A

Project Report On

"Smart Human Following Trolley"

Submitted to **Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur** in the partial fulfilment of the requirements of the Degree of

Bachelor of Engineering

in

Electronics & Communication Engineering

by

Khushali Illarkar | **Aditya Raut**

Aditya Dixit | **Chetan Sawarkar**

Rajat Parate

Under the guidance of

Dr.P.R.Bokde

Priyadarshini Bhagwati College of Engineering,

Nagpur (M.S.)

Department of Electronics & Communication Engineering

Session: 2023-24

Priyadarshini Bhagwati College of Engineering, Nagpur.

Department of Electronics & Communication Engineering

Session: 2023-24

Certificate

This is certify that the seminar report entitled **"Smart Human Following Trolley"** is a bonafied work done under our guidance to

Khushali Illarkar **Aditya Raut**

Aditya Dixit **Chetan Sawarkar**

Rajat Parate

and is submitted to **Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur** in the partial fulfilment of the requirements for the Degree of **Bachelor of Engineering** in **Electronics & Communication Engineering.**

Dr.P.R.Bokde
Project Guide

Dr.S.B.Dhoble
Seminar In-charge

Dr. D. M. Kate
Head of Deptt.

Dr. N. K. Choudhari
Principal

ACKNOWLEDGEMENT

Many people have contributed in bringing this report to its present form. I am the Presenter ascribe my success in this venture to my guide Dr.P.R.Bokde and seminar In charge Dr.S.B.Dhoble, Assistant Professor of Electronics & Communication Engineering Department, P.B.C.O.E. They endeavor for perfection, indefatigable zeal, enthusiasm, foresight and innovation contributed in a big way in completing this report with considerable ease in the stipulated time.

I am also grateful to Ms. D. M. Kate, H.O.D. of Electronics & Communication Engineering Department, P.B.C.O.E. The enthusiastic feedback from her was instrumental improving the presentation and in establishing my confidence in the structuring of the material. I also thank to the entire teaching and the Non-teaching staff of the Department for their co-operation.

We express our admirations for Dr. (Mrs.) A.R. Chaudhari, Dean Academics ,

P. B. C. O. E. for her valuable advice and support throughout this venture.

My sincere thanks are extended to Dr. N. K. Choudhari, Principal, P.B.C.O.E. for constantly encouraging and helping me during the course.

Last but not least, my thanks are extended to all my friends and colleagues, those who gave me inspiration, those who gave their constructive ideas and also those who criticized me for my flaws, which finally made this report, see the light of the day.

Khushali Illarkar

Aditya Raut

Aditya Dixit

Chetan Sawarkar

Rajat Parate

ABSTRACT

In this modern age, due to its abundant applications in everyday life and manufacturing, Human Following robots have been researched and actively developed over the decades. Different techniques such as robot control algorithm, human target detection, and obstacle avoidance are necessary for the human robot to execute. Several human-following robotic procedures have been suggested, such as the use of ultrasonic sensors, fire sensor, voice recognition sensor camera charging-coupled devices (CCD) and so on. These technologies can detect the particular location between a mobile robot and a human. In this paper, we present a new approach to detecting the location of a human robot using an ultrasonic & camera, which is the fundamental technique in the robot's human follow-up. In our project, the robot is equipped with an ultrasonic sensor which captures and detects an individual. A simple application implemented in real time using a PI controller shows some advantages of the proposed method.

CONTENTS

LIST OF ABBREVIATIONS

UGV	Unmanned Ground Vehicles
AUV	Autonomous Underwater Vehicle
UAV	Unmanned Aerial Vehicles
I/O	input/output
PWM	Pulse width modulation
TTL	Time-To-Live
LED	Light Emitting Diode
DC	Direct Current
IDE	Integrated Development Environment
RPM	Revolutions per minute
GNU	GNU's Not Unix.
SLAM	Simultaneous localization and mapping

LIST OF FIGURES AND TABLES

1 INTRODUCTION

Humanoid robots, robots with an anthropomorphic body plan and human-like senses, are enjoying increasing popularity as research tool. More and more groups worldwide work on issues like bipedal locomotion, dexterous manipulation, audio-visual perception, human-robot interaction, adaptive control, and learning, targeted for the application in humanoid robots.

These efforts are motivated by the vision to create a new kind of tool: robots that work in close cooperation with humans in the same environment that we designed to suit our needs. While highly specialized industrial robots are successfully employed in industrial mass production, these new applications require a different approach: general purpose humanoid robots. The human body is well suited for acting in our everyday environments. Stairs, door handles, tools, and so on are designed to be used by humans. A robot with a human-like body can take advantage of these human-centered designs. The new applications will require social interaction between humans and robots. If a robot is able to analyze and synthesize speech, eye movements, mimics, gestures, and body language, it will be capable of intuitive communication with humans. Most of these modalities require a human-like body plan. A human-like action repertoire also facilitates the programming of the robots by demonstration and the learning of new skills by imitation of humans, because there is a one-to-one mapping of human actions to robot actions.

Last, but not least, humanoid robots are used as a tool to understand human intelligence. In the same way biomimetic robots have been built to understand certain aspects of animal intelligence, humanoid robots can be used to test models of aspects of human intelligence.

Addressing all of the above areas simultaneously exceeds the current state of the art. Today's humanoid robots display their capabilities in tasks requiring a limited subset of 2 skills. After some brief historical notes, this article will review the state-of the- art in humanoid robotics and discuss possible future developments.

A robot is a mechanical device that can perform tasks automatically. It may – but need not – be humanoid in appearance. Some robots require some degree of guidance, which may be done using a remote control, or with a computer interface. A robot is usually an electro-mechanical machine that is guided by a program or circuitry. Robots can be autonomous, semi-autonomous or remotely controlled and range from humanoids such as ASIMO and TOPIO to Nano- robots, 'swarm' robots, and industrial robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own. The branch of technology that deals with robots is called robotics.

Machinery was initially used for repetitive functions, such as lifting water and grinding grain. With technological advances more complex machines were developed, such as those invented by Hero of Alexandria in the 1st century AD, and the automata of Al-Jazari in the 12th century AD. They were not widely adopted as human labour, particularly slave labour, was still inexpensive compared to the capital-intensive machines.

As mechanical techniques developed through the Industrial age, more practical applications were proposed by Nikola Tesla, who in 1898 designed a radio-controlled boat[2]. Electronics evolved into the driving force of development with the advent of the first electronic autonomous robots created by William Grey Walter in Bristol, England in 1948. The first digital and programmable robot was invented by George Devol in 1954 and was named the Unimate. It was sold to General Motors in 1961 where it was used to lift pieces of hot metal from die casting machines at the Inland 3 Fisher Guide Plant in the West Trenton section of Ewing Township, New Jersey. [2] Robots have replaced humans in the assistance of performing those repetitive and dangerous tasks which humans prefer not to do, or are unable to do due to size limitations, or even those such as in outer space or at the bottom of the sea where humans could not survive the extreme environments. Some people have developed an awareness of potential problems associated with autonomous robots and how they may affect society. Fear of robot behaviour, such as the Frankenstein complex, drive current practice in establishing what autonomy a robot should and should not have.

The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots There is no consensus on which machines qualify as robots but there is general agreement among experts, and the public, that robots tend to do some or all of the following: move around, operate a mechanical limb, sense and manipulate their environment, and exhibit intelligent behavior — especially behavior which mimics humans or other animals.

