ROBOTIC VEHICLE USING IOT FOR LANDMINE DETECTION

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report "**ROBOTIC VEHICLE USING IOT FOR LANDMINE DETECTION"** is the bonafide work of "**SAYAN PAUL, ABHINABA BISWAS, MITRAJEET DUTTA"** who carried out the project work under my supervision.

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ABSTRACT

The land mine crisis is globally alarming since there are presently 500 million unexploded, buried mines in about 70 countries. Governments are looking into this situation seriously since land mines are claiming the lives of civilians every day. The purpose of this project is to design a robot which is capable of detecting buried land mines and marking their locations, while enabling the operator to control the robot wirelessly from a distance. The project was start from the brainstorming phase together with the research phase and then preceded into the conceptualization or designing phase. The ideas and concepts from the theoretical stages are shaped into the physical hardware components by fabrication of a prototype and then software programs are integrated into the system so as to test and experiment the concepts that had been developed.

Keywords: Landmine, Mapping, Mine Detection, Sensors, Autonomous Robot

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Chapter 1: Introduction

1.1 What is Landmine?

A **Landmine** is an explosive device concealed under or on the ground and designed to destroy or disable enemy targets, ranging from combatants to vehicles and tanks, as they pass over or near it. Such a device is typically detonated automatically by way of pressure when a target steps on it or drives over it, although other detonation mechanisms are also sometimes used. A land mine may cause damage by direct blast effect, by fragments that are thrown by the blast, or by both [16].

Figure 1: Landmines

The use of land mines is controversial because of their potential as indiscriminate weapons. They can remain dangerous many years after a conflict has ended, harming civilians and the economy. 78 countries are contaminated with land mines and 15,000–20,000 people are killed every year while countless more are maimed. Approximately 80% of land mine casualties are civilian, with children as the most affected age group. Most killings occur in times of peace. With pressure from a number of campaign groups organised through the International Campaign to Ban Landmines, a global movement to prohibit their use led to the 1997 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, also known as the *Ottawa Treaty*. To date, 164 nations have signed the treaty.

Land mines are divided into two types: anti-tank mines, which are designed to disable tanks or other vehicles; and anti-personnel mines, which are designed to injure or kill people.

1.2 Types of Landmines

Each landmine consists of three components; the case which may be metal, wood, plastic or mixed, the explosive material which may be TNT, RDX, mixed RDX/TNT, Tetryl, or other high explosives, and an initiator which may include a pressure sensor, an electronic sensor or any other sensor. Landmines can be classified according to their design or their targets.

1.2.1 Classification According to Design

Landmines can be classified according to their design to three main categories; blast, bounding (bouncing Betty) or fragmentation landmines.

1.2.1.1 Blast Landmines

Blast landmines are buried close to the surface of the soil and are generally triggered by pressure (e.g. driving over or stepping on them) or by handling/disturbing. Pressure activated mines generally require approximately 5–16 kg of pressure to explode. The main purpose of these landmines is to destroy an object in close proximity, such as a person's foot or leg. A blast landmine is designed to break the targeted object into fragments, and this can cause secondary damages, such as infection and amputation.

1.2.1.2 Bounding Landmines

These landmines are usually buried with only a small part of the initiator protruding from the ground. When activated, the initiator sets a propelling charge, lifting the mine about 1 m into the air in order to cause injury to a person's head and chest.

1.2.1.3 Fragmentation Landmines

This type of landmines release fragments in all directions, or can be arranged to send fragments in one direction. These landmines can cause injuries up to 200 m away and kill at closer distances. The fragments used in these landmines are either metal or glass.

1.2.2 Classification According to Target

According to the potential target, there are two main types of buried landmines; AP landmines and AT landmines. In addition to landmines, former battlefields can also contain other explosive hazards resulting from unexploded ordnance (UXOs), which are misfired shells or unexploded bombs that still remain buried in land.

1.2.2.1 Anti-Tank Landmines

AT landmines are usually buried in roads or tracks, and designed to explode as a heavy vehicle passes over them. They may be triggered by a person using an electrical cable. They are designed to destroy tanks, armoured personnel carriers, troop trucks and the soldiers inside. There are several types of AT landmines.

Figure 2: Examples of Anti-Tank Mines

1.2.2.2 Anti-Personnel Mines

AP landmines are small devices that explode when stepped on or disturbed. Their main military purpose is to maim enemy soldiers rather than killing them.

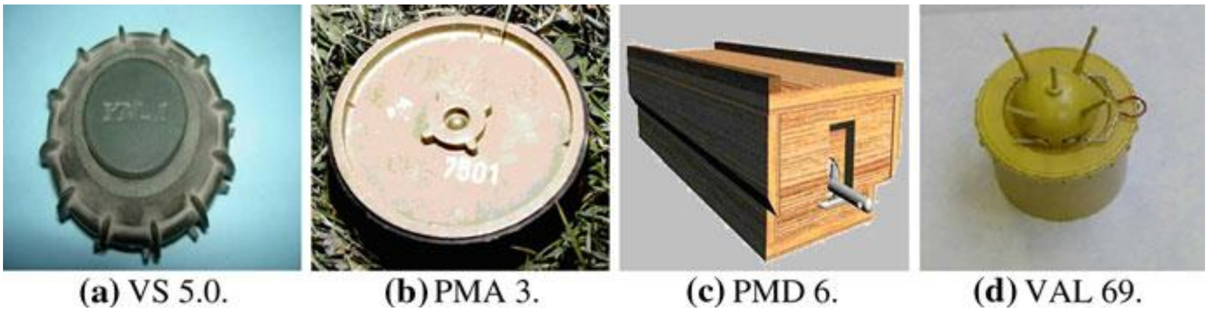

Figure 3: Examples of Anti-Personnel Mines

1.3. Demining Concepts

Demining is the process of detection and removal of buried landmines. There are two distinct types of demining; military demining and humanitarian demining.

1.3.1 Military Demining

The target of military demining is to detect and remove a sufficient number of landmines to create a safe corridor for troops and/or vehicles to move through. Armed forces can accept some losses as an expected part of the conflict. Therefore, a flail machine, which has an 80%

clearance success rate, can be used. This sort of clearance operation is not suited for humanitarian demining.

1.3.2 Humanitarian Demining

The target of humanitarian demining is to free the entire land area from landmines. The United Nations (UN) has specified a landmine clearance standard of 99.6% for humanitarian demining.

1.4 Current Techniques for Landmine Detection & Clearance

The detection of buried landmines is traditionally performed through exhaustive searching by humans using some combination basic tools. Generally, potential mines are located using a metal detector to locate metal fragments such as the firing pin of the landmine & by feeling for mounds or depressions which are caused by the laying of the mines or by subsequent settling of the ground. These potential mines are then investigated further through manual probing. In practice many deminers actually probe the entire ground area regardless of whether they have found a potential mine.

As a result of military action there may be up to 1000 metal fragments to be investigated for each single mine discovered resulting in potentially lethal deminer fatigue. In fact, 80% of all clearance accidents occur during the investigation of metal signatures, although this statistic is debated by some deminers. Such accidents can also be caused by landmines which have moved from the horizontal position such as in the Falkland Islands where 80% of the mines are laid in peat or sand.

The effectiveness of metal detectors is inhibited by mines with extremely low metal content or by soils with high ferrous content, and hence other detection techniques have been investigated. One such technique which is widely used is the detection of the explosive material by smell using a Dog. Dogs can be trained to identify the presence of explosives which are leaked by landmines, although the explosives can be detected up to 10 metres from the mine resulting in only the approximate position being identified. In addition, experience with dogs seems to show that mines do not release significant TNT vapour after 18 months of burial. This technique, however, appears to have potential for the identification of the boundaries of a minefield.

Once detected, landmines are generally destroyed in situ as the risks associated with neutralising or disarming them are too great. Other modern techniques which are currently used for landmine clearance are machines are such as the flail, mine ploughs, rollers & sympathetic detonation. However, these devices do not achieve the standard required for humanitarian demining. In fact, mine clearing has not really advanced a great deal from World War II & most effective & reliable detection technique is still Manual Probing [20].

Figure 4: Landmine Detection with A Dog

Figure 5: Landmine Detection with Metal Detector

1.5 New Sensor Technologies

As mentioned previously, new technologies are being investigated in order to improve the reliability & speed of the landmine detection operation. Recent surveys of new technologies for landmine detection include, & an overview of the main technologies being investigated are presented here.

1.5.1 Ground Penetrating Radar (GPR)

GPR is reasonably well developed & has demonstrated a 100% detection rate for anti-personnel mines in a research context. However, field investigations are required to determine the performance of GPR under real conditions with mine buried to varying depths. Some investigations have been performed which have found, for example, that GPR does not work well in water saturated environments due to ground return.

Figure 6: Landmine Detection with GPR

1.5.2 Detection of Explosive Vapours by Bio-Sensor

It has been addressed although the current systems are either too insensitive, too slow or too large to be used for landmine detection. Further efforts are ongoing.

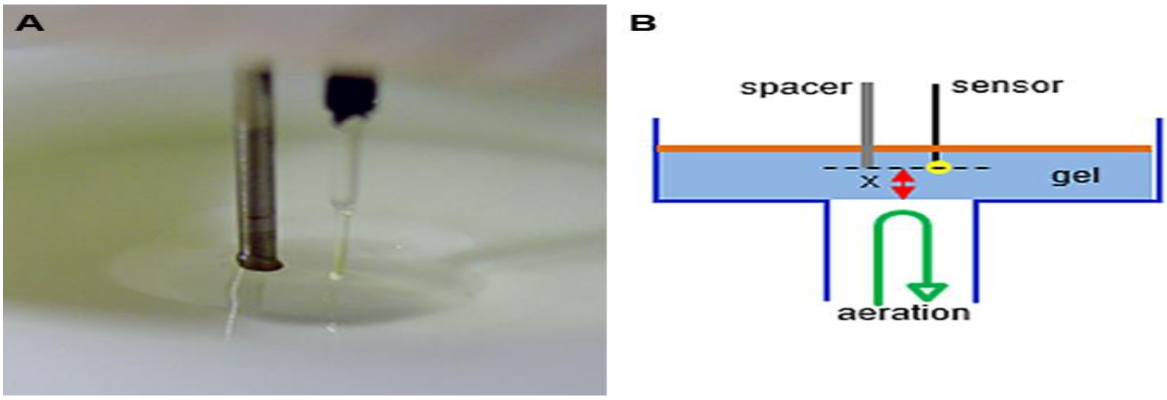

Figure 7: Landmine Detection with Bio-Sensor

1.5.3Infrared Imaging

It relies on a natural or artificial temperature differential between the landmines & their surroundings. Tests have shown that there are practical limitations on the depth to which may be reliably detected.

