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HUMAN FOLLOWING ROBOT

Technology and Communication
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ABSTRACT

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The purpose of this thesis was to create a robot following human movement with Arduino UNO. The goal was achieved by using one distance sensor and two infrared sensors. Each sensor played a critical part to detect human behaviours. To implement a complete motion, attached motor driver shield was used to control four motors by two L293D quadruple half-H drivers.

The code was written in C and Arduino IDE was used as a code editor integrated development environment. Ultrasonic sensor detected human in range to make the robot move forward. While two IR sensors triggered L293D drivers to turn left or right based on signal of IR sensors.

The robot was created that abled to detect and follow human as the final product of this thesis project. It could carry items and luggage as domestic assistant and shopping cart.

Keywords Artificial Intelligence, human following, IR sensor

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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

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1 INTRODUCTION

Over the last few years, robotic technology has evolved significantly that innovations were merely a utopian dream for some. The automation becomes first priority to any kind of works which gives the birth to robot. Robot is a programable, automation device that replace human intervention from basic daily activities to activities that people think it cannot be alternated like consultant or any field related to art. There are plenty of robots can assist multiple aspects of human life. Among those machine assistant, a robot that can detect and follow humans or obstacles within a certain range is known as a 'Human Following Robot'.

Human following Robot can co-exist and enhance the life quality of people. This robot presents as a carrier which deliveries items or packages in daily life in several places such as restaurant, hospital, shopping mall. When it comes to require more strength and speed, the robot can easily surpass the human limitation to acquire the goal more efficient and faster. For example, in military field, the weight of luggage and the harshness of topography types will definitely be a huge disadvantage for human. Thanks to this innovation, human intervention will reduce and be even more productive despite enormous difficulties appeared before.

The chapter 2 researched about application of this robot in three different environments.

2 DOCUMENTATION

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 person-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/

2.1 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 complex mission planning a priori. /1/

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

2.2 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 forefront 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

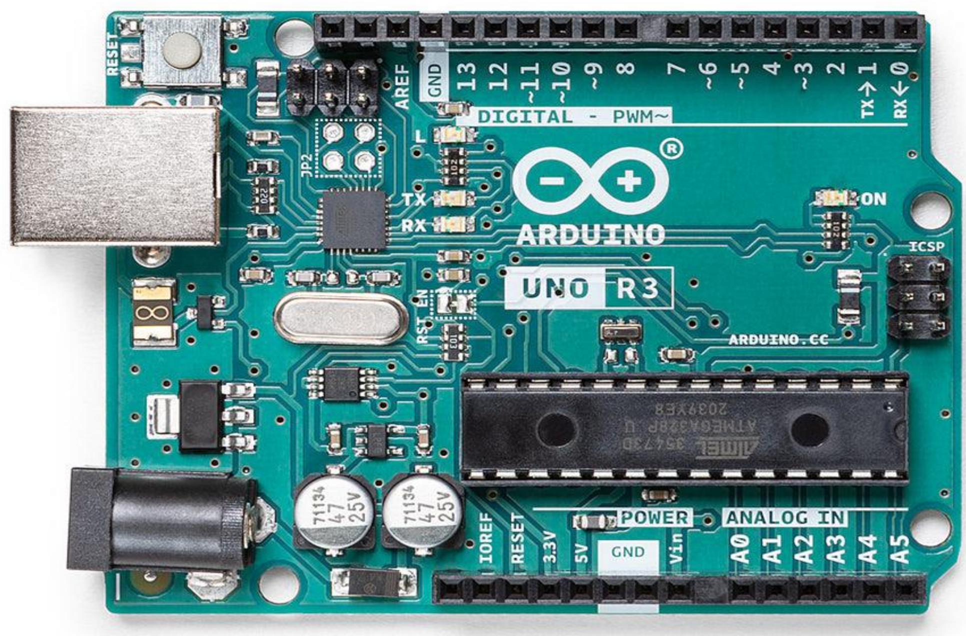


Figure 6. Arduino Uno /2/

Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P 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 of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated 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 L293D Motor Driver Shield