There is no one definition of robot which satisfies everyone and many people have their own. For example Joseph Engelberger, a pioneer in industrial robotics, once remarked: "I can't define a robot, but I know one when I see one." According to the encyclopedia Britannica a robot is "any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner." Merriam-Webster describes a robot as a "machine that looks like a human being and performs various complex acts (as walking or talking) of a human being", or a "device that automatically performs complicated often repetitive tasks", or a "mechanism guided by automatic controls".

2 THEORETICAL BACKGROUND

Person-following scenarios can be classified as ground, underwater, or aerial depending on the means of operation. The canonical example of a person following is **ground service** robots following a human while performing a cooperative task. Such assistant robots are used in a variety of domestic and industrial applications, as well as in health care. **Diver-following** robots can also be used for submarine pipeline and shipwreck inspection, marine life and seabed monitoring, and a variety of other underwater exploratory research activities. Besides, the use of per- son-following **aerial robots** has grown over the last decade as quadcopters have gotten to be well known for filming open air activities such as mountain climbing, biking, surfing, and numerous other sporting endeavours. /1/

2.1 Ground Scenario

Domestic assistant robots and shopping-cart robots are the most common examples of person-following UGV (Unmanned Ground Vehicles). Their usage in several other industrial applications also in health care and military applications are also increasing in recent times. /1/

Figure 1. Domestic assistant /1/

Figure 2. Shopping cart robot /1/

2.2 Underwater Scenario

Underwater missions are often conducted by a team of human divers and autonomous robots who cooperatively perform a set of common tasks. The divers typically lead the tasks and interact with the robots which follow the divers at certain stages of the mission. These situations arise in important applications such as the inspection of ship hulls and submarine pipelines, the study of marine species migration, search-and-rescue, or surveillance. In these applications, following and interacting with the companion diver is essential because fully autonomous navigation is challenging due to the lack of radio communication and global positioning information underwater. Additionally, the human-in-the-loop guidance reduces operational overhead by eliminating the necessity of teleoperation or complexmission planning a priori. /1/

Figure 3. An underwater robot is following a diver /1/

2.3 Aerial Scenario

Unmanned Aerial Vehicles (UAV), also known as drones, are traditionally used for industrial or military applications. More recently, UAVs have become more accessible and popular for entertainment purposes and in the film industry. They are very useful for capturing sports activities such as climbing or skiing from a whole new perspective without the need for teleoperation or a full-scale manned aerial vehicle. Another interesting application is to use person-following UAVs to provide external visual imagery, which allows athletes to gain a better understanding of their motions. These popular use-cases have influenced significant endeavour in research and development for affordable UAVs, and they have been at the fore- front of person-following aerial drone industry in recent times. /1/

There are many types of robots but in this paper, a prototype of a ground human following robot is demonstrated that uses Arduino Uno with some sensors for detection and driven with four DC motors.

Figure 4. A UAV is filming a sport activity while intelligently following an athlete /1/

Figure 5. A UAV is filming an athlete from various viewpoints /1/

3 SYSTEM COMPONENTS

3.1 Core

Arduino Uno and L293D Driver Shield are the brain of this project. They are presented in more detail in the following sections.

3.1.1 Arduino Uno

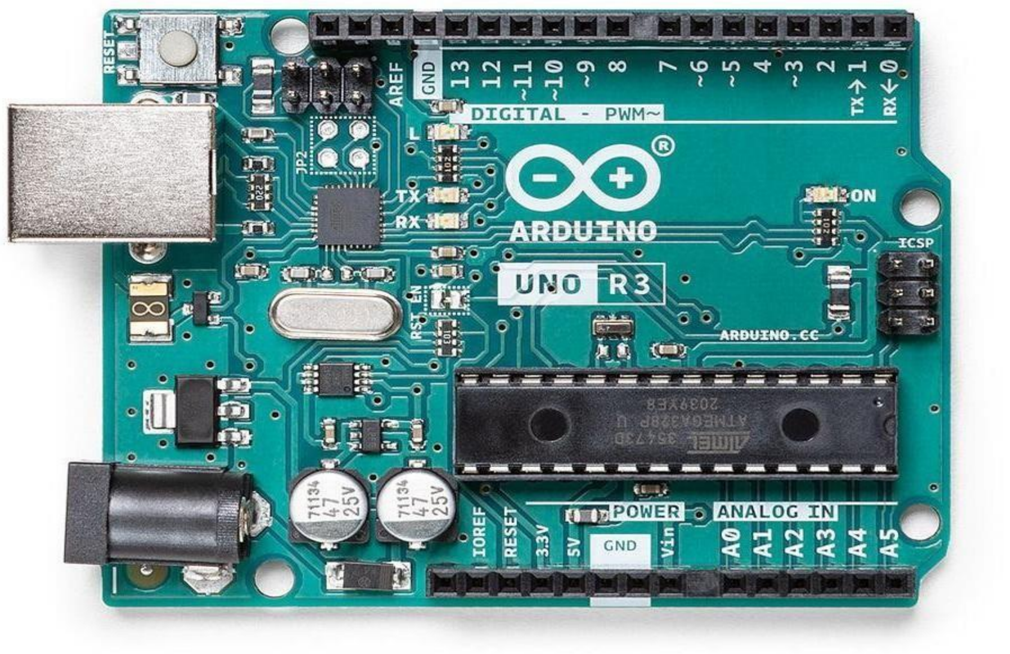

Figure 6. Arduino Uno /2/

Arduino Uno is an open-source microcontroller board based on the Microchip AT-mega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog I/O pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable ofPWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Inte-grated Development Environment), via a USB B 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 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. /2/

3.1.2 Arduino L239D Motor Driver Shield

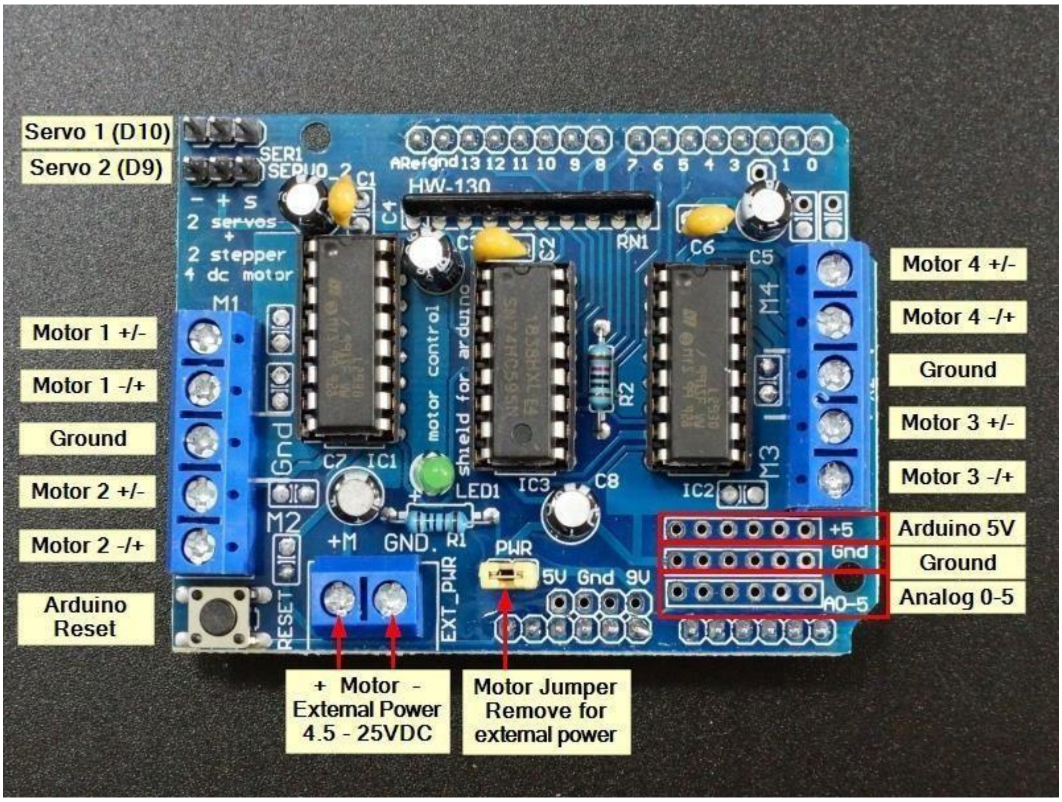

Figure 7. Arduino L293D Motor Driver Shield /3/

The L293D is a fourfold high-stream half-H driver. It will be required for bidirectional drive floods at range 600-mA at voltages from 4.5 V to 36V. The two gadgetscan drive inductive weights like trades, solenoid, DC and bipolar meandering engines, also for the higher- current/high-voltage stocks in sure stock applications.