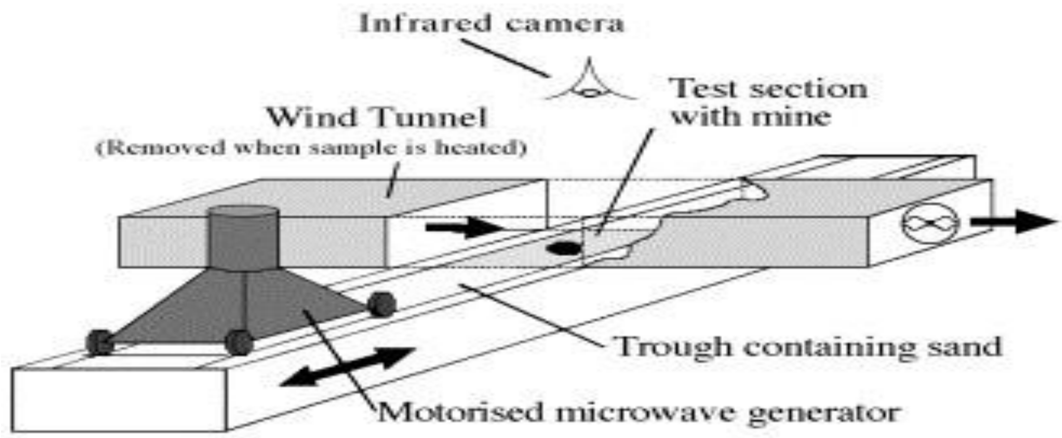

Figure 8: Landmine Detection with Infrared Imaging

1.5.4Thermal Neutron Analysis

TNA attempts to detect the explosive charge by bombarding it with radiation & detecting the Gamma rays emitted by the Nitrogen nuclei in the explosive material. Problems with this technology include limited depth of penetration & false positives caused by nitrogen enriched soil.

Figure 9: Thermal Neutron Activation Sensor for Landmine Detection

1.5.4 Electromagnetic Induction

It can be used to locate shallowly buried non conducting objects such as plastic landmines, although detection at more impressive depths such as 50cm has been demonstrated for metal parts.

1.5.5 RF/Millimetric Radiometry

It is capable of detecting shallowly (down to 3cm) buried mines at a significant distance. (e.g. 35cm)

1.5.6 X-Ray Backscatter

It is also being investigated with a view to applying it to landmine detection [20].

1.6 Objective of The Project

The Landmine Detection Robotic Vehicle project entailed four stages of tasks before a satisfactory finished product was achieved. These stages were research, design, construction, and testing. The research and design stages were completed through the first four week of work on the project. Research of minefields and the needs of deminers was the first area researched, as this research aided in the decisions made about specific details of the vehicle design. Some of these details were the vehicle size, shape, and weight; type of materials used to build the vehicle; type of tires; type and size of batteries; type of motors and motor controller; type of remote-control system; and video camera unit mounted on the front of the vehicle.

The design of the vehicle came from the research done of the many different components of the vehicle. We decided exactly what parts and types of equipment we wanted to use on the vehicle, and then design a graphical model to represent what the finished vehicle would look like. Along with this graphical model, we also developed a list of specifications for the vehicle. These specifications list the precise capabilities needed in this type of vehicle. The specifications were also based on the research done of both the minefields and the parts being used on the vehicle.

The next step was the construction of the vehicle. This involved finishing the finding and ordering of needed parts, and then putting them together by following the vehicle design and specification. We ran into difficulties during the construction phase due to problems associated with welding aluminium. Otherwise, construction progressed smoothly. Once the vehicle was constructed, we tested it. Test results were compared to the following objectives:

- The purpose is to give an efficient solution of the landmines problem by using a tele mobile robot that are capable of exploring buried landmines.
- To construct a simple & cost-effective design for The Robotic Vehicle.
- To provide high reliability of mine detection.
- To use less power & to have battery power in the vehicle that can last for a running time of minimum 2 hours.
- To design the vehicle with the capability to climb a 10% incline.
- To utilize remote control android application which is wirelessly connect with the vehicle can function at a distance of 20 to 25 meters.
- To limit the total weight of the vehicle to under 2 kg.
- To construct a Robot that will not suffer from deminer fatigue.
- To Reduce the number of human casualties due to demining operations.

Chapter 2: System Description

2.1 System Components

2.1.1 Arduino Uno

The **ArduinoUNO** is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.

The word "uno" means "one" in Italian and was chosen to mark the initial release of the Arduino Software. The Uno board is the first in a series of USB-based Arduino boards, and it and version 1.0 of the Arduino IDE were the reference versions of Arduino, now evolved to newer releases. The ATmega328 on the board comes pre-programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.

While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter [13].

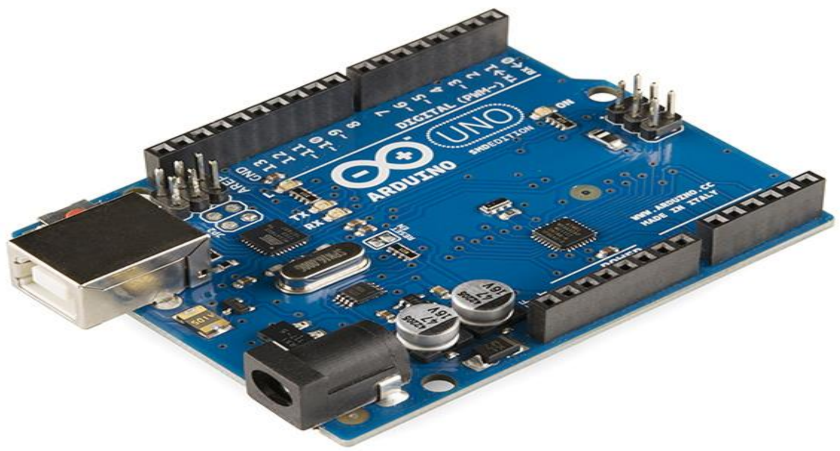

Figure 10: Arduino Uno

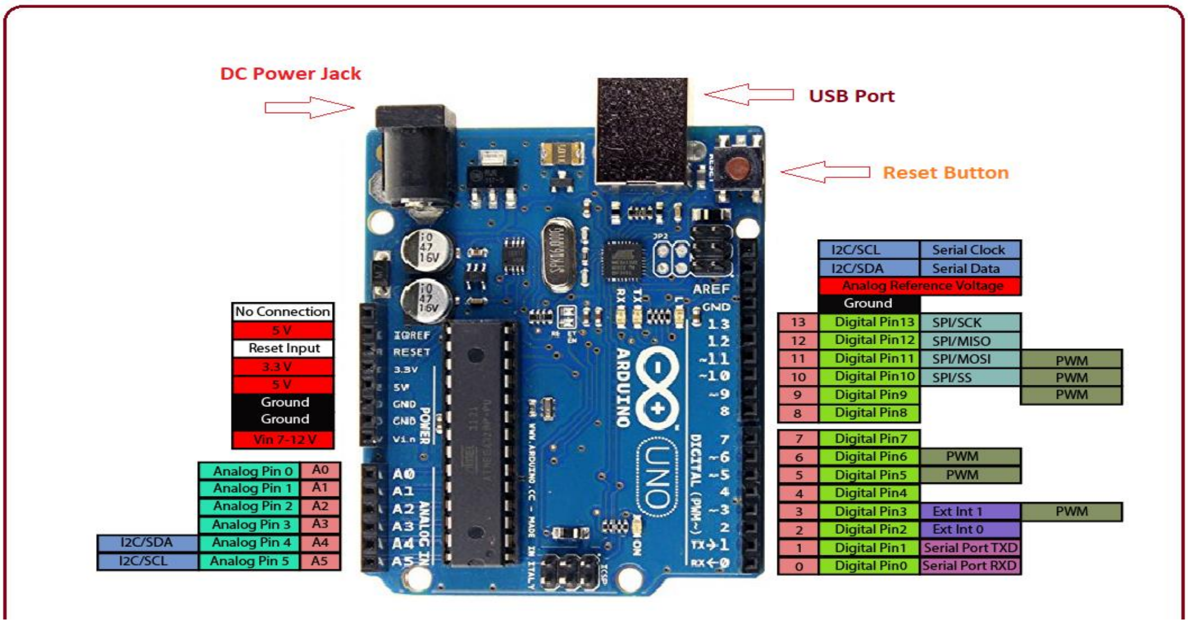

Figure 11: Arduino Uno Pin Diagram

2.1.2 Ultrasonic Sensor

The **HC-SR04 Ultrasonic (US) sensor** is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The sensor works with the simple high school formula that

Distance = Speed × Time

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below

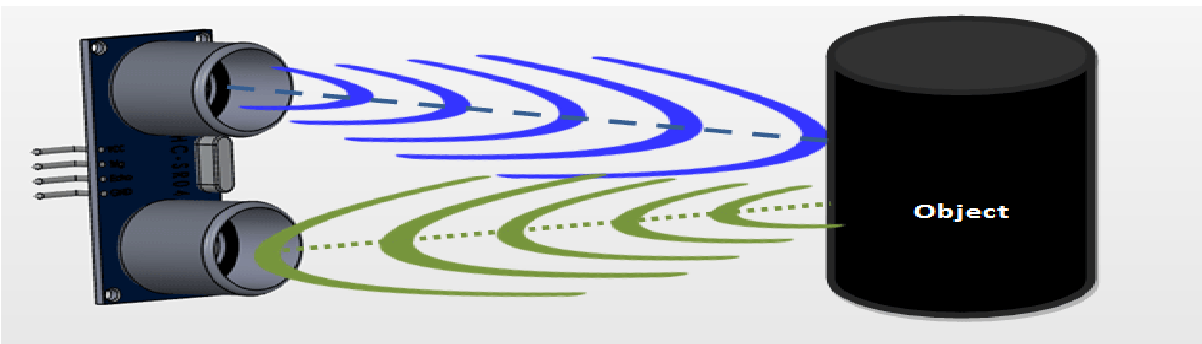

Figure 12: How Ultrasonic Sensor Works?

Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a microcontroller or microprocessor [17].

Figure 13: HC-SR04 Ultrasonic Sensor

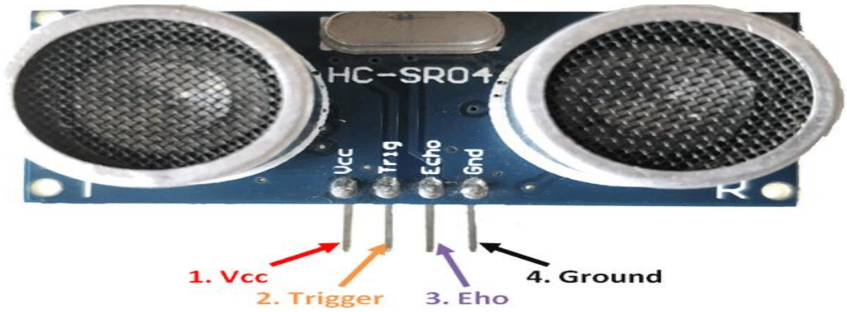

Figure 14: Ultrasonic Sensor HC-SR04 Pin Diagram

2.1.3 Servo Motor

Servo motors are great devices that can turn to a specified position. Usually, they have a servo arm that can turn 180 degrees. Using the Arduino, we can tell a servo to go to a specified position and it will go there. As simple as that! Servo motors were first used in the Remote Control (RC) world, usually to control the steering of RC cars or the flaps on a RC plane. With time, they found their uses in robotics, automation, and of course, the Arduino world.

A servo motor has everything built in: a motor, a feedback circuit, and most important, a motor driver. It just needs one power line, one ground, and one control pin.

Servos are clever devices. Using just one input pin, they receive the position from the Arduino and they go there. Internally, they have a motor driver and a feedback circuit that makes sure that the servo arm reaches the desired position. But what kind of signal do they receive on the input pin?

It is a square wave similar to PWM. Each cycle in the signal lasts for 20 milliseconds and for most of the time, the value is LOW. At the beginning of each cycle, the signal is HIGH for a time between 1 and 2 milliseconds. At 1 millisecond it represents 0 degrees and at 2 milliseconds it represents 180 degrees. In between, it represents the value from 0–180. This is a very good and reliable method.

Remember that using the Servo library automatically disables PWM functionality on PWM pins 9 and 10 on the Arduino UNO and similar boards [21].

Figure 15: Tower Pro SG90 180 Degree Servo Motor

2.1.4 Metal Detector

A **metal detector** is an electronic instrument which 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 handheld unit with a sensor probe which can be swept over the ground or other objects. If the sensor comes near a piece of metal this is indicated by a changing tone in earphones, or a needle moving on an indicator. Usually the device gives some indication of distance; the closer the metal is, the higher the tone in the earphone or the higher the needle goes. Another common type are stationary "walk through" metal detectors used for security screening at access points in prisons, courthouses, and airports to detect concealed metal weapons on a person's body.

The simplest form of a metal detector consists of an oscillator producing an alternating 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 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 [13].

Figure 16: Metal Detector Module

2.1.5 L298 Motor Driver

L298 is a dual full bridge driver that has a capability to bear high voltage as well as high current. It receives basic TTL (Transistor Transistor Logic) logic levels and is able to operate the different loads such as DC motors, stepper motors, relays etc.

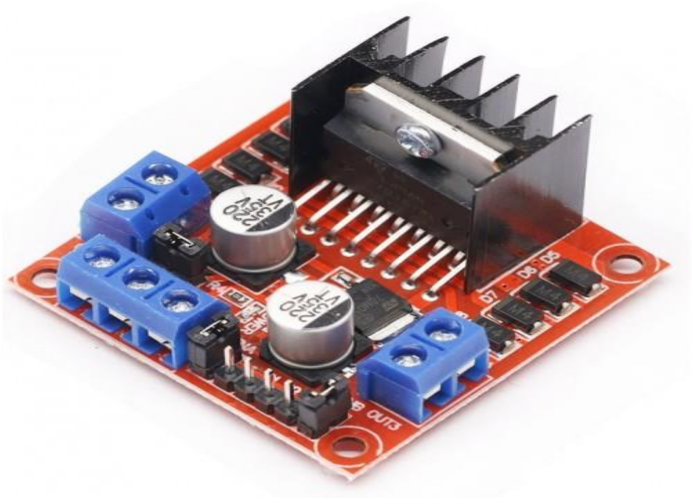

Figure 17: L298 Motor Driver

L-298 has two enable input to control any device by enabling or disabling it. L 298 IC is most commonly used to make motor drivers or motor controllers. These motor controllers can be controlled by any micro controller e.g Arduino, PIC, Raspberry Pi etc. They receive input from micro controllers and operate the load attached to their output terminals correspondingly. L-298 motor driver (H-Bridge) is able to control two different DC motors simultaneously. While it can control a single stepper motor as well. L 298 has two Pulse Width Modulation (PWM) pins. PWM pins are used to control the speed of the motor. By changing the voltage signal's polarity at its input we can rotate the motor in either clockwise or counter clockwise direction. It has a lot of real life applications e.g robotics, doors lock systems, CNC machines etc [13].

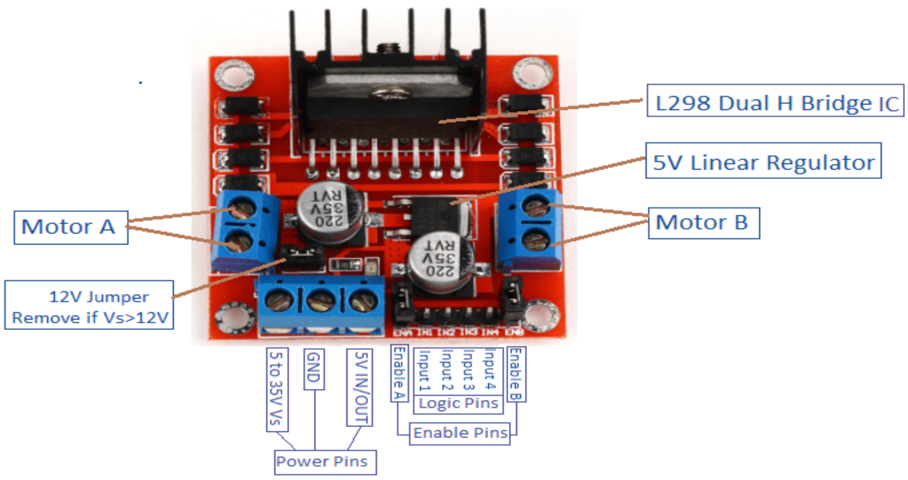

Figure 18: L298 Motor Driver Pin Diagram

2.1.6 Robot Chassis with Motors & Wheels

This DIY 2 Wheel Drive Robot Chassis is the perfect mechanical platform for your robotics projects. This kit includes all the hardware and mechanical components required to build your robot, including motors, wheels, chassis, nut and bolts, etc. Just add your electronics - Arduino/Raspberry Pi and Motor Driver and you can start programming your robot. It offers a large space with predrilled holes for mounting sensors and electronics as per your requirement. This robot chassis lets you get your mechanical platform ready in minutes and quick start your robot building process. Allows you to spend your time and effort on programming your robot rather than designing and fabricating your own custom platform.

Wheeled Robots are most popular robot platforms and are easy to run, maintain and use. Simple to build and program, this kit is the simplest robot platform. Highly recommended for beginners and novice users. Building robots using this wheeled kit is fun and a great learning experience too. This 2WD Robot Kit costs less, is simple to build, maintain and program. Our 4WD Kit lets you go faster, carry more weight, and carry bigger load compared to the 2WD Kit. You can build line following robots, obstacle avoiding robots, maze solvers, and other robots using this kit [18].

Figure 19: Robot Chassis with Motors & Wheels

2.1.7 3.7 Volt 18650 Series Rechargeable Batteries

An 18650 battery is a cell that's 18mm x 65mm in size. The name, 18650, refers exclusively to the size of the lithium-ion battery cell, but there can be minor variations even here. The 18650 has become the new gold standard for replaceable and rechargeable batteries.

They offer the performance of a lithium-ion cell, a capacity in the range of 1800mAh to around 3500mAh, and an output of 3.7 volts. They're used in a huge range of devices from laptops to laser pointers, and camera accessories like gimbals and sliders [19].

Figure 20: 3.7 V 18650 Series Rechargeable Batteries

2.1.8 HC-05 Bluetooth Module

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol)module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate)3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project, etc [22].

