“Intelligent Navigation Stick for Visually Impaired People”

A minor project report,
submitted in partial fulfillment of the requirement for the award of
B.Tech. degree in computer science and engineering

by

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CANDIDATES DECLARATION

We hereby certify that the work, which is being presented in the report, entitled **Intelligent Navigation Stick for Visually Impaired People**, in partial fulfillment of the requirement for the award of the Degree of **Bachelor of Technology** and submitted to the institution is an authentic record of our own work carried out during the period *May 2019* to *July 2019* under the supervision of **Dr. Anuraj Singh** and **Dr. Santosh Singh Rathore**. We also cited the reference about the text(s)/figure(s)/table(s) from where they have been taken.

Date: Signatures of the Candidates

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Date: Signatures of the Research Supervisors

ABSTRACT

The main goal of this project is to help visually impaired people avoid stepping into obstacles by utilizing Machine Learning, Computer Vision and IOT. Our main aim is to assist a blind person in navigating safely and securely around streets and critically dangerous areas. In order to achieve our goal we have implemented two modes, Navigation Mode and Object Detection Mode. Each of which can be chosen using a switch mounted on the stick. In object detection mode an image will be captured using a pi camera fixed at the top to stick and obtain results using our self developed API (hosted on heroku using Flask) containing SSD algorithm for Object detection and classification, the results will be provided as an Audio feedback to the blind person using Earphones. In Navigation mode we will detect the obstacles offline as they come in-front of the person in real-time using python OpenCV Library and light-weight object detection algorithm with continuous assistance as an audio feedback to the blind person using Raspberry Pi processor.At last we have tested the stick in semi crowded regions and it works completely fine with an accuracy above 90 percent. We have deployed our main object detection Model as an API service online on heroku platform using Flask framework of python.

Keywords: Pi Camera, API, Heroku, SSD, openCV, Raspberry Pi, Python.

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Finally, we are grateful to our colleagues and Institution whose constant encouragement served to renew our spirit and focus our efforts in carrying out the work.

(Prajwal Singh) (Aman Kumar Rai)

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ABBREVIATIONS

YOLO	You Only Look Once
SSD	Single Source Detection
API	Application Programming Interface
CMOS	Complementary Metal-Oxide-Semiconductor
FPS	Frame Rate per Second
PC	Personal Computer
OpenCV	Open Computer Vision
JSON	JavaScript Object Notation
GPS	Global Positioning System
IOT	Internet Of Things

CHAPTER 1

Introduction

The World Health Organization (2018) states that globally, approximately 253 million people live with some form of vision impairment. Visual impairment limits the ability to perform everyday tasks and adversely affect the quality of life, ability to interact with the surrounding world, thus discouraging individuals navigating unknown environments.[11]

We decided to build something which provides a solution through which blind people can detect obstacles and can enhance their visual abilities. This problem is very much important because a large population of the humans include the blind and if they are not able to visualize things properly then it can lead to dangerous situations.

Also, it is our basic responsibility to help the blind people in whatever way possible. The main intent behind taking up this project is to help the blind people by providing them a navigation device through which they can visualize things in front of them and can react accordingly with the help of the device. The device is for the safety of both blind as well as non blind people since both are at risk in case of any mishap.

1.1 Main features

1.Obstacle Detection, Classification and Localization.

2.Voice Feedback through Earphones regarding the detected Obstacles.

3.Distance Measuring using Ultrasonic Sensor.

4.Live Video as well as Still Image capture using Pi Camera for processing.

5.Push Buttons to choose specific mode while navigation.

CHAPTER 2

Literature Survey

Different literature that we have studied for the purpose of making of the project tells us about the different components that we have used and their importance. And how to connect the components so that we can connect to get the desired results. Also we studied different Algorithms for Object detection which can run accurately on small processing devices like Raspberry Pi. We are operating using push buttons to select between different modes. [2,5,6]. We also get the idea of improvements in those projects [1]. We came to know the background and the importance of this project. As their are many similar projects we needed to study all of them to extract the best parts of them and assemble them into a single project.[1] We were able to understand the advantages of this project as well.