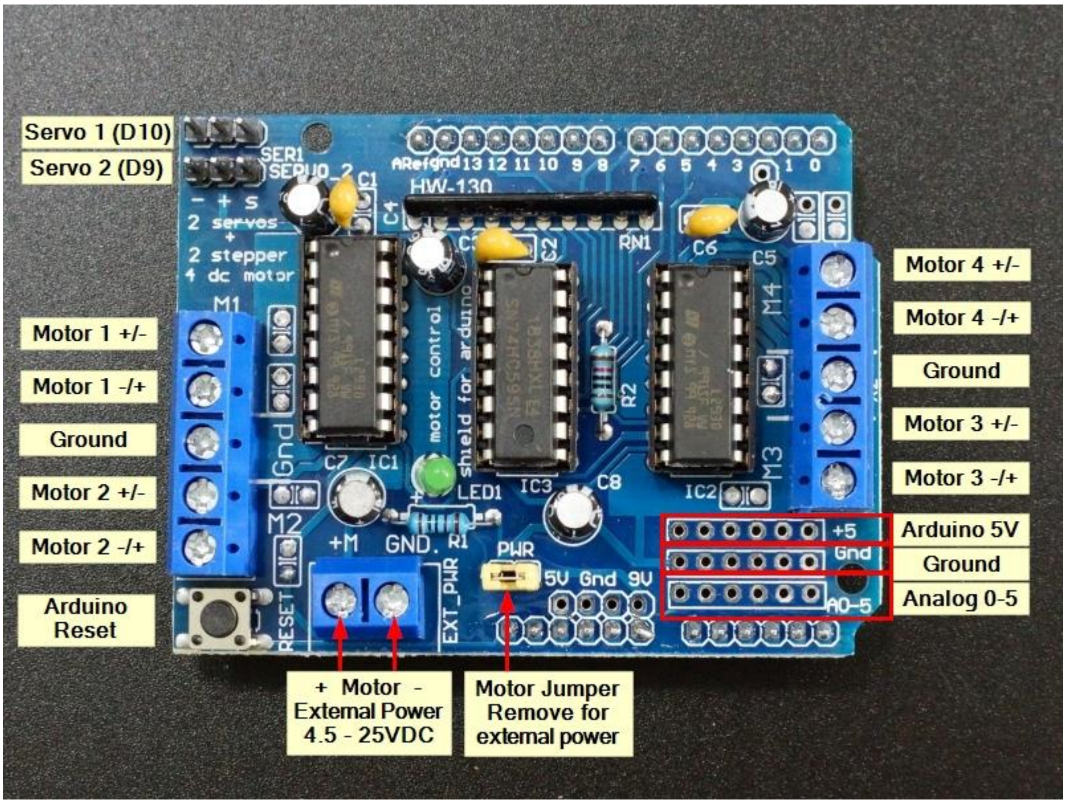


Figure 7. Arduino L293D Motor Driver Shield /3/

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 gadgets can 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 drivers 3 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. The distance can be estimated by multiplying the travel time by the sound speed. /4/

3.2.2 Infrared Sensor

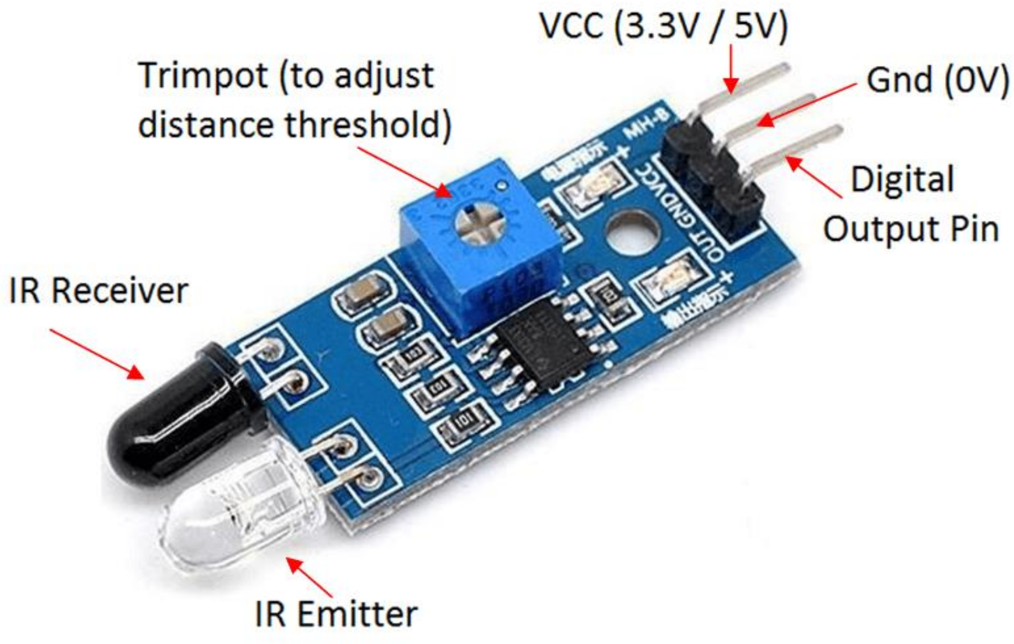


Figure 9. Infrared Sensor /5/

The infrared radiation is recognized by the using the infrared (IR) sensor. It is an electronics device where its functions are perceived infrared in surrounding area. William Herchel understood that the temperature of the red tone is the most significant during assessing this temperature for every shade light (segregated by a gem). As the recurrence is longer than that of perceptible light (anyway this point on a comparative electromagnetic reach), IR will be imperceptible for common eyes. Infrared radiation is sent by whatever produces heat (the temperature around five degrees Kelvin is least for everything).

