NAVIGATION SYSTEM FOR BLIND PEOPLE USING MACHINE LEARNING

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APPROVAL

This Project/internship titled **"Navigation System for Blind People Using Machine Learning"**, submitted by Md. Atiqur Rahman, ID No: 172-15-9866, Sadia Siddika, ID No: 172-15-9913, Md. Abdullah Al-Baky, ID No: 172-15-9638, to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 02.06.2021.

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We hereby declare that this project has been done by us under the supervision of **Md. Jueal Mia, Sr. Lecturer, Department of CSE** at Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Proper navigation and detailed perception in familiar or unfamiliar environments are the main roles for human life. Eyesight sense helps humans to abstain from all kinds of dangers and navigate to indoor and outdoor environments. These are challenging activities for blind people in all environments. Usually, they are navigated to their natural sense but sometimes this is not adequate because human senses can be affected by external noise. Many assistive tools have been developed by the blessing of technology like white canes, braille compasses that help blind people to move around the world. In this project, we have developed a cloud and vision-based navigation system for visually impaired people or the blind. Our aim is not only to navigate them but also to perceive the environment in as much detail as a normal person. The proposed system includes ultrasonic sensors detecting obstacles, stereo camera to capture videos to perceive the environment using deep learning algorithms. The proposed system also includes a face recognition system that identifies known faces in front of him. Blind people interact with the whole system through a speech recognition module and all the information is stored in the cloud. Web application and Android application are used to track blinds, visited areas, etc. For that, the guardian is able to monitor them all the time. Blind is also contact their guide in an emergency situation. The experimental results show the proposed system can provide more abundant surrounding information and interaction with the newly proposed system.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

According to World Health Organization (WHO) statistics about 385 million people are visually impaired which about 39 million people are blind in which 82% are blind whose age is 50 or older [1]. According to WHO (2012) around 4.24% of people are visually wretched and 0.58% are visually blind (estimated)- BCVA (best-corrected visual acuity) 0.05% in the better eye and 3.65% have low vision. Overall, from 39 million, 6 million (15%) from Africa and gradually 2.7 million (7%), 23 million (67%), 3.2 million (8%), 5 million (12.5%) from Europe, Asia, America and Eastern Mediterranean (re-2015). And among them, 82% of them are over 50 years and in Bangladesh, the number of blind people ages 30 and above is 750,000, 85 percent of them become blind due to cataracts [2]. Nowadays It is becoming an important term to develop a system for blind people to navigate as normal people.

In this research, an IoT-based new navigation system for blind people is designed. This will not only give guidance but also provide perceiving the environment as much as possible like normal people, such as which object is present in front of the blind (e.g. person, car, bus, currency, chair and etc.), his current location, recognize known faces in front of him and etc. Also, blind can measure distance within 5m and get distance if any person is present in front of them and for knowing anything they can search their query by saying their search query from the web. In this system, we have used raspberry pi to implement a navigation system. The stereo camera is used as a virtual eye for the blind, an ultrasonic sensor is used to detect obstacles in front of him and measure the distance from the blind person. The camera captures the video sequence from the environment then processes the query through the system with voice delivered by the blind. While navigating in the outdoor GPS module, take the location data and send it to the cloud. Then the cloud stores the data and provides the current location to his guide. The system also uses the cloud for storing different types of data while blind interacting with the devices (e.g. search query, location data, etc.). The system uses a smartphone hotspot with 4G mobile data connection to transfer data into the cloud and search web queries. Smartphone application tracks the blind while visiting in the outdoor environment. The web application helps the guidance to track a blind person from anywhere. This web application provides an overview of the system, visited the area, and the last location of their blind. The speech recognition module provides smart interaction with the system for the blind that can easily communicate through their formal English language.

This proposed system provides a smart navigation system for both indoor and outdoor environments. This system ensures safe navigation, more practical and fruitful than the present navigation system with the branch of advantages.

1.2 Motivation

According to World Health Organization (WHO) statistics about 39 million people are blind in the world and in Bangladesh, above 750,000 people are blind whose age is above 30[2]. They are not able to perceive the environment like normal people. So the navigation of blind people is challenging to their daily life. Many supporting navigation systems are being developed like white cane, trained dogs but most of them are not reliable, not user-friendly. To overcome the challenges of blind people and ensure high reliability, trustworthiness, and safe navigation, we have developed a system that navigates them with safety, reliability, and can get the environment in as much detail as normal people. There are also some specific motives in our research-based project:

- To give better navigation
- Control with voice
- Advance tracking system (Android and Web-Based)
- Relative Recognition

1.3 Rationale of the Study

In the research area, there are many proposed systems to navigate blind people. But most of them are not efficient, less reliable, high costing, and some of them are partially developed. Also, navigating blind people is more challenging with perceiving the environment with advanced technology because navigating the blind safely is not easy.

1.4 Expected Outcome

Our research work aims to navigate blind people safely, perceiving the environment in Indoor and Outdoor as much as possible with cost-efficiency. The output of our work should be:

- Safe navigation in Indoor and Outdoor
- Object detection and recognition
- Face (Relative) Recognition
- BDT currency recognition
- Cloud-based Tracking and device management by their guardian
- Emergency contact system
- And the overall system has controlled by voice command

1.5 Project Management and Finance

Our research is based on IoT and several components had to be bought from the market. The project management and finance are completed by ourselves. The following table shows the finance of our components.

TABLE 1.5.1: THE FINANCE OF COMPONENT THAT USED IN OUR RESEARCH

Component Name	Amount (Approximate) BDT
Raspberry Pi 4 Model b 4GB	7000
Ultrasonic Distance Sensor (HC-SR04)	75
Ublox Neo GPS 7M	700
Breadboard	78
Stereo Camera (pi camera)	700
Raspberry Pi power adapter	200
16 GB SD Card	400
3x1k Ω Resistor	15
Jumper wires	50
Total	9218

1.6 Report Layout

In this chapter, we have discussed the introduction, motivation, rationale of the study, and the expected outcome of the thesis. In a later chapter we will discuss as follows:

In chapter 2, we will discuss the background study of our research.
In chapter 3, we will illustrate the research methodologies.
In chapter 4, we will discuss experimental results and discussion.
In chapter 5, we will elaborate on the impact on social, environmental, and sustainability.
In chapter 6, we will discuss the conclusion and our future work.

CHAPTER 2
BACKGROUND

2.1 Terminologies

In recent days, the number of visually impaired increasing day by day. We are trying to make them as efficient as normal people. We are developing a very efficient research-based project which can make change for blind people or visually impaired people. They can easily move from one place to another place, they can easily detect relatives, they can easily detect all goods that we regularly use. They can easily select their goal and easily move towards that goal.

This is actually mind-blowing work for visually impaired people. Actually, they visually think that they are the curse in our society. But by this work they can feel this world. They can find out the main meaning of living.

2.2 Related Works

Many navigation systems already exist. But they work with some limited datasets and those can perceive a little information.

The researchers [3] navigate the system by using CMOS Time-of-Flight sensors, some are using RFID. These elements or systems are generally costly. And CMOS Time-Of-Fight sensor-based navigation system is wired, which is not user-friendly. And RFID-based navigation systems have a chance to lose data to read data at a time.

Author [4] used a cloud and vision-based navigation system for blind people. The system works with speech recognition, SLAM (Simultaneous Localization and Mapping), path - planning, based on a deep learning algorithm. Blind can communicate with the system through voice.

The author [5] a two-dimensional tactile pin-matrix display-based navigation system also has many limitations like they are working with some limited data.

Author [6] ambient assisted living; mobile technology; Blind; Ultra-sound systems are organized into different parts for collecting data then organize them and then detect the data and then by Ultrasound system convert those into voice then by the help of mobile technology reach those towards blinds ear.

Researchers [8,12] use neural networks to help blind people. The researchers use two cameras to detect the pedestrian path and LiDAR to detect the surroundings. At first, they can image the data by the camera then they get 3 voice attitude information.

Author [11] Some machine learning-based systems are developed by CNN algorithm and deep learning for object detection and categorized them. And YOLO is used for image segmentation and classification.

Author [13] used an SSD algorithm to make devices for blind people. Also used some electronics to make the output.

Authors [14] are working to make an efficient smart glass for the blind.   This device is designed with the help of deep learning technology and composed into smart glass using Raspberry pi.

Author [15] navigates and implements a system that is actually based on a robotic system. It's actually based on a voice navigation system that is commonly used and they used an assistive robot, Blind Pilot, which actually guided blind users. Blind Pilot, an RGB camera, presents the position of the object and uses lidar to build a 2D map of the surroundings.

But in our proposed cloud and vision-based navigation system, where we used the different modules to interact with the blind using machine learning algorithms and natural language techniques.

2.3 Comparative Analysis and Summary

From the work of other researchers, we can confidently say that our work is absolutely the best of the others. In our project, we were working with a huge amount of data with different types of identification. We worked on object detection, voice recognition, relative identity, human distance / focal distance, and so on. And the accuracy rate of it is also very highly good. In other papers, they just work with a part of it but we work for all the components.

The table below shows the comparison of our work to other existing work.

TABLE 2.3.1: THE COMPARATIVE ANALYSIS OF RELATED WORKS.

Author	Object Detection	Voice Recognition	Face Recognition	Focal Distance	Accuracy
This work	yes	yes	yes	yes	98.9%
Larisa Dunai[3]	yes	yes	yes	no	-
Jinqiang Bai[4]	yes	yes	yes	no	99%
Bornschein[5]	yes	yes	yes	no	-
Sivan[6]	yes	yes	yes	no	97.5%
Yánez[7]	yes	yes	yes	yes	-
Setiadi[8]	yes	yes	yes	no	-

Anandan[9]	yes	yes	yes	no	-
Anas Majid[10]	yes	yes	yes	no	-

2.4 Scope of the Problem

From this research-based project, we may find out an essential solution to a major problem. Visually impaired people feel that they are the curse in this society, they don't have any chance to do something for society. They are a burden for their family and their family members. The relatives of them feel bothered to make conversation with them. Especially those who are blind.

Our project is a permanent solution to this problem. Many people are working for it and many of them already worked but this may be the best solution for blind people and visually impaired people. We are doing this with a large amount of data and with a lot of security systems. So, this is a really effective device for our society, for our country, and for our world.

I don't find any major problem with our project but the cost may be a fact. We are working with Raspberry pi which is moderately costly. But the amount is around 12,000 taka only. We don't think this is a big amount. If our government gives us funds then we will do around 5,000 takas.

So, we have a really good scope to do something extraordinary for visually people, which can make them happy and self-confident.

2.5 Challenges

We face a lot of challenges to reach the goal. When we were thinking about this project, we felt that we would do it very easily and we were trying to add more features and we did that. In the initial stage, we don’t know anything about it. How we step forward. Our advisor helped us to move on and gave advice that we have to learn a lot of things about machine learning.

We were starting to learn how to implement this project. From YouTube and Google and from different websites we learn some basic things and our advisor always helps us to find out the path where we step forward.

We were starting to learn about the Object detection system, Voice recognition, Relative identity, Focal distance count, and so on. We were to learn all of the basics of these topics and try to implement them. In the time of implementation, we face problems and we try to learn. We face problems again and again and we learn again and again by the help of our advisor, with the help of Google, YouTube, and from different websites.

Our advisor gave us direction and we were a step ahead. When we succeeded to reach gold for object detection, we thought that we could do it. That output gives us a lot of inspiration to move on. And we were moving forward rapidly about our coding part. And we succeeded in our coding part.