CHAPTER 3

Requirements Analysis and Specification

3.1 Tools Description

3.1.1 Raspberry Pi 3 Model B

The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word-processing, browsing the internet and games. It also plays high-definition video.Other than being a PC, it also has a set of 40 Pins, which can be controlled using code, and those can be used to control external components (motors, lights, switched, etc.). Hence this makes the Pi a good component for robotics projects [3].

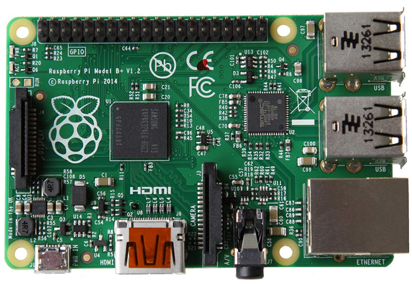

Fig. 3.1.1 Internal View of Raspberry Pi3

3.1.2 Raspberry Pi Camera V2

The Raspberry Pi Camera Module is a 5MP CMOS camera with a fixed focus lens that is capable of capturing still images and video. Still Images are captured at a resolution of 2592 x 1944, while video is supported at 1080p at 30 FPS, 720p at 60 FPS and

640x480 at 60 or 90 FPS.The camera is supported in the latest version of Raspbian, Raspberry Pi's preferred operating system [6].

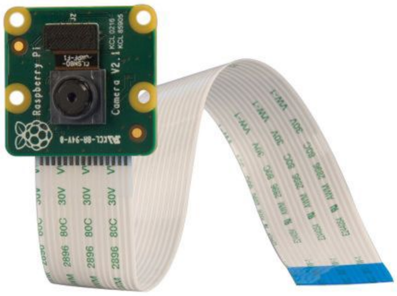

Fig. 3.1.2 Raspberry Pi Camera V2

3.1.3 Ultrasonic Sensor HC-SR04

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package. From 2cm to 400 cm or 1" to 13 feet. It operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module [4].

Fig. 3.1.3 Ultrasonic Sensor HC-SR04

3.1.4 Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. It is used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses [4,5].

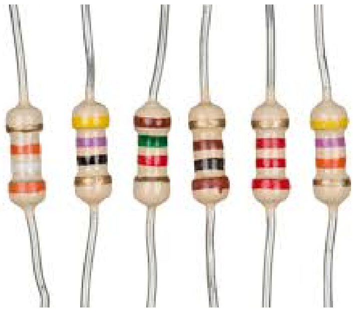

Fig. 3.1.4 Resistors

3.1.5 Push buttons

A push-button or simply button is a simple switch mechanism for controlling some aspect of machine or a process [5].

Fig. 3.1.5 Different types of Buttons

CHAPTER 4

System Design, Project Description and Methodology

4.1 System Design

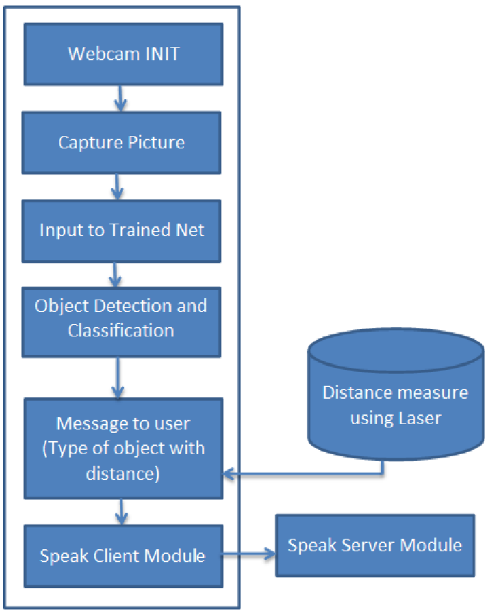

Fig. 4.1.1 Block Diagram of the Circuit and Flow of Control. The camera takes and image and passes it down to our trained SSD model for classification, the results of which are transmitted through earphone along with distance measured through Ultrasonic sensor.

We are using Raspberry Pi 3 to control the circuitry. The main programming language to drive the project is done in Python. Power supply of 5V through adapter. Push buttons as control switches to select the modes. Raspberry Pi Camera V2 to capture the live images and video. Ultrasonic sensor HC-SR04 to measure the distance of obstacle in-front. Resistors and Jumper wires here are acting as wires and A pair of earphones through which we will provide audio feedback of the obstacles in-front [1,4,5,6].