When it is used as a combination of an IR transmitter and a receiver, the beneficiary's repetition should move closer to the transmitter. The beneficiary is an IR photodiode, and the transmitter is an IR LED. The infrared photodiode can be used with infrared light provided by an infrared LED. With respect to the infrared light captured, the square of the photograph diode and the difference in yield voltage are calculated. This is the terrible working standard of the IR sensor. When the infrared transmitter emits emanation, it is detected by the object, with a portion of the outflow reflecting back toward the infrared collector. The sensor yield can be set by the IR collector based on the reaction's power. /5/ /6/

The functional criteria of the infrared sensor is similar to that of the item identification sensor. The sensor fuses (IR LED) and (IR photodiode), and soon the two are connected to form an optocoupler. This true scientific law for sensors is sheet radiation, Stephen Boltzmann law. The Stefan–Boltzmann law describes the power radiated from a black body in terms of its temperature. Specifically, the Stefan–Boltzmann law states that the total energy radiated per unit surface area of a black body across all wavelengths per unit time (also known as the black-body radiant emittance) is directly proportional to the fourth power of the black body's thermodynamic temperature /7/.

IR LEDs are generally emitters that emit IR radiation. The LED is apparently similar to standard LEDs with radiation that not discernible for normal eyes. Infrared beneficiaries essentially use infrared emitters to sense radiation. These infrared receivers are accessible in a photodiode structure. Infrared photodiodes are classified as standard photodiodes because they basically see infrared radiation.

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 10. Wheel

3.3.1 TT DC Motor

A DC motor is a device that transforms any sort of energy into mechanical energy to make something move. A motor plays an important role in the construction of a robot since 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 current of 190mA while possessing a gearbox ratio of 48:1 and a wheel speed of 140 RPM unloaded. /8/

Figure 11. TT DC motor /8/

3.3.2 Servo Motor

A servomotor will be turning actuators or direct actuators that ponder exact control of other straight positions, speed & speed increment. This incorporates a legitimate motored coupled with sensors of positioned input. This requires an appropriately unusual regulator, reliably an submitted module masterminded unequivocally to utilize within the servomotor. The servomotor will be a shut circle servo mechanism that uses positions to investigate for last positions development & controlled. This obligation for the control will be a sign (direct & electronic) watching out for their positions prepared to the yield shaft.

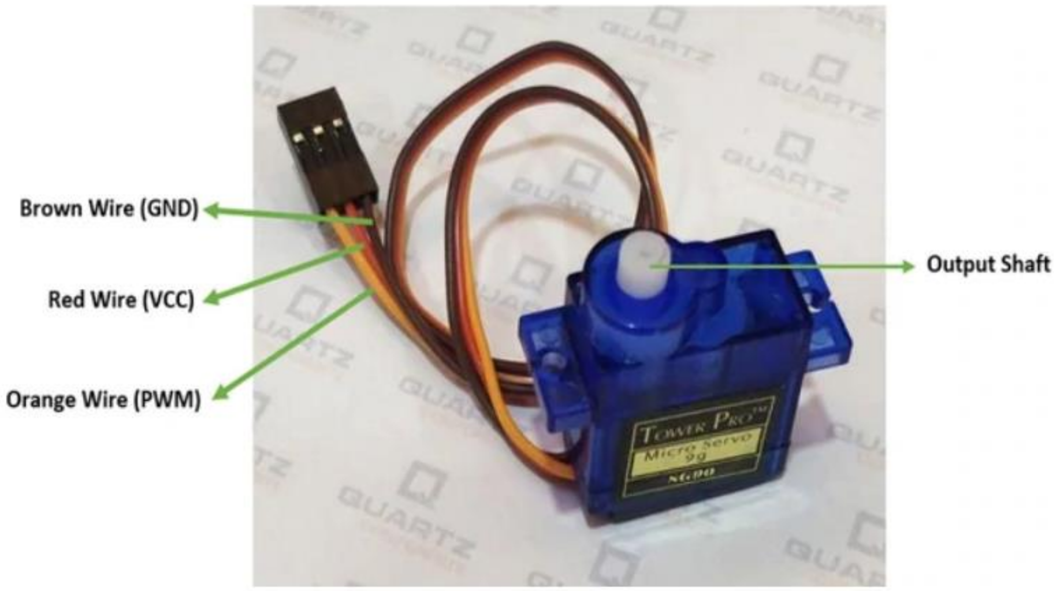


Figure 12. The tower pro SG90g /9/

For allotting coordinates and speeds examination, these motors are connected by a type of position encode. In any case, the position is essentially surveyed. The yield's purposeful situation varies depending on the soliciting position and the exterior responsibility for control. If the yield positions contrasts require it, a blunder signal is sent, which causes the engine to pivot in any scenario, depending on the condition to pass on the yield shaft for genuine position. As such a position approaches, this jumble of signals fades away for nothing as the engine comes to a halt. For this engine, the most obvious servomotors use positions, basically recognizing through a potentiometer and bang-bang control; then the engine reliably turns with the maximum gage (will halt). These types of servomotors are really not widely used in today's modern development controls, but they are the reason for the quick and simple servos used in radio-control models./9/