But in the implementation part, we actually face the real problem. We don't have any idea how to work with Raspberry pi and with the other components. With the help of our advisor, we started our work and we thought that our varsity authority would give us Raspberry pi. But they don't. In this Covid situation, we face a lot of hassle to buy these components. And we are students, we face problems collecting the money also. The total cost is around 15,000 takas, we face a lot of problems to collect this amount of money also. So, we face problems in every single step and every single process. Because it's our first research base project.

At last, we face a big problem using google API. For its authentication, we need a master card that is enabled in twin currency. But we don't have any Mastercard. We managed to get a Mastercard from our friend but that did not work. We manage another one, which also does not work, Because it's only for a single currency. If we apply for a dual currency Mastercard then we need a passport, we don't have any passport. We are searching, searching and searching. At last, we managed a friend's elder brother. And it works and we feel relief.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Research Subject and Instrumentation

The machine learning approach has been used in our research-based project. Our research works on developing a system that helps blind people to navigate or guide like normal people with perceiving the nearest environment and avoiding obstacles. The system should be user-friendly so that they can easily interact with the system and the guide is able to track blinds where they visit with also live tracking GPS navigation. So, they can see the activity of their blinds.

We have used different types of machine learning techniques and API for developing our system. To detect objects we have used computer vision techniques and the system is able to detect 80 types of real-life objects. On another hand, we have used different sensors to perceive the environment such as ultrasonic sensors for measuring the distance from an object, stereo camera as virtual eye, Neo GPS 7M for locating a person.

For implementing our research we had used much equipment that is as follows:

- Hardware
  I. Raspberry pi 4 Model B
  II. Ultrasonic Sensor
  III. Ublox Neo GPS 7M
  IV. Stereo Camera
  V. Breadboard
  VI. Jumper Wires
  VII. 3x1k resistors
  VIII. Laptop

- Software and Tools
    I. Yolo v4 framework
    II. LabelImg image annotation Tool
    III. Google Colab
    IV. Pycharm
    V. laravel php framework
    VI. Android studio
    VII. Google map API

- Model
    I. coco
    II. currency.model
    III. haarcascade_frontalface_default.xml

- Packages
    I. opencv-contrib-python
    II. numpy
    III. face_recognition
    IV. RPi.GPIO
    V. datetime
    VI. os

3.2 Data Collection Procedure

Another important task for any research is data collection and the quality of data. The accuracy of the result depends on the quality of data because the train of good quality data gives higher accuracy for the dataset. In this thesis we have used two types of the dataset, these are:

- Coco dataset for detecting real-life images
- Currency dataset

We have collected the coco dataset from the internet. For the currency recognition dataset, we have collected in

- Capture Image: Most of our currency data were collected by taking images using a smartphone.
- Internet: A few pieces of data were collected from the internet.

In this research, we have collected a currency dataset from BDT notes(taka) in real-time images.

3.3 Statistical Analysis

At first, we prepared our hardware environment with average costing with good quality products. Then we downloaded the coco dataset that has 330k images where >200k labeled images with 80 classes and 5 captions per image [16]. After that, we plan to build our country's (BDT) currency recognition and collect currency datasets from real images and some internet source images. Finally, we have collected 200 images of objects which contain 10 classes. To build our dataset with higher efficiency we have preprocessed our data. After preprocessing we have got 100 images and every class contains 10 images. To get higher accuracy and smoothness of the system process we have minimized our code that can run into our raspberry pi smoothly. We also did a feasibility study to improve our system.

3.4 Proposed Methodology

In this IoT-based thesis we try to give a better navigation system as much as possible by receiving the environment details that may give to blind and they can enjoy their day with reliability.

The following figure represents the proposed model of Blind Navigation IoT-based system.

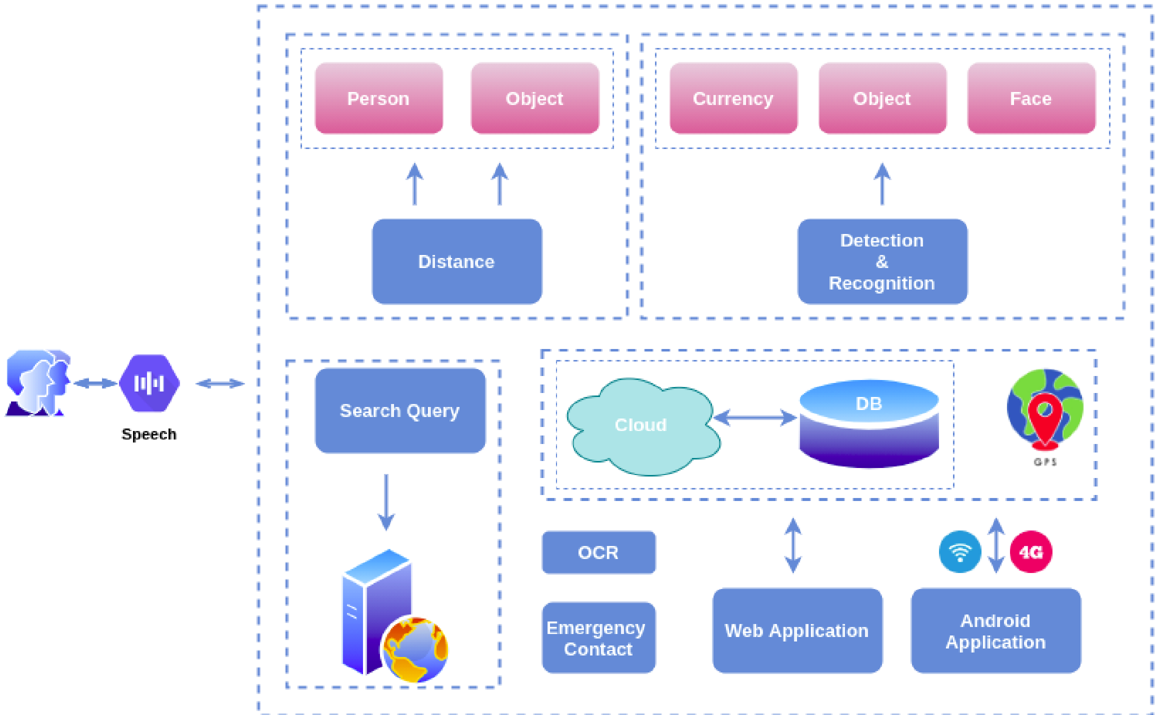


Figure 3.4.1: The proposed model diagram.

There are several steps to develop our system. We have divided into bellow parts which are as follows:

- Hardware
- Environment set up
- Preparing Dataset
- Install required packages
- Train and Export model
- Object detection
- Distance Measuring
- Face Recognition
- Optical Character Recognition (OCR)
- Speech Recognition

- GPS Module Integration (Tracking)
- API building
- Web Application
- Android Application
- Emergency Contact

Let's briefly discuss the above proposed methodology.

Hardware:

The research uses several hardware devices such as raspberry pi 4B 4GB (Credit Card Size Computer), ultrasonic (HC-SR-04) distance sensor, Ublox NEO GPS 7M, Stereo Camera, Breadboard, 3x1k ohm resistors, Jumper wires, and power supply. We have bought this hardware from BD's online market platform.

Environment Set up:

We use different environments to implement our project. Let's discuss the environment set up procedure:

Hardware Environment set up:

First of all, we have set up a hardware environment. For that we took bellow steps:

- ➔ At first, flashed raspberry pi os (Raspbian OS) into 16GB class 10 memory card
- ➔ Add sensors (Ultrasonic, GPS Module) to breadboard
- ➔ Set up pi camera on Raspberry pi
- ➔ Connect all the equipment with wires in raspberry pi computer and breadboard
- ➔ At last, Power to Pi to run the device

The following figure shows the hardware environment setup using necessary hardware components.

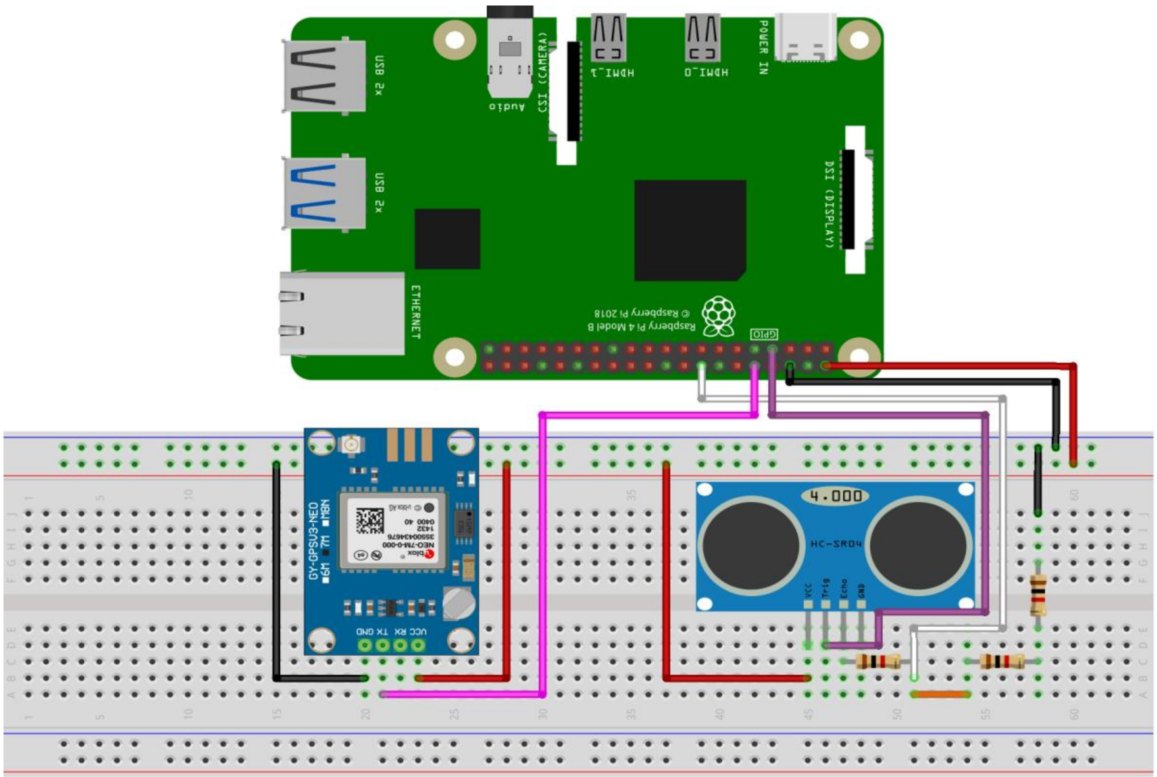


Figure 3.4.2: Hardware setup with several components.

Data Training Environment:

For data training, we have used google colab because our machine can't perform for training data with GPU and as we know google colab provides free GPU to perform our higher task. For that we took bellow steps:

- ➔ First enter into Google Colab through - https://colab.research.google.com
- ➔ Create a new notebook
- ➔ Enable GPU
- ➔ Run the Notebook's all Shell or run each shell one by one

Coding Environment:

For coding, we have used pycharm IDE and general text editor on pi os to implement and test our code.

Preparing Dataset:

Preparing the dataset cannot be done in single steps. We have taken the below steps to prepare our dataset for the model. Such as

Object Detection Model:

For detecting objects in the real-world we have used coco image dataset which have 330k+ images with 270k+ labeled images. For this reason, we use the yolov4 model.