4.2 Methodology

Our main aim is to assist a blind person in navigating safely and securely around streets and critically dangerous areas using Machine Learning and Computer Vision implemented on Raspberry Pi. We are making an Intelligent Navigation Stick which uses SSD MobileNet algorithm for detection and recognition, Pi Camera for image capture and Ultrasonic sensors for distance calculation. The Ultrasonic sensor calculates distance of obstacles on the way, if the distance is less than a certain threshold it activates the Pi Camera. The Image taken using Pi camera is processed using SSD MobileNet algorithm for object detection. The Objects detected will now be converted to an audio feedback using Python ESpeak Module. The vocal feedback acts as an assistance for the blind person. Along with this the system also suggests the location of object from the perspective of camera. This mechanism helps a person detect and avoid obstacles in the way and move safely [2,7,10].

4.3 Project description

In this project we will be processing images taken through Pi Camera mounted on our smart Navigation Stick. In the Object Detection Mode the Obstacles in front of the blind person will be captured, the results of image processing will consist of Detected Objects along with their spatial location. We will be processing still images using our self developed API hosted on Heroku[8,9], the results will then be converted to an audio feedback using python ESpeak module and will be fed into the earphones of the user.[7] The live video will be processed using OpenCV libraries and SSD MobileNet Lite algorithm on real time frames to produce detections.This mode is active when we press the Navigation button on the stick.[2,10]

CHAPTER 5

Implementation Results

We have Selected MobileNet SSD algorithms due to their good mAP Accuracy and higher fps rate. We tested our models on both interior and exterior environments and the results were successful. The Distance calculated using Ultrasonic sensors have a limitation of 2.5 meters and have a accuracy of about 70 percent. The assembled components works accurately as per the requirements. The project is mobile, portable and of small size which can be easily fitted on a walking stick [4].

5.1 Test Cases and Test Results

The Various Testing phases :

- On Local Machine : The two models initially were run on a local python machine and they provided an accuracy of about 90-95 percent and a CPU usage of around 70 percent.
- Testing the Pi Camera and Push Buttons : This involved activation of Pi Camera on pushing button and also switch between different modes using buttons.
- Deploying The MobileNet SSD Model on Heroku : This involved development of a POST API for object detection and classification using Flask framework in Python and its deployment on Heroku platform as an API service. The API works perfectly fine even in case of slow internet connection and gives results within 3-10 seconds based on uploading speed.
- Integration and Final Testing : After the successfully integrating all the components, a proper test was done on both the modes. The Object Detection API worked perfectly to provide the output results short time of around 8-10 seconds [8,9]. Once the button is pressed the camera gets activated and captures an image, which it sends to our API and obtains the results as text. The ESpeak Module

then converts the text to speech and feeds it into the earphones with an accuracy of 100 percent. This complete cycle takes around 15-20 seconds.

- The Live Navigation mode which uses Raspberry Pi processor, also gives a high accuracy of 80 percent. It uses SSD MobileNet Lite algorithm for object detection and the CPU Usage is more than 85 percent in this case, it works completely offline [10].

