BORDER SECURITY SYSTEM USING ROBOTICS AND IMAGE PROCESSING

A Project Report Submitted By

SHREYAS ARUNESH	**4NM15EC161**
KAJAL	**4NM16EC048**
KRITHI R SHETTY	**4NM16EC055**
NEHA RUDRESH	**4NM16EC072**

Under the Guidance of

Mr. Prajwal Hegde N
Assistant Professor

in partial fulfillment of the requirements for the award of the Degree of

Bachelor of Engineering
in
Electronics and Communication Engineering

from
Visvesvaraya Technological University, Belagavi

NITTE EDUCATION TRUST | NMAM INSTITUTE OF TECHNOLOGY
Nitte-574110, Karnataka, India

April-2020

NITTE EDUCATION TRUST | N.M.A.M. INSTITUTE OF TECHNOLOGY
(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi)
Nitte – 574 110, Karnataka, India
ISO 9001:2015 Certified, Accredited with 'A' Grade by NAAC
☎:08258 - 281039 – 281263, Fax: 08258 – 281265

Department of Electronics and Communication Engineering

Certificate

Certified that the project work entitled ***Border Security System Using Robotics And Image Processing*** *is a bonafide work carried out by* ***Shreyas Arunesh(4NM 15EC161), Kajal(4NM16EC048), Krithi R Shetty(4NM16EC055) &Neha Rudresh (4NM16EC072)*** *in partial fulfillment of the requirements for the award of* ***Bachelor of Engineering Degree in Electronics and Communication Engineering*** *prescribed by Visvesvaraya Technological University, Belagavi during the year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of the project work prescribed for the Bachelor of Engineering Degree.*

Signature of the Guide **Signature of the HOD**

Signature of the Principal

Semester End Viva Voce Examination

	Name of the Examiners	**Signature With Date**
1.	_____	_____
2.	_____	_____

Abstract

The surveillance of International border areas has been one of the major concerns all across the globe. It is very essential that unauthorized people should not enter inside the restrained areas. The supervision of these restricted areas by border guarding forces is impossible at each and every moment. The proposed work presents a design and development of a new security solution which integrates vision, machine intelligent algorithm and multipurpose smart robot technology. Wireless camera for continuous monitoring of the restricted area form the base station and through machine intelligent algorithm harmful gases, fire, metal sensors, GPS (Global Positioning System) to locate the robotic vehicle is mounted on the robot, these information are continuously transmitted and displayed in the base station to alert the anomalies appearing in the border vicinity. The framework of this robot is that, it can be operated by both Automatic and Manual mode. Ultrasonic sensors are functional for automatic action whereas Joy stick is interfaced with Raspberry pi 4 controller to operate in Manual mode. Robotic Arm is used for pick and place of any object and to capture the enemies. Base station is equipped with advanced biometric security system i.e Face Recognition (FR) using LBP and PCA algorithm. IN Addition, a GSM (Global System for Mobile) module is interfaced to alert the Authority if there is any intruder who is trying to access the control. The proposed work would create a revolution in military applications as a surveillance and inspection robot.

Acknowledgement

Our project would not have been successful without the encouragement, guidance and support by various personalities. First and foremost, we would like to express our sincere gratitude towards our project guide **Mr. Prajwal Hegde N**, Assistant Professor, Department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for his/her guidance, encouragement and inspiration throughout the project work.

We extend our gratitude to **Dr. Rekha Bhandarkar**, Professor and Head, Department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for her encouragement and providing necessary facilities in the department.

We wish to acknowledge the support of **Dr. Niranjan N. Chiplunkar,** Principal, N. M. A. M. Institute of Technology, Nitte, for providing motivational academic environment.

We would like to express our sincere thanks to all the teaching and non-teaching staff of the department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for their patience and help during our project work.

Finally, we would like to thank all our friends and well-wishers who have helped us whenever needed and supported us.

Shreyas Arunesh
Kajal
Krithi R Shetty
Neha Rudresh

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

1.1 General Introduction

Nowadays robotics field is growing drastically; some of the common applications are in the industries, defence, academic and research communities. Utilizing the human face is a key to border security, " Biometric Confront Acknowledgement Innovation " has gotten tremendous consideration because of its potential for a wide assortment of utilizations.
The proposed system is divided into two parts 1. Robotic vehicle and 2. Base station. The robotic vehicle uses Embedded C Language to program the ARM Controller and the Sensory network involves Metal detector, temperature sensor, gas sensor. When any deviation from the original state, according to fed algorithm robot transmit the signals to the base station through Xbee transceiver where authority can take necessary actions using Robotic Arm. Wireless camera is used for continuous monitoring and wireless control provides additional benefits including increased flexibility and reduced installation cost.
Base station uses Python language to program the Raspberry Pi 4 controller board. Developing a set of image acquisition for database and recognition is done using Local Binary Pattern(LBP) algorithm. The design of the system use microprocessor Broadcom BCM2711 as main control unit. The aim is to develop a base station with face recognition as a biometric security that is quick, fairly straightforward, and correct in affected environments like an workplace or a social unit.This system might not fully replace the responsibility of the soldiers, but manages to take the supreme reliability and thus reduces human mistakes on the border.

1.2 Aim

The project aims at developing a Robotic vehicle and a secured base station for border security to detect and alert threat and anomalies in border vicinity using ARM Cortex M3 and Raspberry Pi 4.

1.3 Objectives

1. Metal detector is used for detecting metals at the border areas because mines, bombs, pistols, electronic circuits are made up of metals.
2. Temperature and gas sensors to monitor the weather forecast and transmit it to the base station through XBee transceiver.
3. Robotic Arm is used to pick and place any objects like metal and to capture the enemies.
4. Face Recognition biometric to unlock the remote for authorized officials.
5. GSM module to alert the authority in case of any intruder.
6. Implementation of Automation technology i.e. Autonomous Driving System (ADS).

1.4 Problem Formulation

The dead zones and border areas may have traps, land mines, poor visibility and varied climatic condition. It is not possible to watch the border at each and every moment. An essential requirement of this situation is a robot which automatically detects trespasser in the border and report nearby board security base station and intruders might try to access the control. Hence to alert the authority immediately, highly secured biometric system is embedded in the base station.

1.5 Proposed Method

The proposed method is as follows 1. Sensory networks to detect parameters like human presence, weather forecast, harmful gases, pistols, bombs, mines, fire and gas. These signals are transmitted to base station through Xbee transceiver.
2. Wireless camera for continuous monitoring and real time audio and video signals to communicate from base station to robot vehicle.
3. Robotic Arm and directions of vehicle is controlled through Joystick from the base station.
4. Face detection and generating a database using Haar cascade classifier.
5. Face recognition using LBP and PCA algorithm.
6. GSM module to alert the Authority in case of any intruders.
7. Ultrasonic sensors are used to avoid collision in Autonomous Driving System (ADS).

1.6 Methodology

1.6.1 Sensory Networks

In the proposed system Embedded C Language is used to program the ARM Cortex M3 controller board in the vehicle side. On board sensors are Metal detector, gas sensor, temperature sensor and ultrasonic sensor. Each sensor are interfaced with the ARM cortex controller with necessary algorithms programmed in the controller to receive the signals from these sensors when there is any deviations from the original state occur in the robot (Vehicle Side). For every sensor One GPIO (General Purpose Input/output) pin is SET. When metal detector detects metals, guns, pistols, bombs, mines respective GPIO pins are set high and the output signal can be transmitted to the base station and is displayed on the LCD. Similarly when Gas, smoke is detected Gas sensor activated and for weather forecast, temperature sensor is used to produce an electrical signal proportional to temperature (C) when the temperature in the surrounding goes beyond the specified value. The voltage signal thus obtained is converted and is transmitted to base station and the value is displayed on the LCD in base station.

1.6.2 Processing Units

Xbee transceiver is used for the wireless communication between robotic vehicle and base station. Wheels and Robotic Arm are interfaced with ARM cortex controller using dc geared motor and necessary action can be performed using the Joy stick from the base station based on the signals from the onboard sensors. Robotic Arm can be used for pick and place of heavy objects and also to capture enemies. Wireless camera is placed above the robot vehicle for 360 degree continuous real time monitoring from the base station.

1.6.3 Remote Control Unit

Python language is used to program Raspberry Pi 4 controller board in the base station and Pi camera, GSM module, Joy stick, LCD, xbee transceiver is interfaced with the controller board. Push buttons are used to raise an interrupt for onboard sensors. Automatic / manual switch is to shift between manual mode and Automatic mode i.e. Autonomous Driving System (ADS). Joy sticks are interfaced with Aurdino UNO as the signal from joy stick is analog.

1.6.4 Biometric

1. The input to the system is image captured through PI camera when a person stands in front of the camera while the remote is in lock state. Face recognition methodology biometric involves following steps:
• Convolution Face detecting using Haar cascade classifier.
• Creating a data base and training of images captured.
• Face recognition techniques using LBP and PCA algorithms.
2. Interface GSM module to send alert to authorized person through SMS and CALL if an intruder is trying to unlock the base station.

