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Mine Detection with 3 DOF Robotic Arm

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Abstract*— Mining is a major factor for the process of extraction of minerals from the Earth's surface. Thee minerals can be of two types, metallic and non-metallic. In this project, we are focusing on metallic minerals/substances detection. But these materials are randomly located that their presence is not easily predictable. To make it easy and efficient to locate these materials, we intend to use robots in these areas to avoid save time and avoid risk causing to human life while deploying./extracting. This project throws a vivid light on how effectively we use robotics in the process of mining. The robot here is made to move on wheels that are controlled by two DC Motors which are drive-by L298 driver IC. A proximity sensor is connected to the tip of the robot arm. This sensor is used for the detection of metallic presence, so it uses a principle of the magnetic field for this purpose. Since mines are also metallic substances, this project can be used for both mining and military purpose as well. As the name suggests proximity, means closeness, when this sensor is made to come near a metal substance, an LED that is present over it is made to glow. This indicates the presence of metal. This project uses a wireless technology i.e. a Bluetooth module for the robot movement. All the components used in this are interfaced with Arduino, a microcontroller that can be easily programmed to instruct all the components. A buzzer is also connected so that it makes a buzzing sound when metallic material is detected.

Keywords—Robot vehicle, Proximity sensor, Arduino UNO, L298 Motor Driver

I. INTRODUCTION

Robots are widely used in day-to-day life these days. This paper focuses on the detection of metallic materials. Robots are used everywhere these days as they provide security and are very flexible in applications. Mining is the process of extraction of minerals from the ore body of Earth, that cannot be grown by human beings. Most minerals are deep underground and are required to dig. Mine detection robots help the miners who are working in hazardous areas from exposure to uneven and underground surfaces.

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Earlier minerals were not easily found. Rocks are broken apart to check for the existence of minerals. These pieces of rocks that do not contain any minerals are then poured into water bodies to avoid any dust coming out from them. This causes an imbalance in the environment.
Hence we use these Mine detection robots to detect the existence of minerals in the rocks and are designed in such a way that these beeps whenever minerals are found in them using a buzzer. This is done with the help of an inductive proximity sensor. Extraction of mines has been a troublesome process for many miners as it has to work on extreme environmental areas. The presence of metals was unpredictable before the introduction of robots for mining purposes.[6] But this project gives a perfect solution to overcome pollution.

1.2 LITERATURE SURVEY:

Demining has been an issue for decades now. This is because, if the landmines are not exploded and are buried underground after the world war, may result in danger for human life. These can now be easily determined using mine detection robots and deteriorated so that no harm shall be caused to people living around. This paper[14] explains the benefits of using a robotic method for the detection of mines that are hidden underground, has a very simple working architecture. This robot uses an NRF for wireless transmission, wherein its receiver works according to the commands of its transmitter. For the purpose of detection of a metal, a metal sensor is been used, in order to drill the rock material or ground, a drilling machine is been fixed to avoid any human labour, an arm is used to collect the material. The camera has also been installed to transmit the location of the robot. A Microcontroller is fixed which takes commands from the control pilot. This paper[11] presents a model of land mine detecting robot that is easy to access, which has got high accuracy and precision as well with low cost. It uses a simple camera module for a visual interface for plotting the landmines. It uses a GUI (Graphical User Interface) software in order to control the robot. It is a simple and powerful control unit. In this, [7]the proposed system consists of two links. Wherein the first link is used to move the vehicle in right and left directions on a smooth horizontal plane. This movement is made possible with the help of four wheels that are made wide. Whereas the second link is consists of a metal detector and a camera. This link is used to take snaps of the environment and also to detect the metal presence. This robot is based on a framed that is of less weight making this robot featherlight and easy access. Our project uses simple components and the price in making one is also less.

1.3 PROPOSED SYSTEM:

This Mine Detection Robot is made to move wirelessly with the help of Bluetooth module that has a frequency of 2.4GHz and which can support up to 8 devices in a piconet, is used and is operated from mobile. An Arduino UNO board that is highly flexible and also cheaper with ATmega 329 microcontroller designed on it.