Currency Recognition Model:

At first, we collected images from two sources, one is a real image that was captured by a smartphone and another source was from the internet. After collecting images from the sources, we had a different shape of images in our collection. We make those images into the same size and format. After that, we have divided our 80% data for training and 20% of data for testing purposes. We build a currency recognition dataset of 250 images and that is classified into ten (10) classes following the grade of the datasets (i.e. ১৳, ২৳, ৫৳, ১০৳, ২০৳, ৫০৳, ১০০৳, ২০০৳, ৫০০৳, ১০০০৳). To build our dataset more efficiently we preprocessed our image data until it removed inconsistency and inappropriate data. That increases the quality of data and helps to increase model accuracy. The following figure shows the pre-processing of our dataset.

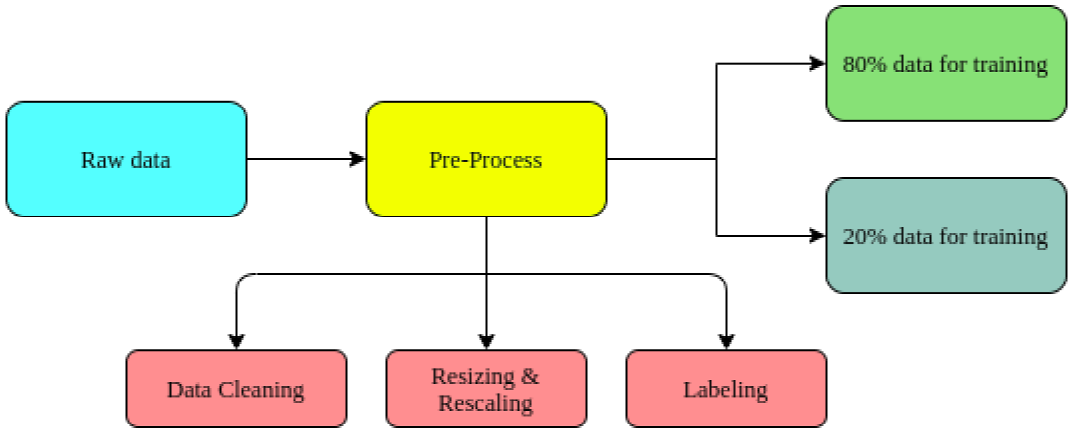


Figure 3.4.3: Data pre-processing for training in Yolov4.

Install Required Packages:

As we know Python comes with lots of machine learning libraries or packages. We use different packages by pip installation. We have installed the required packages like opencv-contrib-python, numpy, scikit-image, GPIO, pytesseract, etc.

Train and Export model:

For the first one, detecting objects we have used a yolov4 pre-trained model (yolov4.model and yolov4-tiny.model).

The other one we have a trained currency recognition system. In this part, we have written lines of code to train our currency dataset. The procedure as follows:

- ➔ Open the Google Colab NoteBook that we have created in the Data Processing section.
- ➔ Connect google drive to store trained model
- ➔ Run all the shells or manually run each shell to run the training process
- ➔ configpath to config the model
- ➔ weightsPath = path to training

After training we got the yolov4 weights file. The following figure explains the training process and model of yolov4.

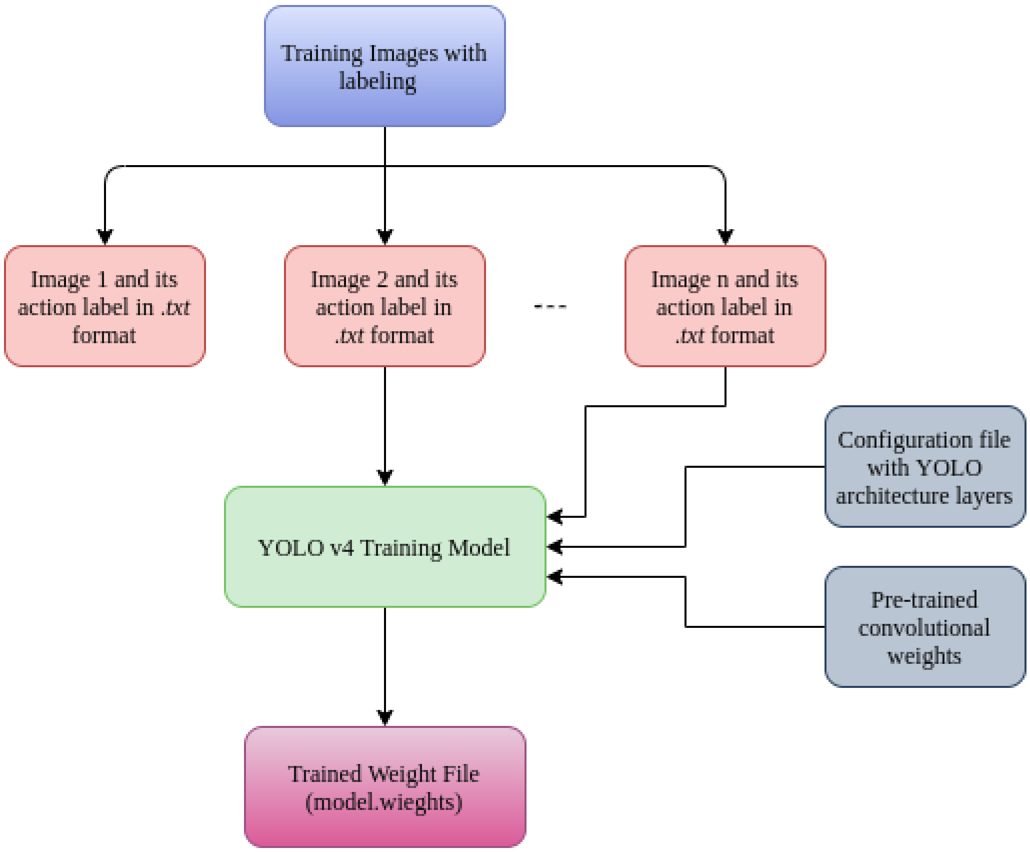


Figure 3.4.4: Yolov4 custom object detection flow diagram.

After completing all shells the trained model was saved into google drive for each epoch. Then we used the last trained model named yolov4-last.weights and downloaded it to our local machine. In further use, we renamed it to currency-recognition-model.weights.

Object Detection:

Object detection for blind people is divided into two parts, one is for indoor object detection and outdoor object detection. For those environments, we have used the same model to detect real-time objects. In Pycharm IDE we have written the necessary code to detect objects using the camera by installing the required python packages. The figure 3.4.5 shows how the object is detected and recognized using Yolov4.

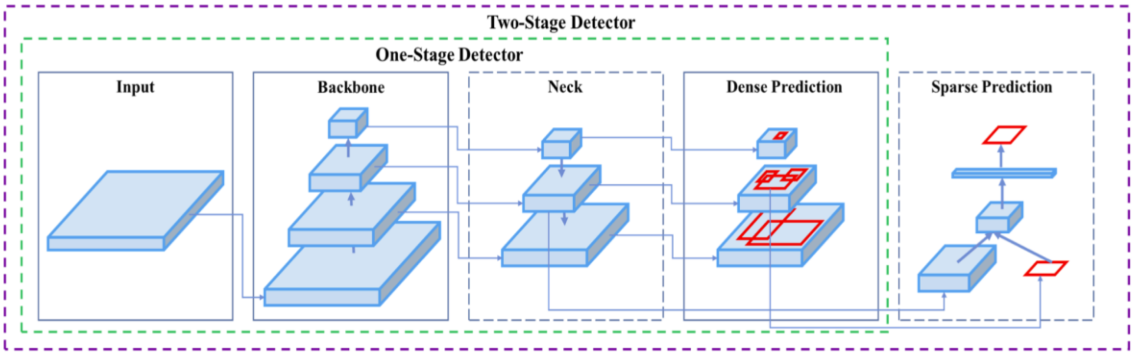


Figure 3.4.5: Yolov4 architecture of Object detection.

Distance Measurement:

It is important to measure the distance from the nearest objects. This part divided into two part such as:

Using Ultrasonic Sensor:

Figure 3.4.6: Mechanism of measuring the distance of Ultrasonic.

When it gives a high signal to the trig pin the sensor emits an eight-cycle sonic brust at 40kz. Then the sensor sets the echo pin high till the sonic burst returns --called reflection from the object and we know that length of pulse is proportional to how far the object is[20].

Now, we can measure the distance from the object using two pulses and the speed of the sound is 340 meters per second. The following calculation use to measure distance:

$$Speed(S) = Distance(D) / Time(T)$$

$$340 = (2D) / T$$

$$D = 170 \, x \, T$$

We measured distance using an ultrasonic distance sensor in 5 meters. If any objects are found in that area, then it can detect the object and give the measurement from an object.

Using Camera:

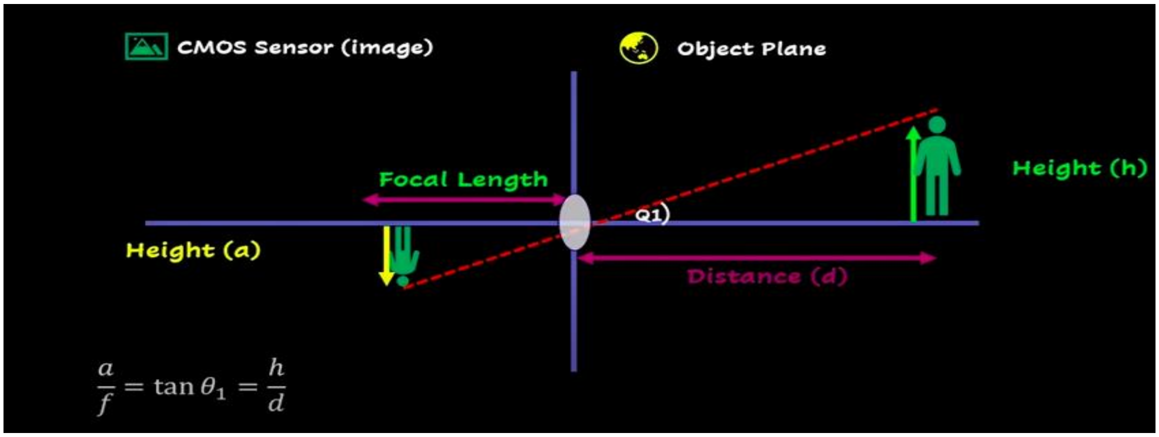


Figure 3.4.7: How to measure distance using Focal Length.

In this part, we have measured the distance of any person detected in front of the blind. At first, we detected faces using the haarcascade_frontalface.xml file. Then measure distance using a focal length from our known object. In order to ordain the distance from the camera to a person, to utilize triangle similarity and the triangle similarity goes something like this we have an object with a known width W[17]. In our thesis, we have a known face and in general the width of the face is about 14cm.