Every yield is a finished request hierarchy of leadership driven circuits, as well as a Darlington semiconductor sinker as well as Pseudo-Darlington sources. The driver is occupied with sets, with drivers 1 and 2 empowered by 1,2EN and drivers3 and 4 empowered by 3,4EN. Precisely that the draw in inputs is higher, then the associated drivers are empowered, the yields are dynamic along the stage as well as information sources. Whenever this connect with inputs are lower, the driver would disable, along the yields were off & could be high-impedance state. Within then fitting information input, every set at the driver traces a full-H (structure) reversed drives reasonable to solenoids or engine application. /3/

3.2 Detection

We used two fundamental sensors for object detection: the HCSR04 ultrasonic sensor and the IR infrared sensor.

3.2.1 Ultrasonic sensor HCSR04

Figure 8. Ultrasonic Sensor HC-SR04 /4/

The HC-SR04 is a non-contact ultrasound sonar device that consists of two ultrasonic transmitters (basically speakers), a receiver, and a control circuit for measuring distance to an object. The transmitters send out a 40kHz ultrasonic pulse that travels through the air and bounces off nearby solid objects or obstacles, and the receiver listens to any return echo. The control circuit then analyzes the echo to determine the timing difference between the transmitted and received signals. This time may then be used to calculate the distance between the sensor and the reflected object using some smart arithmetic.

3.2.2 DHT 11 (Temperature Humidity Sensor)

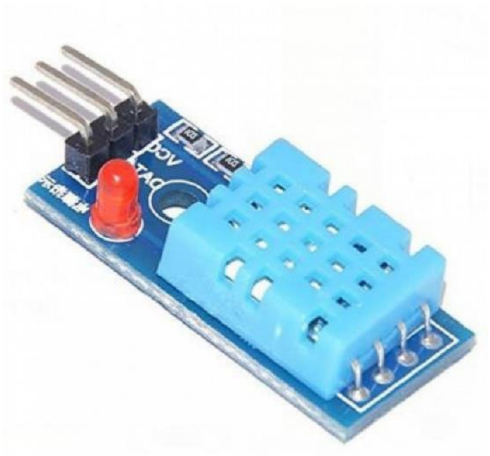

Figure 9. DHT 11 (Temperature Humanity Sensor) /5/

The DHT11 is a digital temperature and humidity sensor that is widely used in various projects for environmental monitoring. It comes with the capability to measure both temperature and humidity levels in the surrounding environment. What distinguishes it from some other sensors is its provision of digital output, which facilitates easier integration with microcontrollers like Arduino, Raspberry Pi, etc.

Internally, the DHT11 comprises a capacitive humidity sensing element and a thermistor for temperature measurement. These components are complemented by an integrated signal conditioning circuitry, ensuring accurate and reliable digital output. Moreover, its communication with external devices is streamlined through a single-wire digital interface, which simplifies the wiring process and conserves resources on the microcontroller.

In terms of communication protocol, the DHT11 utilizes a straightforward approach. prompted by the microcontroller, it sends out a start signal, after which it transmits the measured temperature and humidity data. This simplicity in operation contributes to the sensor's popularity, especially among hobbyists and DIY enthusiasts, owing to its affordability and ease of use.

3.2.3 Buzzer

Figure 10. Buzzer

A buzzer is an electronic device commonly used to produce sound or an audible alert in various applications. It consists of a piezoelectric element or an electromagnetic coil that generates vibrations when an electrical current is applied to it. These vibrations produce sound waves, creating the audible sound emitted by the buzzer.

In simpler terms, when an electrical signal is provided to the buzzer, it causes the buzzer's component (either a piezoelectric element or an electromagnetic coil) to vibrate rapidly. This vibration generates sound waves in the air, resulting in the audible sound produced by the buzzer. By controlling the electrical signal supplied to the buzzer, such as varying the voltage or frequency, the intensity and tone of the sound produced can be adjusted.

3.2.4 Fire Sensor

A fire sensor, also known as a flame detector or fire detector, is a device designed to detect the presence of fire or flames in its vicinity. These sensors are crucial components in fire alarm systems, safety equipment, and industrial processes where the risk of fire is present.

The primary function of a fire sensor is to detect specific indicators of fire, such as heat, smoke, or flames, depending on its design and technology. Some fire sensors use optical sensors to detect the characteristic patterns of flames or smoke particles in the air, while others rely on temperature sensors to detect rapid increases in temperature associated with fires.

Once a fire sensor detects the presence of fire or flames, it typically triggers an alarm or activates other safety measures, such as sprinkler systems, fire suppression systems, or ventilation systems to contain or extinguish the fire and alert occupants to evacuate the area.

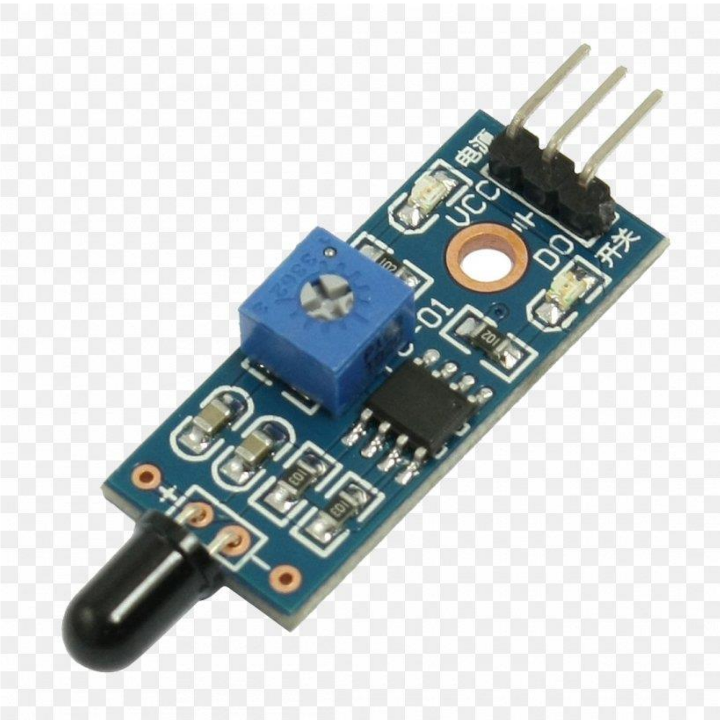

Figure 11. Fire Sensor

3.2.5 I2C Display

Figure 12.I2C Display

An I2C display, also known as an I2C LCD or I2C OLED display, is a type of screen that communicates with other devices using the I2C (Inter-Integrated Circuit) protocol. Unlike traditional displays that require many pins to connect with a microcontroller or other hardware, an I2C display requires only two wires for communication, which makes it easier to connect and use in projects.