It is a high edge platform for interfacing many electronic components and to that of a PC as well. This is an integrated system since we use Arduino and wireless network system as it transmits data based on wireless communication using Bluetooth technology. The Robot is made to move on two DC Motors which is driven by an L298D Motor Driver IC.

DOF is a number that reflects the single-axis rotations in the robotic arm. Here we use a robot with 3 DOF for higher flexibility. So three Servo motors are used. Wherein one is fixed at the bottom that is used for the rotation and the second one at the middle of the arm for its movement up and down. While the third is fixed at the top.

For the detection of the presence of a metallic substance, an Inductive Proximity sensor that performs a non-contact detection is used. This has got high precision and Long life. A buzzer is also used to make a buzzing sound whenever metal is made in contact with the sensor. All these devices are interfaced with the Arduino.

This paper comprises of: Section I describes the Introduction, Section II comprises of Design and Experimental Details. Finally, Section III Result and conclusion.

II. DESIGN AND EXPERIMENTAL DETAILS

2.1 Block Diagram:

Figure 1 shows the block diagram of the Mine Detection Robot. Here the Arduino UNO receives the signals from Bluetooth Module through which the Robot and its arm is moved. Also, the signals from proximity sensors are received by the Arduino.

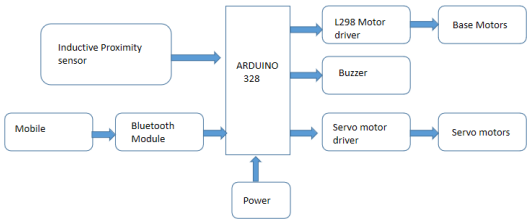

Fig. 1 Mine Detection Robot Block diagram

2.2 ARDUINO UNO BOARD:

Fig 2 shows the Arduino Microcontroller Board used in this project. Arduino UNO microcontroller board, an open source programming, comprises of ATmega328p microcontroller. It includes 14 advanced pins and 6 analog pins. Out of the 14 pins, 6 of them can be utilized as PWM yield pins and the rest 8 advanced pins can be utilized as information or yield pins. Though the 6 simple pins are totally input pins. Its working voltage is of 5V which can be given from a battery yet it can withstand up to 20V. It comprises of a USB connector, a force port, a 16MHz gem oscillator, a Reset switch and Tx and Rx pins which are fundamentally the advanced pins. There are likely possibilities that the board may get shaky if the graceful voltage is under 7V[15]. What's more, if flexibly is more than 12V, there comprises of a voltage controller that sits between the port and the connector and shields the board from getting overheated.

Fig.2 Arduino

Here we could control the board working by transmitting certain orders to the microcontroller on the board through transferring a program that is by means of Arduino IDE, as appeared in fig 3. The Arduino IDE utilizes a rearranged adaptation of C++ and scarcely any different dialects making it simpler to figure out how to program[12].

Arduino Programming (IDE) comprises of the accompanying: a text editor- where is principle program is composed. This territory shows messages and blunders also. A text console- for the showing of the sequential screen i.e. Serial Monitor. A menu bar that comprises of specific instruments. This Arduino IDE is utilized to speak with the equipment and the program is made to transfer through a link.

Fig. 3 Arduino IDE

2.1 Proximity Sensor:

Inductive Proximity Sensors are used to detect the presence of metallic materials. Hence we use a magnetic field for its detection. So, when Ferrous metals come in contact with the magnetic field, eddy currents are induced on their surfaces as shown in figure 4[4]. These are the closed loop currents that are induced whenever there is a change in the magnetic field according to Faraday's law which predicts how the magnetic field will interact with an electric circuit to produce EMF. These eddy currents will thereby induce power loss fluctuations within the oscillatory circuit thereby causing a reduction in its amplitude.