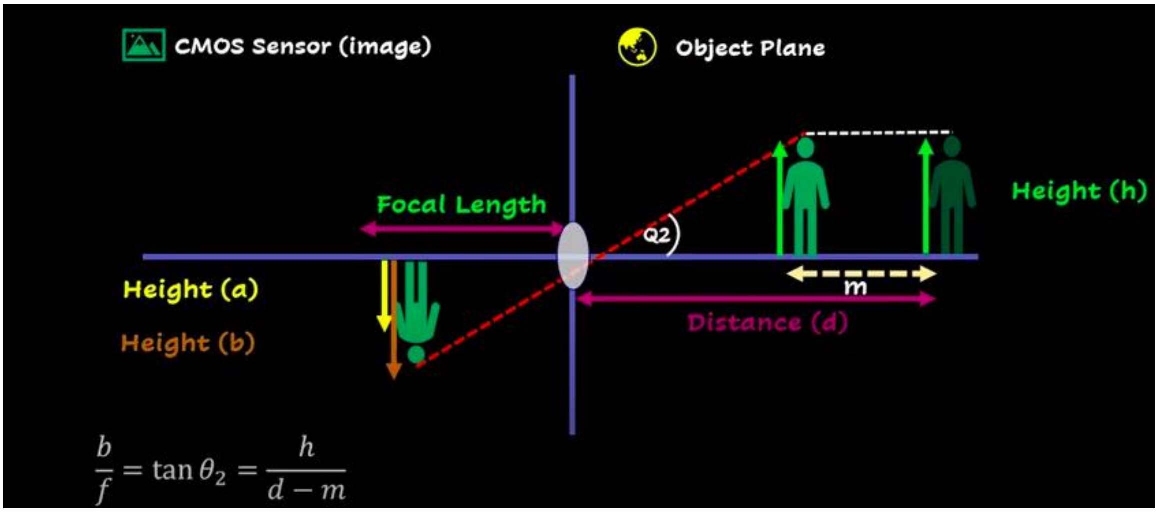


Figure 3.4.8: Extends measuring distance using focal length.

Then we capture the object image through the camera and then measure the apparent width in pixel P. This helps us to derive the perceived length F of our camera. The equation we have followed:

$$F = (P \ x \ D) \ / \ W$$

But when the stereo camera is moving in both nearest and further away from the object, we can apply the triangle similarity to ordain the distance of the object to the camera:

$$D' = (W \ x \ F) \ / \ P$$

Face Recognition:

The face recognition approach helps to navigate blind people in a more advanced way. Face detection is computer vision technology that determines the locations and sizes of human faces in arbitrary(digital) images [18]. In this technology. it detects faces by ignoring anything else, such as trees, bodies, or any parts of images. At below figure, it tells how the face recognition system works.

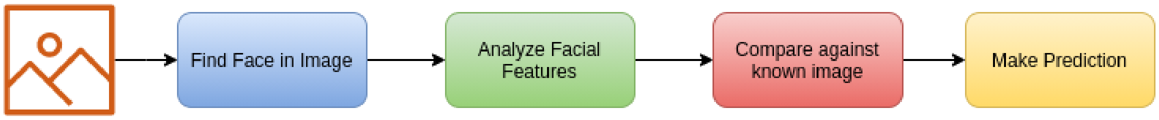


Figure 3.4.9: Face Recognition approach of detecting Faces.

Let's briefly discuss the face recognition procedure step by step that we have implemented in our project.

- Finding all the faces:
  The first step in face recognition is detecting faces in the captured images. For that, we located faces in photographs and then made the images into black and white because we do not need the colored images for finding faces.

- Posing and Projecting Faces:
  We had a problem while faces moving in different directions look totally different to a computer

  A human can easily recognize that both images are of the same person, but machines would see these captured images as two completely separate people. To overcome this issue, we have done using a **face landmark estimation** algorithm. The basic idea comes up with 68 specific points (called *landmarks*) that exist on every face — the top of the chin, the outside edge of each eye, the inner edge of each eyebrow, etc. Then we will train a machine-learning algorithm to be able to find these 68 specific points on any face [18].

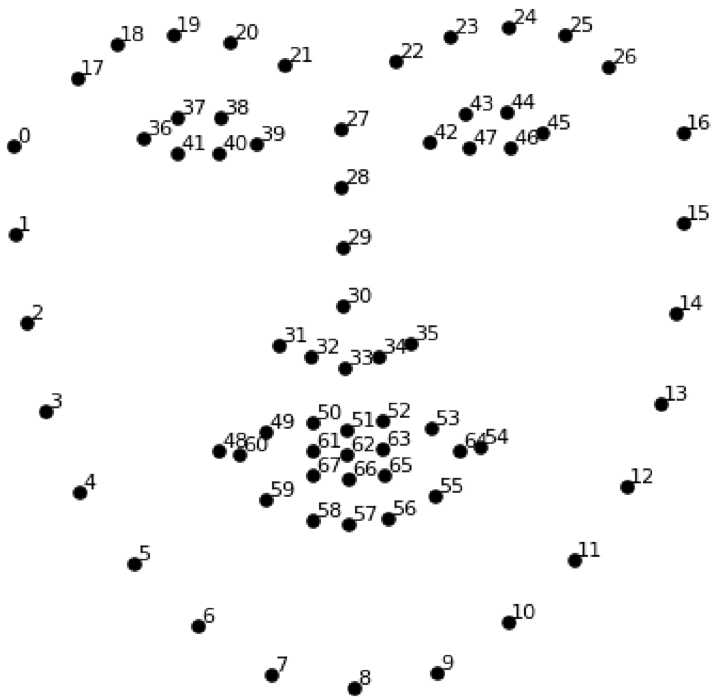


Figure 3.4.10: Every face locates the 68 landmarks [18].

For this algorithm, we can identify where the eyes and mouth are, we will simply scale, rotate and shear the face image so that the mouth and eyes are centered as best as possible.

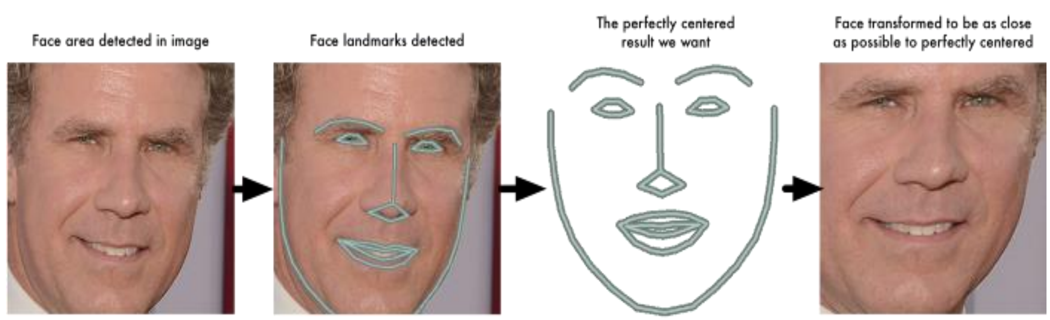


Figure 3.4.11: The above figure shows the affine transformation of different angles of the image[18].

Now, no matter how the face is turned, it is possible to center the eyes and mouth in roughly the same positions in the image. This helps our next step a lot more accurately.

- Encoding Face Images:

  In this step, we will encode faces for getting better accuracy by taking less time (milliseconds). So, we got 128 measurements for each face using a trained network.

- Find the person's name:

  We will get the name of the detected known faces from the encoding part In the encoding part we get the face measurement of 128 points. The name of the person is being stored while encoding faces.

To complete all the above procedures, we had used the **face-recognition** python package.

Optical Character Recognition (OCR):

Optical character recognition or Optical character reader (OCR) is the electric or mechanical conversation of images of typed, handwritten, or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image [19]. In our thesis, we have used **OCR** to recognize text from images or roadside directions or text. We installed tesseract OCR on our ubuntu machine using the installation method. The procedure for implementation of OCR is:

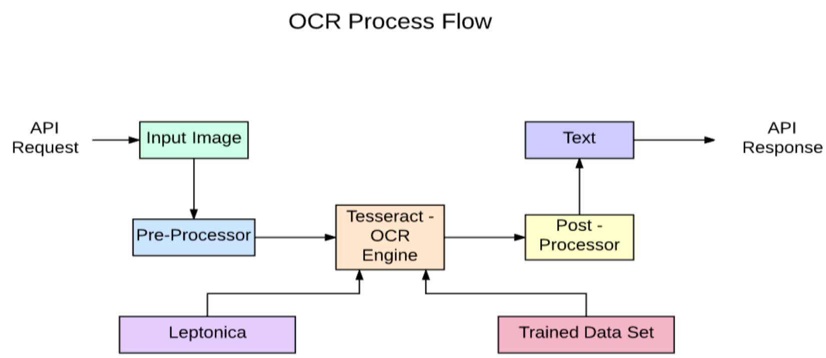


Figure 3.4.12: The Figure shows the process of OCR.

We have used **pytesseract** python library to recognize text from images or real-time videos and **pytesseract** is a wrapper for Tesseract-OCR Engine. Using this we were able to recognize black text with white background with higher accuracy. But for other images or videos we had a problem with accuracy then we pre-process images by rescaling, binarization, noise removing to avoid dropping tesseract output accuracy.

GPS Module Integration:

Global Positioning System (GPS) is a navigation system that uses satellites, a receiver, and algorithms to synchronize location, velocity, and time data for air, sea, and land travel [18]. We have used Ublox Neo **GPS** 7M Module to get the latitude and longitude to receive the exact location of blind people to track where they travel. The below figure shows how we implement a GPS module to get location data and store it into the cloud.

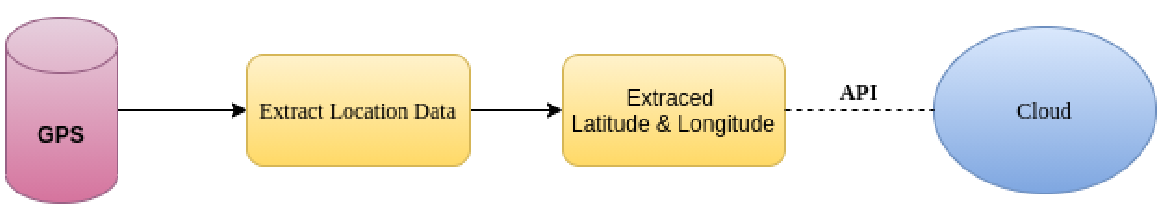


Figure 3.4.13: GPS Module Integration in our research.

Speech Recognition Module:

The speech recognition module is implemented to control the device for blind people. The voice commands work with the formal English language. The following figure shows the speech recognition module works in our research.

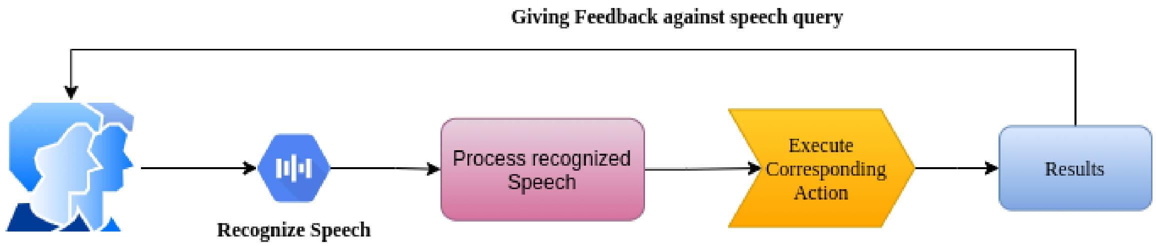


Figure 3.4.14: Working principle of speech recognition module.

The proposed system works with a specific function that means specific commands responsible for executing a specific function. For example ‘Start Device’ to run the program, ‘What is it ?’ to execute object detection, ‘Where I am ?’ to get a current location for the blind where blind is and etc. The Following Table 3.4.1 shows the functionality of the speech recognition module.