Internally, an I2C display consists of a display controller and the actual screen (LCD or OLED). The display controller manages the screen's operations, such as refreshing the display and interpreting commands from the connected device. The screen itself can vary in size and type, ranging from simple alphanumeric LCDs to more advanced graphical OLED displays.

Communication between the microcontroller and the I2C display occurs over the I2C bus, which consists of two signal lines: Serial Data (SDA) and Serial Clock (SCL). The microcontroller sends commands or data to the display by transmitting them over the SDA line while synchronizing with the clock signal on the SCL line.

To use an I2C display, the microcontroller needs to be programmed to communicate with it using the I2C protocol. This typically involves sending specific commands or data packets to the display controller, instructing it to update the screen with text, graphics, or other information.

One advantage of using an I2C display is its simplicity of wiring and reduced pin usage, which can be beneficial in projects with limited available pins or where space is a concern. Additionally, since the I2C protocol allows multiple devices to communicate over the same bus, you can easily add multiple I2C devices to your project without needing additional pins for each device.

Overall, I2C displays are popular in various electronics projects, including Arduino and Raspberry Pi-based projects, DIY electronics, robotics, and IoT applications, thanks to their ease of use, versatility, and minimal wiring requirements.

3.3 Movement

In order to make the robot move itself, wheels, TT direct circuit motor, and servo motor were used. The TT DC motor manipulated the direction of robot movement. It controlled independently four wheels of robot that it could mimic any 4-wheel behavior that could enable the robot to turn in any direction.

Figure 13. Wheel

3.3.1 TT DC Motor

A DC motor is a device that transforms any sort of energy into mechanical energy tomake something move. A motor plays an important role in the construction of a robotsince it allows the robot to move.

The robot is driven by four DC motors in this scenario. The gearmotors used require a voltage of 4.5V with a no-load cur- rent of 190mA while possessing a gearbox ratio of 48:1 and a wheel speed of 140RPM unloaded. /8/

Figure 14. TT DC motor /8/

3.4 Power

3.4.1 18650 Li-on Battery

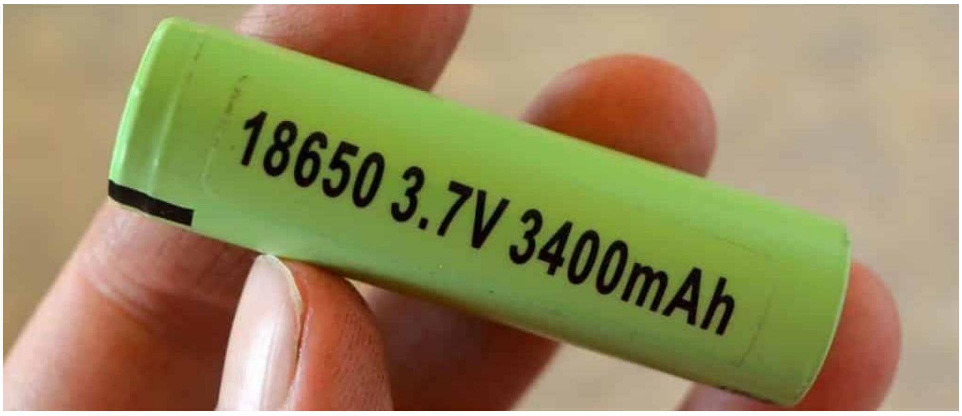

Figure 15. 18650 Li-on Battery/10/

An 18650 is a lithium-ion rechargeable battery. Their proper name is “18650 cell”. The 18650 cell has voltage of 3.7v and has between 1800mAh and 3500mAh (milli-amp-hours). 18650s may have a voltage range between 2.5 volts and 4.2 volts, or a charging voltage of 4.2 volts, but the nominal voltage of a standard 18650 is 3.7volts. There are two types: protected and unprotected. In this project we used protected type. /10/

18650 protected batteries have an electronic circuit. The circuit is embedded in the cell packaging (battery casing) that protects the cell from “over charge”, heat or “over discharge”, over current and short circuit. An 18650 protected battery is safer than an 18650 unprotected battery (less likely to overheat, burst or start on fire). /11/

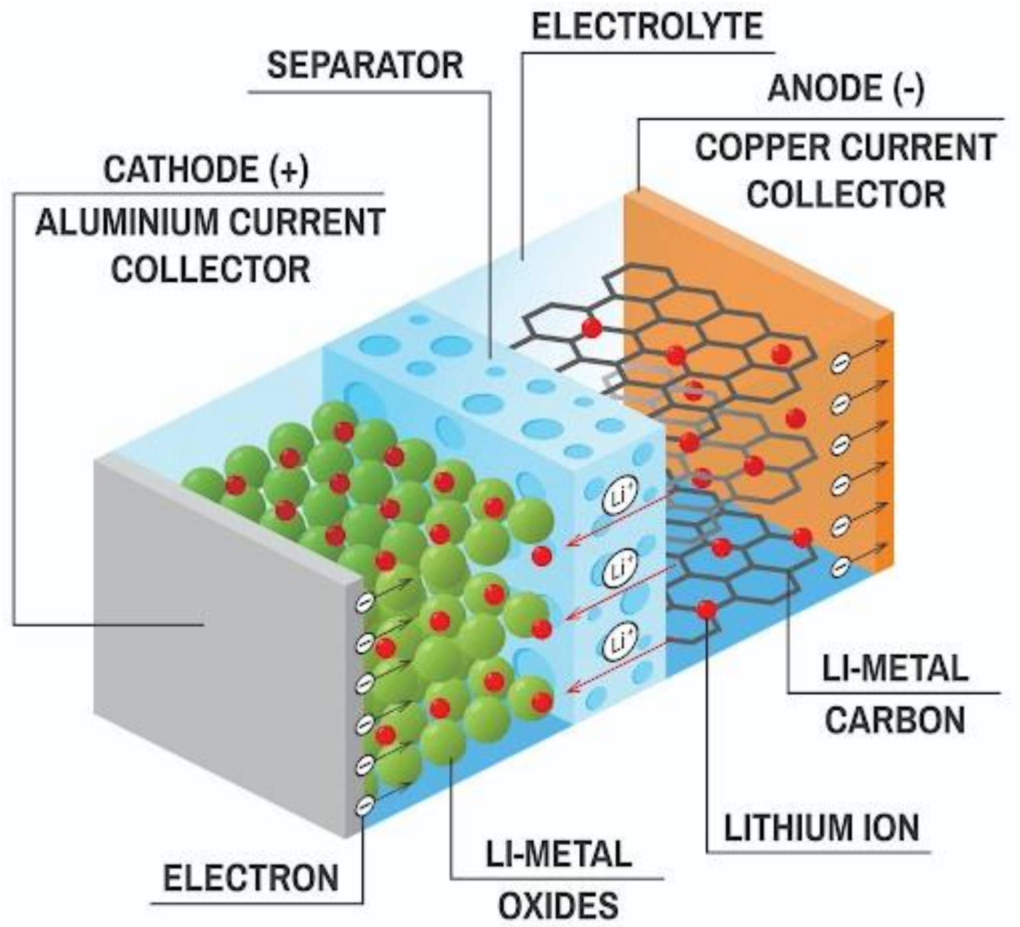

Figure 16. Inside 18650 Battery /11/

4 METHODOLOGY

A human following robot has two building stages: **hardware** and **software**.