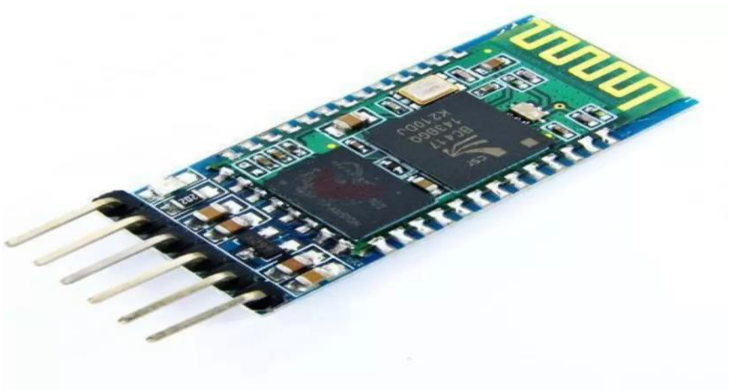

Figure 21: HC-05 Bluetooth Module

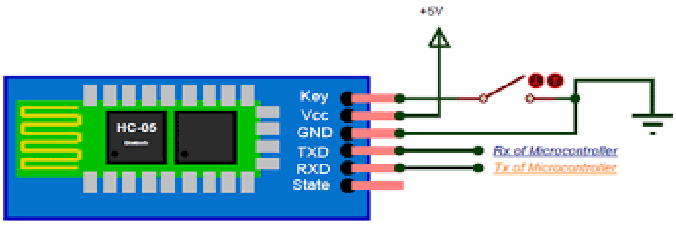

Figure 22: HC-05 Bluetooth Module Pin Diagram

2.2 Proposed Mechanism

2.2.1 Design Considerations

Step 1: Mount the DC Motors & The Wheels on The Robot Chassis

Step 2: Mount L298 Motor Driver on Top of The Robot Chassis & Connect it with DC Motors

Step 3: Place Arduino Uno Microcontroller on Top of the Robot Chassis

Step 4: Assemble Servo Motor & Ultrasonic Sensor on The Robot Chassis

Step 5: Assemble Metal Detector Sensor on The Robot Chassis

Step 6: Place Bluetooth Sensor on The Robot Chassis

Step 7: Connect All the Components with Arduino Uno

Step 8: Attach Batteries to Supply Power to The Robot

2.2.2 Description of the Hardware Assembling:

Aim of the proposed algorithm is to minimize the Robot's weight by using of light weighted components or materials and to maximize the robot's reliability by use of simple but effective interfacing.

Step 1: Mount the DC Motors & The Wheels on The Robot Chassis

We have mounted two DC motors below the Robot Chassis at left & right sides respectively. These DC Motors provides the required speed for the robot to move and provides high torque at the rated speed and current. Then We have attached two big wheels at left & right sides of the Robot Chassis respectively.

Step 2: Mount L298 Motor Driver on Top of The Robot Chassis & Connect it with DC Motors

We have mounted L298 Motor Driver on top of the Robot Chassis. L298 is a dual full bridge driver that has a capability to bear high voltage as well as high current. It receives basic TTL (Transistor Transistor Logic) logic levels and is able to operate DC motors quite well.L298 IC is most commonly used to make motor drivers or motor controllers. We are using Arduino Uno microcontroller to operate this motor driver. It receives input from micro controller and operate the load attached to the output terminals correspondingly. Finally, we have connected two DC motors with two motor terminals of L298 Motor Driver.

Robot Kinematics

- **Forward Kinematics**

Forward kinematics of robot consists of calculating the end point of robot, while knowing the start point and velocities of both wheels. Following equations are used to calculate the final point of robot.

$$x' = ((Vl + Vr)/2) * \sin\theta$$
$$y' = ((Vl + Vr)/2) * \cos\theta$$
$$\theta' = (Vr - Vl)/Bw$$

Where x', y', θ' are the linear and angular velocities of robot. Vr and Vl are the velocities of the wheel of differential drive. Bw is the distance between the two wheels. θ is the orientation of robot[8].

- **Inverse Kinematics**

Inverse kinematics is the calculation of motion of wheels to reach specified robot motion. Since this is a two degree of freedom problem, two parameters are specified as the velocity in x axis (x') and theorientation of robot (θ') Following equations are used to solve the velocity of left wheel (Vl) andvelocity of right wheel (Vr)[8].

$$=(x'/\sin\theta)+(Bw * \theta'/2)$$
$$=(x'/\sin\theta)-(Bw * \theta'/2)$$

Step 3: Place Arduino Uno Microcontroller on Top of the Robot Chassis

We have placed Arduino Uno microcontroller on top of the Robot Chassis. Arduino Uno is a microcontroller board based on the ATmega328P .It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection**,** a power jack, an ICSP header and a reset button. Atmega328p is the microcontroller we are using because, it is more efficient, less cost and easily programmable.

Step 4: Assemble Servo Motor & Ultrasonic Sensor on The Robot Chassis

We have attached Servo motor at the front side of robot. This servo motor can rotate from0 to 180degree angle. Due to its position at the head of this robot we can attach the Ultrasonic sensor with this servo motor. Hence this Servo will rotate from 0 to 180 degree.

Ultrasonic Sensor HC-04 is a transducer that is employed to exchange ultrasound signals into electrical signals & mechanical signals. It is used in our robot for the purpose of obstacle detection & obstacle avoidance. The HC-04 is used to determine distance with high stability. It has no effect of environment on it. The precision of sonar sensor is from 2cm -400cm. It includes transmitter, receivers and a command circuit, it frequently sends eight 40 KHz cycles. Distance is measured by calculating the period of sending and receiving of the sound waves back to the sensor using the formula given below.

Distance = S

S = peak time * velocity (340m/s) / 2

Step 5: Assemble Metal Detector Sensor on The Robot Chassis

Metal Detector circuit is most useful for security checking. Metal Detectors available in the market are quite expensive. This metal detector can be used to detect slightly big size metallic objects. It used a sensing coil. This coil should be kept near metallic objects for detection. Input of circuit is a weak colpitt's R.F. range Oscillator. Sensing coil forms parts of tunes oscillator. When coil is brought near a metallic object magnetic energy is absorbed and oscillator fails to work. Then final transistor conducts and buzzer is activated.

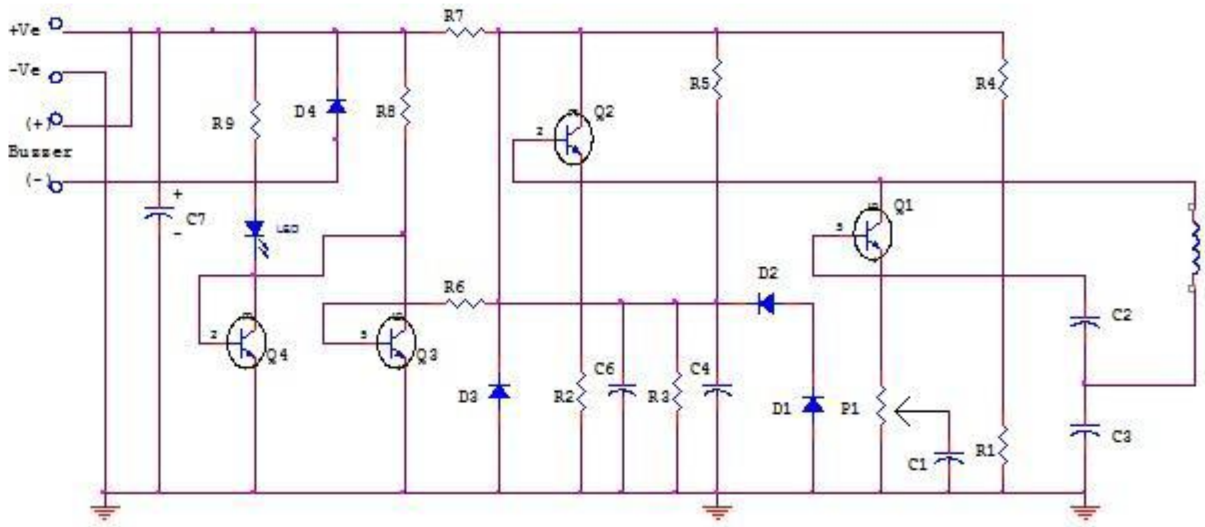

Figure 23: Metal Detector Circuit

The heart of this sensor is the inductive oscillator circuit which monitors high frequency current loss in coil. The circuit is designed for any metallic body detection by detecting the variations in the high frequency Eddy current losses. With an external tuned circuit they act as oscillators. Output signal level is altered by an approaching metallic object.

Output signal is determined by supply current changes. Independent of supply voltage, this current is high or low according to the presence or the absence of a close metallic object. This hand can easily attach on the front of Robot Chassis, hence it will detect the metallic objects in land[10].

Step 6: Place Bluetooth Sensor on The Robot Chassis

We have placed HC-05 Bluetooth Sensor on the top left side of the Robot chassis. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication.

We use it simply for a serial port replacement to establish connection between Robot Controlling App and The Robot.

Step 7: Connect All the Components with Arduino Uno

Finally, after assembling all the components on the robot chassis. We have connected L298 Motor Driver, Servo Motor, Ultrasonic Sensor, Metal Detector & Bluetooth Sensor with Arduino Uno by using Jumper Wires.

Step 8: Attach Batteries to Supply Power to The Board

Finally, we have supplied power to The Robot by attaching two 3.7 Volt 18650 series Lithium-ion rechargeable batteries on a battery holder below the Robot chassis & connected it with Arduino Uno. They offer the performance of a lithium-ion cell, a capacity in the range of 1800mAh to around 3500mAh, and an output of 3.7 volts. They're used in a huge range of devices from laptops to laser pointers, and camera accessories like gimbals and sliders.