CHAPTER 6

Screenshots of Project with Descriptions

6.1

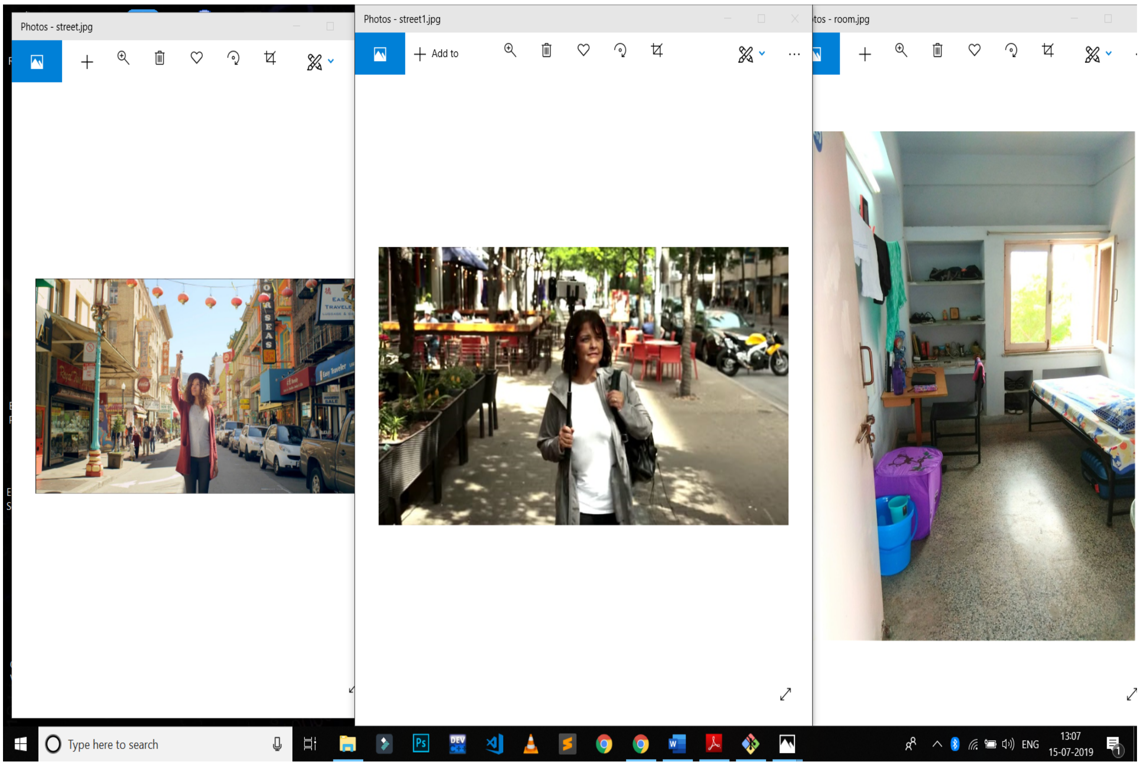

Fig. 6.1.1 Screenshot of Test Images for Object Detection

This is a set of Test Images for our Object Detection Algorithm. The First two images consists of a person standing in the middle and a few cars on the either side. The Third Image is an interior view of a room which has a bed on the right side. We have tested our code on the following images and obtained results.

