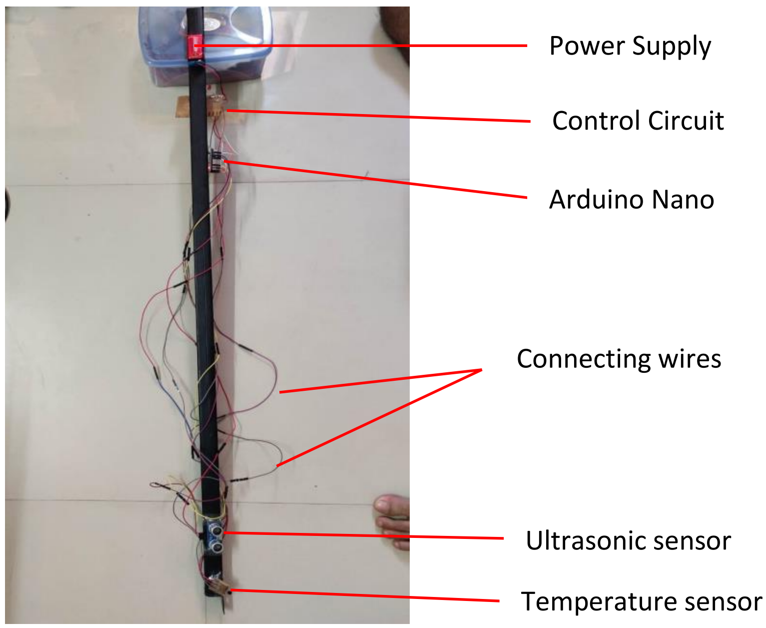
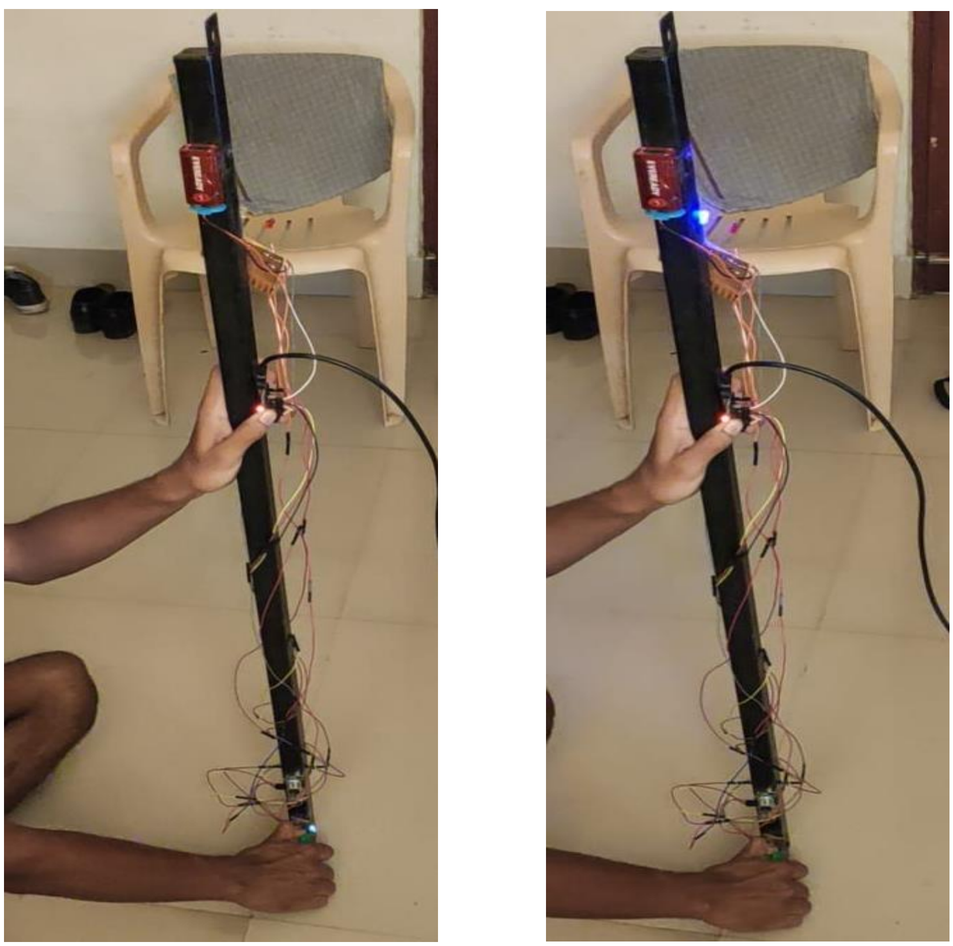


Figure 17: Prototype of Smart Stick

6. 2. Real Time Obstacle Detection

Figure 18(a): Red light indicates output when obstacle is near

Figure 18(b): No output when obstacle is sufficiently far



(a) (b)

Figure 19: (a) No output in normal conditions (b) Blue light indicating output when fire encountered

6. 3. Real Time Object Detection

The camera was used to take some images of indoor objects and perform object detection on them. Each of the following images contain bounding boxes around the detected objects with the confidence score of the predicted class.