3.4 Power

To power the whole robot, we needed 2 18650 Li-on Batteries.

3.4.1 18650 Li-on Battery

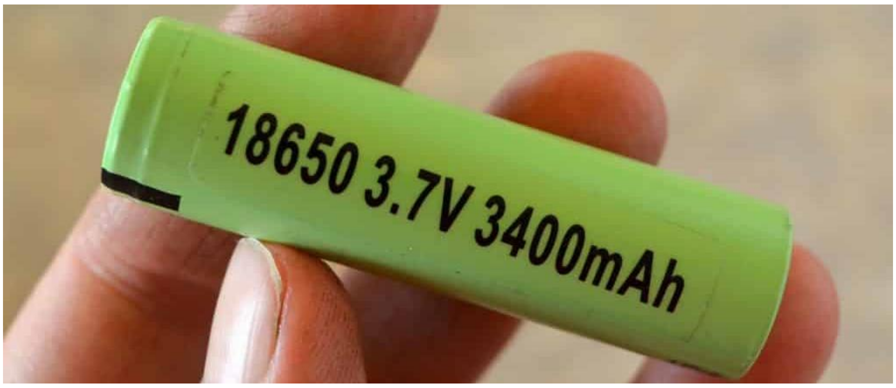


Figure 13. 18650 Li-on Battery /10/

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 3.7 volts. 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/

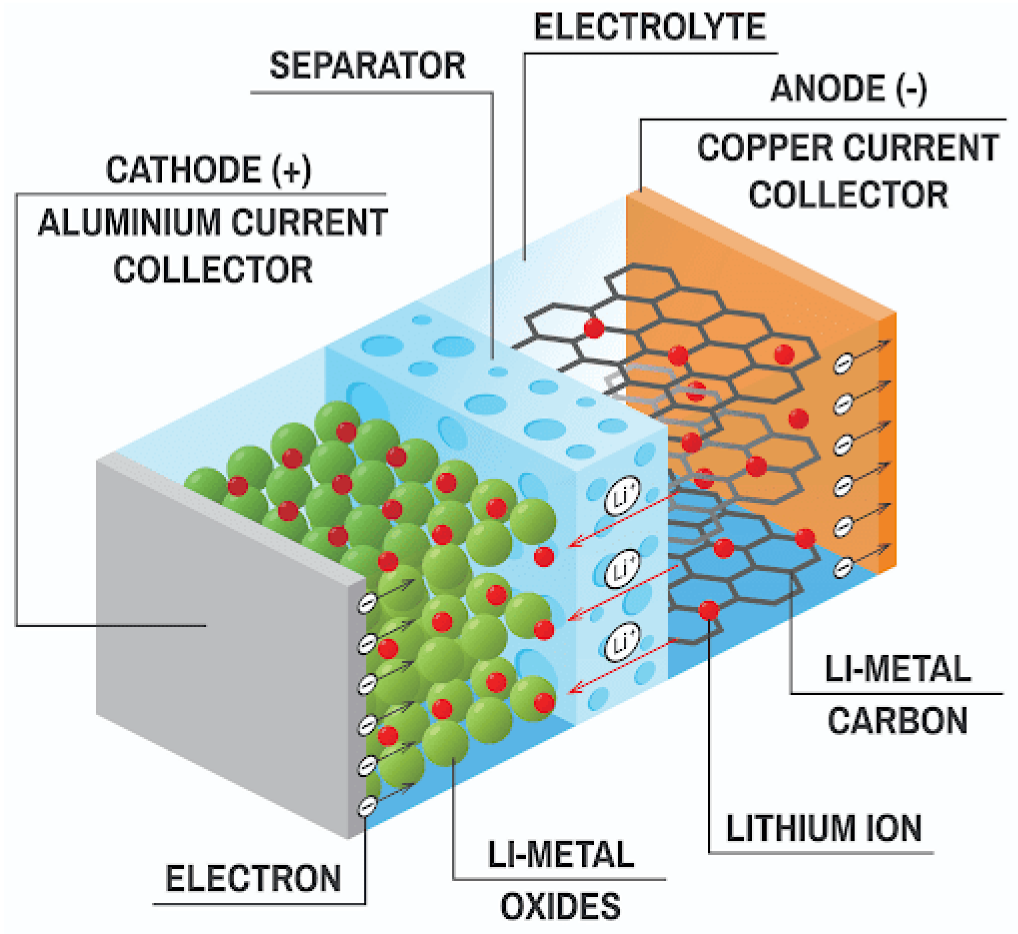


Figure 14. Inside 18650 Battery /11/

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 help the robot operate and navigate its path by avoiding obstacles and maintaining a specific distance 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 and IR 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 displacement. IR sensor controls the movement of motors and ultrasonic sensor detects 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.