1.7 Literature Survey

Patrolling the border at all times is a difficult task. Hence to provide a solution to this, Abdalla, G.O.E. et al.'s [1] paper proposed an essential requirement at this situation is a robot which automatically detects a trespasser at the border. The proposed work presents designing and development of a multi-purpose smart robot for detecting humans, fire, harmful gases, metals, obstacles at remote areas and sends information to main location.
The IAV (Integrated Autonomous Vehicle) is an automatic robot which has the capability to reach any corner of the security region without alarming the enemy. Maini, R. et al paper [2] says that it could be used in military and defence sectors for certain purpose like as a spying robot, bomb disposal unit, suspect/threat detection and demolition, in such areas where our soldiers couldn't have an easy access to and complex conflicts irrational of any situation and atmosphere
Sudhakar S. et al paper [**?**] gave an approach to a Raspbian operating system-based spy robot platform with remote monitoring and control algorithm is being used. The spy robot system comprises of Raspberry pi, night vision pi camera and sensors [**?**]. The Spy Robot used is capable of things like the presence or absence of the unwanted folks in war areas which can be determined by the PIR sensor which sends a signal to the Raspberry Pi when a human - being is in the ambient of the Robot. In turn, the Pi triggers the camera module immediately to capture an image and send it to the web page. The brain of the spy robot is the Raspberry Pi minicomputer.
Further, Saeedi, S. et al [**?**] paper proposes a design and implementation of a low-cost smart security camera with night vision capability using Raspberry Pi (RPI). It has human detection and smoke detection capability that can provide precaution to potential crimes and potential fire.The credit card size Raspberry Pi (RPI) with Open Source Computer Vision (OpenCV) software handles the image processing,

control algorithms for the alarms and sends captured pictures to the user [**?**]. Using the aid of OpenCV, the surveillance system will be able to identify or differentiate the context of the scene being monitored. An ordinary webcam with its infra- red (IR) filter removed can be utilized for night vision sensing with the aid of IR Light Emitting Diode (LED) illuminator. Night vision capability is achieved by using IR LED illuminator and a modified webcam. For the alarm system, Raspberry Pi was utilized to output the designated audio sound to the speaker and sent the captured positive detection images was taken from Maini, R. and Aggarwal, H.'s paper [**?**]. Image processing is a methodology to overhaul unrefined images got from cameras or sensors or pictures taken in conventional regular day to day existence for various applications. The algorithm used in the proposed system for face detection is Haarcascade algorithm and for face recognition is Local Binary Pattern Histograms (LBPH), Fisher faces and Eigen faces algorithm by Swain, K.B. et al [**?**]. The open source library packages OpenCV 3.1.0 contains built in face recognition algorithms. The proposed system uses Raspberry pi and Python language for the hardware implementation.

The project focuses on designing and developing a robotic vehicle that can sense metals in front of it on its way like detecting land mines. A metal detector circuit interfaced to the control unit that alarms the user about a suspected metal ahead by referring to Abaya,W.F et al [5] paper. The metal detector circuit is mounted on a robotic vehicle and its operation is to detect metals underneath automatically [8]. Temperature sensor measures the temperature and when the temperature goes beyond the limits then according to the algorithm robot transmits the signals to user side where user is available to take the actions. The hardware requirements are Microcontroller, Metal Detector, Human Detector, Obstacle Detector, Gas Detector, Ultrasonic Sensor, Temperature Sensor, Wireless Camera and RF Module [2]. Wireless camera mounted on the robot provides a continuous streaming of the defined outdoor area and a stepper motor is used for the rotation of the wireless camera in 360- degree direction. The camera picture is transmitted through a signal to remote side with the help of transmitter, where detected quantity is displayed on LCD screen. It transmits real time audio and video inputs which can be observed on a monitor in the base station from where the robot will be controlled in user mode [**?**].

This whole robot system works in two modes namely automatic mode and user controllable mode. By default, robot works in automatic mode in which all sensors are functional for automatic action. In user controllable mode, user sends the signal to the robot car and gives directions to change path accordingly [2].

1.8 Organization Of Report

Chapter 1 introduces the main purpose of the project, need for the project in present situation and also deals with the literature survey view.
Chapter 2 deals with the block diagram of the proposed system.
Chapter 3 gives the brief information of the process taking place.
Chapter 4 gives the hardware components description used in the project.
Chapter 5 deals with the software details used in the project.
Chapter 6 deals with the result of the proposed system.
Chapter 7 gives the conclusion and future implementation of the project.

Chapter 2
System Overview

2.1 Intelligent Approach Of Vehicle Section

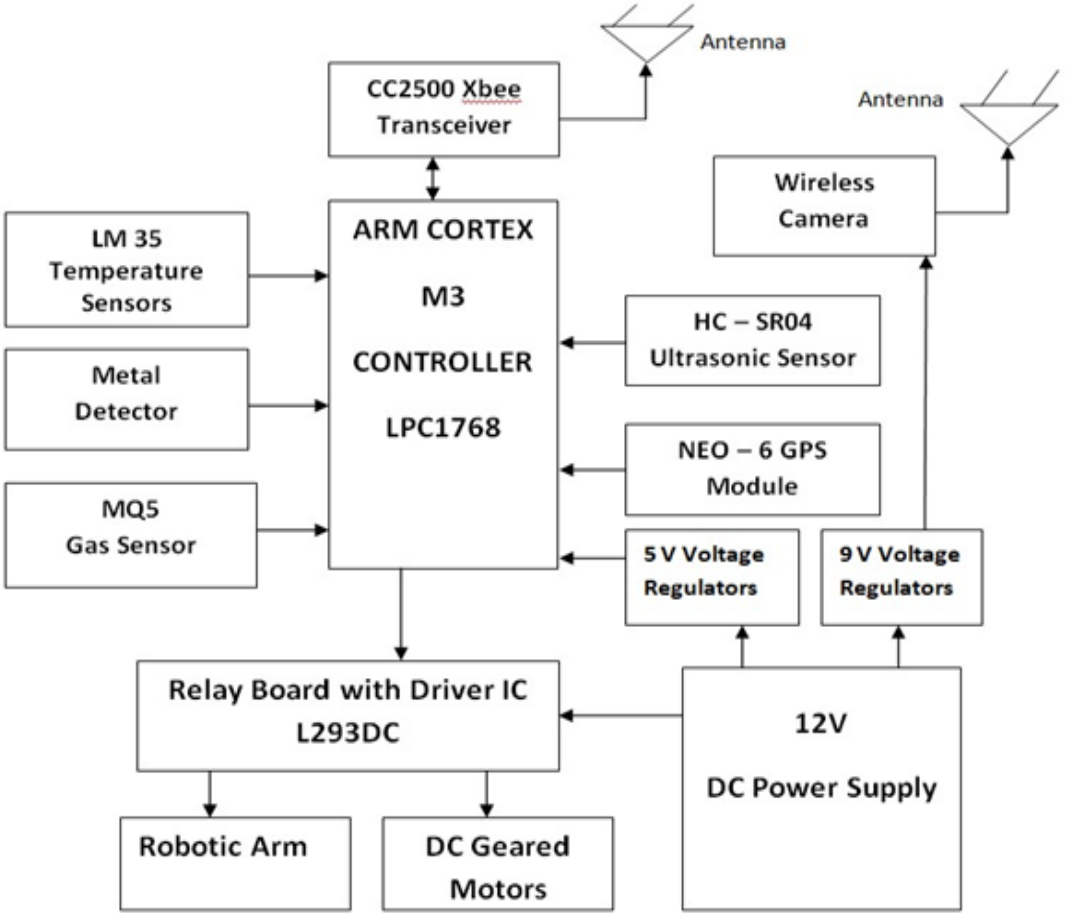

Figure 2.1: Vehicle Side Block Diagram

The Figure 2.1 shows the block diagram of the vehicle section of the proposed system.Arm Cortex M3 LPC1768 Microcontroller acts as the heart of the Robot Module. It consists for following modules and the intelligent approach in this section is shown bellow using the following modules.

2.1.1 Onboard Sensors

LM35 is a temperature sensor that can be used to measure temperature and produce an electrical output proportional to the temperature(C). It can measure temperature more accurately when compared with a thermostat. The voltage obtained from the sensor can be converted into temperature using the conversion formulae. MQ5 Gas sensor is used to sense LPG gas, smoke which are in range of 100 – 3000 ppm. The signal obtained is in analog so, ot is fed to ADC (Analog to Digital Converter) of the controller. Metal detector which is an inductive oscillator circuit and when any metallic objects like pistols, bombs, mines comes in contact the current in the metal detector changes and thus produces an high output indicating metal detected.

2.1.2 Wireless Communication Units

The wireless communication system involves an Xbee transceiver CC2500 module which is interfaced with the ARM cortex controller. It is communicated via Universal Asynchronous Receiver/Transmitter(UART) 0 port of the ARM board with the help of Serial Interfacing (I/O) commands and networking commands.

2.1.3 Driving System

Driving system involves Robotic arm and the wheels of the robotic vehicle is interfaced with ARM cortex controller through driver IC L2963D, where the DC geared motors are connected to NC (Normally closed) terminal which is 5v supply in the relay board. When the microcontroller receives a serial commands from the base station through Xbee transceiver, respective GPIO (General Purpose Input /Output) pins of port are set high as per the algorithm programmed in the controller and the relay board switches to the NO (Normally Open) terminal which is 12v connected to power supply. By this the motors are operated and through this necessary actions can be performed.