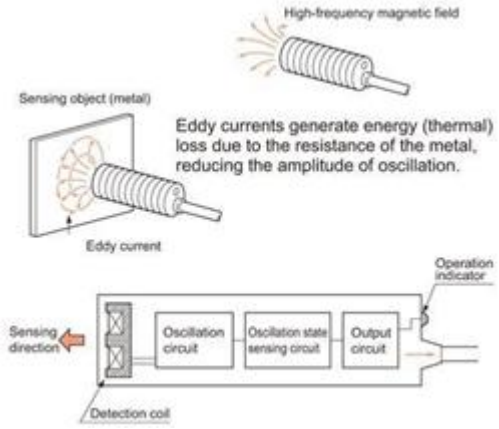

Fig. 4 Principle of Proximity Sensor

Features:

1. Proximity Sensors are usually used for the detection of metallic substances only. They have a target range of 0.5- 40mm so that they are not intended to touch the objects.
2. Proximity Sensors are very flexible in usage as they can be used in hazardous environments.
3. Proximity Sensors have great response time and are fast in execution.
4. Proximity Sensors also can be used at high temperatures ranging from −40 to 200°C.

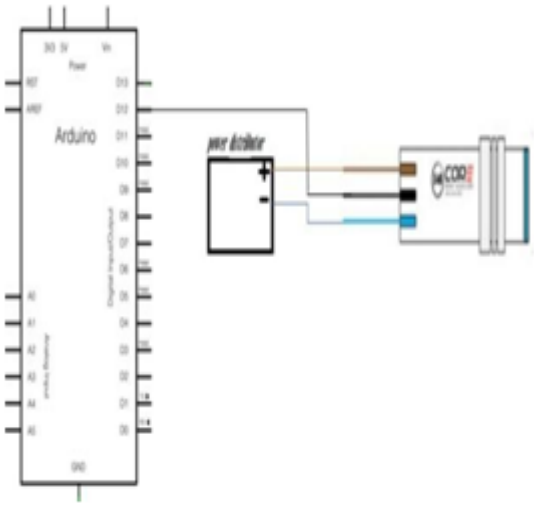

Fig. 5 Sensor Interfacing

Sensor has three pins brown color pin is positive power, blue color pin is ground and black color pin is output.

2.1 Bluetooth Module:

Bluetooth is a remote systems administration innovation that is utilized for transmission and reception of the data over a short scope of separations. It is an imperceptible wire that associates various gadgets. Interfacing a few gadgets frames a Piconet which is a small scale system of unmistakable radio waves conveying between gadgets. The transmitting waves of Bluetooth are short that is around 15 meter span. Likewise, it has a frequency of 2.4-2.8 GHz which falls under ISM band[1]. A Bluetooth utilizes a spread range of Frequency Hopping full duplex sign at a pace of 1600 hops for each second.

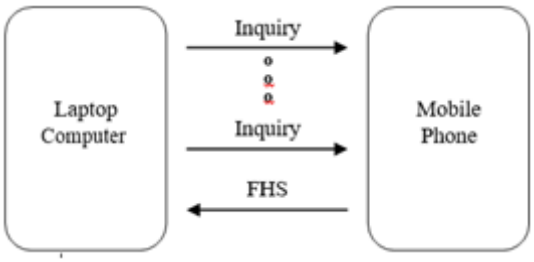

Fig. 6 Discovering a Bluetooth Device

It has 5 pins that are: VCC and Ground which both combined together gives power to the module. Tx and Rx pins- that are used to communicate via Serial communication. Key/State- that is used to bring the module in A/D command mode, which is not usually used. We are able to communicate serially by having set the Module to a baud rate of 9600.

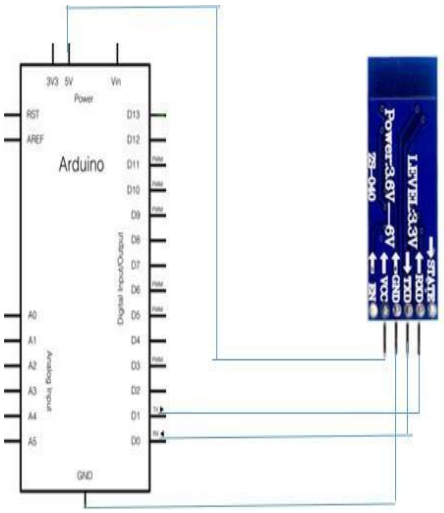

Fig. 7 Interfacing of Bluetooth Module

So, the module here is powered by connecting VCC to 5V pin of Arduino. For the data transmission purposes, Tx of the module is connected to Rx of Arduino and the Rx of the module to the Tx.