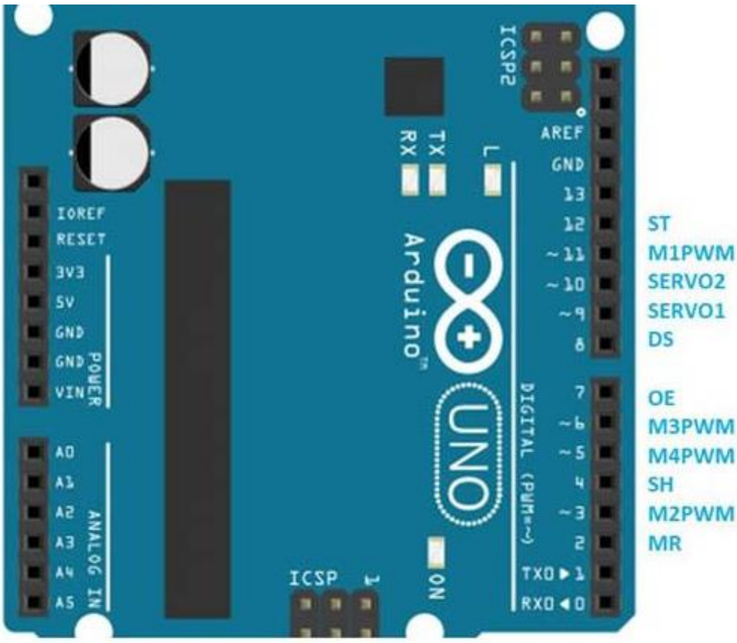


Figure 15. Pin mapping

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.

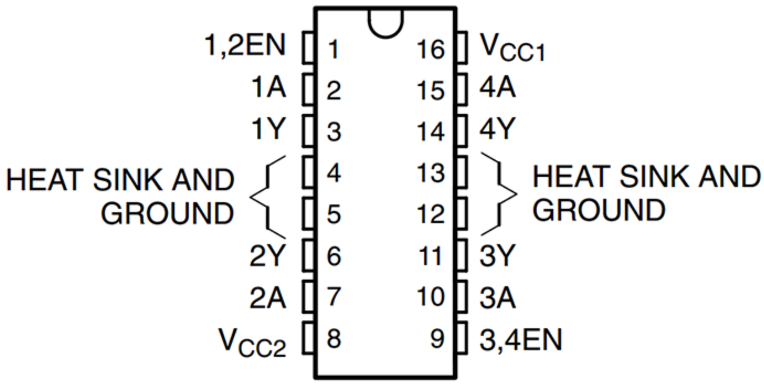


Figure 16. L293D pin function /12/

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.