4.1 Hardware

Our system is made up of a four-wheel robotic vehicle with its own microprocessor and control unit, as well as various sensors and modules, such as ultrasonic sensors and infrared sensors, which help them to follow people and objects in their surroundings. The aforementioned sensors work in coordination with each other to helpthe robot operate and navigate its path by avoiding obstacles and maintaining a specificdistance from objects. Ultrasonic sensors were used to avoid obstacles and keep objects at a specific distance. Two infrared sensors on both sides are used to detect orientation.

4.2 Ultrasonic Sensor Principle

This ultrasonic sensor is mounted on the robot's top, and a pair of IR sensors are mounted on either side of it. We used an ultrasonic sensor to avoid obstacles and keep the object at a fixed distance. The ultrasonic sensor has a range of 4 meters and is extremely accurate. Ultrasonic sensors operate by calculating the times differences. When an object is detected by infrared radiations, the beam from the transmitter returns to the receiver with an angle after reflection, also known as method of triangulation. This helps in the calculation of the distance travelled by the robot and eliminates any further errors in the robotic movement due to dis-placement. IR sensor controls the movement of motors and ultrasonic sensor de-tects the obstacle and stops the motors.

4.3 L293D Motor Driver

To have full control over the DC motor, we must control the DC motor speed and rotation direction. By combining these two methods, this can be accomplished.

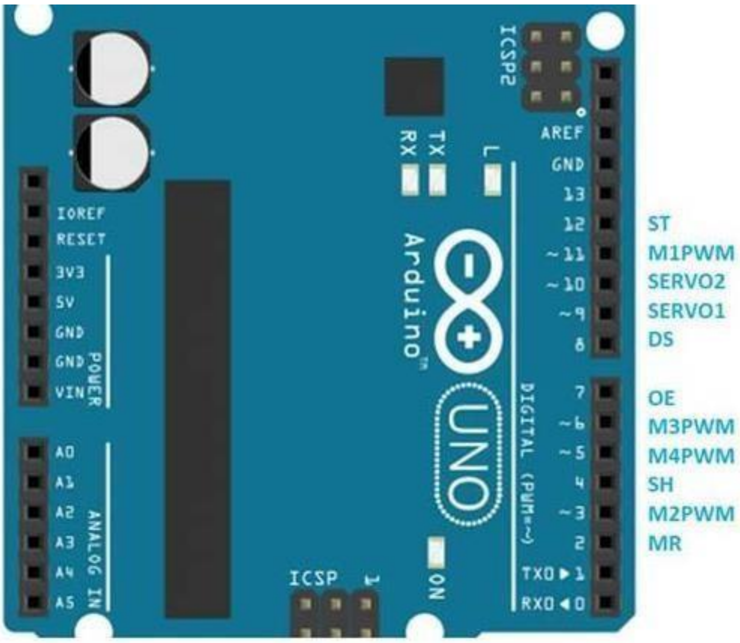

Figure 17. Pin mapping

Those pins in **APPENDIX 1** connect follow the above figure 16.

ST, **DS**, **OE**, **SH**, and **MR** is used for driving Shift Register. **M1PWM**, **M2PWM**, **M3PWM**, and **M4PWM** are used for controlling DC motor speed. If DC motor speed controlling is not necessarily making these pins HIGH. **SERVO1** and **SERVO2**for Servo Motors.

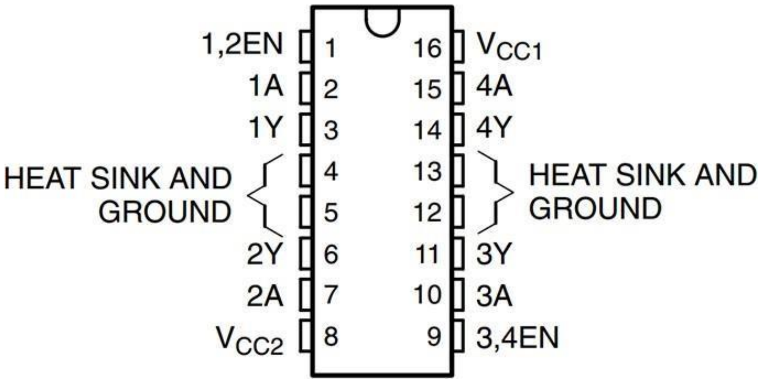

Figure 18. L293D pin function /12/

Pin	Name	Function
1	Enable1,2	Enable pin to control 1,2 driver
2	Input 1A	Input to control 1Y
3	Output 1Y	Output, connect to motor
4	GND	Ground and heat sink
5	GND	Ground and heat sink
6	Output 2Y	Output,connect to motor
7	Input 2A	Input to control 2Y
8	Vcc2	Output supply voltage
9	Enable3,4	Enable pin to control 3,4 driver
10	Input 3A	Input to control 3A
11	Output 3Y	Output, connect to motor
12	GND	Ground and heat sink
13	GND	Ground and heat sink
14	Output 4Y	Output, connect to motor
15	Input 4A	Input to control 4Y
16	Vcc1	Supply voltage(7 max)

Table 1. Pin Function

4.3.1 PWM for Speed Controlling

The speed of a DC motor can be controlled by varying its input voltage. A common technique for doing this is to use Pulse Width Modulation (PWM)

PWM is a technique where average value of the input voltage is adjusted by sending a series of ON-OFF pulses. The average voltage is proportional to the width of the pulses known as Duty Cycle**.** The higher the duty cycle, the greater the average voltage being applied to the DC motor (High Speed) and the lower the duty cycle, the less the average voltage being applied to the dc motor (Low Speed). /8/

Figure 18 illustrates the PWM technique with various duty cycles and average voltages.

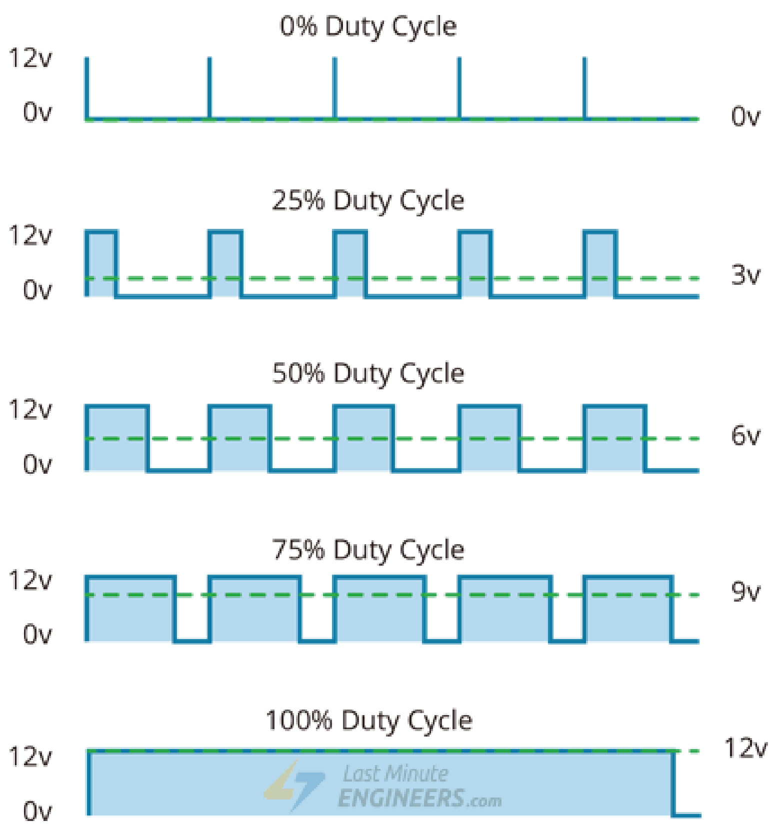

Figure 19. Pulse Width Modulation (PWM) Technique /8/

4.3.2 H-Bridge for Rotation Direction Control

The rotation direction of the DC motor can be controlled by changing polarity of its input voltage. A common technique for doing this is to use an H-Bridge. An H-Bridge circuit contains four switches with the motor at the center forming a letter "H" arrangement.