2.2 Intelligent Approach Of Base Station

The Figure 2.2 shows the block diagram of Base Station, Raspberry PI 4 Model B acts as a heart of the base station. The other models in these sections are as follows:

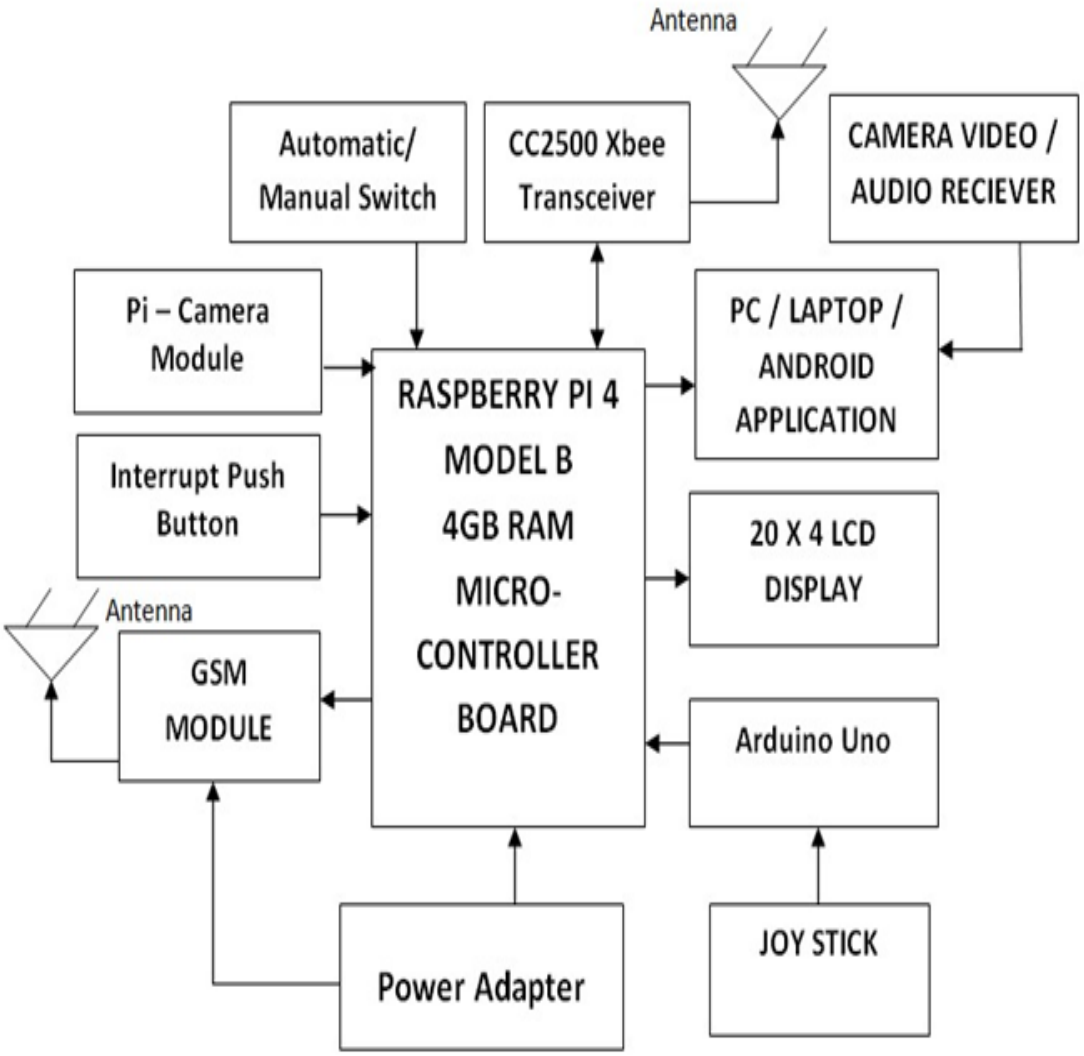

Figure 2.2: Base Station Block Diagram

2.2.1 Biometric security

The access to the base station can be achieved by the latest biometric i.e. Face Recognition (FR), this is divided into two steps. First step is to capture the image of the authorized person and creating a database. By using " Haar cascade classifier " features are extracted from the images captured in different location with various light intensity i.e totally 200 images are stored in the database. Second step is Face Recognition i.e. to compare these images stored in the database with live captured image; this is done through LBP algorithm. If the output is positive, the remote is unlocked and authority is accessed to the base station. If negative, the "AT and ATD commands " are sent to the Global System for Mobile (GSM) to alert the authority by sending Short Message Service (SMS) and CALL if the intruder is trying to access multiple times.

2.2.2 Driver unit

Two Joy Sticks are interfaced to controller through Arduino UNO Joy Stick no.1 to control the DC geared motors connected to the wheels for the directions of the vehicle and Joy Stick no.2 to control the movement of the Robotic ARM. CC2500 Xbee transceiver for wireless communication with the vehicle and Push Buttons, Automatic/ Manual mode dd88545switch is interfaced with the controller. When the push button is activated, an interrupt is raised on the Vehicle side and the values from the Onboard Sensors are displayed on the 20 X 4 LCD display. Except for the Metal detector, there is no interrupt raised and the information is continuously transmitted and displayed.

2.2.3 Autonomous Driving System (ADS)

Automatic / Manual mode switch is used to shift between the two states. In manual state Joy stick is used to control the directions of the robotic vehicle manually. Whereas in Automatic state, according to the algorithm fed to ARM Cortex the ultrasonic sensors are used to control the directions of the robotic vehicle. The shift between these two states is very fast without any delay.

2.2.4 Communication Unit

CC2500 Xbee transceiver is connected to the Tx and Rx pin of the controller where the communication is held by sending RF (Radio Frequency) signal of 2.5 GHz. Through this frequency band all the commands are sent and the signals are received between robotic vehicle and remote. The signals from V380 Robo camera is received and processed in PC/ Android phone.

Chapter 3
Algorithm And Flowchart

3.1 Flowchart of Vehicle Section

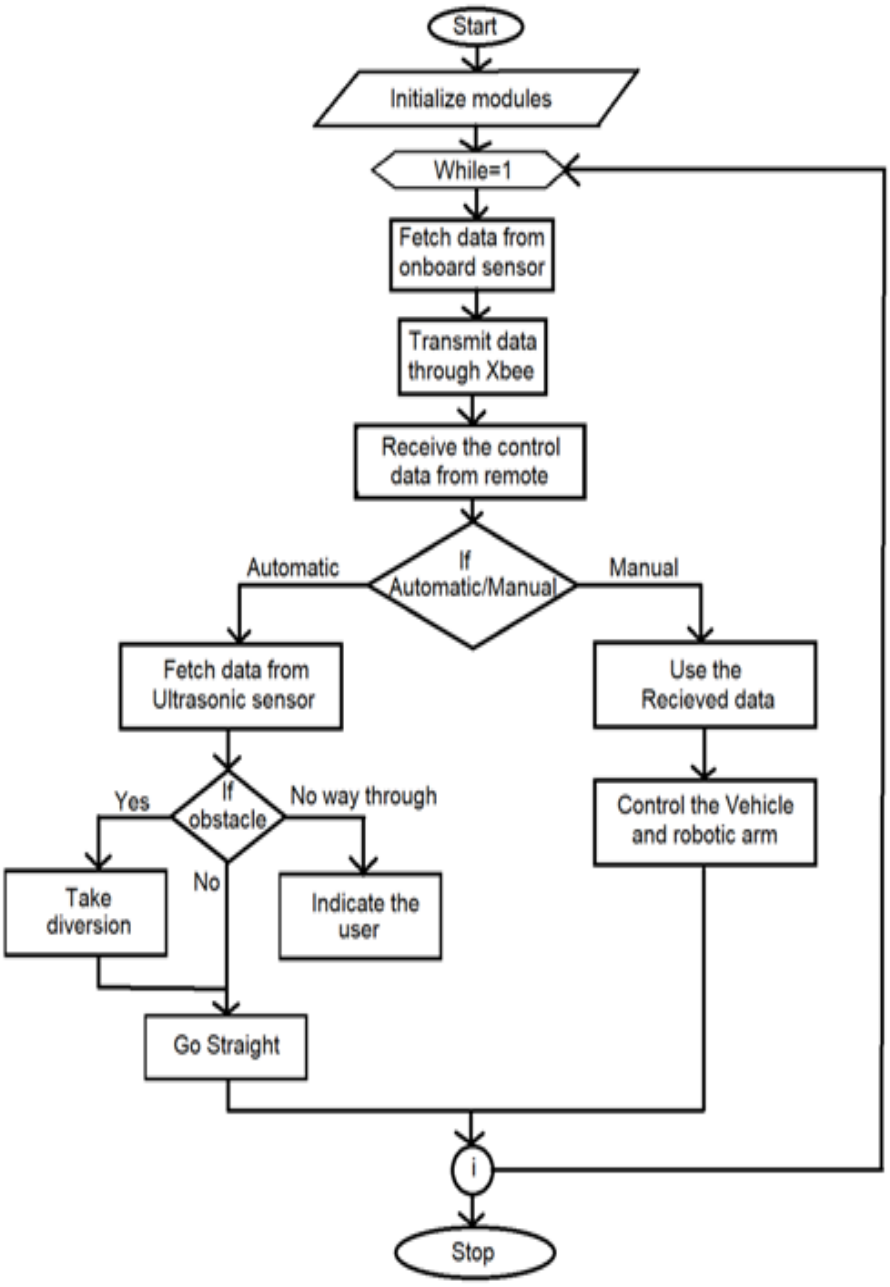

Figure 3.1: Flowchart of Vehicle Section

The figure 3.1 shows the flowchart of Vehicle Section.The intelligent approach

on vehicle section and the data flow in the robot section is as shown below:
Step 1: Start the process.
Step 2: Initializing all the sensor modules and fetch the data from the following modules.
• Temperature value from LM 35 (Temperature sensor) in Degree Celsius.
• MQ 5 Gas Sensor to detect Methane, LPG and other harmful gasses ranging from 100 – 3000 ppm.
• Metal Detector to detect Bombs, iron, brass etc...
• NEON - 6 GPS which gives signals of pseudo-random code, Ephemeris data and Almanac data.
Step 3: Transmit the on board Sensor values through Xbee transceiver to the base station.
Step 4: Receive command from the base station about the following mode.
Step 4.1: Automatic Mode - Operates as per the logic used as shown in Fig 5: Algorithm used for Autonomous Driving System (ADS)
Step 4.2: Manual Mode – Operates based on the user input from the base station.
Step 5: Return to Step 2.
Step 6: Stop the process.