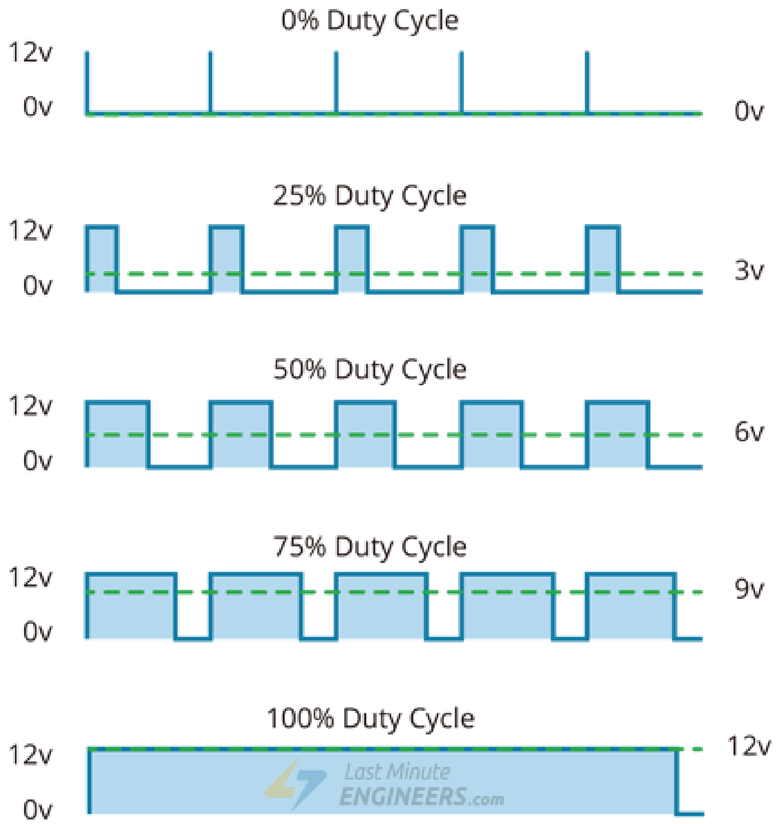


Figure 17. Pulse Width Modulation (PWM) Technique /8/

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/

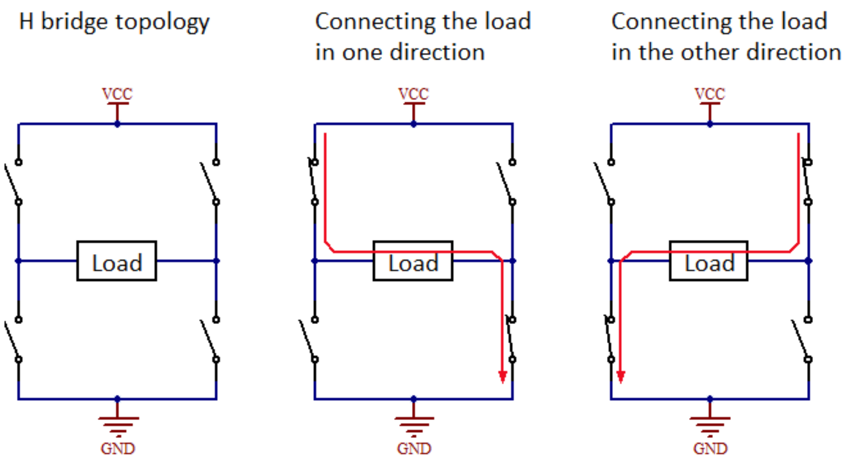


Figure 18. H-Bridge circuit

4.1 Hardware Block Diagram

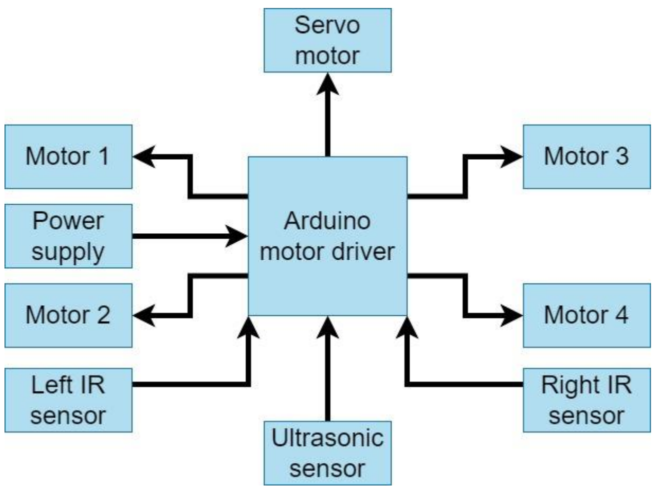


Figure 19. Hardware block diagram

First of all, when the power supplies a motor driver, the Servo motor will instantly be heading to the left side making an angle of 180 degrees and heading to the right side, making an angle of 0 degrees, then goes back to the beginning position which is facing straight ahead. After all it is ready to go.

Go forward: If the ultrasonic sensor detects an object in range between 10 centimetres and 30 centimetres, four wheels will go straight ahead toward the object and stop when the distance between the robot and the object is less than 10 centimetres.