6.2

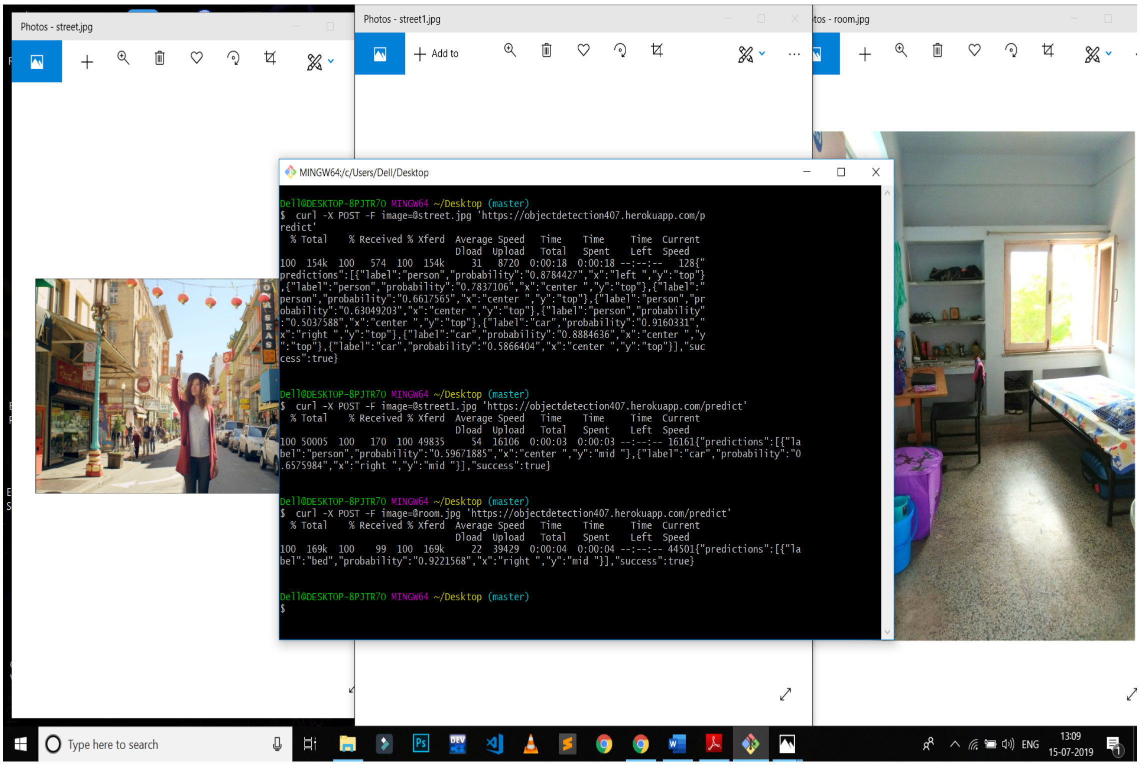

Fig 6.2.1 Screenshot of Results on Test Images from API

Here we obtain the results as a JSON object from our API hosted on Heroku platform. As we can see the Git Bash console contains 3 results each corresponding to 3 POST requests which send the test images for detection. The Results contain the Label, Probability, X and Y coordinates of the objects in the image.

6.3

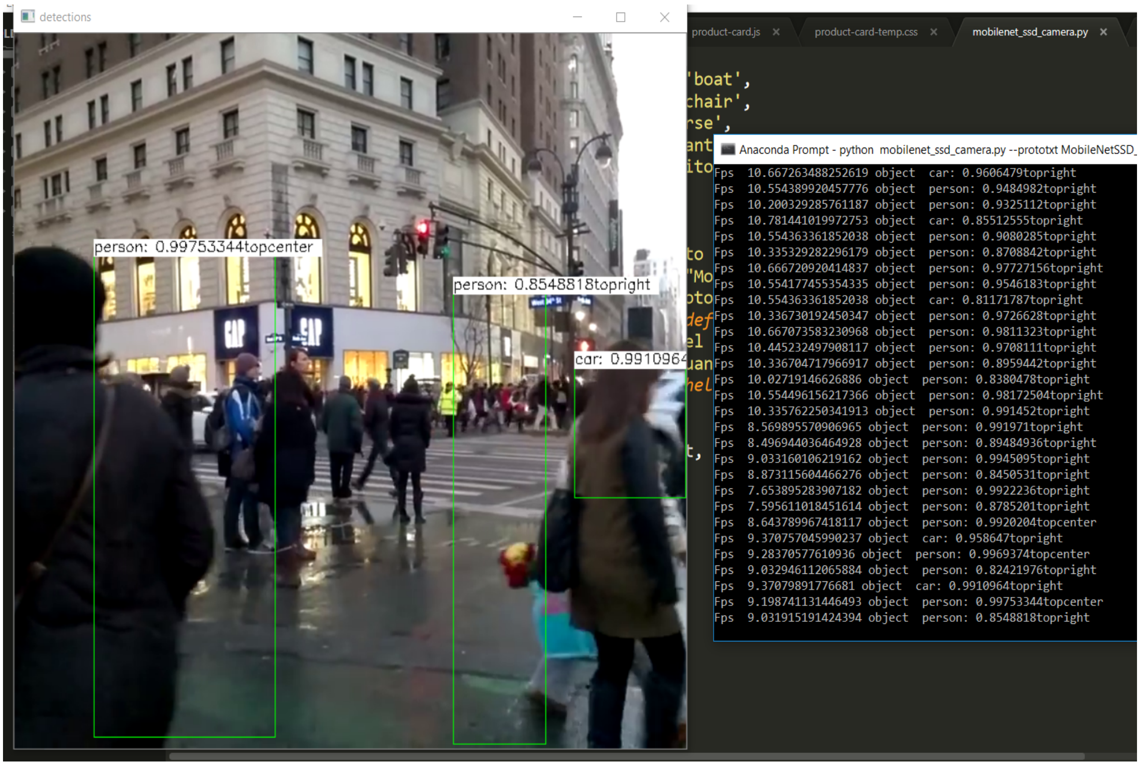

Fig. 6.3.1 Screenshot of Navigation Mode Live Video and its Results

This screenshot depicts results from our Navigation Mode which runs on live video. It detects Objects from a set of few common objects in real-time and marks a bounding box around them. On the Right side we can see the console representing the results as well as the frame rate at which the video is being processed.