TABLE 3.4.1: THE FUNCTIONALITY OF SPEECH RECOGNITION MODULE

Speech	Actions	Output
‘Start Device’	‘The main program starts‘	Program has Started
‘Where I am ?’	‘The getLocation() method called’	Your Location is ‘name of Current Location’
‘Start Indoor Navigation’	‘indoorNavigation() executes	Started Indoor Navigation
‘What is it?’	‘findObjects() ’	Object Name
‘Distance from Object’	‘ultrasonicDistance() gets excute’	Measurement of Object Distance
‘Start Outdoor Navigation’	‘OutdoorNavigation() ’	Outdoor Navigation Starts
‘What is it?’	‘findObjects() ’	Object Name

'Distance from the person'	'getDistanceFromPerson() '	Human Distance from Blind
' Known Faces'	'faceReconition() executes	No/Yes - If yes then the name of known faces
'Search something'	'searchOnWeb() executes	Results of Search query
'Need Emergency Contact'	'emergencyContact()' executes	Email will send with current location data

API Building:

Application Programming Interface (API) is the acronym for Application Programming Interface, which is a software intermediary that allows two applications to communicate with each other [19]. The following figure represents the workflow from device to cloud through API.

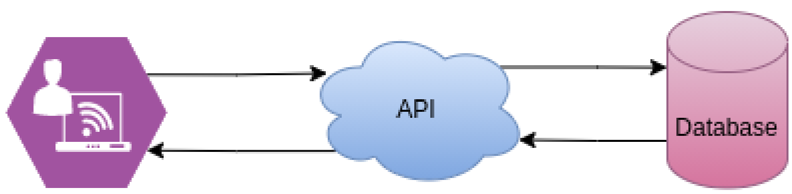


Figure 3.4.15: API implementation for our research .

In our thesis, we have implemented an API to send the data into the cloud to manage blind data for customer support and track them from anywhere. API is being also used for developing Android Application (Blind Navigation) with blind data. We built a RESTful API with a Laravel web application framework.

Web Application:

We have developed a Web Application named 'Blind Navigation' to ensure adequate safety of the blind's traveling, also the web application is developed for the guide to help the blind navigate with some emergency situation. In our web application, the guide can do live tracking when they are in outdoor traveling and they also track location history for blind's traveling. In a web application we retrieve the data from the database that is stored using API then we have used in our application. The following Figure shows how a web application looks like:

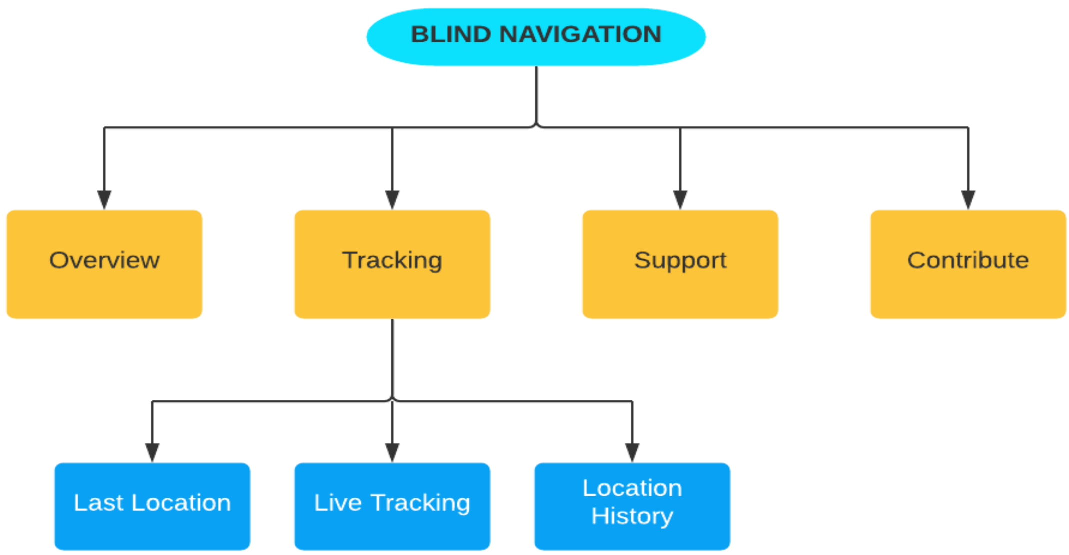


Figure 3.4.16: Figure shows the Web Application Work Procedure.

Android Application:

We also developed an android application that helps to track blinds, checking the history of the visited areas. The smartphone integrates a software platform (called Blind Navigator) which plays an important role to navigate blind people smartly.

Android Application works with the API that we have built using Laravel. We used Kotlin language to implement our application with the Retrofit 2 API management package. The system will transmit the data achieved by the components attached with the pi to the cloud and receive the data from the cloud using a Mobile hotspot, Wi-Fi, or 4G mobile communication.

Emergency Contact:

In our research, we have implemented a contact system in emergency situations. If blind fall in danger or need urgent communication with their guides the blind will be able to contact the guide through voice command. Then an email will be sent to the guider's inbox with the present location of the blind. The diagram shows the mechanism of an emergency contact in complex situations.

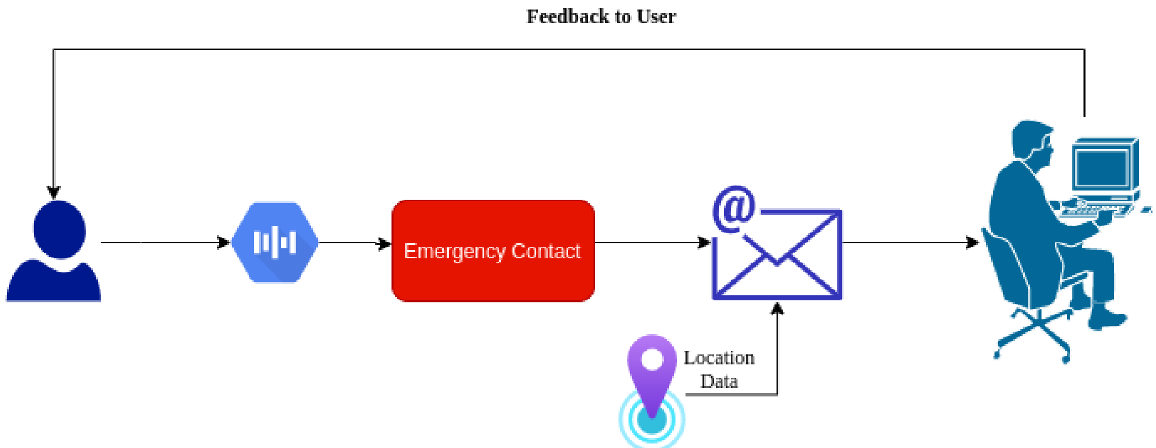


Figure 3.4.17: Figure shows the process when blind face complex situations.

3.5 Implementation Requirements

For implementing the research project we needed some hardware and software requirements. The main execution requirements were:

- Hardware
  - Raspberry Pi 4 (Model B) 4GB
  - 16 GB SD card
  - Ultrasonic HC-SR-04
  - Ublox Neo GPS 7M
  - 3x 1Ω Resistor
  - Breadboard

- Jumper wires(Male-Male, Female-Male)

- Software and Packages
    - Pycharm
    - LabelImg
    - Google Colab
    - Yolo Framework
    - Python 3.9
    - php
    - Kotlin
    - pytesseract
    - pyaudio
    - face-recognition
    - PhpStorm (Web Application)
    - Android Studio

- Knowledge
    - Raspbian os
    - Python Programming
    - Php
    - Kotlin
    - SQL
    - API
    - Machine Learning
    - Basic of Neural Network
    - Basic of NLP

CHAPTER 4
EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Experimental Setup

Machine learning approach has been used in our research-based project. Our research works on developing a system that helps blind people to navigate or guide like normal people with perceiving the nearest environment and avoiding obstacles. The system should be user-friendly so that they can easily interact with the system and the guide is able to track blinds where they visit with also live tracking GPS navigation. So, they can see the activity of their blinds.The following Figure shows the hardware environment.

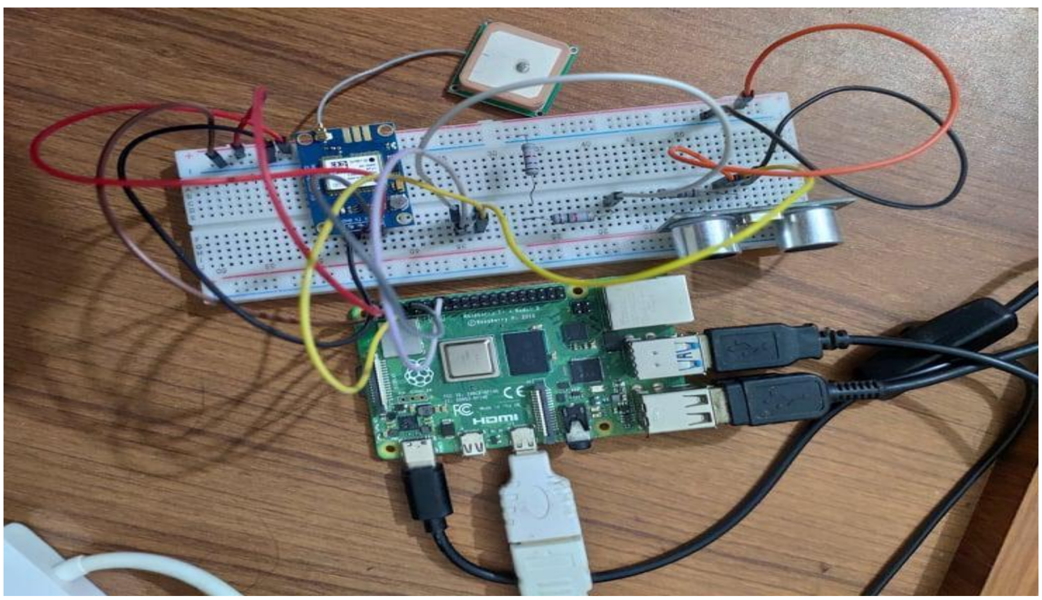


Figure 4.1.1: Environment of hardware components.

4.2 Experimental Results

In order to evaluate the overall system experimental results, several steps of the experiment have been driven. Such as perception tests, including object detection and object recognition, currency recognition, OCR, navigation test, including indoor and outdoor navigation, GPS module, the third one is device control, including speech recognition and the last one is cloud environment, including Web application and Android application.

4.2.1 Object Detection and Recognition

The object detection and recognition can identify 80 kinds of environmental objects, in Figure 4.2.1. The proposed system can identify different kinds of goods also (shown in Figure 4.2.2, which can tell the blind what the good exactly is. Both Indoor and Outdoor Object Detection with Recognition.

Figure 4.2.1: Detection and recognition of objects with goods.

The below image shows the detection and recognition of different kinds of objects and goods.

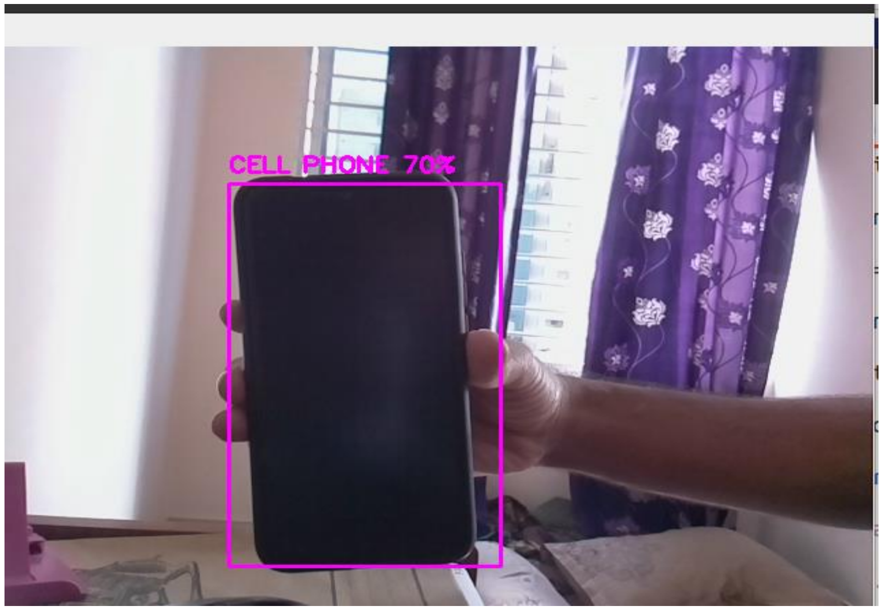


Figure 4.2.2: Single Object detection and recognition.