2.1 DC Motors:

DC motor chips away at the guideline of Fleming's left hand rule as shown in figure 8[2]. At the point when a present conductor is set in a magnetic field, it encounters some power in a specific way. The fundamental development of a DC motor contains a current conveying armature that is associated with the supply through commutator sections and brushes. The armature is put among North and South shaft of electromagnet[13]. If we supply DC via commutator system, the current will start to flow. Its heading is given by Fleming's left hand decide which expresses that when thumb, pointer and centre fingers of the left hand are spread out to such an extent that they are at 90 degrees with one another, and if the thumb finger focuses to the course of the mechanical current, the pointer finger focuses to the attractive field, at that point the centre finger speaks to the bearing of current.

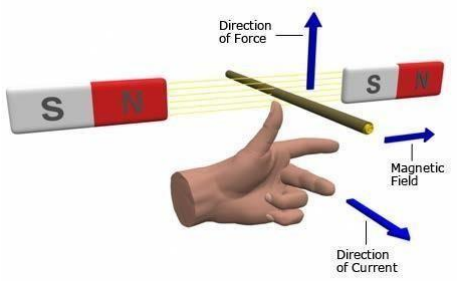

Fig. 8 Fleming's Left Hand Rule

Specifications:

- RPM (Revolutions per minute): It represents the number of revolutions a shaft takes in one minute.
- No-load Speed: It is the speed of the motor when there is no load attached to it.
- Stall Torque: A torque that is produced when the output speed is zero is Stall torque.
- Maximum Current: The high endpoint of the current that the motor will be able to work. If the current limit is exceeded, the motor may get damaged.

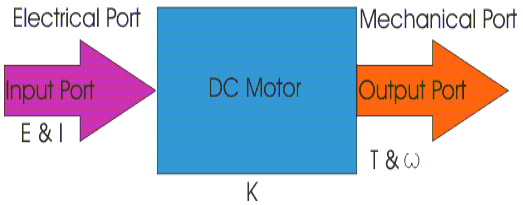

Fig. 9 DC Motor Working View

2.1 L298D Motor Driver IC:

This is driver IC that is used to control two motors simultaneously and independently so that it can rotate in any direction that it wants to. It has four outputs. Outputs 1 and 2 are connected to one motor and output 3 and 4 to the other. It can provide current up to 2A. These can be used to give higher input voltage to the motors if the voltage from the microcontroller is not sufficient.

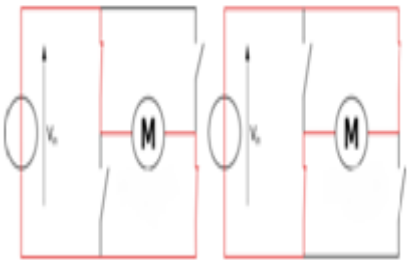

Fig. 10 H-bridge states

This motor driver works on the principle of the h-bridge circuit. One h-bridge circuit can control one motor. So there are two h-bridge circuits present in this motor so as to control two motors simultaneously[9]. H-bridge consists of four switches say s1, s2, s3, s4. When s1 is on and s3 is off, then the motor is rotated in one direction. Similarly, when s2 is on and s4 is off, the motor is rotated in the opposite direction.

Table 1 Operation of Motor Driver

Input1	Input2	Input3	Input4	Motor State
1	0	0	1	Clockwise rotation
0	1	1	0	Anticlockwise Rotation
0	0	0	0	Idle [High Impedence State]
1	1	1	1	Idle

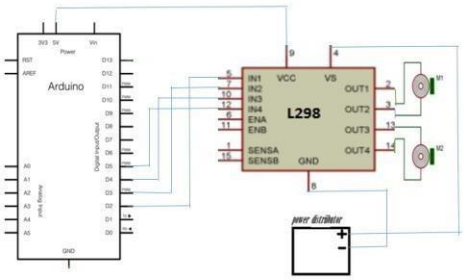

Fig. 11 Interfacing with L298

The four input pins of the Motor Driver are connected to any of the digital pins of Arduino. While the four output pins to DC Motors. Depending upon the signals from the Arduino, the Motors will move.