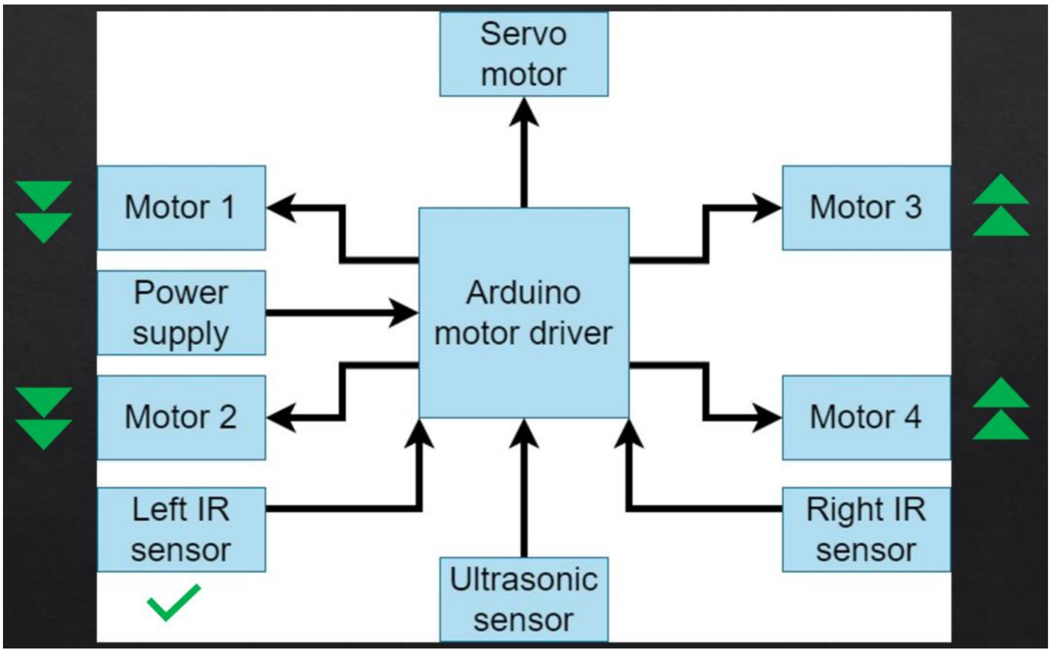


Figure 20. Go Forward

Turn Right: If the **Right** IR sensor detects an object, two motors on the **right side,** which are motor 3 and motor 4, will rotate **backward** and two motors on the **left side,** which are motor 1 and motor 2, will rotate **forward**. That makes the robot turn to **right.**

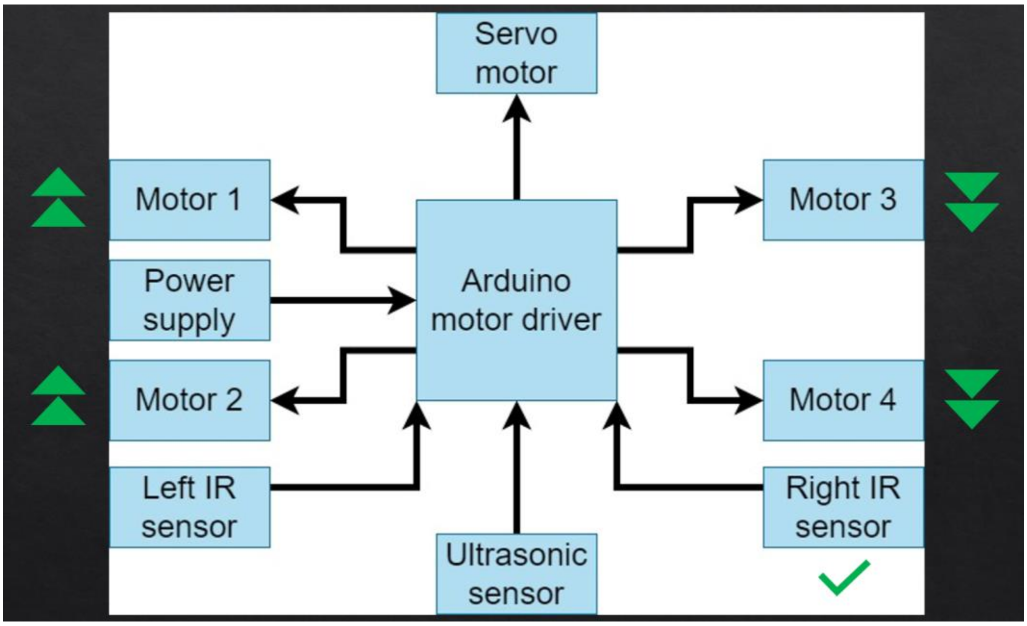


Figure 21. Turn right

Turn Left: If the **Left** IR sensor detects an object, two motors on the **left side,** which are motor 1 and motor 2, will rotate **backward** and two motors on the **right side,** which are motor 3 and motor 4, will rotate **forward**. That makes the robot turn to left.