Closing two particular switches at the same time reverses the polarity of the voltage applied to the motor. This causes change in spinning direction of the motor. /8/

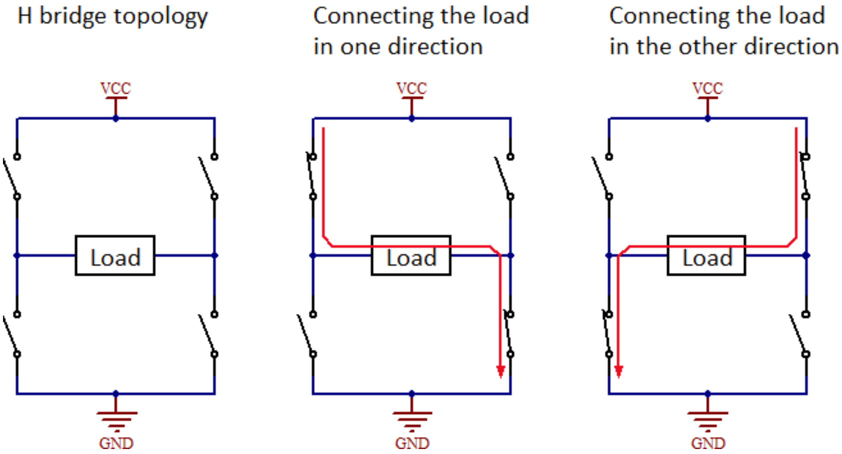

Figure 20. H-Bridge circuit

An H-bridge is a circuit configuration used to control the direction of rotation of a motor. It consists of four switches arranged in an H configuration, with the motor connected between the switches. By toggling the switches in specific combinations, you can control the direction of the current flow through the motor, hence controlling its rotation direction.

This setup allows for forward, reverse, braking, and off states of the motor. Control signals from a microcontroller or other control circuitry dictate the switch states to achieve the desired motor operation. H-bridges are commonly used in robotics, RC vehicles, and automation systems for precise motor control.

H-bridges are commonly used in robotics, RC vehicles, automation systems, and many other applications where precise control over motor direction and speed is required. They offer an efficient way to control motor direction with relatively simple circuitry.

4.4 Circuit Diagram

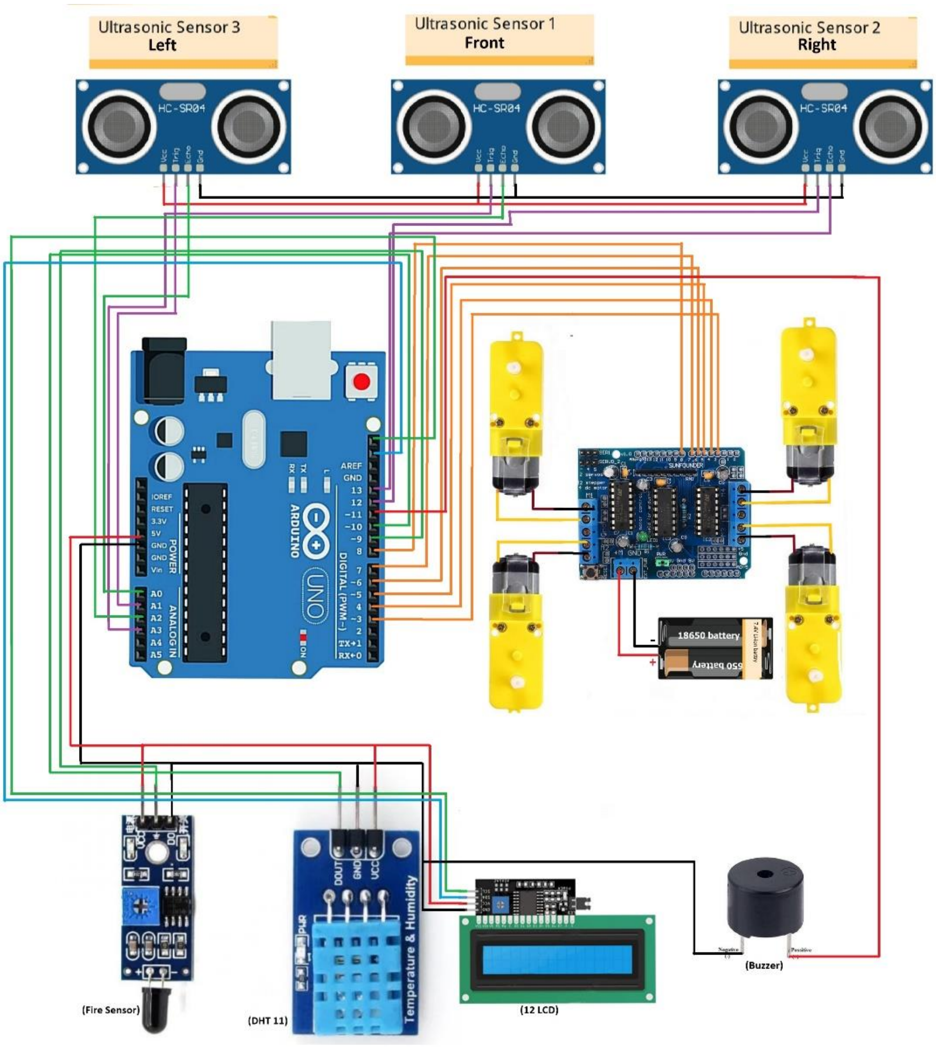

Figure 21. Circuit diagram

4.5 Software

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, mac OS, Linux) that is written in the Java programming language. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the C and C++ languages 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. The 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 board's firmware.

A human-following software is a type of program or algorithm designed to enable a robot or autonomous system to track and follow human movement or commands. It utilizes sensors such as cameras, LiDAR, or depth sensors to detect the presence and movements of humans in its environment. The software processes the sensor data in real-time to determine the direction and speed of human movement relative to the robot's position. Based on this analysis, the robot adjusts its own movements to follow the human accordingly. This technology is commonly used in various applications such as service robots, autonomous vehicles, and surveillance systems.

The software relies on input from various sensors, such as cameras, LiDAR (Light Detection and Ranging), depth sensors, or a combination of these technologies. These sensors capture information about the environment, including the presence of humans and their movements. Initially, the software processes the sensor data to detect and recognize human shapes or features within the environment.