3.2 Algorithm and Implementation Of Vehicle Section

The Robot module works in two modes namely:

3.2.1 Automatic Mode

The implementation of this mode is also referred as Autonomous Driving System (ADS).When the Automatic mode is enabled, depending on the algorithm defined in the microcontroller the vehicle moves. For any obstacle in path two Ultrasonic sensors are installed in the front side of the vehicle and the sensors are triggered and echo signals are received continuously and the distance is calculated. Both sensors are programmed to detect obstacle within 30 cm range. The vehicle moves straight until the sensors distance measured goes bellow 30 cm. If distance of any one of the sensors becomes less than or equal to 30 cm.
The vehicle operates as per the logic shown in the Figure 3.2. Algorithm used for Autonomous Driving System (ADS), thus avoiding collision. If distance of both

the sensors goes low simultaneously, then the vehicle stops and indicates the authority. Most important thing is that all other sensors work normally even in this mode and vehicle can be continuously monitored from the wireless camera where real time audio and video signals are transmitted to the base station.

```
15
16 if(distance1<=29&&distance2>=30)     // Change the direction
17    {
18      LPC_GPIO1->FIOCLR = 0x0F000000;
19      LPC_GPIO1->FIOSET = 0x09000000;     // Go Right
20        delay(400000);
21        LPC_GPIO1->FIOCLR = 0x0F000000;
22        LPC_GPIO1->FIOSET = 0x0A000000;   //Go staight
23        delay(400000);
24        LPC_GPIO1->FIOCLR = 0x0F000000;
25        LPC_GPIO1->FIOSET = 0x02000000;   // Go Left
26       delay(400000);
27    }
```

Figure 3.2: Algorithm used for Autonomous Driving System (ADS)

3.2.2 Manual Mode

In this mode of operation, the user can control the vehicles directions and robotic arm manually through joy sticks from the base station by sending the RF (Radio Frequency) signal of 2.5 GHz to the vehicle side. The 2 axis in the Joy stick indicates directions of vehicle i.e Forward, Backward, left, Right respectively. If the joy stick position is in the centre, it means Neutral. The logic used in controller in this mode is if the voltage value is 2.5v then vehicle in in stop position, is the voltage is greater than 2.5V (>2.5V) the vehicle moves forward/ Right based on the axis and if the voltage value is less than 2.5V (<2.5V) then vehicle moves Backward / left. The voltage values w.r.t Joy Sticks position are shown in tables:..... bellow. Even in this mode all the onboard sensors work normally when an interrupt is raised. And Wireless camera is used for real time monitoring to control the robot. This mode is useful if vehicle in Automatic mode malfunctions, thus avoids a disaster in the border area.

Joy stick position	Voltage reference	Direction indication of joy stick 1	Direction indication of joy stick 2
+ve X - axis	5 volt	Front (F)	Fire (f)
-ve X - axis	0 volt	Back(B)	Release(r)
Centre(Origin)	2.5 volt	Neutral(N)	Neutral(n)
+ve Y - axis	5 volt	Right(R)	Hold(h)
+ve Y - axis	0 volt	Left(L)	Release(r)

Table 3.1: Voltage to Direction based on Joy Stick position)

3.3 Base Station

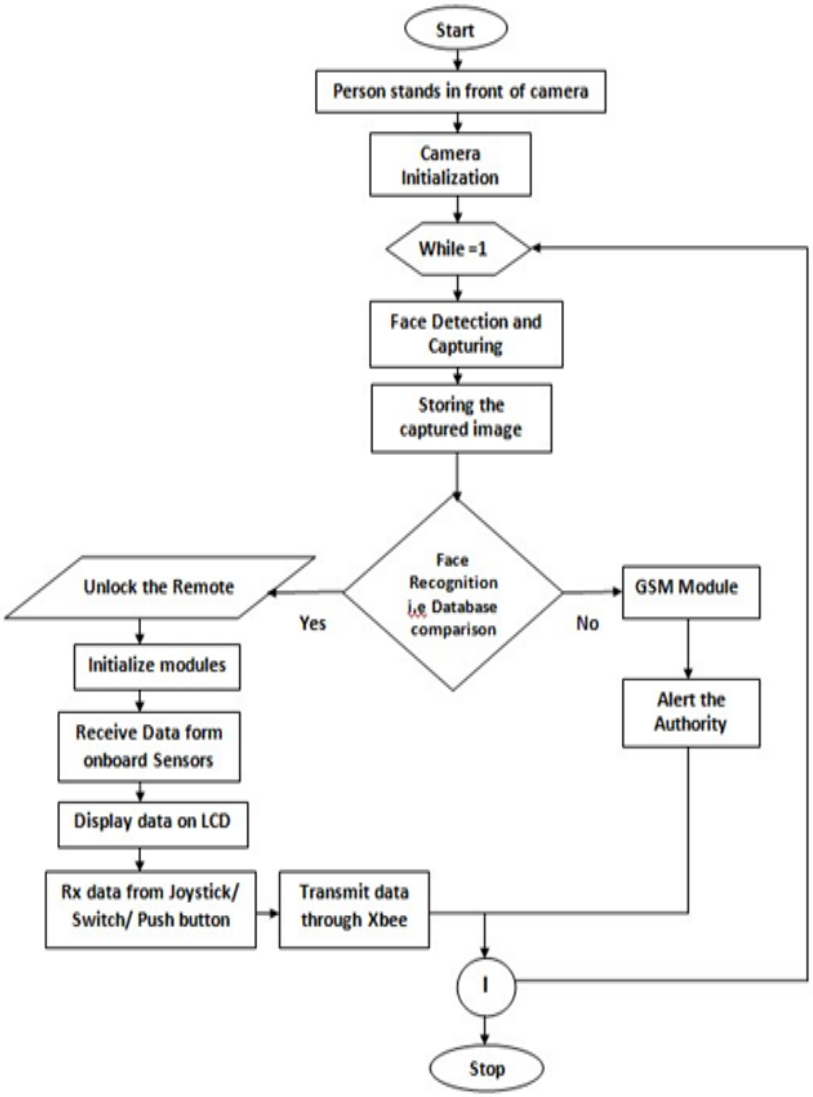

Figure 3.3: Flow Chart Of Base Station

The Figure 3.3 shows Flow Chart of Base station. The intelligent approach in Base station and the data flow of this section is as shown below:

Step 1: Start the process.
Step 2: Initialize camera when the person stands in front of it.
Step 3: Detecting face using " Haar cascade classifier " and storing it in the database.
Step 4: Comparing the live captured image with the existing database using LBP algorithm.
Step 5: If the o/p is negative, AT AND ATD commands are sent to GSM module to alert the authority.
Step 6: If the o/p is positive Communicate through Xbee perform following actions:
• Raise an interrupt and receive the data from the sensors.
• Receive commands from joystick.
• Display on Joy Stick.
Step 7: Return to step 2 .
Step 8: Stop.

3.4 Algorithm used for Face Recognition

The process is done by 3 main steps:

3.4.1 Convolution Face detection

The successive algorithm used for detection and identification is " Haar cascade classifier ". Haar based cascade classifier is machine learning based approach where cascade function is trained using a lot of positive images of faces and negative images without faces to train the classifier. This training technique is called boosting. Boosting provides the ability to train a highly accurate classifier by taking a weighted average of the decisions made. Haar-like features are digital image features used in object recognition. A Cascade classifier instructs OpenCV what to look for in images. The number of images depends on a variety of factors such as quality of images and object to recognize.

3.4.2 Feature Extraction

In the feature extraction phase, the most useful and unique features (properties) of the face image are extracted. This is done by artificial Neural Network. The Figure 3.4 shows the Neural Network. The advantage of using this neural network is that once the network is trained only the testing data parameters are loaded which

results in fast prediction of the output which is very essential for Face Recognition [FR]. There are four nodes in the output layer where each node corresponds to the features of face: First each frame is cropped and converted to a numPy array. Then the train image is paired with train label (human input). Finally, all paired image data and labels are saved into a npz file. The neural network is trained in OpenCV using back propagation method. Once training is done, weights are saved into a extensible Markup Language (XML) file. To generate predictions, the same neural network is constructed and loaded with the trained XML file. Figure: shows structure of neural network.

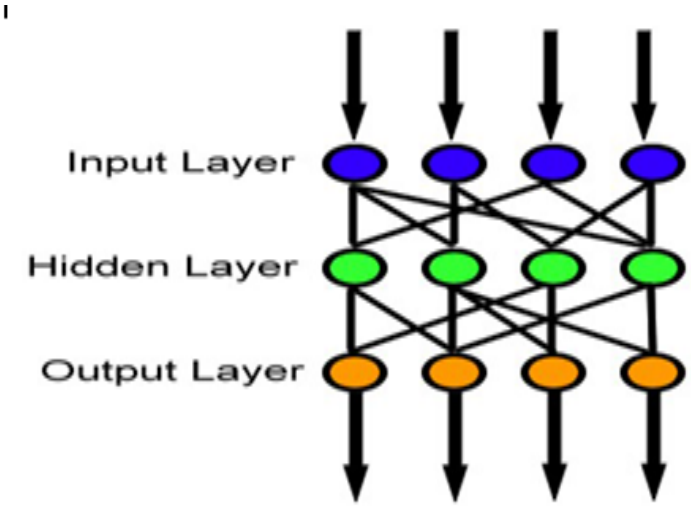

Figure 3.4: Neural Network

3.4.3 Classification

This is done by Local Binary Pattern (LBP) algorithm. The features obtained by these face image is compared with the images from the database. The output of the classification part is the identity of a face image from the database with the highest matching score, thus with the smallest differences compared to the input face image. Also a threshold value can be used to determine if the differences are small. A LBP is called uniform if it contains at most two bitwise transitions from 0 to 1 or vice versa when the binary string is considered circular. The operator labels the pixels of an image by doing threshold on the 3x3-neighbourhood of each pixel with the center value and considering the result as a binary number. Then the histogram of the labels can be used as a texture descriptor. Figure 3.5 describes an illustration of the basic LBP operator.