We have tested our detection method in the outdoor environment. The following Figure shows the detection and recognition outdoors.

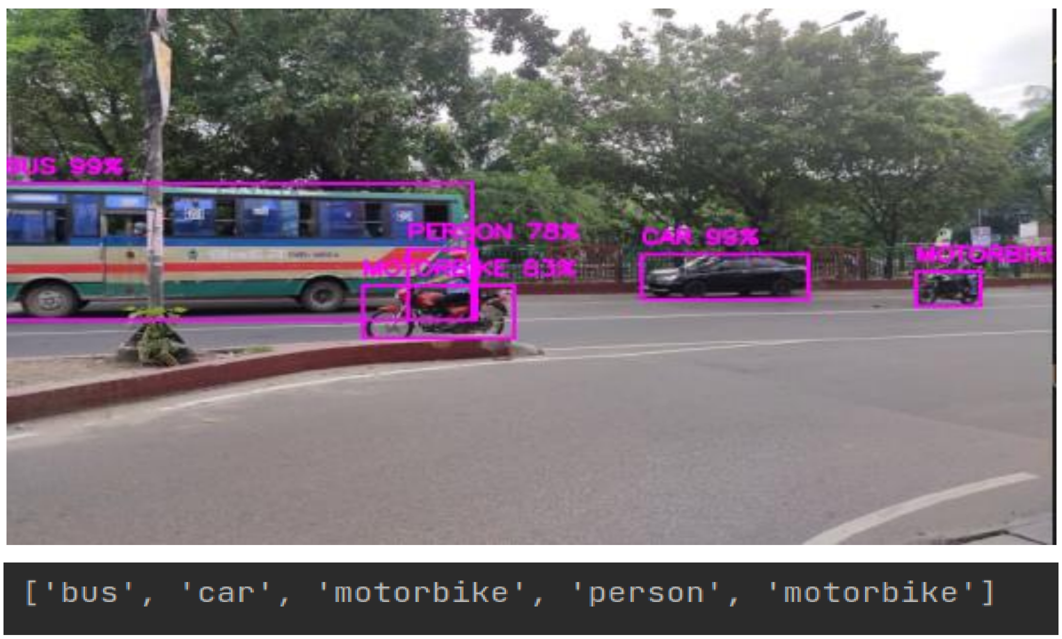
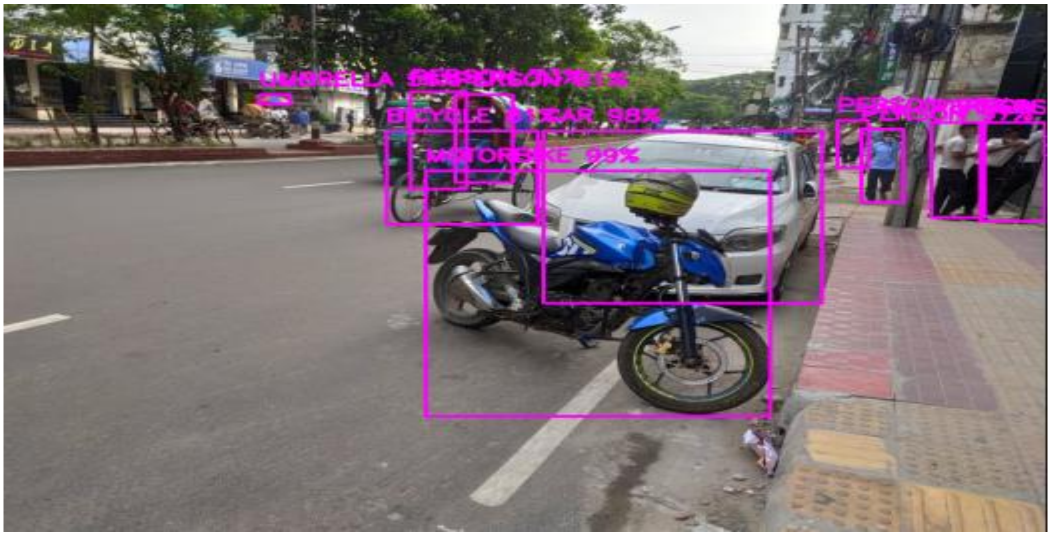


Figure 4.2.3: Multiple object detection outdoor environment 1.



```
['motorbike', 'car', 'person', 'person', 'person', 'person', 'bicycle', 'person', 'person', 'umbrella']
```

Figure 4.2.4: Multiple object detection outdoor environment 2.

4.2.2 Currency Recognition

The currency recognition module is mainly designed to detect and recognize Bangladeshi currency. The currency recognition results are shown in Figure 4.2.5 with higher accuracy. However, this currency recognition model cannot recognize or identify whether the currency is fake or not. In the future, we will implement other technology (like ultraviolet rays) to identify the authenticity of currency.

Figure 4.2.5: BDT Currency Recognition.

4.2.3 Distance Measurement

Distance measurement can be divided into two parts, one is measuring the distance from the nearest object using an ultrasonic sensor and another one is measuring the distance from the person if any person's face is available in front of a blind camera. The system can perform calculating distance using the focal length of the object. Ultrasonic gives the distance from the object and sensor that is shown in Figure 4.2.6 and distance using the camera from the person that is shown in Figure 4.2.7.

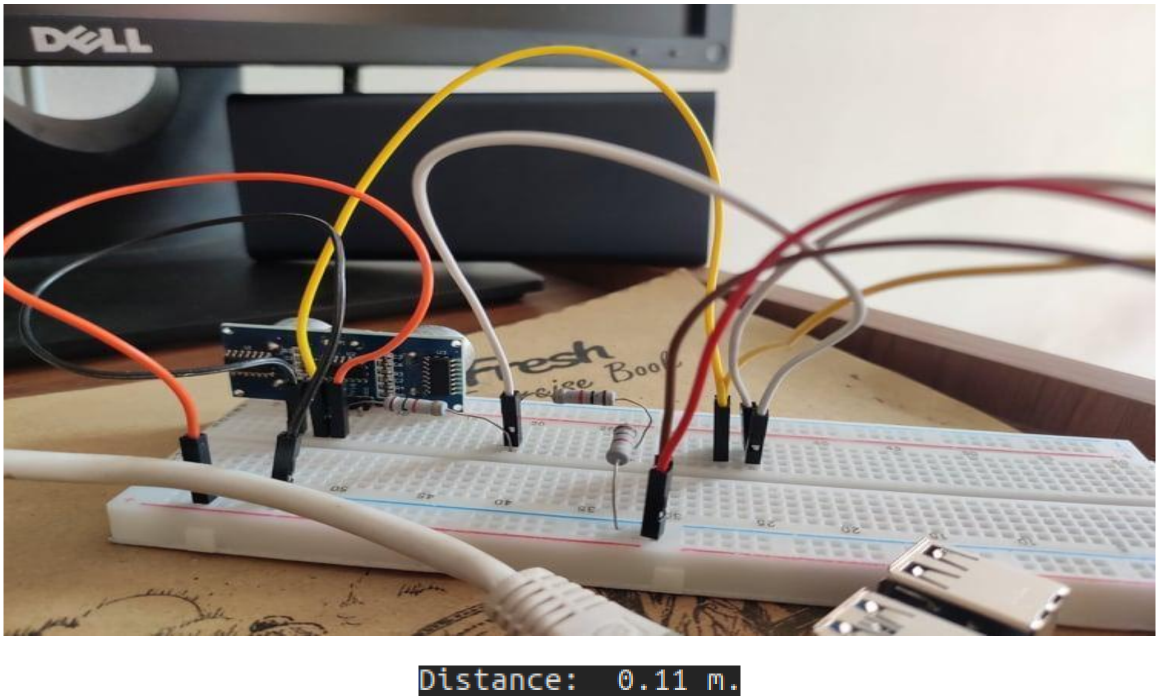


Figure 4.2.6: Distance Measurement using Ultrasonic.

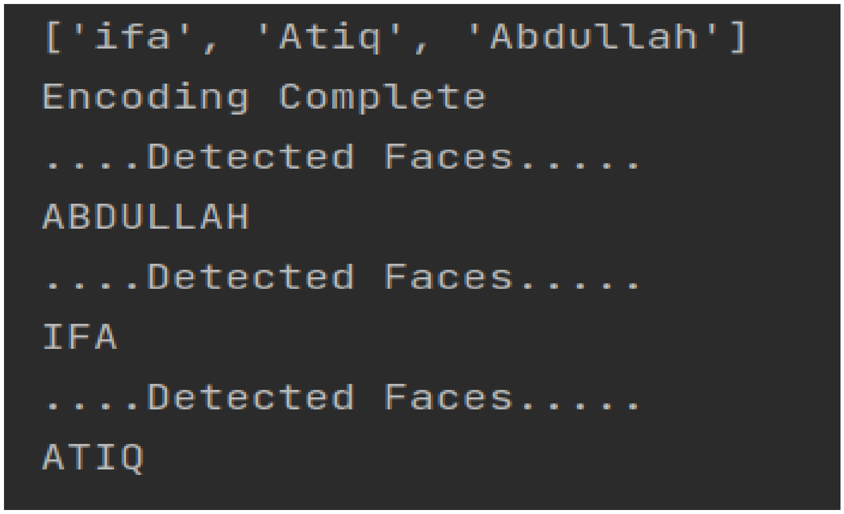
Figure 4.2.7: Distance Measurement using Focal Length of Person.

4.2.4 Face Recognition

The face recognition module can detect known faces that are previously trained by the system. The accuracy of detecting is pretty good. The 4.2.8 Figure shows detecting a single face while navigating and Figure 4.2.9 shows detecting faces if they're more than one face in images. Figure 4.2.10 shows the encoded image name and detected face are printed.

Figure 4.2.8: Single Face Detection using real-time video.

Figure 4.2.9: Face Detection in more than one face (Group photo).

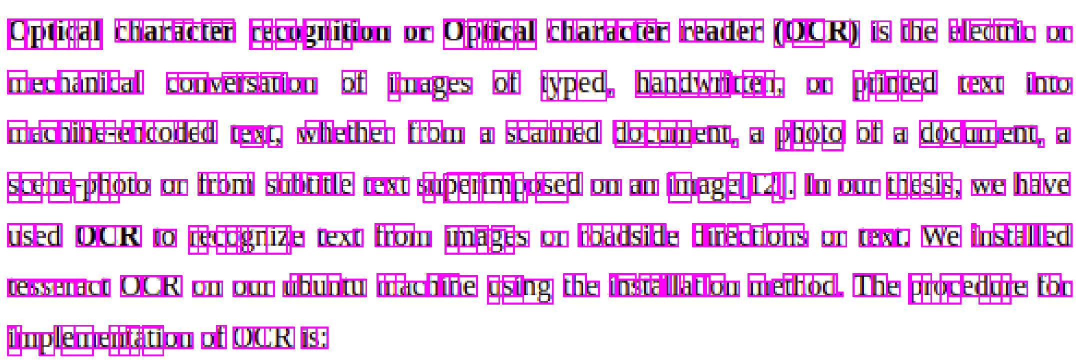


```
['ifa', 'Atiq', 'Abdullah']
Encoding Complete
....Detected Faces.....
ABDULLAH
....Detected Faces.....
IFA
....Detected Faces.....
ATIQ
```

Figure 4.2.10: Encoding and detecting Known Faces.