4.5.1 Programming

```
#include <AFMotor.h>
#include <DHT11.h>
DHT11 dht11(10);
#include <Wire.h>
#include <LiquidCrystal_I2C.h>


// Set the LCD address to 0x27 for a 16 chars and 2 line display
LiquidCrystal_I2C lcd(0x27, 16, 2);

#define FIRE 9  // FIRE sensor connected to DIGITAL pin D9 of Arduino Uno:
#define DHT 10   // DHT sensor connected to DIGITAL pin D10 of Arduino Uno:
#define buzzer 11 // BUZZER connected to DIGITAL pin d11 of Arduino Uno:
AF_DCMotor motor1(1); // Motor 1 connected to M1
AF_DCMotor motor2(2); // Motor 2 connected to M2
AF_DCMotor motor3(3); // Motor 3 connected to M3
AF_DCMotor motor4(4); // Motor 4 connected to M4

const int trigPinFront = A3; // Ultrasonic sensor front
const int echoPinFront = A2;

const int trigPinLeft = A1; // Ultrasonic sensor left
const int echoPinLeft = A0;

const int trigPinRight = 2; // Ultrasonic sensor right
const int echoPinRight = 13;

void setup() {

  Serial.begin(115200);
        // initialize the LCD
          lcd.init();
        // Turn on the blacklight and print a message.
        lcd.backlight();
     pinMode(FIRE, INPUT); //set FIRE PIN as an input:
```

```
  pinMode(buzzer, OUTPUT);  //set BUZZER PIN as an OUTPUT:
  pinMode(trigPinFront, OUTPUT);
  pinMode(echoPinFront, INPUT);

  pinMode(trigPinLeft, OUTPUT);
  pinMode(echoPinLeft, INPUT);

  pinMode(trigPinRight, OUTPUT);
  pinMode(echoPinRight, INPUT);
  digitalWrite(buzzer, LOW);

}

void loop() {
  int fireSensorValue = digitalRead(FIRE);


 // Condition 1: FIRE sensor triggered
  if (fireSensorValue == LOW) {
    digitalWrite(buzzer, HIGH);  // Turn on buzzer
    lcd.clear();                 // Clear LCD
    lcd.print("Fire Detected");   // Display message on LCD
    Serial.println("Fire Detected"); // Print message to serial monitor
    delay(2000);                 // Wait for 2 seconds
  } else {
    digitalWrite(buzzer, LOW);    // Turn off buzzer
  }


    int temperature = 0;
    int humidity = 0;

    // Attempt to read the temperature and humidity values from the DHT11 sensor.
    int result = dht11.readTemperatureHumidity(temperature, humidity);


    if (result == 0) {
        Serial.print("Temperature:");
```

```
      Serial.print(temperature);
      Serial.print("°C\tHumidity:");
      Serial.print(humidity);
      Serial.println("%");

      lcd.setCursor(0, 0);
      lcd.clear(); // Clear the display
      lcd.print("Temperature:");
      lcd.print(temperature);
      lcd.print("C");
      lcd.setCursor(1, 1);
      lcd.print("Humidity:");
      lcd.print(humidity);
      lcd.print("%");
        delay(10);
  } else {
      // Print error message based on the error code.
      Serial.println(DHT11::getErrorString(result));
        //lcd.print("Hello, world!");
  }

// Measure distances
long durationFront, distanceFront;
long durationLeft, distanceLeft;
long durationRight, distanceRight;

digitalWrite(trigPinFront, LOW);
delayMicroseconds(2);
digitalWrite(trigPinFront, HIGH);
delayMicroseconds(10);
digitalWrite(trigPinFront, LOW);
durationFront = pulseIn(echoPinFront, HIGH);
distanceFront = (durationFront * 0.0343) / 2;

digitalWrite(trigPinLeft, LOW);
delayMicroseconds(2);
digitalWrite(trigPinLeft, HIGH);
delayMicroseconds(10);
```

```
  digitalWrite(trigPinLeft, LOW);
  durationLeft = pulseIn(echoPinLeft, HIGH);
  distanceLeft = (durationLeft * 0.0343) / 2;

  digitalWrite(trigPinRight, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPinRight, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPinRight, LOW);
  durationRight = pulseIn(echoPinRight, HIGH);
  distanceRight = (durationRight * 0.0343) / 2;

  // Print distances
  Serial.print("Front: ");
  Serial.print(distanceFront);
  Serial.print("cm   Left: ");
  Serial.print(distanceLeft);
  Serial.print("cm   Right: ");
  Serial.println(distanceRight);

  // Adjust movement based on distances
  if (distanceFront < 400 && distanceLeft > 20 && distanceRight > 20 && distanceFront > 
50) {
    forward();
  } else if (distanceFront > 10 && distanceLeft > 10 && distanceRight < 100 && 
distanceRight < 30 ) {
    turnRight();
  } else if (distanceFront > 10 && distanceLeft < 100 && distanceRight > 10 && 
distanceLeft < 30 ) {
    turnLeft();
  } else if (distanceFront < 20 && distanceLeft > 10 && distanceRight > 10) {
    backward();
  } else {
    stop();
  }

}

void forward() {
```

```
  motor1.setSpeed(150);
  motor1.run(BACKWARD);
  motor2.setSpeed(150);
  motor2.run(BACKWARD);
  motor3.setSpeed(150);
  motor3.run(BACKWARD);
  motor4.setSpeed(150);
  motor4.run(BACKWARD);
  //digitalWrite(buzzer, HIGH);
}
void backward() {
  motor1.setSpeed(150);
  motor1.run(FORWARD);
  motor2.setSpeed(150);
  motor2.run(FORWARD);
  motor3.setSpeed(150);
  motor3.run(FORWARD);
  motor4.setSpeed(150);
  motor4.run(FORWARD);
  digitalWrite(buzzer, HIGH);
delay(1000);
digitalWrite(buzzer, LOW);
}


void turnLeft() {
  motor1.setSpeed(150);
  motor1.run(FORWARD);
  motor2.setSpeed(150);
  motor2.run(FORWARD);
  motor3.setSpeed(150);
  motor3.run(BACKWARD);
  motor4.setSpeed(150);
  motor4.run(BACKWARD);
   digitalWrite(buzzer, HIGH);
 delay(1000);
}
```

```
void turnRight() {
  motor1.setSpeed(150);
  motor1.run(BACKWARD);
  motor2.setSpeed(150);
  motor2.run(BACKWARD);
  motor3.setSpeed(150);
  motor3.run(FORWARD);
  motor4.setSpeed(150);
  motor4.run(FORWARD);
   digitalWrite(buzzer, HIGH);
  delay(1000);
}

void stop() {
  motor1.setSpeed(0);
  motor1.run(RELEASE);
  motor2.setSpeed(0);
  motor2.run(RELEASE);
  motor3.setSpeed(0);
  motor3.run(RELEASE);
  motor4.setSpeed(0);
  motor4.run(RELEASE);
  digitalWrite(buzzer, LOW);
}
```

4.6 Difficulty

Suppose there are two targets like **Figure 33**, target A and target B. First, the robotis following target A and suddenly target B passes between the robot and target A. At that time the robot will lose the track of target A and detect target B. Finallythe robot will switch to follow target B instead of the original target which is A.

To fix this problem, in the future work, a target-centric approach is adopted. First,the locally sensed information is used to create a partial map of the environment; traditional SLAM-based techniques are most commonly used for this purpose (Ahnet al., 2018; Cosgun et al., 2016). Robot creates a 3D (depth) map of the partially observed environment in order to find the optimal path for person-following (Sky-dio, 2018). Such reactive path planning sometimes leads to non-smooth trajectories, particularly if the person moves fast in a zigzag trajectory (Tarokh and Merloti,2010). Anticipatory planning, i.e., predicting where the person is going to be next and planning accordingly, can significantly alleviate this problem and thus widely used in practical applications (Nikdel et al., 2018; Tarokh and Shenoy, 2014; Hoeller et al., 2007).