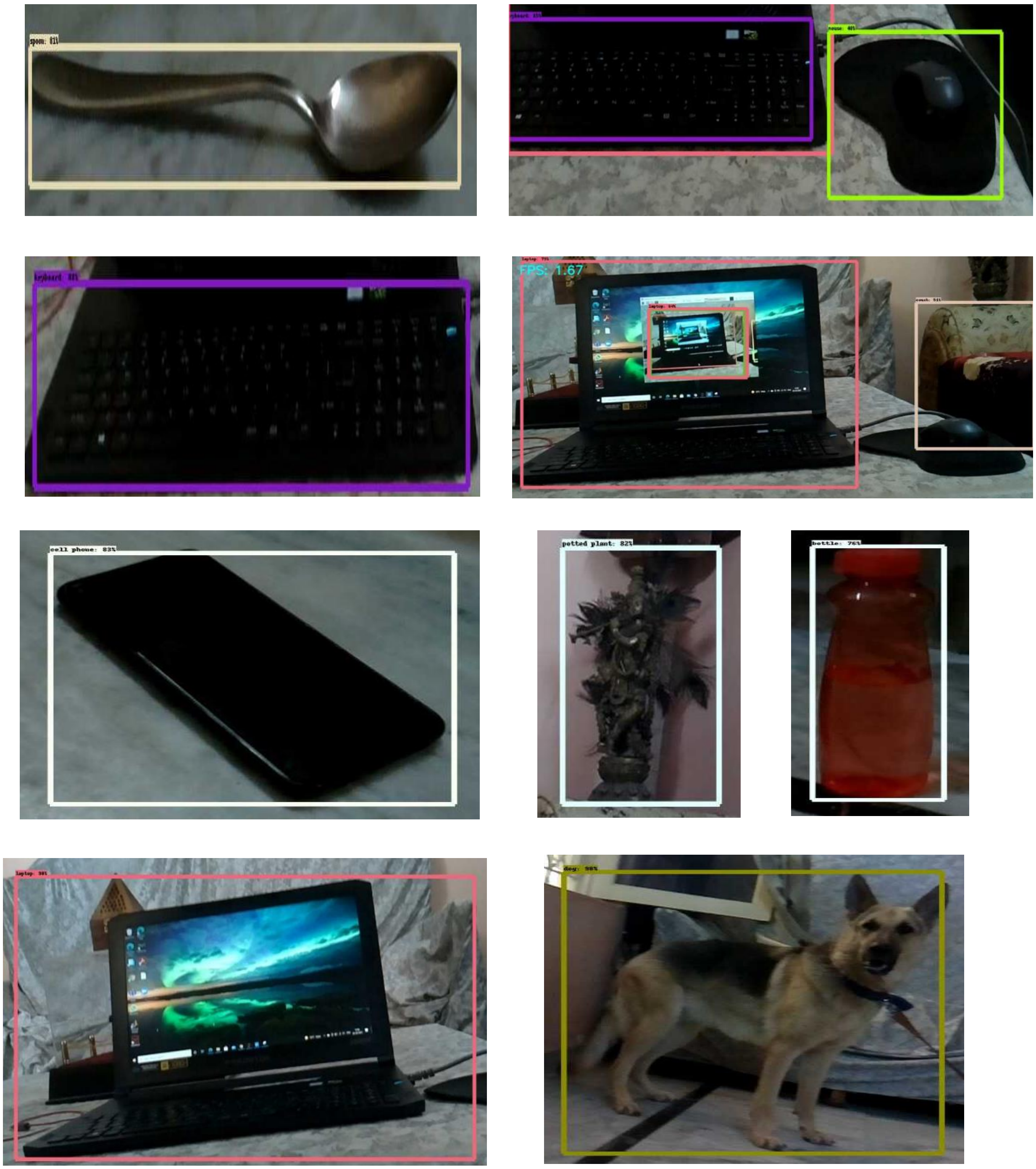


Figure 20: Boundary boxes around detected objects and confidence score

6. 4. Conclusion & Future Scope

A low-cost, reliable, robust smart stick to aid blind people has been proposed. The stick is to be equipped with various sensors, GPS, GSM as well as Object Detection techniques to help the user. The sensors are to be handled by Arduino and the Object Detection by Raspberry Pi. Data obtained from the sensors and object detection is to be processed to make decisions for the user. A suitable method of guiding the user (such as buzzer or vibration motor or Audio Playback) is required. Integration of GPS & GSM combination with camera module can be done in a way that along with the location coordinates, images of the surroundings taken by camera are also sent to the relatives through GSM, thus enabling better tracking. More features can be added to come up with a more viable and advanced solution (if cost isn't an issue).

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