2.1 Servo Motor:

Servo engine circle includes a control circuit, shaft, amplifier and an encoder as shown in figure 12[10]. It is an independent electrical gadget that pivots the parts with high exactness and accuracy. The yield shaft of this motor can be moved to a specific point that a regular engine doesn't. The servo engines comprise of normal motors which couple with a sensor for feedback to control rotational speed and position. This engine can be controlled with an analog or digital signal. The encoder here goes about as a sensor is utilized to give this feedback of position.

Fig. 12 Servo Motor

It is very lightweight with high output power. This servo can pivot 90 toward every path. Likewise, based on the sort of current, the servos can be orders as either AC or DC kind of servo engines. Well the main contrast between them is their capacity to control speed. The speed in the DC engine is corresponding to the supply voltage. In an AC engine, speed is controlled by the recurrence. However both these engines are utilized in Servo, yet AC can withstand higher flows and are usually utilized where high exactness is required. Servo engines deal with the guideline of Pulse Width Modulation. PWM is a circuit that has a comparator which compares the modulating signal and Saw Tooth Generator signals.

The below table 2 shows the number of pins of a Servo motor and their working.

Pin Configuration:

Wire Number	Wire Color	Description
1	Brown	Ground wire connected to the ground of system
2	Red	Powers the motor typically +5V is used
3	Orange	PWM signal is given in through this wire to drive the motor

Table 2 Pin configuration of Servo Motor

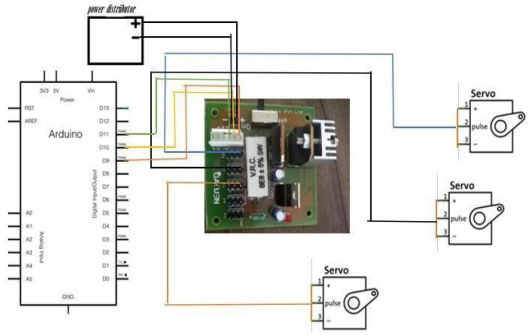

Fig. 13 Interfacing with Servo Motor

2.1 Flow Chart:

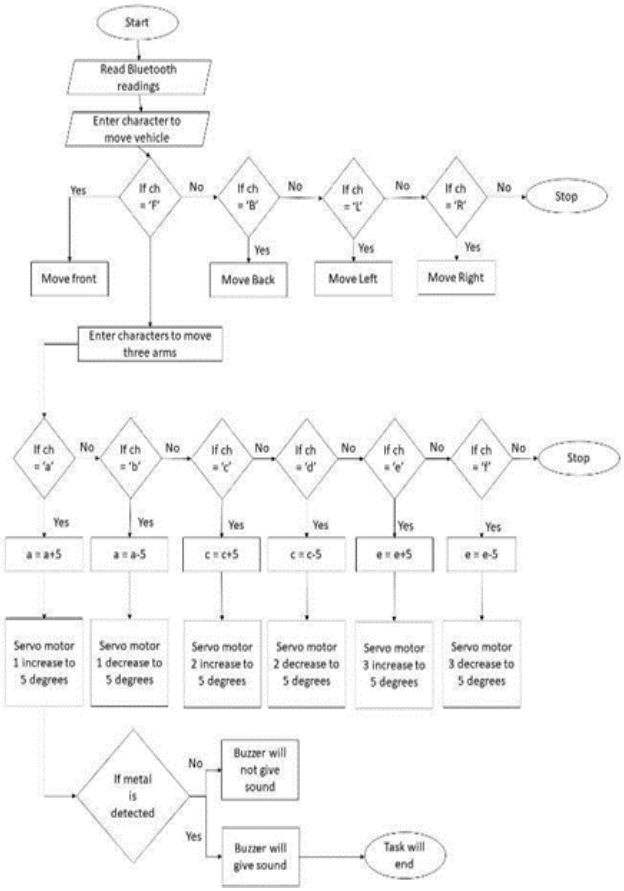

Fig. 14 Flow Chart

Arduino reads the data through the Bluetooth module. If we enter F, the vehicle is supposed to move forward, B for Backward, L for Left and R for the right direction. This is done with the help of 'My Robolab Robot' application that is to be installed on the mobile.