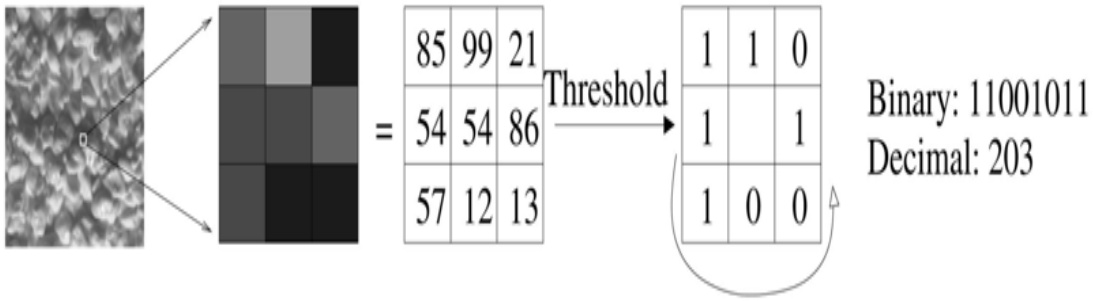

Figure 3.5: Illustration of the basic LBP operator

Chapter 4
Hardware Description

4.1 Arm cortex M3

The Figure 4.1 shows the ARM Cortex M3(LPC1768) and Architecture of ARM Coretx M3. The ARM stands for Advanced Reduced Instructions Set Computer (RISC) machine and it is a 32-bit reduced instructions set computer (RISC) microcontroller. The ARM architecture is a ' Harward architecture ' which offers separate data and instruction buses for communicating with the ROM and RAM memories. It consist a 3-stage pipeline to fetch, decode and execute the instructions sequentially. The cortex-M3 arm processors ensures high code density and reduce the program memory equipment because it is implemented by THUMB instruction set based on THUMB-2 technology.

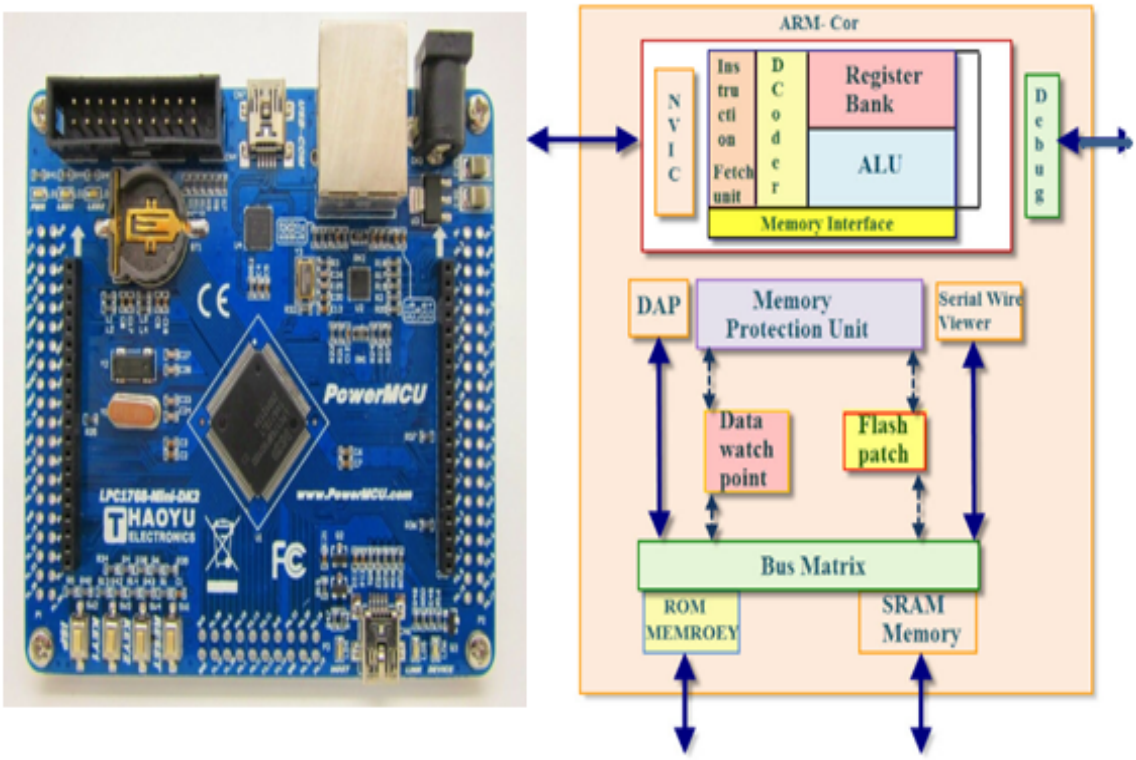

Figure 4.1: ARM Cortex M3

4.1.1 Features

1. Arm Cortex-M3 processor built in Nested Vectored Interrupt Controller (NVIC) and running at frequencies of up to 100 MHz.
2. On-chip flash programming memory is up to 512 kB and on-chip static RAM (SRAM) is up to 64 kB.
3. It has eight channel General Purpose Direct Memory Access (GPDMA) controller.
4. Ethernet Media Access Control Address(MAC), a Universal Serial Bus (USB) interface that can be configured as either Host, Device, or On-The-Go(OTG).
5. The controller is Serial Peripheral Interface(SPI) with synchronous, serial, full duplex communication.
6. There are two Synchronous Serial Port (SSP) controllers with first-in, first-out (FIFO) and multi-protocol capabilities and three enhanced inter interconnected (I2C) bus interfaces.
7. There are 70 General Purpose I/O (GPIO) pins with configurable pull-up/down resistors, 12 bit Analog to Digital Converter (ADC) with conversion rates up to 200 kHz and 10 bit Digital to Analog Converter (DAC) with dedicated conversion timer.
8. Repetitive interrupt timer provides programmable and repeating timed interrupts and each peripheral has its own clock divider for further power savings.
9. Four reduced power modes: Sleep, Deep-sleep, Power-down, and Deep power-down and 4 MHz internal RC oscillator trimmed to 1 percentage accuracy.

4.2 Raspberry Pi 4

The Figure 4.2 shows the Raspberry Pi 4 Model. Raspberry Pi 4 Model B is the latest product in the popular Raspberry Pi range of computers. It offers ground-breaking increases in processor speed, multimedia performance, memory, and connectivity compared to the prior-generation Raspberry Pi 3 Model B+, while retaining backwards compatibility and similar power consumption. For the end user, Raspberry Pi 4 Model B provides desktop performance comparable to entry-level x86 PC systems. This products key features include a high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, up to 4GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on). The dual-band wireless LAN and Bluetooth have modular compliance certification, allowing the board to be designed into end products with significantly

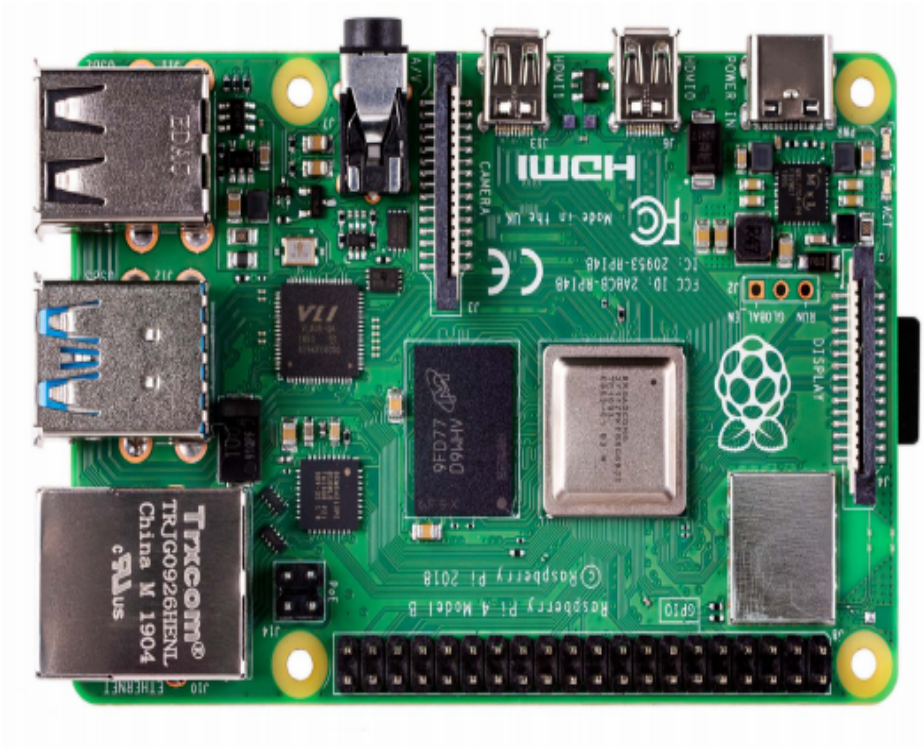

Figure 4.2: Raspberry Pi 4

reduced compliance testing, improving both cost and time to market.

4.2.1 Features

1. Processor: Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz.
2. Memory: 1GB, 2GB or 4GB LPDDR4 (depending on model).
3. Connectivity: 2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless LAN, Bluetooth 5.0, BLE Gigabit Ethernet 2 × USB 3.0 ports 2 × USB 2.0 ports.
4. GPIO: Standard 40-pin GPIO header (fully backwards-compatible with previous boards.
5. Video and sound: 2 × micro HDMI ports (up to 4Kp60 supported) 2-lane MIPI DSI display port 2-lane MIPI CSI camera port 4-pole stereo audio and composite video port.
6. Multimedia: H.265 (4Kp60 decode), H.264 (1080p60 decode, 1080p30 encode), OpenGL ES, 3.0 graphics.
SD card support: Micro SD card slot for loading operating system and data storage.
7. Input power: 5V DC via USB-C connector (minimum 3A1) 5V DC via GPIO header (minimum 3A1) Power over Ethernet (PoE) enabled requires separate PoE

HAT.
8. Environment: Operating temperature 0–50ºC.