2.3 System Designs

2.3.1 Block Diagram of The Robotic Vehicle

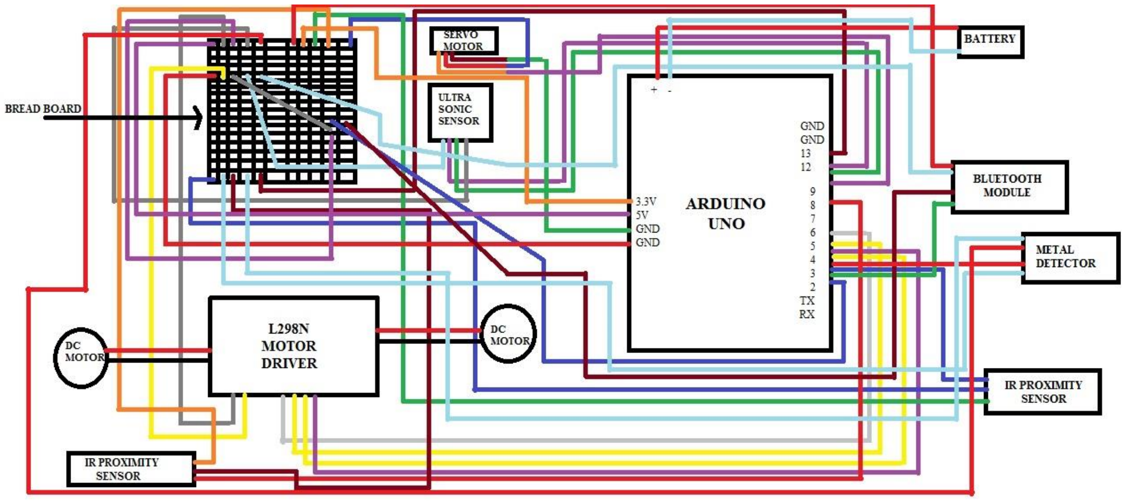

Figure 24: Block Diagram of The Robot

2.3.2 Snapshots of The Robotic Vehicle

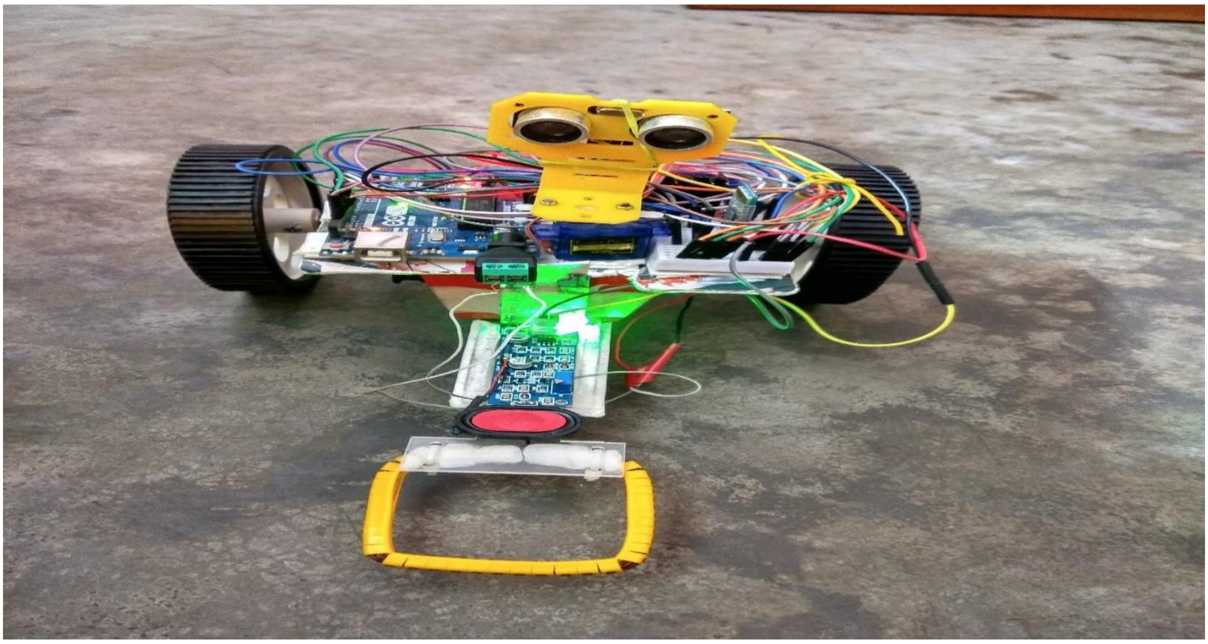

Figure 25: Front View of The Robot

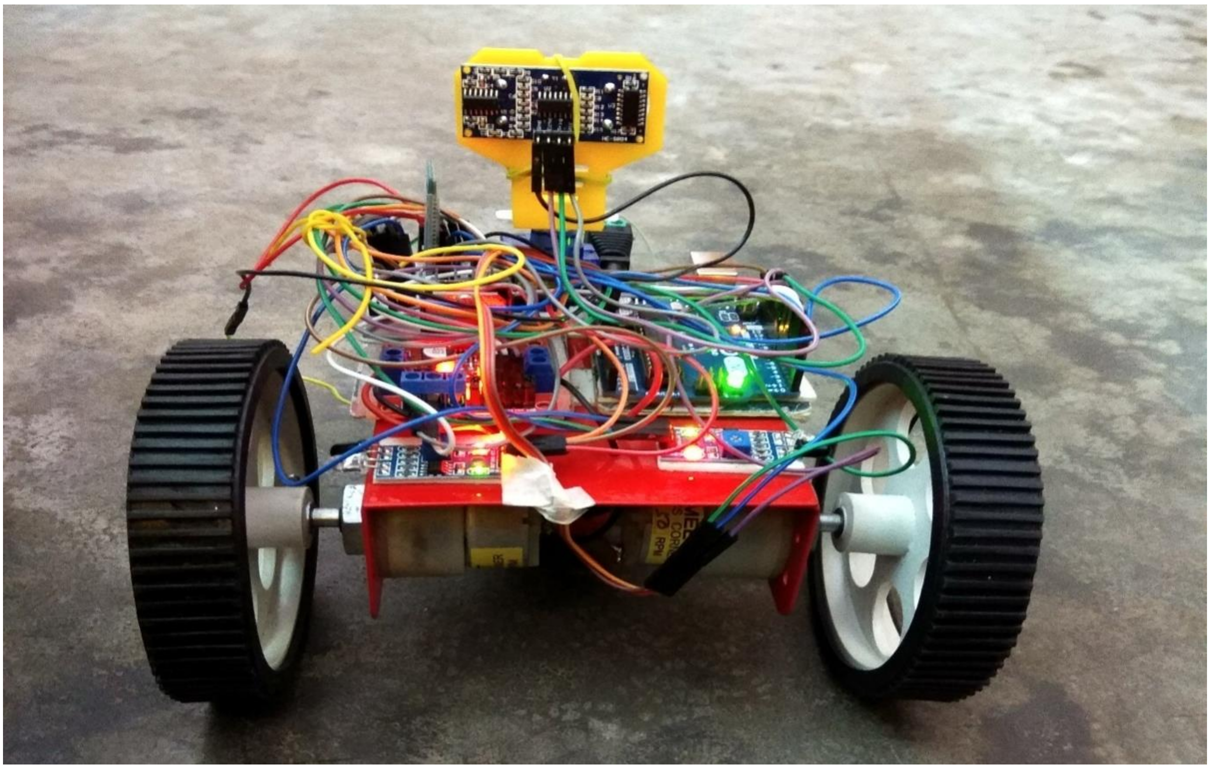

Figure 26: Back View of The Robot

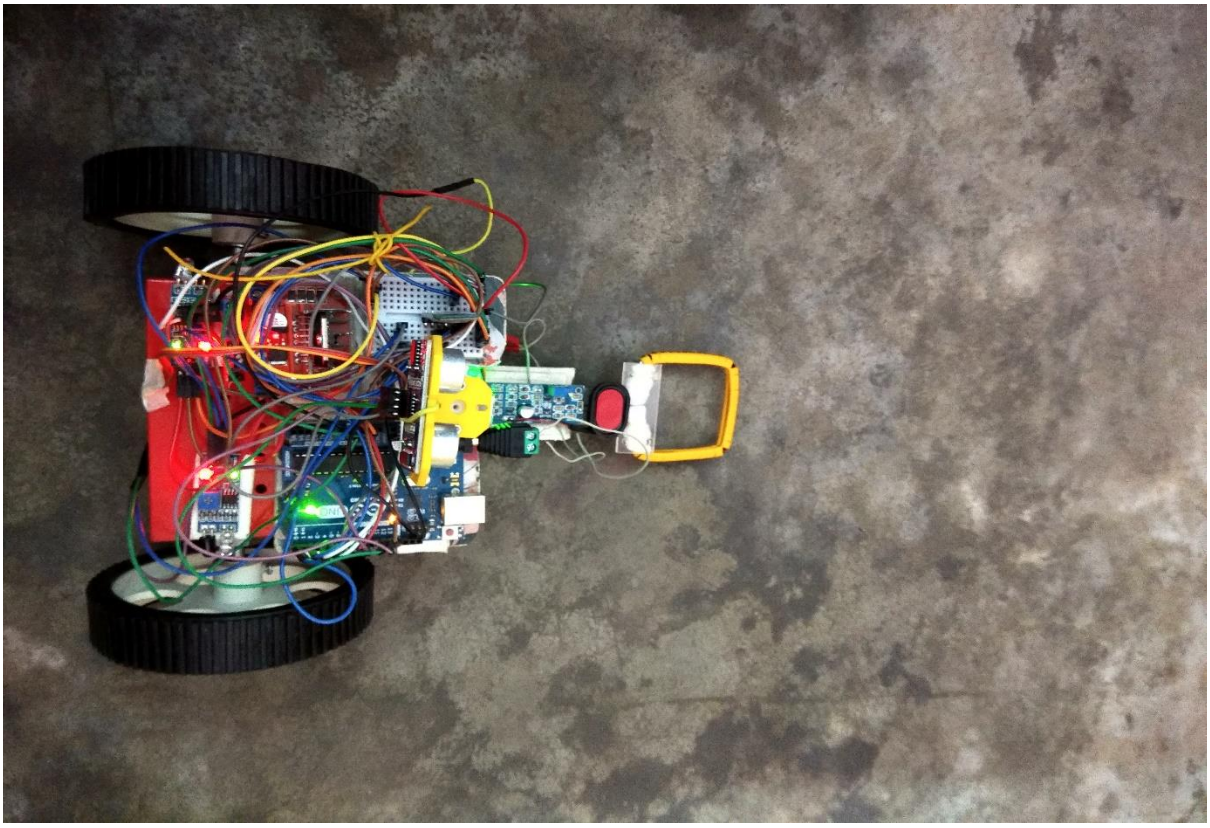

Figure 27: Top View of The Robot

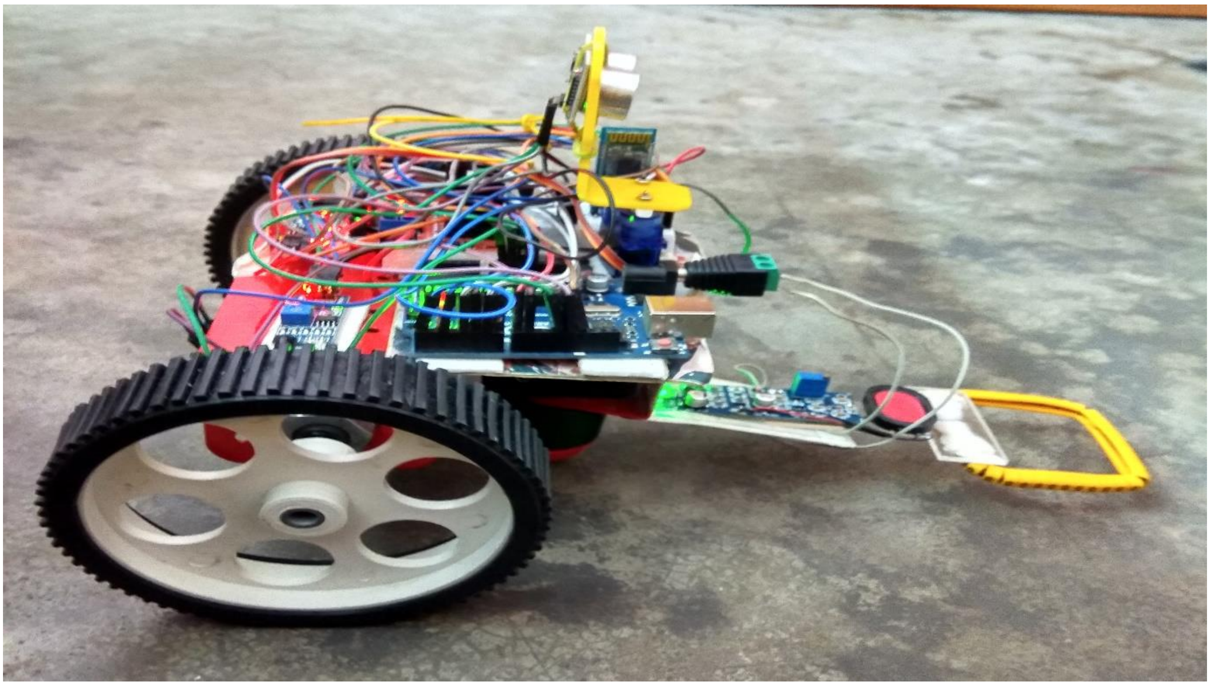

Figure 28: Side View of The Robot

2.3.3 Snapshot of The Robotic Vehicle Controller App Design

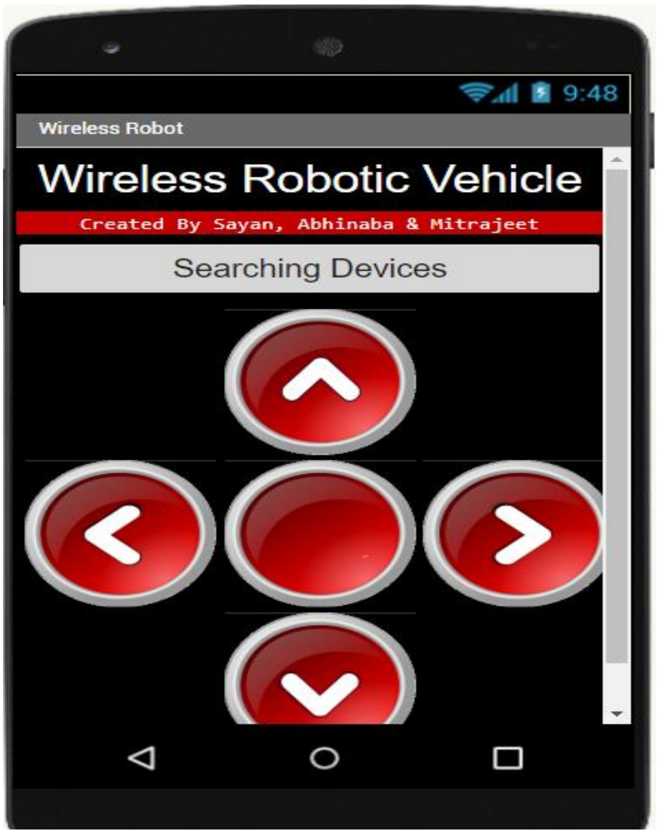

Figure 29: Design of The Robot Controller App

2.4 Working Principle

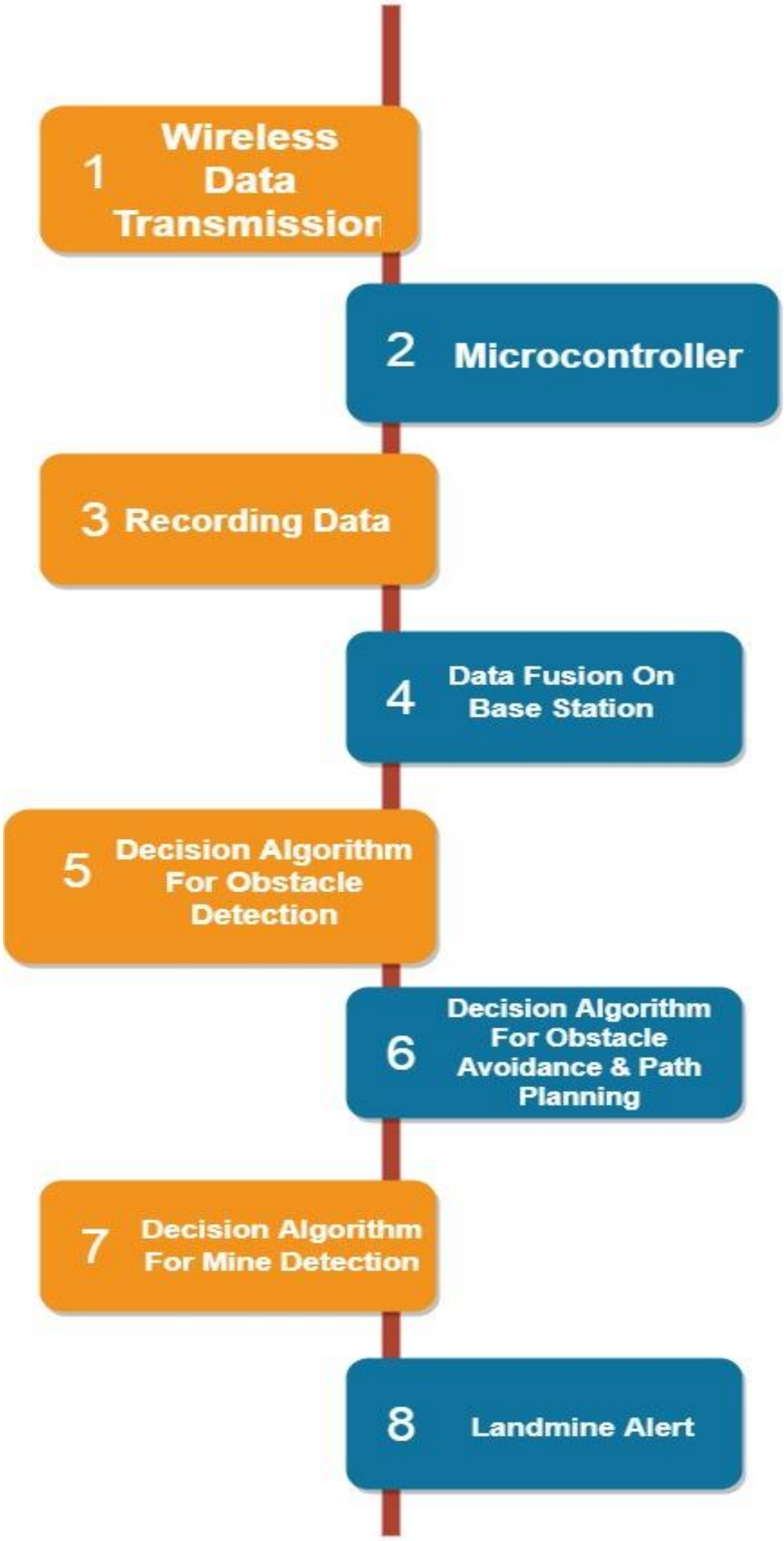

Figure 30: Block Diagram of The Working Principle

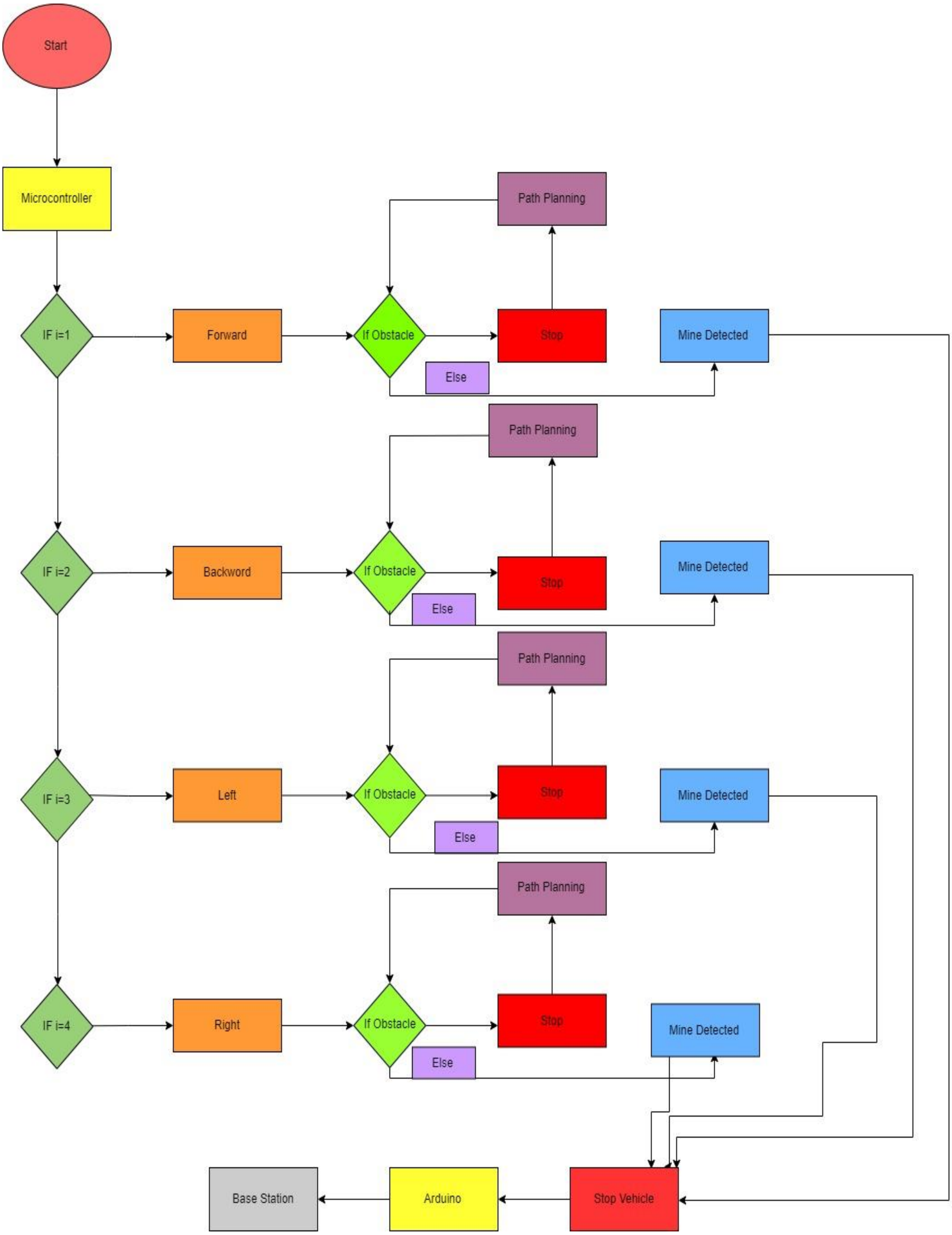

Figure 31: Flow Chart of The Working Principle

Chapter 3: Coding

3.1 Code for The Operations of The Robotic Vehicle

We wrote the codes for the operations of the Robotic Vehicle in **ArduinoIDE**(Integrated Development Environment) using simplified version of C++ language. Arduino IDE is a ready-made software which is used to write & upload the computer code to the physical board such as Arduino Uno. It is compatible to various Operating Systems such as Windows, IOS & Linux. The codes are given below:

#Code for Mine Detection with obstacle detection & avoidance

```
#include <Servo.h>
//sensor pins

int trigPin=12; int echoPin=13;int metalD=3;
long duration,cm;

int distance = 100;

Servo servo_motor; //our servo name

char getstr;
//L298 motor driver pin
const int LeftMotorForward = 7;
const int LeftMotorBackward = 6;
const int RightMotorForward = 4;
const int RightMotorBackward = 5;

int lookRight(){
servo_motor.write(60);
delay(500);
  int distance = readPing();
delay(100);
servo_motor.write(90);
  return distance;
}

int lookLeft(){
servo_motor.write(120);
delay(500);
  int distance = readPing();
delay(100);
servo_motor.write(90);
  return distance;
delay(100);
}
//Reading the distance of obstacle
int readPing(){
```

```
delay(70);
digitalWrite(trigPin,LOW);   delayMicroseconds(5);
digitalWrite(trigPin,HIGH);  delayMicroseconds(10);
digitalWrite(trigPin,LOW);

  duration = pulseIn(echoPin,HIGH);