Here we have 3 Servo motors. A character has to be entered from a mobile device. If the entered character is 'a', the Servomotor 1 is increased by 5 degrees, for 'b', the Servomotor 1 is decreased by 5 degrees, for character 'c', the Servomotor 2 is increased by 5 degrees, for character 'd', the Servo motor 2 is decreased by 5 degrees, for character 'e', the Servomotor 3 is increased by 5 degrees and if the character 'f' is entered, then the Servomotor 3 is made to decrease by 5 degrees. The Proximity Sensor fixed, will detect the presence of any metallic material. If metal is made in contact with the sensor, a Buzzer sound is made.

III. RESULT

The power supply is given to the entire system using a LiPo battery. Here the robotic vehicle is controlled using Bluetooth. By giving certain commands from the mobile, like F(Front), B(back), L(Left), R (Right), the vehicle is made to move. These movements are made possible by programming the Arduino.

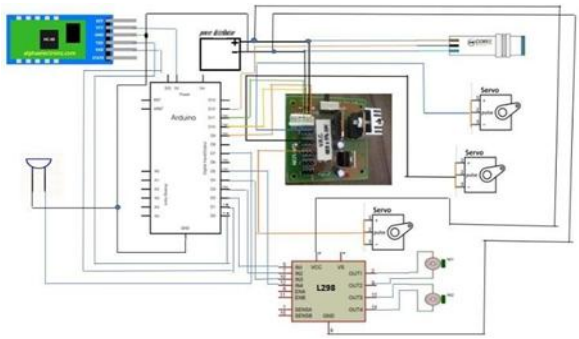

Fig 15 Interfacing Unit

So in order for the vehicle to move, 2 base motors are used. In order to provide sufficient voltage for the motors i.e. 12V, an L298 motor driver is used. This driver will be able to provide the amount of voltage required to both the motors at a time. This helps in the process of movement of the vehicle.

In order to make a certain angle movement with the arm, Servomotors are been installed. Servo motors help in making the move up to the certain required amount of angles only. We have used 3 Servomotors in this project.

Again the commands can be given through mobile. Various characters for various movements of the motor are used.

3.1 RESULT:

Programming is done with the help of Arduino IDE. Arduino IDE, an open source software is used in order to communicate with the hardware.

Here the logical code is composed and the procedure of compilation is likewise done to check for any syntactical mistakes. The language utilized in Arduino IDE and is basically the more simpler type of C. And the functions and libraries utilized are totally written in C/C++. Along these lines, it is simply C/C++ and barely any basic languages. Additionally, Java can be utilized to communicate with the Arduino board.

Fig. 16 Arduino programming

The above figure 16 shows the programming screen that is used in this project.
The sketch is the program code composed for Arduino. Arduino IDE is the product essentially utilized for writing sketches. The Arduino IDE consists of the following parts in it:

- Text editor: This is the major area where the actual logical programming is written.
- Message area: In this area, any error regarding syntaxes or any messages such as saving and uploading are displayed here.
- Toolbar: Various buttons such as Upload for dumping the code to Arduino, verify for verifying the code, New for the new page are all present in this bar.

It has two primary loops.

void setup(): Where all the input and output pins are to be declared.

void loop(): Where the logical program is written.

Fig 17 Servo motor with Driver IC

Fig 17 shows the Servo motor with Servo connections. The power supply connections were giver from the power distribution board.

Servo Motors has 3 pins Brown, Red and Orange. Brown pin which is a ground pin connected to the ground of the Servo Motor Driver IC. The red colour wire is used to power the Servo motor. Typically 5V of supply is used. Orange colour pin to which PWM signals are given to drive the motor.

There are three Servo Motors used in this project. the commands can be given through mobile such as on pressing the character ‘a’, the first servo motor increases its angle by 5 degrees. Similarly, on entering the character ‘b’, the Servo motor 1 decreases its angle by 5 degrees. Similarly, on pressing the character ‘c’ increases the angle by 5 degrees of the second Servo, by pressing the character ‘d’, decreases the angle by 5 degrees of second Servo. By pressing the character ‘e’, increases the angle by 5 degrees of third Servo and by pressing the character ‘f ’ from the mobile application, it decreases the angle by 5 degrees if the third Servo.