4.3 Raspberry Pi Camera

The figure 4.3 shows Raspberry Pi Camera. The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. The module has a five mega pixel fixed-

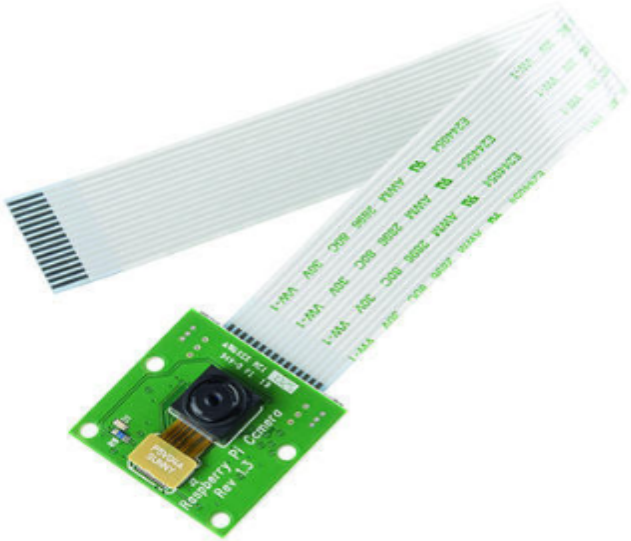

Figure 4.3: Raspberry Pi Camera

focus camera that supports 1080p30, 720p60 and VGA90 video modes, as well as stills capture. It attaches via a 15cm ribbon cable to the Camera Serial Interface(CSI) port on the Raspberry Pi.
The camera consists of a small (25mm x 20mm x 9mm) circuit board, which connects to the Raspberry Pi's Camera Serial Interface (CSI) bus connector via a flexible ribbon cable. The camera's image sensor has a native resolution of five megapixels and has a fixed focus lens. The software for the camera supports full resolution still images up to 2592x1944 and video resolutions of 1080p30, 720p60 and 640x480p60. Installation involves connecting the ribbon cable to the CSI connector on the Raspberry Pi board.

4.4 Arduino

The Figure 4.4 shows the Arduino Uno board .An Arduino is an open-source microcontroller development board to read sensors and control things like motors and lights and allows to upload programs to the board which can then interact

with things in the real world.
Arduino Uno is the most used and documented board in the world. It has an on-board LED attached to digital pin 13 for fast an easy debugging of code and a button to reset the program on the chip.
The chip on the board plugs straight into your USB port and registers on the computer as a virtual serial port and 32 KB of flash memory for storing your code.

Figure 4.4: Arduino Uno

4.4.1 Features

1. It has 14 digital input-output pins of which 6 can be used as Pulse Width Modulation (PWM) outputs, 6 analog inputs, a 16 MHz quartz crystal, a Universal Serial Bus(USB) connection, a power jack, an In Circuit Serial Programming(ICSP) header and a reset button.It has Universal Serial Bus(USB) interface.
2. Very convenient power management and built-in voltage regulation and has connection of an external power source of up to 12v and it will regulate it to both 5 volts and 3.3 volts.
3. Cross-platform:The Arduino software runs on Windows, Mac and Linux operating systems. Most microcontrollers are limited to Windows.
4. Open source and extensible software/hardware: The Arduino software is published as open source tool, available for extension. The Arduino hardware is based

on Atmels ATMEGA8, ATMEGA16 microcontrollers.The plans for modules are published under a Creative Commons license, so flow experienced as well as inexperienced designers can build several versions of module.

4.5 Metal Detector

The Figure 4.5 shows the metal detector.Metal Detector is an electronic instrument that detects the presence of metal nearby. Metal detectors are useful for finding metal inclusions hidden within objects, or metal objects buried underground. They often consist of a hand held unit with a sensor probe which can be swept over the ground or other objects.

The simplest form of a metal detector consists of an oscillator producing an alter-

Figure 4.5: Metal Detector

nating current that passes through a coil producing an alternating magnetic field. If a piece of electrically conductive metal is close to the coil, eddy currents will be induced (inductive sensor) in the metal, and this produces a magnetic field of its own. If another coil is used to measure the magnetic field (acting as a magnetometer), the change in the magnetic field due to the metallic object can be detected.The eddy current will be induced in the metal when a piece of electrically conductive metal is close to the coil and it produces magnetic field of its own. The change in the magnetic field due to the metallic object can be detected by using one more coil.

4.6 Temperature Sensor

The Figure 4.6 shows the Temperature sensor LM35. The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. The temperature sensor used is LM35

Figure 4.6: Temperature Sensor

and it has three terminals and required Maximum of 5.5 V supply. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the temperature in Celsius . The output voltage is converted to temperature by a simple conversion factor. The general equation 4.1 and 4.2 is used to convert output voltage to temperature is:

$$Vout(mV) = (10mV/^{\circ}C) \times T \tag{4.1}$$

$$T = (ADCresult \times 330)/4096 \tag{4.2}$$

4.6.1 Features

- Calibrated Directly in Celsius (Centigrade.
- Linear + 10-mV/°C Scale Factor.
- $0.5^{\circ}C$ Ensured Accuracy (at $25^{\circ}C$).
- Rated for Full -55°C to 150°C Range.
- Low-Cost Due to Wafer-Level Trimming and Suitable for Remote Applications.
- Operates From 4 V to 30 V.
- Less Than 60μA Current Drain.

- Low Self-Heating, 0.08°C in Still Air and Low-Impedance Output, 0.1Ωfor 1-mA Load.
- Non-Linearity Only $\pm 1/4$°C Typical.

4.7 Gas Sensor

Figure 4.7: Gas Sensor

The Figure 4.7 shows the Gas sensor MQ5. A gas sensor is a device which detects the presence of gases such as hydrogen, carbon monoxide, methane and LPG in an area.
The output of the sensor is fed into analog to digital converter unit [ADC 0804] which is further processed in to digital form before passing it to microcontroller unit. The concentration of the gas can be determined by measuring the current discharge in the device. Concentration of gas in air is calculated according to the equation 3.3 :

$$PPMofgas = analogoutput(mV) \times 2. \tag{4.3}$$

4.7.1 Features

1.High sensitivity to LPG, natural gas , town gas and Small sensitivity to alcohol, smoke.
2. The concentration of gas at outside environment is measured in Parts Per Million (PPM) and ranging from 100 ppm to 3,000 ppm.
. 3. Simple drive circuit and fast response.

4.8 Ultrasonic Sensor

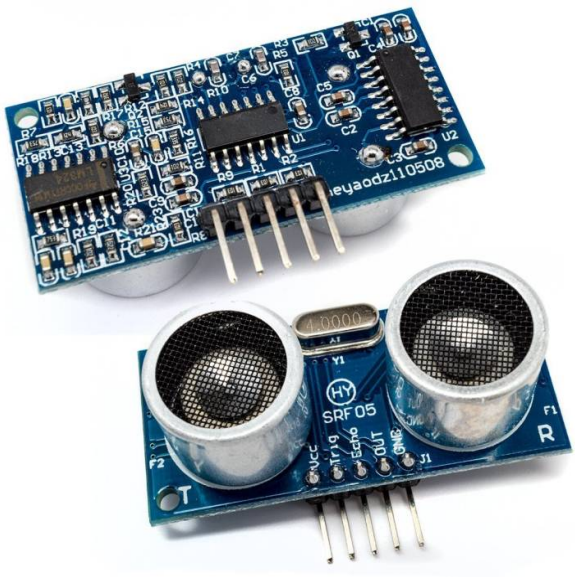

Figure 4.8: Ultrasonic Sensor

The Figure 4.8 shows the HC-SR04 Ultrasonic sensor.The HC-SR04 is a typical ultrasonic sensor which is used in as obstacle detector and electronic distance measurement tapes. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit. An Ultrasonic Sensor is a device that measures distance to an object using sound waves. It works by sending out a sound wave at ultrasonic frequency and waits for it to bounce back from the object. The time delay between transmission of sound and receiving of the sound is used to calculate the distance. It is done using the formula as shown in the equation 3.4:

$$Distance = (Speed of sound * Time delay)/2 \tag{4.4}$$

The distance formula is divided by 2 because the sound waves travel a round trip from the sensor and back to the sensor which doubles the actual distance. The operating and current range is 5 volt and 15 mA. The ultrasonic sensor measures the distance in the range from 2cm to 400 cm and angle is less than 15 degree.

4.9 Liquid Crystal Display

The Figure 4.9 shows the 20 x 4 LCD display .A liquid-crystal display (LCD) is a flat- panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polariser. LCD's are

a great way to output a string of words or sensor data to a display for visual feedback. Liquid crystals do not emit light directly, instead using a back light or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and seven-segment displays as in a digital clock.

A 20 x 4 LCD means it can display 20 characters per line and there are 4 such lines.