  cm=(duration/2)/29.1; //*0.0341
  if (cm==0){
    cm=250;
  }
  return cm;
}

//Forward Movement Function
void _mForward()
{

digitalWrite(LeftMotorForward, HIGH);
digitalWrite(RightMotorForward, HIGH);

digitalWrite(LeftMotorBackward, LOW);
digitalWrite(RightMotorBackward, LOW);
Serial.println("go forward!");
}
//Backward Movement  Function
void _mBack()
{

digitalWrite(LeftMotorBackward, HIGH);
digitalWrite(RightMotorBackward, HIGH);

digitalWrite(LeftMotorForward, LOW);
digitalWrite(RightMotorForward, LOW);
Serial.println("go back!");
}

//Left Movement Function
void _mleft()
{

digitalWrite(LeftMotorBackward, HIGH);
digitalWrite(RightMotorForward, HIGH);

digitalWrite(LeftMotorForward, LOW);
digitalWrite(RightMotorBackward, LOW);

delay(1000);

digitalWrite(LeftMotorForward, HIGH);
```

```
digitalWrite(RightMotorForward, HIGH);

digitalWrite(LeftMotorBackward, LOW);
digitalWrite(RightMotorBackward, LOW);

Serial.println("go left!");
}
//Right Movement Function
void _mright()
{

digitalWrite(LeftMotorForward, HIGH);
digitalWrite(RightMotorBackward, HIGH);

digitalWrite(LeftMotorBackward, LOW);
digitalWrite(RightMotorForward, LOW);

delay(1000);

digitalWrite(LeftMotorForward, HIGH);
digitalWrite(RightMotorForward, HIGH);

digitalWrite(LeftMotorBackward, LOW);
digitalWrite(RightMotorBackward, LOW);
Serial.println("go right!");

}
//Stop Function
void _mStop()
{
digitalWrite(RightMotorForward, LOW);
digitalWrite(LeftMotorForward, LOW);
digitalWrite(RightMotorBackward, LOW);
digitalWrite(LeftMotorBackward, LOW);
Serial.println("Stop!");
}


//Pin Declaration
void setup()
{
Serial.begin(9600);
pinMode(RightMotorForward, OUTPUT);
pinMode(LeftMotorForward, OUTPUT);
pinMode(LeftMotorBackward, OUTPUT);
pinMode(RightMotorBackward, OUTPUT);

servo_motor.attach(9); //our servo pin

//Ultrasonic sensor pin
```

```
pinMode(trigPin,OUTPUT);
pinMode(echoPin,INPUT);
  // metal detector pin
pinMode(metalD,INPUT);
servo_motor.write(90);
delay(2000);
  distance = readPing();
delay(100);
  distance = readPing();
delay(100);
}

void loop()
  {
 int m=25;
   int distanceRight = 0;
  int distanceLeft = 0;
delay(50);

  distance = readPing();
Serial.println(distance);
delay(300);

    if (distance <= 20){