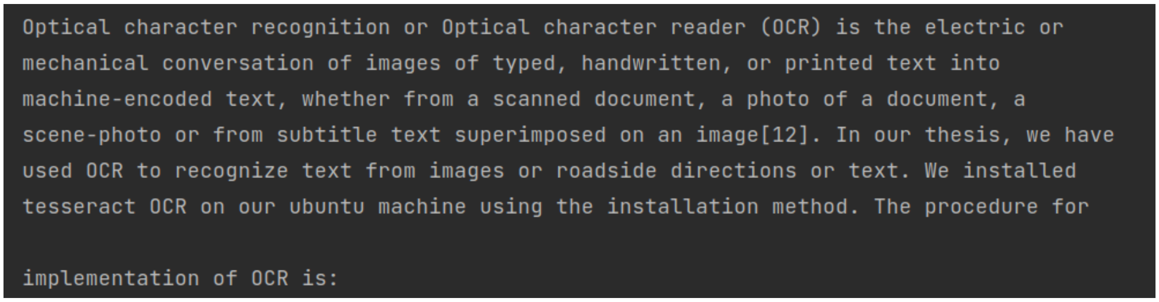
4.2.5 Optical Character Recognition

The Optical Character Recognition (OCR) module can recognize English alphabetic, digital characters, and Bengali characters. As shown in the figure below, even if the images are blurred, the recognition results are still very accurate. Figure 4.2.11 shows the OCR can detect each character with higher accuracy and Figure 4.2.12 shows the extracted data with respect to Figure 4.2.11. For Bengali, character detection is shown in Figure 4.2.13 and extracted data is shown in Figure 4.2.14 with respect to Figure 4.2.13.



Optical character recognition or Optical character reader (OCR) is the electric or mechanical conversion of images of typed, handwritten, or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image[12]. In our thesis, we have used **OCR** to recognize text from images or roadside directions or text. We installed tesseract OCR on our ubuntu machine using the installation method. The procedure for implementation of OCR is:

Figure 4.2.11: Detected each character with a bounding box.


Optical character recognition or Optical character reader (OCR) is the electric or mechanical conversation of images of typed, handwritten, or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image[12]. In our thesis, we have used OCR to recognize text from images or roadside directions or text. We installed tesseract OCR on our ubuntu machine using the installation method. The procedure for

implementation of OCR is:

Figure 4.2.12: Extracted data of the detected text.

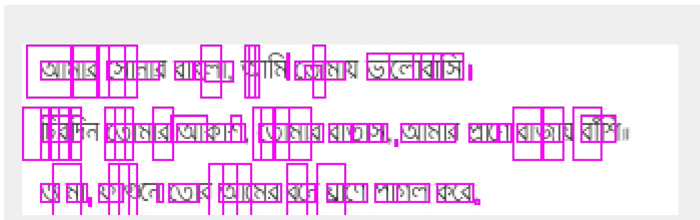


Figure 4.2.13: Character Detection of Bengali Language.

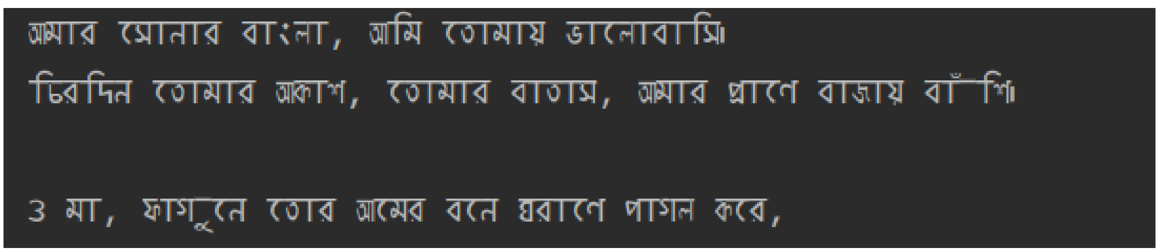
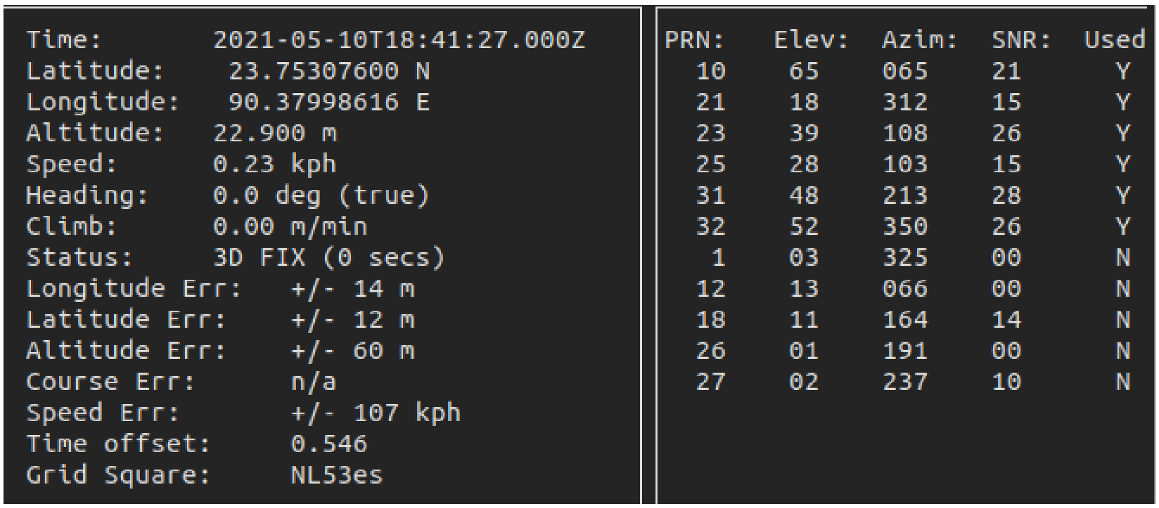


Figure 4.2.14: Extracted data(text) of Figure 4.2.13.

We have tested OCR in different images and got higher accuracy while detecting and recognizing data from images and videos. It also gives good results on different types of images like jpg, png, jpeg, and it works on pdf also for extracting data.

4.2.6 GPS Module

The Global Positioning System is being used to track blind people while they are navigating outdoors. As we know, the GPS module performs outdoors with higher accuracy. From the GPS module (Neo GPS 7M) we took latitude(lat) and longitude(lng). Figure 4.2.15 shows the live latitude and longitude from the module implemented with Raspberry pi.



```
Time:          2021-05-10T18:41:27.000Z    PRN:   Elev:   Azim:   SNR:   Used
Latitude:       23.75307600 N                10     65     065     21      Y
Longitude:      90.37998616 E                21     18     312     15      Y
Altitude:      22.900 m                      23     39     108     26      Y
Speed:         0.23 kph                      25     28     103     15      Y
Heading:       0.0 deg (true)                31     48     213     28      Y
Climb:         0.00 m/min                    32     52     350     26      Y
Status:        3D FIX (0 secs)                1     03     325     00      N
Longitude Err:    +/- 14 m                   12     13     066     00      N
Latitude Err:     +/- 12 m                   18     11     164     14      N
Altitude Err:     +/- 60 m                   26     01     191     00      N
Course Err:       n/a                        27     02     237     10      N
Speed Err:        +/- 107 kph
Time offset:      0.546
Grid Square:      NL53es
```

Figure 4.2.15: Latitude and longitude from Neo GPS Module.

4.2.7 Speech Recognition

The Speech Recognition module is implemented to control the device by the blind person. The module works with the natural English language. Figure 4.2.16 shows the voice command. The specific function is being called with respect to a specific command. In the future, we will implement the recognition of the voices of friends and relatives.

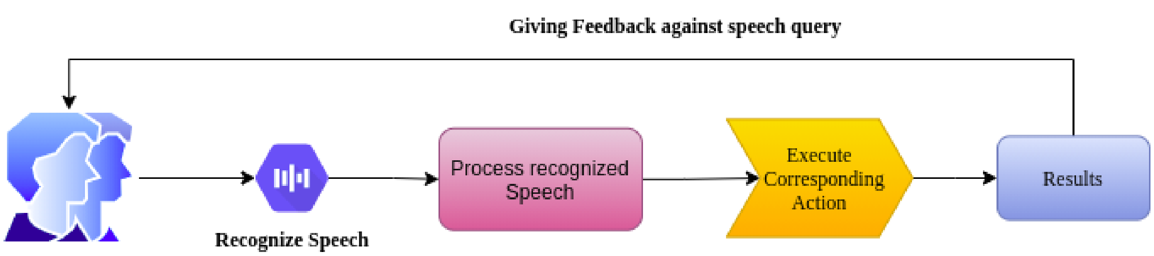


Figure 4.2.16: Speech Processing for each action.

4.2.8 Web Application

The cloud is a way to manage and store data for blind interaction. We have developed a Web Application to track blind people in real-time. The guide can track their blind person, they can see the history of the visited area. They can also contact the help for any update for their device. The Figure 4.2.17 shows the Dashboard of a Web Application named Blind Navigation. Figure 4.2.18 shows the live tracking interface while navigating in an outdoor environment, and The guide can see the last location where the blind was navigated as shown in Figure 4.2.19.

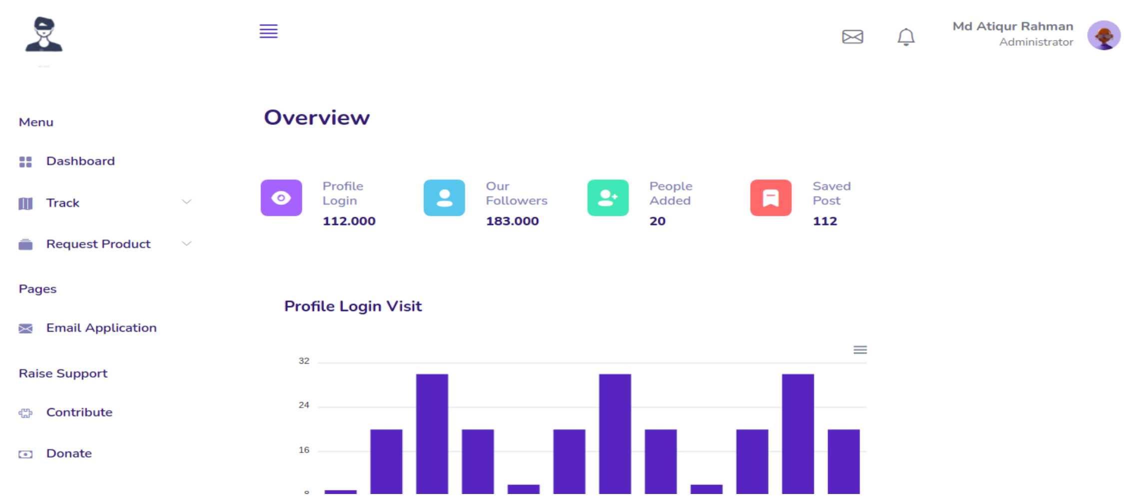


Figure 4.2.17: Overview of a Web application for Blind.