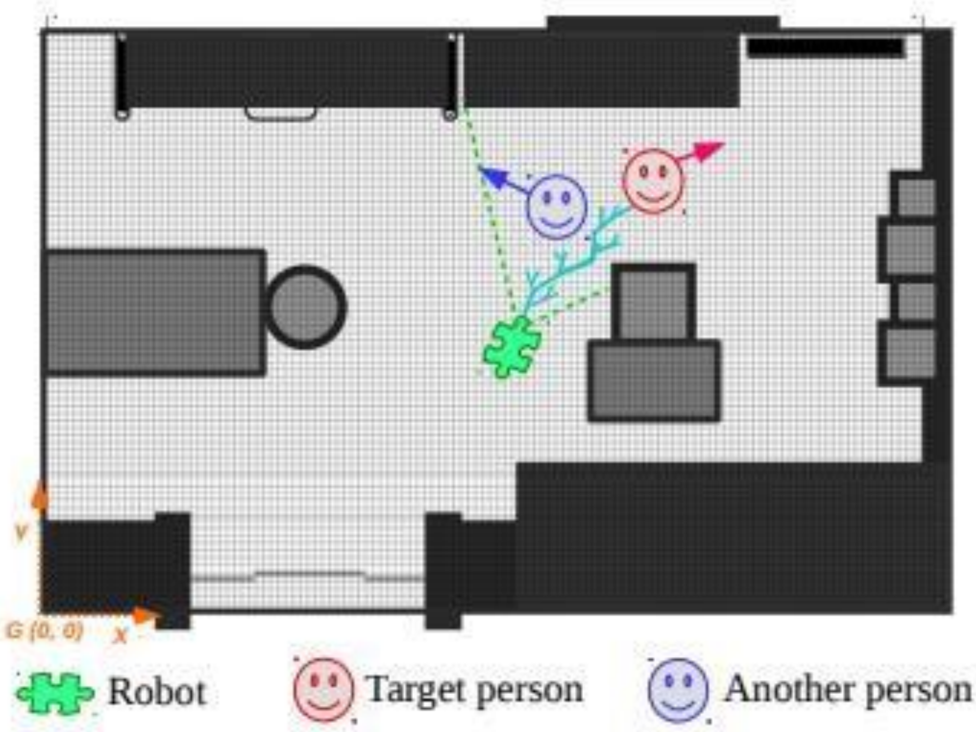

Figure 33. The robot follows the wrong object

4.7 Result

Several experiments were carried out, and the performance of the human follow-ing robot was evaluated. The ultrasonic and infrared sensors were tested. It was discovered that the sensor was accurate within a range of 4 meters. Then we ran the test to see if the robot kept a specific distance from the target object. The serial communication between Arduino, motor shield, and various motors was then tested. We made the necessary changes to the processing and control algorithm based on the results of these tests and experiments. Following the completion, we discovered that the results were very satisfying, with the robot perfectly following the person wherever it went. As a result, the goal of implementing a good Human-Robot interaction was met.

4.7.1 Advantages

The robot can work around the clock and be more accurate than humans in orderto save time, minimize staff and increase productivity. Code compatibility and scalability across different Arduino boards is also a definite advantage In addition,the ultrasonic sensor has a large range and can be used in any lighting conditions.

The schematic of Arduino is open source. So, for future enhancements to the project, the board can be expanded to add more hardware capabilities.

4.7.2 Applications

When we look closely at the environment or our surroundings, we notice the need for such robots to help and serve people. Robots like this can be used for a variety of purposes. The robot can also be used as a human companion with a few modifications. This robot's possibilities are limitless, and also include assisting people in hospitals, libraries, airports, and other settings.

4.7.3 Future Work

The ultrasonic situating framework utilized in the execution of an individual following portable robot is a stable framework kept on the robot. The robot may neglect to follow the target if the objective individual deliberately moves out of this reach. What is more, while the robot is carrying out impediment aversion, the expansion in the bearing because of the rotating of the robot could be an issue. Itis worth noting that the robot will wander around in the weather until it finds theobjective sign again. A functioning ultrasonic situating framework might be an answer for this issue. The ultrasonic situating framework can keep up the view to the objective individual and keep following the sign in any event, when the robot is finishing a turn.

Another technique to determine this issue is to incorporate an assessment modelof the objective individual's movement in the calculation. The Kalman channel is one of the applications. Particularly when the objective individual goes out of the ultrasonic sensor cone, this system gives more precise data to the robot, so the robot can distinguish the objective sign again in a generally more limited time stretch. Thus, the general capacity of an individual following portable robot can bemade to work in a more adaptable way. The ultrasonic situating framework and the sonar sensor framework both utilize acoustic standards. Subsequently, the strength of the global positioning framework in a climate with sound-level clam- ours can be inspected later on work.

5 CONCLUSIONS

A successful implementation of a prototype of human following robot is illustratedin this paper. This robot does not only have the detection capability but also the following ability as well. While making this prototype it was also kept in mind thatthe functioning of the robot should be as efficient as possible. Tests were per- formed on the different conditions to pinpoint the mistakes in the algorithm and to correct them. The different sensors that were integrated with the robot pro- vided an additional advantage. The human following robot is an automobile system that has ability to recognize obstacle, move and change the robot's position toward the subject in the best way to remain on its track. This project uses Arduino, motors, different types of sensors to achieve its goal. This project challenged all the separate parts to cooperate with each other, communicate, and expand understanding of electronics, mechanical systems, and their integration withprogramming.

The significant point of this framework was to plan and develop a devotee auto- mated truck utilizing ultrasonic sensor which can follow the objective individual in unstructured conditions. The devotee automated truck is accomplished utilizing ultrasonic sensor, engine drivers and microcontroller. The framework gives an- other approach in the field of advanced mechanics. This truck would be useful in lessening work while playing out certain assignment. The follower automated truck has a better degree sooner rather than later.

6 REFERENCES

/1/ Md Jahidul Islam, Hong, Jungseok Hong and Sattar. 2015. Person Following by Autonomous Robots: A Categorical Overview. Access 22/02/2022.

https://www-users.cse.umn.edu/~islam034/papers/ijrr19_person.pdf/

/2/ Arduino Uno. Wikipedia, 2022. Accessed 22/02/2022. https://en.wikipedia.org/wiki/Arduino_Uno

/3/ L293D Motor Driver Shield. Protosupplies, 2022. Accessed 23/02/2022. https://protosupplies.com/product/l293d-v1-motor-driver-shield/

/4/ Ultrasonic Sensor HC-SR04. Piborg, 2022. Accessed 23/02/2022. https://www.piborg.org/sensors-1136/hc-sr04/

/5/ Infrared Sensor. Solarduino, 2022. Accessed 23/02/2022.

https://solarduino.com/infrared-ir-sensor-module-with-arduino/

/6/ Light Emitting Diodes. Accessed 27/02/2022. http://hyperphysics.phyastr.gsu.edu/hbase/Electronic/leds.html/

/7/ Stefan–Boltzmann law. Wikipedia. 2022. Accessed 23/02/2022. https://en.wikipedia.org/wiki/Stefan%E2%80%93Boltzmann_law/

/8/ TT DC Motor. 2022.Last minute engineers. Accessed 23/02/2022. https://lastminuteengineers.com/l293d-dc-motor-arduino-tutorial/

/9/ Servo motor. Quartzcomponents, 2022. Accessed 23/02/2022. https://quartzcomponents.com/products/tower-pro-sg90-servo-9-gms-minimicro-servo-motor/

/10/Neverman August. 2022. Everything You Need to Know About the 18650 Battery. Common-Sense-Home. Accessed 23/02/2022.

https://commonsensehome.com/18650-battery/

/11/ Danielle D. 2021. The ultimate guide to the 18650 Battery. Fenixlighting. Accessed on 23/02/2022.

https://www.fenixlighting.com/blog/the-ultimate-guideto-the-18650-battery/

/12/ L293D Motor Driver Shield. Sunfounder, 2018. Accessed 5/5/2022. http://wiki.sunfounder.cc/index.php?title=L293D_Motor_Driver_Shield/

/13/ Arduino IDE. Wikipedia, 2022. Accessed 22/02/2022. https://en.wikipedia.org/wiki/Arduino