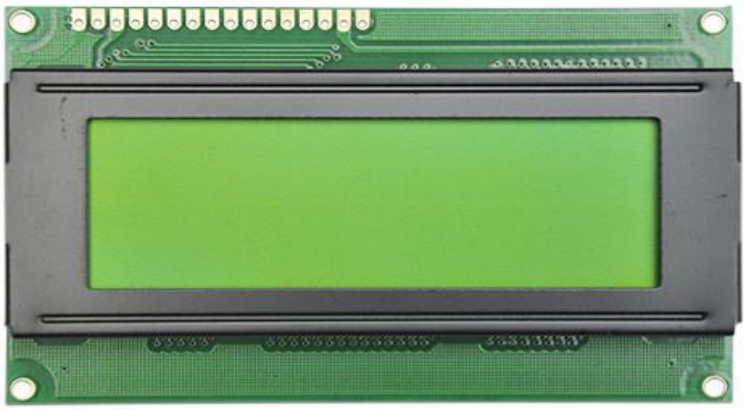

Figure 4.9: Liquid Crystal Display

In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, command and data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a pre defined task like initializing it, clearing its screen, setting the cursor position, controlling display and so on. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

4.10 Relay board

The Figure 4.10 shown is relay board with eight (10 Amps at 250 VAC switching) relays. A relay is a kind of switch which is controlled by an electric current. A relay makes it possible for a low voltage low current circuit to switch a high voltage or high current device safely. A relay board is a commercially manufactured circuit board fitted with a relay, LED indicator, back Electro-Motive Force (EMF) preventing diode, and easy to use screw-in terminal connections. A low-current signal voltage is required to control each relay because it has its own transistor and

Figure 4.10: Relay Board

the circuit board has a 12 VDC connection. A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contact.

4.10.1 Features

- Control high-power devices up to 10 A with a simple high/low signal.It provides isolation between the microcontroller and device being controlled.
- Screw terminals for relay connections 3-pin servo-style header for power/signal interface LED indicator provides visual feedback

4.11 Xbee

The Figure 4.11 shows CC2500 Xbee Module. Xbee and IEEE802.15.4 are standards based protocols that provide the network infrastructure required for wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and Xbee defines the network and application layers.It is suitable for transmitting and receiving data at multiple baud rates, the module is direct line in replacement for serial communication and finds applications for wireless sensor network, wireless device control, wireless data transfer, wireless energy metering, robotics, wireless

data loggers and others.

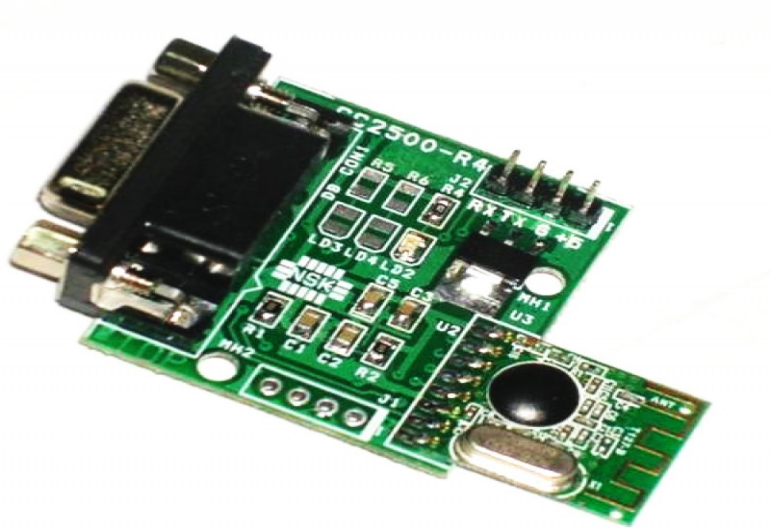

Figure 4.11: Xbee Module

4.11.1 Features

1. CC2500 Transceiver work on ISM band (2.4 gHz) with Baud rate 9600.
2. The wireless Radio Frequency(RF) CC2500 Transceiver support multiple frequencies within same band rate that helps in avoiding data collision.
3. The wireless CC2500 Trans-receiver do not require external antenna and work on 5-9v DC supply with standard UART interface.
4. Low power consumption, flexible and extendable.
5. Reliable and self healing.

4.12 DC Geared motors

The Figure 4.12 shows Geared DC motors. It can be defined as an extension of DC motor which already had its insight details demystified. A Direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy. An Inductor (coil) inside the DC motor produces a magnetic field that creates rotary motion as DC voltage is applied to its terminal. Inside the motor is an iron shaft, wrapped in a coil of wire. This shaft contains two fixed magnets on both sides which cause both a repulsive and attractive force, in turn, producing torque. A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing

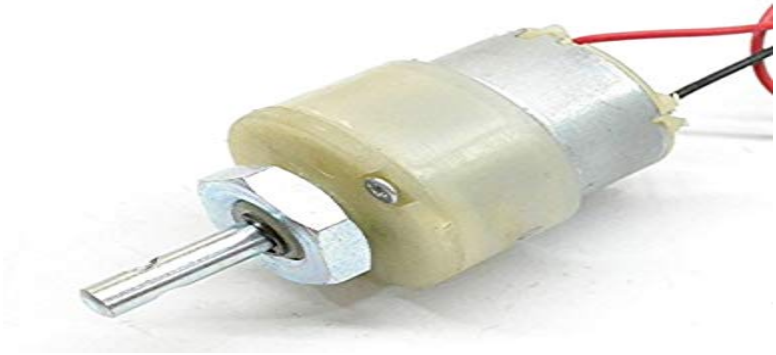

Figure 4.12: DC geared Motor

the torque output. The most important parameters in regards to gear motors are speed, torque and efficiency.

4.13 Joy Stick

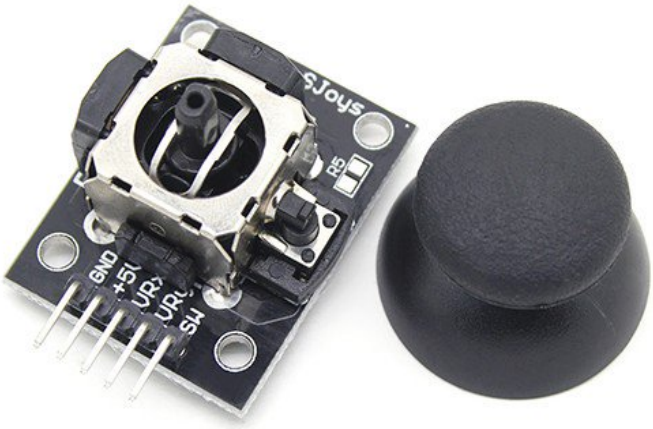

Figure 4.13: Joy Stick

The Figure 4.13 shows the Joystick with hat. A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. This is a dual axis high quality joystick Module. It can be used to sense movements in 2 directions or axis. It also has a inbuilt switch which can be activated by pressing the stick.
Directional movements are simply two potentiometers - one for each axis. Pots are 10k each. The measurement of position coordinates on the X and Y axis can be

done by moving the " hat " with the help of Joystick Module.
It also contains a switch that is press-able by pushing the " hat ". It also contains a switch that is press-able by pushing the " hat " down. The X and Y axis are two 10k potentiometers which control 2 dimensional movement by generating analog signals. When the module is in working mode, it will output two analog values, representing two directions.
The module uses the 5V power supply, and value, when reading through analog input, would be about 2.5V, a value will increase with joystick movement and will go up till maximum 5V; the value will decrease when the joystick is moved in other direction till 0V.

4.14 GPS Module

The Figure 4.14 shows the NEO-6 GPS module. GPS receivers are generally used in smartphones, fleet management system, military etc. for tracking or finding location.Global Positioning System (GPS) is a satellite-based system that uses satellites and ground stations to measure and compute its position on Earth.GPS is also known as Navigation System with Time and Ranging (NAVSTAR) GPS. GPS receiver module gives output in standard (National Marine Electronics Association) NMEA string format. It provides output serially on Tx pin with default 9600 Baud rate. The NEO-6 module series is a family of stand-alone GPS receivers featuring the high performance u-blox 6 positioning engine. These flexible and cost effective receivers offer numerous connectivity options in a miniature 16 x 12.2 x 2.4 mm package. Their compact architecture and power and memory options make NEO-6 modules ideal for battery operated mobile devices with very strict cost and space constraints.
This NMEA string output from GPS receiver contains different parameters sepa-

Figure 4.14: GPS Module

rated by commas like longitude, latitude, altitude, time etc. Each string starts with '$' and ends with carriage return/line feed sequence. The result will be in following form:
$GPGGA,184237.000,1829.9639,N,07347.6174,E,1,05,2.1,607.1,M,-64.7,M,,0000*7D $GPGSA,A,3,1
$GPGSV,3,1,11,15,47,133,46,25,44,226,45,18,37,238,45,26,34,087,40*72
$GPGSV,3,2,11,12,27,184,45,24,02,164,26,29,58,349,,05,26,034,*7F
$GPGSV,3,3,11,21,25,303,,02,11,071,,22,01,228,*40
$GPRMC,184237.000,A,1829.9639,N,07347.6174,E,0.05,180.19,230514,,,A*64
From the above result the extracted data is:
$GPRMC,184237.000,A,1829.9639,N,07347.6174,E,0.05,180.19,230514,,,A*64

Pin Description:

1. Vcc: Power Supply 3.3 – 6 V.
2. GND: Ground.
3. TX: Transmit data serially which gives information about location, time etc.
4. RX: Receive Data serially. It is required when we want to configure GPS module.