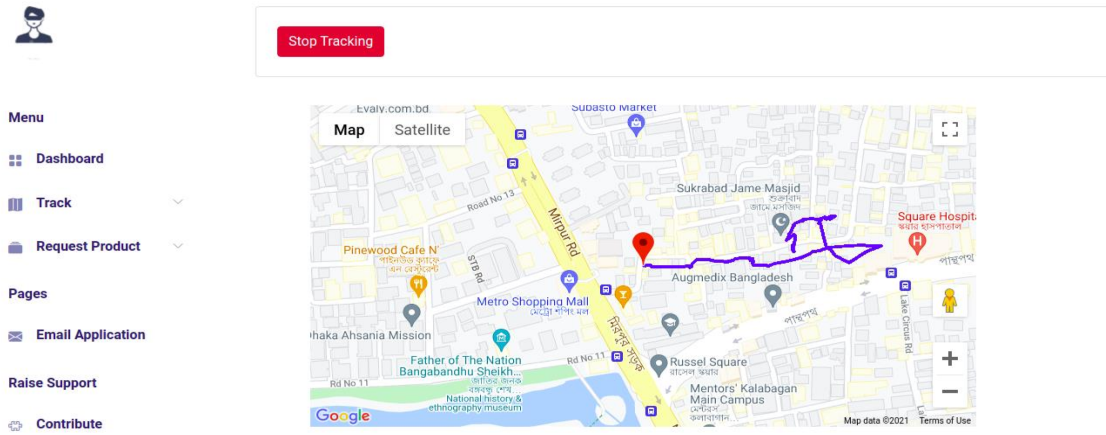


Figure 4.2.18: Live tracking of a blind person while visiting.

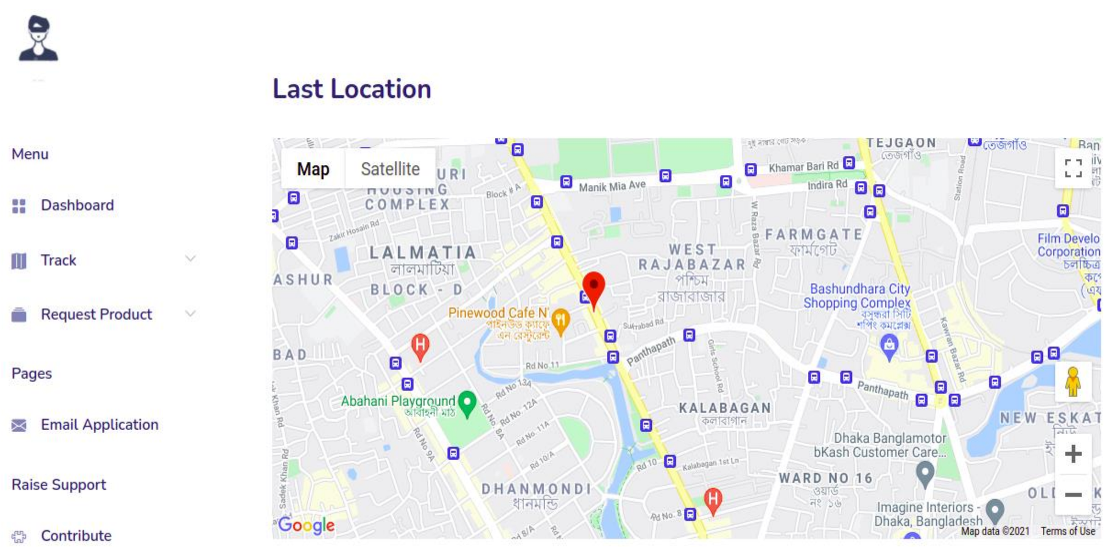


Figure 4.2.19: Last location where blind people visited.

4.2.9 Android Application

The Android Application named ‘Blind Navigator’ is developed to give user experience friendly. Using the android app the guide can set it up for the blind or they can be able to interact as a web application does. Figure 4.2.20 shows the interface of a live tracking system to track blinds people.

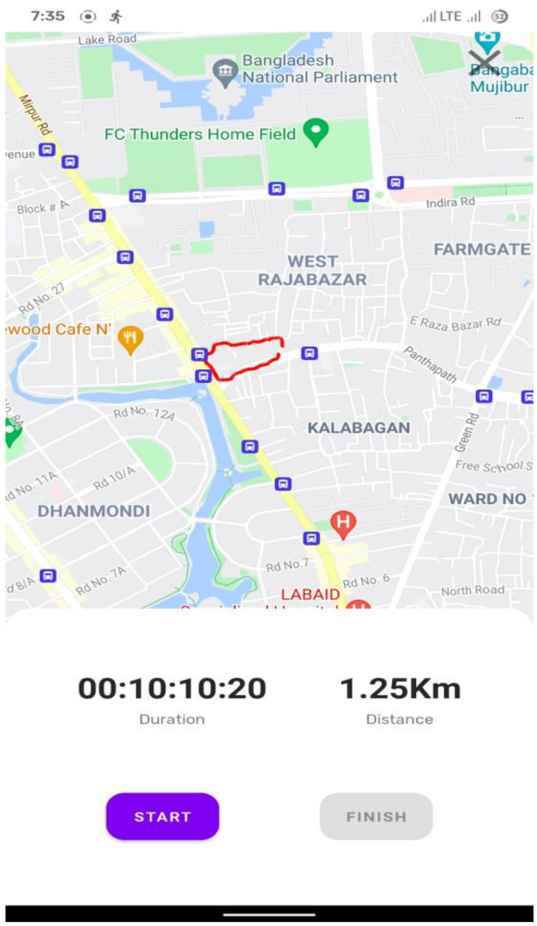


Figure 4.2.20: Live Tracking while navigating in Android.

4.3 Discussion

Blind people navigation is a research-based project. In this research, we have tried to implement the real-time navigation system with perceiving as much as possible details of the environment. This is an IoT-based system that takes the data from the IoT devices and uploads it into a cloud server that is managed and accessed by the administrator and the blind guide. We have tried to give user-friendly behavior from their devices. Not only that, the guide can track the blind while they are navigating in an outdoor environment. In an outdoor environment, they are able to detect 80 objects by a measuring distance if the object is human. With the proposed system the blind can detect their known faces by the camera.

We have developed a Web and Android-based application that the guide can track their blind person named 'Blind Navigation'. While doing this project there were different kinds of challenges like hardware implementation. In this proposed system there were also some drawbacks. In a further study, we will overcome these drawbacks and will make a more feasible system.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT, AND SUSTAINABILITY

5.1 Impact on Society

This will make a very good positive impact on our society. If we are thinking about the amount of visually impaired people we will see the impact of it. Especially in our society, we feel those who are visually impaired are actually a curse in our society. They also feel they are actually a burden for their family, for their village, for their country. But they are as clever as normal people are. They are as talented as normal people are. But they feel they are the cause. Especially those who are totally blind.

We think if the government helps us we will do something extraordinary and we will make unique things which will change our society. There will be a society where no one will feel that they are a burden. No visually impaired person. This is our main motive. By this, a blind can easily move from one place to another place. They can identify their regular use of things. They can identify their relatives, their nearest people. They can identify all the things we use in our daily life like currency and all objects. When blind people use it they will feel the world, they can touch the world with their third eye. They will feel that this is their life.

So, from the above discussion, we can easily feel that it will make a very very positive impact on our society.

5.2 Impact on Environment

It will make a very good impact on our environment because it will make a very good impact not only for the blind people, it will make a big impact for those people who feel

that blinds are the curse of society. Some people of our society try to misbehave with the blind and they always try to roast them.
This environment must be changed by this project. This project may create a magnificent impact for the blind. How our environment accepts them, that environment will be changed. The blind will also feel the world and work and move like normal people.
So, our project has a very good impact on this environment.

5.3 Ethical Aspects

We are working for the blind. Those are really helpless and really neglected in our society. This is our responsibility to do something for them. We saw that they have talent like us but they are begging. They move as if they have nothing. So we have to do something for them. That is our responsibility. We live in the same society. They have two legs, two hands, and a talented head. All are like us. Just for their one organ, they will pass their life like animals.

They have no respect, no especially, no dignity. So, we have to do something for them and this is for them which will change their life.

5.4 Sustainability

We are developing it and we have many many planes around this. Already we are working with a large amount of data but we want more data. We already do something really special but we want to do something more special. We want to add more features in our project and we will work widely and for more people.
We will make it more feature day by day.

CHAPTER 6

SUMMARY, CONCLUSION, AND FUTURE WORK

6.1 Summary of the Study

In our paper, we are trying to make a device that will make a very good impact in the daily life of blind people. This is a vision-based navigation system where we use raspberry pi and different instruments for different work.

We are working here with a huge amount of data and we are working for object detection, voice recognition, face recognition, focal distance, and so on. This all in the same device. Every single part of this project is a big project and people are working with a single part of the project. But we make a combined feature. Which is really effective and which is really usable for blind people.

6.2 Conclusion

In this research, an innovative approach for blind people has been proposed. For the output of this project, we use Raspberry pi 4 Model B, Ultrasonic Sensor, Ublox Neo GPS 7M, Breadboard, Jumper Wires, 3x1k resistors, Laptop, Yolo v4 framework, LabelIng image annotation Tool, Google Colab, Pycharm, laravel PHP framework, Android studio, Google map API and so on. And we use some effective models and many packages also. We also use web applications and android applications.

The proposed system provides object detection, distance measuring, face, and relative recognition, optical character recognition, Optical Character Recognition(OCR), Speech Recognition, GPS Module Integration (Tracking), API building, Train and Export model, and so on. In addition, this system provides smart navigation in an indoor and outdoor environment. So, it can ensure the safe navigation of blind people in some complex and emergency situations with an emergency contact method.

In this research, we used two types of data. One is the coco data set and another one is the current dataset. In the coco dataset, 330k data have been used where more than 270k data set is labeled. In the current dataset, more than 250 data sets have been used. Which is a really big amount. But if we focus on the accuracy of the system, we can see that the accuracy of the system is more than 98%. This system actually works really well. This is an ultrasonic sensor and raspberry pi-based system and also uses GPs and web application which is really effective and that works really well. We use deep learning which is really effective for object detection and currency recognition in many places. Although this is a really good navigation system for blind people, there are some places where we can actually improve. We use ultrasonic sensors which can detect objects between 5 meters, which is not a very big range. There are some sensors that are more effective than them but those are expensive. Although we already use a lot of data, if we want, we can use more.

In the future, we will add more features and more sensors to make it more effective.

6.3 Future Work

In this research, an innovative approach for blind people has been proposed. For the development of this project, we use Raspberry pi 4 Model B, Ultrasonic Sensor, Ublox Neo GPS 7M, Breadboard, Jumper Wires, 3x1k resistors, Laptop, Yolo v4 framework, LabelIng image annotation Tool, Google Colab, Pycharm, laravel PHP framework, Android studio, Google map API and so on. And we use some effective models and many packages also. We also use web applications and android applications.

In future work, we will try to overcome the ultrasonic 5m distance. We will use another module that can detect rear objects and measure the distance of far objects. We will do more work and study for updating our research methodology, developing modules, will use more advanced technology that navigates blind people more safely, and improving our accuracy that makes the system user-friendly. Android and web applications will improve system UI, more interacting interfaces, and lots of options that help the blind guide to track, manage their blind.

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