A Servo Driver is used through which all the three Servo motors are connected. It is powered from the power distribution board. And this is able to provide power for all the Servo motors at a time. Following Fig 18 shows the connections of DC motors to the L298 Driver which is interfaced with the Arduino. The power distribution board is also shown that supplies power to the Arduino.

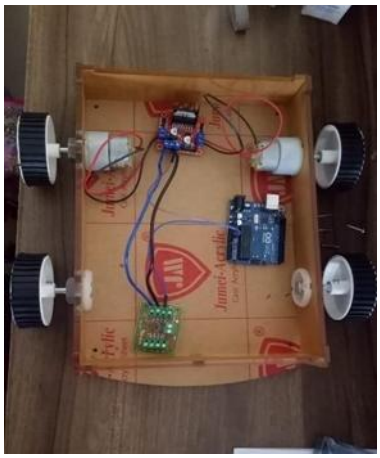

Fig 18 Motor Connections

By giving certain commands such as an alphabet ‘F’ from the mobile, the vehicle is made to move forward. Similarly command ‘B’ for making the vehicle to move Backward, ‘R’ for the vehicle to make a Right turn and ‘L’ for the vehicle to make a left turn. These movements are made possible by programming the Arduino.

These movements are possible with the help of Bluetooth Module that is also interfaced with the Arduino. And the characters are given from the mobile using ‘My Robolab Robo’ application.

Fig. 19 Dumping the program

As shown in the figure, we use the Arduino IDE for programming the Arduino. It is system independent that means it can be operated on any platform. Figure 19 shows how the program is dumped to the Arduino.

This is done with the help of a USB 2.0 cable which is very commonly used to transmit the data from PC to Arduino.

Fig. 20 Mine Detection Robot

In figure 20, the vehicle is made to move on DC Motors, the sensor is fixed at the third Servo i.e. at the tip of the arm. This is called an Inductive Proximity sensor. This sensor is interfaced with Arduino. This sensor is used to detect the presence of any metallic materials present in rocks or any other materials. It has an LED at the bottom which blinks when a metal is detected.

A Buzzer is also interfaced with the Arduino. This is connected in accordance with the Sensor. So when the sensor detects any metal. This produces a buzzing sound. And when no metal is detected, then this also doesn't produce any buzzing sound.

This robot comes into great use to human life by decreasing their effort by working in uneven area and conditions. Since we've used the devices like Proximity sensor and Motors that has got good precision values, the output is also considerably accurate. Using Arduino made its code very easy to understand. Also, it has a robust structure and consists of less weight. Servo motors are used here to make the arm movements and DC Motors for the movement of the vehicle, a Proximity Sensor to detect for the presence of any metal.

Applications

- Used in bomb squads.
- Used for crime operations like surgical strikes and military operations.
- These are used to detect the presence of any metallic minerals present in rocks.

IV. CONCLUSION:

The below tabular form 3 shows the functioning of the vehicle in accordance with the commands given from mobile application.

Command from application	Outcome
F	Forward movement of the robot
B	Reverse movement of the robot
L	Make a left turn
R	Make a right turn
a	Increment the Servo motor 1 by 5 degrees
b	Decrement the Servo motor 1 by 5 degrees
c	Increment the Servo motor 2 by 5 degrees
d	Decrement the Servo motor 2 by 5 degrees
e	Increment the Servo motor 3 by 5 degrees
f	Decrement the Servo motor 3 by 5 degrees
S	Stop the movement

Table 3 Functioning of Vehicle

This project was experimented both indoors and outdoors several times to check its functioning. Upon experimenting, the buzzer triggered only when it is bought under the contact of a metallic substance and a buzzing sound is made. This helps us to identify the metallic objects nearby. The vehicle can move easily on uneven surfaces without putting many efforts. This project will give us access to identify the metallic substances available within the Earth's core without causing much of environmental pollution and not endangering human life.

Future Scope

During its design, we examined that there were chances for the battery to drain out easily and may cause any trouble during the working process. So by adding a solar panel that can help in charging the batteries may add an extra feature to this project and reduce its limit[8].

Also if a gas sensor is installed here, it can provide even better feature as it helps the miners to detect the harmful gases that may erupt suddenly and thereby reducing the risks.

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