4.15 GSM Sim900A Modem

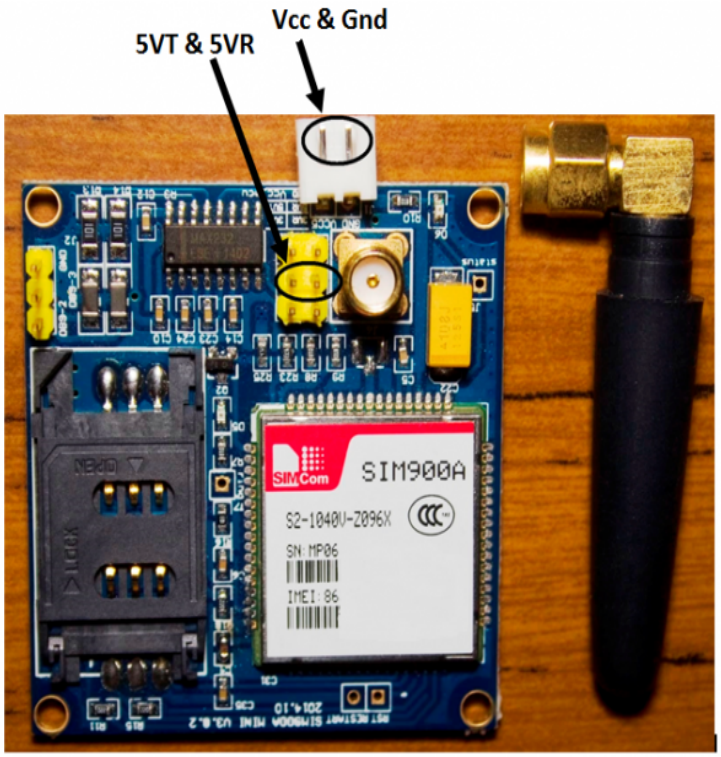

Figure 4.15: GSM Module

The Figure 4.15 shows the GSM SIM900A Modem With SMA Antenna. The Global System for Mobile GSM Modem is having internal Transmission Control Protocol/Internet Protocol (TCP/IP) stack to enable things to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in machine to machine interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply.

4.15.1 Features

• Dual-Band 900/ 1800 MHz.
• GPRS multi-slot class 10/8GPRS mobile station class B.
• Compliant to GSM phase 2/2+Class 4 (2 W @850/ 900 MHz).
• Class 1 (1 W @ 1800/1900MHz).
• Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands).
• Low power consumption: 1.5mA(sleep mode).
• Operation temperature: -40°C to +85 °C.
• Status indicator(D5):It will flashes continuously whenever the call arrives otherwise it is left ON.
• Network LED(D6):This led will blink every second which indicates that the GSM module is not connected to the mobile network. Once the connection is established successfully, the LED will blink continuously every 3 seconds.

4.16 Wireless camera

The Figure 4.15 shows the Wireless Camera.V380 WIFI Camera with REMOTE MONITORING by Mobile app AND 2 Way TALK with Video Recording using memory card: 2 Way Audio Intercom , voice message , Wide Angle View , Motion Detection Alarm , Real-time monitoring and Night Vision Megapixel IP Wifi Camera with good Picture Quality. The live feed can be viewed through V380 Mobile App. Best Suitable for 20 x 20 Feet area. Low Internet data consumption Watch Live from remote using mobile app. Motion Sensor gives alarm and recording both features .

4.16.1 Specifications

- This camera has 360° rotation angle.

Figure 4.16: Wireless Camera

- This can be mount with memory card supported up to 64GB and can be connected to mobile Power Bank so that we use it without electricity
- 5V 2A USB Power Camera comes with Adaptor and USB Cable. It has a inbuilt Mic and Speaker for communication with mobile App .

4.17 Robotic Arm

The Figure 4.16 shows the Robotic Arm. The Robotic Arm has a 180◦ rotation angle and can provides 2 degrees of freedom. The kit included a parallel jaw gripper with a maximum opening span of 55mm. A Robotic Arm module is divided into two major working modules, one is the gripper module and other is gearbox module. These both modules are made up from laser cut metal and acrylic which assure their durability in various robotics applications. The gear box module consists of a worm gear assembly which increases torque so that the end effect can pick up more load. The gripper module is specially designed for pick and place objects. These modules can be combined together to form a pick and place assembly with an ability to lift heavy loads. This assembly can be used in a robotic system to automate existing pick and place system.

Figure 4.17: Robotic arm

Chapter 5
Software Description

5.1 Keil μVision 4

The μVision IDE combines project management, run-time environment, build facilities, source code editing, and program debugging in a single powerful environment.The μVision is easy-to-use and accelerates your embedded software development.The μVision supports multiple screens and allows you to create individual window layouts anywhere on the visual surface.

The μVision Debugger provides a single environment in which you may test, verify, and optimize your application code. The debugger includes traditional features like simple and complex breakpoints, watch windows, and execution control and provides full visibility to device peripherals. With the μVision Project Manager and Run-Time Environment you create software application using pre-build software components and device support from Software Packs. The software components contain libraries, source modules, configuration files, source code templates, and documentation. Software components can be generic to support a wide range of devices and applications.

The integrated μVision Editor includes all standard features of a modern source code editor and is also available during debugging. Color syntax highlighting, text indentation, and source outlining are optimized for C/C++. Vision works with add-on products which extend its functionality.

5.2 Arduino Integrated Development Environment (IDE)

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. The Arduino project provides the Arduino Integrated Development Environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages processing and wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text,

automatic indenting, brace matching, and syntax highlighting and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a tool bar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. The project is developed on Arduino software (IDE) version 1.8.1. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the boards firmware.

A minimal Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consist of only two functions:
•setup(): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
• loop(): After setup() function has been called, function loop is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

5.3 Raspian OS

Of all the operating systems such as Arch, Risc OS, Plan 9 or Raspbian that are available for Raspberry Pi, Raspbian comes out on top as being the most user-friendly, best-looking,which has the best range of default software's and optimized for the Raspberry Pi hardware. Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. There are several versions of Raspbian including Raspberry Stretch and Raspbian Jessie. Raspbian is highly optimized for the Raspberry Pi line's low performance ARM CPUs. It is composed of a modified LXDE desktop environment.

Raspian OS is one of the official operating systems available for free to download and use. The system is based on Debian Linux and is optimized to work efficiently with the Raspberry Pi computer. In case of Pi operating System is a set of basic programs and utilities that runs on a specified hardware. Debian is very lightweight and makes a great choice for the Pi. The Raspbian includes tools for browsing, python programming and a GUI desktop. The Raspian desktop environment is known as the "Lightweight X11 Desktop Environment" or in short LXDE. This has a fairly attractive user interface that is built using the X Window System software and is a familiar point and click interface.

5.4 OpenCV

Open Source Computer Vision Library (OpenCV) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3 dimensional models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene etc.
OpenCV-Python makes use of Numpy, which is a highly optimized library for numerical operations with a MATLAB-style syntax. All the OpenCV array structures are converted to and from Numpy arrays. This also makes it easier to integrate with other libraries that use Numpy such as SciPy and Matplotlib.

5.4.1 Numpy

NumPy is a library for the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high level mathematical functions to operate on these arrays. The NumPy array as universal data structure in OpenCV for images, extracted feature points, filter kernels and many more vastly simplifies the programming work flow and debugging.

Using NumPy , Python gives functionality comparable to MATLAB since they are both interpreted and they both allow the user to write fast programs as long as most operations work on arrays or matrices instead of scalars. NumPy is intrinsically integrated with Python, a more modern and complete programming language. In Numpy images with multiple channels are simply represented as three-dimensional arrays, indexing, slicing or masking with other arrays are very efficient ways to access specific pixels of an image.

5.5 Flash magic

Flash Magic is a PC tool for programming flash based microcontrollers from NXP using a serial or Ethernet protocol while in the target hardware.

Flash magic is a straight forward and intuitive user interface tool. It programs intel hex files. It automatically verifies after programming. It uses high speed serial communications on devices that supports it. It supports half – duplex communications for many devices. Also an Ethernet boot loader for LPC1xxx/LPC2xxx devices. This supports programming certain LPC1xxx/LPC2xxx devices via Ethernet.

It has a feature of reading the device signature. The support for programming ARM-Cortex devices over CMSIS-DAP/DAPLink (experimental). It is powerful, flexible Just In Time Code feature. This displays information about the selected Hex File, including the creation and modification dates, flash memory used, percentage of the current device used. It controls the DTR and RTS RS232 signals to place the device into BootROM and Execute modes automatically (requires hardware support). It sends commands to place the device in Bootloader mode.Flash Magic works on Windows Vista, 7, 8 and 10. 50Mb of disk space is required.

Chapter 6
Model and Results

Chapter 7
Conclusions and Future Scope

7.1 Conclusion

7.2 Future Scope

Bibliography

[1] G. O. E. Abdalla and T. Veeramanikandasamy, "Implementation of spy robot for a surveillance system using internet protocol of raspberry pi," in *2017 2nd IEEE International Conference on Recent Trends in Electronics, Information Communication Technology (RTEICT)*, 2017, pp. 86–89.

[2] K. Jain and V. Suluchana, "Design and development of smart robot car for border security," *International Journal of Computer Applications*, vol. 76, pp. 23–29, 08 2013.

[3] M. Raman and H. Aggarwal, "Study and comparison of various image edge detection techniques," *International Journal of Image Processing*, vol. 3, 03 2009.

[4] S. Sudhakar, E. P. Kumar, and S. Thiyagarajan, "Border security and multi access robot using embedded system," 2016.

[5] G. Yin, Z. Sun, and W. Wang, "Multi-robot simultaneous localization and mapping based on pose graphs fusion," *IOP Conference Series: Earth and Environmental Science*, vol. 170, p. 042167, 07 2018.

[6] K. B. Swain, S. Dash, and S. S. Gouda, "Raspberry pi based integrated autonomous vehicle using labview," in *2017 Third International Conference on Sensing, Signal Processing and Security (ICSSS)*, 2017, pp. 69–73.

[7] W. F. Abaya, J. Basa, M. Sy, A. C. Abad, and E. P. Dadios, "Low cost smart security camera with night vision capability using raspberry pi and opencv," in *2014 International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*, 2014, pp. 1–6.

[8] S. Meghana, T. V. Nikhil, R. M. Murali, S. Sanjana, R. Vidhya, and K. J. Mohammed, "Design and implementation of surveillance robot for outdoor security," *2017 2nd IEEE International Conference on Recent Trends in Electronics, Information Communication Technology (RTEICT)*, pp. 1679–1682, 2017.

Chapter 8
ARM CORTEX