6.4

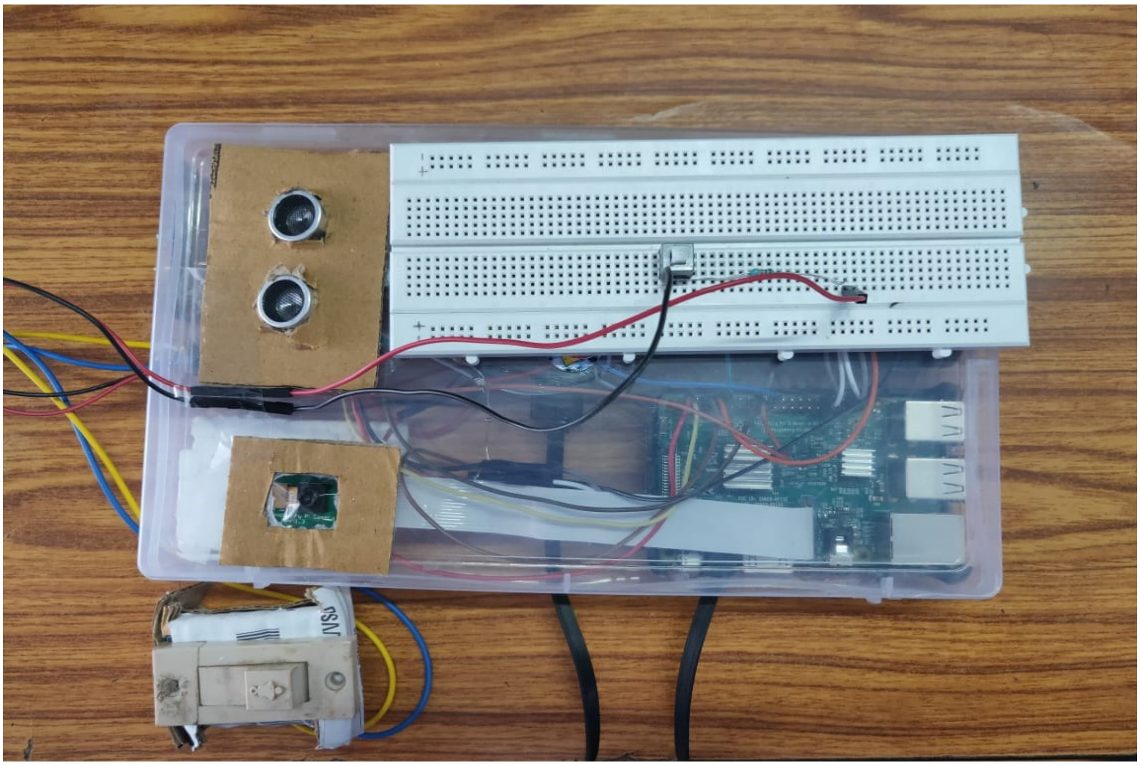

Fig. 6.4.1 Assembled Hardware circuitry of the project

This is how our hardware circuitry of the project looks like. It has all the components mentioned earlier: Raspberry Pi, Pi Camera, Ultrasonic sensor, push buttons, Resistors, Power bank, bread board and Jumper wires.

6.5

Fig. 6.5.1 Final Assembled Intelligent Navigation Stick

This is the image of finally assembled Intelligent Navigation Stick, along with LEDs which represent the currrent active mode and Push button to control the current active mode. Also it has connected earphones through which the blind person can listen to the audio feedback given by our program.

CHAPTER 7

Conclusion and Future Scope

7.1 Conclusion

In this project, object detection and classification on Realtime Video as well as image is done. We are using Raspberry Pi as processing unit. We have used SSD mobile Net model for classification. The push buttons can be used to switch between Navigation mode and Object Detection Mode. The Ultrasonic sensor detects distance of the obstacle from the stick. Thus overall the stick will help the visually impaired in navigating around the streets and will provide audio feedback through earphones about the environment around.

7.2 Future Scope

In future, We hope to build a panic button pressing which will notify the relatives of the person about the GPS co-ordinates via email/message. Also we can switch to vibration sensation to guide the person instead of a audio command [1].

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