Serial.println(distance);
     _mStop();
delay(300);
    _mBack();
delay(1000);
    _mStop();
delay(300);
distanceRight = lookRight();
Serial.println("Right:");
Serial.println(distanceRight);
delay(300);
distanceLeft = lookLeft();
Serial.println("Left:");
Serial.println(distanceLeft);
delay(300);

     if (m >= distanceRight){
      _mleft();
      _mStop();
    }
    else if(m >distanceLeft)
    {
      _mright();
      _mStop();
    }
  }
```

```
else{
   _mForward();
  }
//Metal Detection
If(digitalRead(metalD)==LOW){
            Serial.println("Metal Detected");
                 _mStop();
}

distance = readPing();

  //Wireless Controlling
getstr=Serial.read();

 if(getstr=='F') //For Forward Movement
  {
   _mForward();
  }
  else if(getstr=='B') //For Backward Movement
  {
   _mBack();
delay(200);
  }
  else if(getstr=='L') //For Left Movement
 {
   _mleft();
delay(200);
  }
  else if(getstr=='R') // For Right Movement
  {
   _mright();
delay(200);
  }
  else if(getstr=='X') // For Stop The Car
  {
    _mStop();
  }

   distance = readPing();
}
```

3.2 Code for Developing the Robotic Vehicle Controller App

We have created Mine Detection Robot Controller App using **MIT App Inventor 2**. App Inventor is a web application integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create application software(apps) for two operating systems (OS): Android, and iOS, which, as of 8 July 2019, is in final beta testing, scheduled to be released publicly in summer 2019. It is free and open-source software released under dual licensing: a Creative Commons Attribution ShareAlike 3.0 Unported license, and an Apache License 2.0 for the source code.

It uses a graphical user interface (GUI) very similar to the programming languages Scratch and the StarLogo TNG user interface, which allows users to drag and drop visual objects to create an application that can run on mobile devices. In creating App Inventor, Google drew upon significant prior research in educational computing, and work done within Google on online development environments.

App Inventor also supports the use of cloud data via an experimental Firebase Database component [15].

The Blocks or The Main Logic Part of the App is given below:

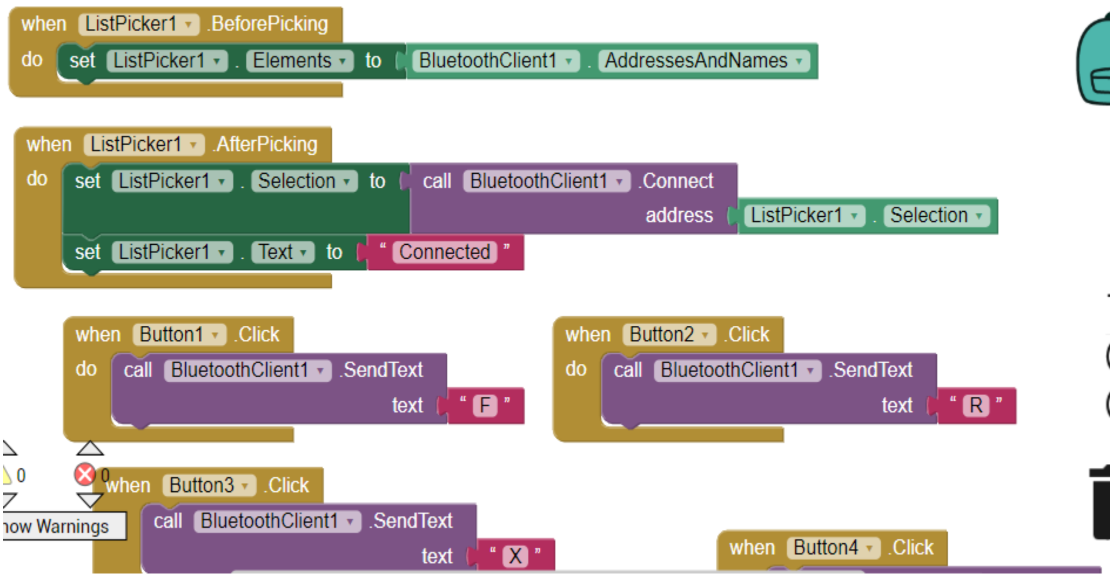

Figure 32: Blocks of Robot Controller App

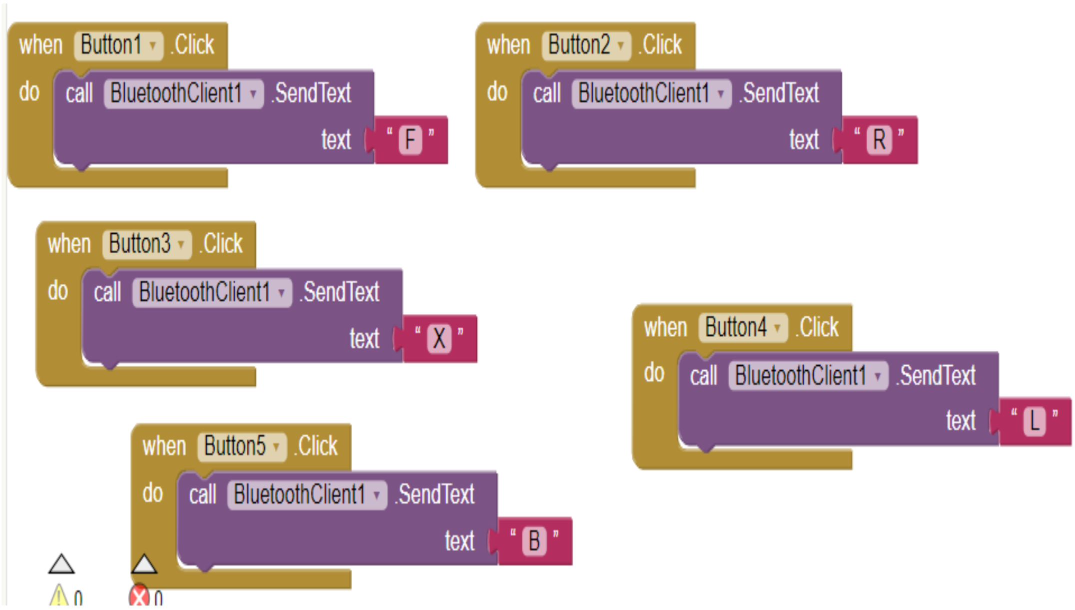

Figure 33: Blocks of Robot Controller App

Chapter 4: System Testing

4.1 Hardware Testing

Through our design process, testing of our Hardware designs led to a variety of alterations and improvements upon our initial plan to try to satisfy our system requirements. The following is an overview of the testing process and the adaptations of our design during the development of our robot.

The system requirements of our robot that were of greatest concern to the mechanical systems in our robot were the ability of the robot to traverse a field, the ability to detect mines within the sweep of the robot, and the ability to mark those mines with our marking system. In order to test these requirements and ensure that we were able to fulfil them we needed to test each of the following aspects:

- **Robot Moving in Forward Direction**

  Test the robot move in the forward direction a command is given such as top arrow key in the android application. Once the data is obtained by the Arduino board, both the dc motor runs in clockwise direction. The robot keeps on moving in the forward direction until the command is changed or an obstacle is detected or metal is detected. If an obstacle is detected the direction of robot changes accordingly while if a metal is detected the robot stops instantly and provides the location of the infected place.

- **Robot Moving in Backward Direction**

  Test the robot move in the backward direction a command is given such as down arrow key, once the data is obtained by the Arduino board, both the dc motors run in anticlockwise direction continuously. The robot keeps on moving in the backward direction until the command is changed, an obstacle is detected or metal is detected. If an obstacle is detected the direction of robot changes accordingly while if a metal is detected the robot stops instantly and provides the location of the infected place.

- **Robot moving in the Left Direction**

  In order to test the autonomous vehicle, the command has to be given through Android application. Once the start command is given the autonomous vehicle a start moving in forward direction i.e. the dc motor rotates in clockwise direction. To make the robot move in the left direction a command is given such as left arrow key through Android application. Once the data is obtained by the Arduino board the left dc motor stops running while the other motor runs continuously in clockwise direction. The robot keeps on moving in the left direction until the command is changed or an obstacle is detected. If an obstacle is detected the direction of robot changes accordingly.

- **Robot moving in the Right Direction**

  To make the robot move in the right direction a command is given such as right arrow key. Once the data is obtained by the Arduino board, the right dc motor stops running while the other motor runs continuously in clockwise direction. The robot keeps on moving in the right direction until the command is changed or an obstacle is detected or a metal is detected. If an obstacle is detected the direction of robot changes accordingly while if a metal is detected the robot stops instantly and provides the location of the infected place.

Table 1: Control Mechanism of Robot

Command	Movement
Top Arrow Key	Forward Direction
Bottom Arrow Key	Backward Direction
Left Arrow Key	Left Direction
Right Arrow Key	Right Direction
0	Stop

Figure 34: Control Mechanism of Robot

- **Detection of Land Mines**

  After testing the movement mechanism of autonomous vehicle the detection of mines through metal detector is studied. The metal detector is placed in front of the vehicle in an inclined position. The supply is given to the metal detector using a 5v battery. The signal of metal detection is send to microcontroller 2 pin. The instant when metal is detected the autonomous vehicle stops and make sound in buzzer.

- **Obstacle Detection & Avoidance**

  After testing the detection of Land Mines the obstacle avoidance part came into the role. The autonomous robot consists of ultrasonic sensor for obstacle detection which is the first condition for the movement of vehicle. While in moving if an obstacle is detected it changes its direction else keeps the same track of motion. In the designed robot there is a servo motor which hold the ultrasonic sensor. when an obstacle come near to the robot at first it stop moving there and rotate the servo. ultrasonic sensor check the both angles and it changes its direction accordingly.

4.2 Software Testing

Testing of the software required testing the codes, testing the wireless connection between the microcontroller and the android application, and testing the wireless transmission to ensure that all data was being properly sent and received by the robot and it working according to your control or not.

Robot software control consists of two parts: detection control and robot driving control. Detection control consists of metal detector which senses the mines and to detect the corresponding infected place location and send to the appropriate persons. Robot walking is mainly controlled by robot drive motor, consisting of two DC motors, which can realize forward, backward, left and right walks. Robot is programmed by using HC-05 module for its navigation which is controlled by android application and a ultrasonic sensor are attached to it for obstacle avoiding.

Testing of the full wireless software involved testing our code’s ability to properly send and receive packets of information containing the position of both the app buttons and the robot and the metal detector signals from the robot.
By operating the robot from a reasonable distance by the android application, the entire software system is shown to be functional. To move the robot, the input must be received through the application, encoded and sent to the robot, and decoded and implemented by the motors. So long as lag is not observed, the system is satisfactory.
The detection system can be directly tested by placing metal in 3cm range of the detectors, and observing if the appropriate indicator lights up. The metal can be moved to determine the range of the detectors, and they were calibrated to meet requirements. Furthermore, it functioned through all tests.

Chapter 5: Conclusion

To measure the level of success of our project, we had to examine our specified objectives to determine whether they were met by our final product. We found that most of our major objectives were indeed satisfied, as shown in the following sentences, by our remote operated vehicle. Our desired product would be adaptable for various uses in the minefield, and our vehicle has this capability. Our desired remotely control range was 20 metres to 25 metres, which we easily exceeded. We specified 10 minutes to change batteries, and this can be done in 5 minutes. Our desired run time on one charge of batteries was an hour, which our vehicle can do. We specified that our vehicle must be able to climb a 10-degree incline, which it can do. Our budget for the project was 5000 Rupees, and we spent 3500 Rupees. Nearly all of our objectives were met.

Two of our objectives were not completely satisfied by our vehicle. One is our desired vehicle is not autonomously controlled, it is controlled only via remote or mobile app. However, hopefully this objective we can fulfil into the future, despite the autonomously controlled. Second is Reliability. As Our Robotic Vehicle is made of cheap components So, the reliability is uncertain. It is also not tested in all weather conditions & in rough terrains.

Overall, our remote operated vehicle was definitely a success. Only two of our minor objectives were not satisfied, and these do not affect the vehicle’s capability to function properly. There were also several other minor problems such as motor stability and loose connections, and these are discussed more fully in the recommendations for future work. These problems were also fairly minor, and while it was disappointing to see any problems occur, these were fairly insignificant to the overall success and workability of our vehicle.

We learned a great deal about working on a major engineering project through this experience. Other than learning much about the specific design and manufacturing elements that this particular project required, there are

several overriding concepts that we have taken from this project are:

- Allow more time than you think you need for each step of the process. Things take longer than expected, and this impacted us particularly in the construction phase of our project. Machining, welding and making circuit boards are just several areas where our project construction was more time-consuming than anticipated.
- Organize and plan a specific construction process. When there are many different construction aspects that all need to be done, it is important to think carefully and plan what needs to be done first, second etc. This helps to avoid problems where one process is completed before another one that needed to be done first.
- Test early, so that changes can be made and problems can be solved. Once again, things do not get finished as quickly as expected, so testing early gives time to correct problems that had not necessarily been anticipated.

These principles can be applied to many different kinds of projects and construction processes, and this project has shown us how important planning and organization are when taking on any type of major project. A realistic timetable for completion, a proper order of processes, and planning on various types of failures occurring are things that are easy to overlook, but doing so could cause a project to fail or never get completed. As engineers, we have been trained to design, analyse, and build, and this project has shown us that these three principles must be combined with two other crucial ones: planning and organization.

Chapter 6: Future Scope

In future, the robot would be even more effective if it did not require constant supervision and instruction from an operator, which would be accomplished through the addition of an autonomous mode. This would be difficult since the microcontroller would have to be able to independently sense its environment and position itself over a detected mine in order to mark it.

Another future advancement would be The Path Planning. By developing a Path planning algorithm, the autonomous robot will move through the specific paths to cover up the whole assigned area to detect mines.

Another future addition would be a digital copy of the locations of the mines, creating a map for future reference. This would require significant programming to accurately track the relative location of the robot and the location of the mines.

In the future the landmine detection robotic vehicle with GPS positioning can play wide role in different application such as vehicle tracking in like to find what is the current position of the vehicle.

The power system can be develop in future by replacing the battery with the solar panels to produce continuous power.

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