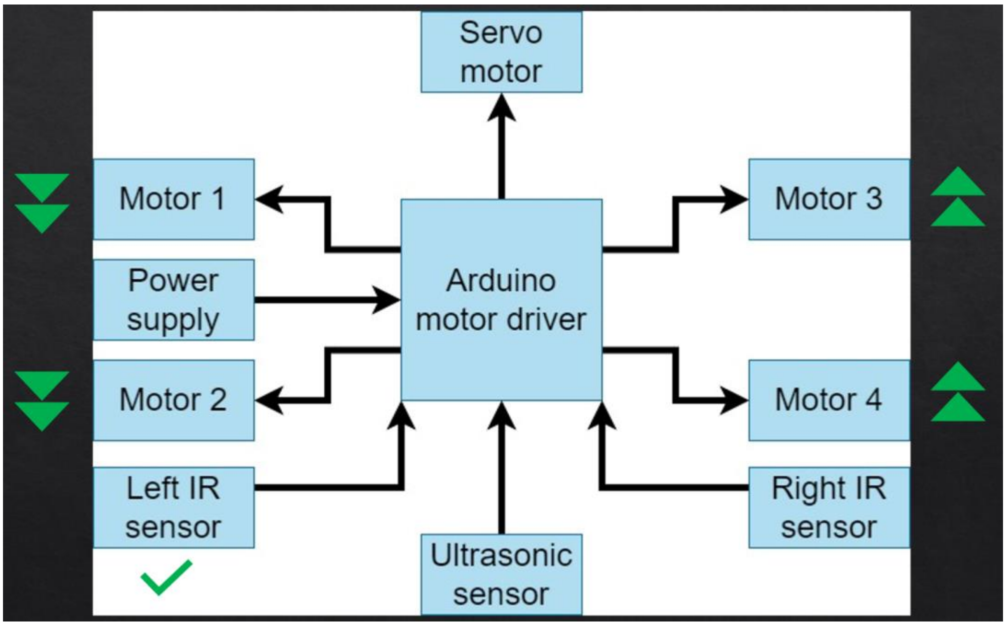


Figure 22. Turn left

4.2 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. /13/

4.2.1 Flow Chart

The idea of this project was visualized as figure 21. The robot waited for the trigger of any sensors. All of the sensors worked simultaneously, so robot did not have to wait for any latency delay. If ultrasonic distance sensor detected human in range between 10-50 centimeters, the robot would follow that human and go forward. Otherwise, it would stay at the same position.

Meanwhile, both two IR sensors on the left or right perceived any movement from human on that side which led the robot to turn depend on that signal direction. In combination, when both distance sensor and any of those IR sensors triggered concurrently, this innovation would move straight ahead and bias toward the IR sensors received radiation.

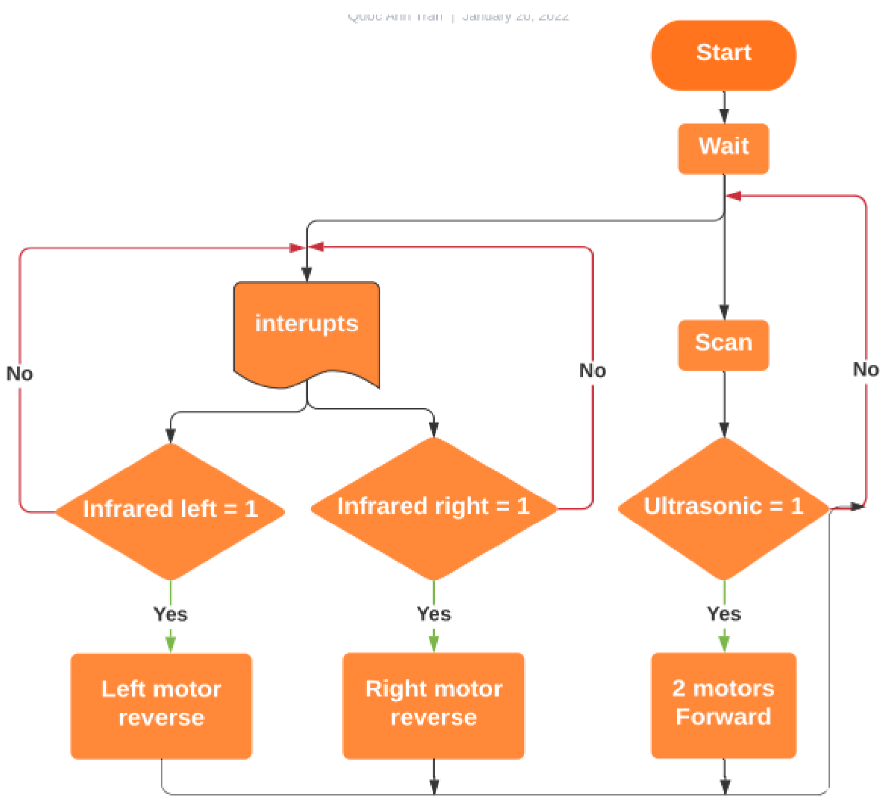


Figure 23. Flow Chart

4.2.2 Programming

First of all, outside libraries must be included in the sketch.

```
#include<NewPing.h>
#include<Servo.h>
#include<AFMotor.h>
```

Figure 24. Include library

NewPing - To read data from Ultrasonic sensor.

Servo - To control the Servo motor.

AFMotor - To recognize L293D motor and control 4 wheels.

The **#define** directive allows the definition of macros within the source code. These macro definitions allow constant values to be declared for use throughout your code.

Macro definitions are not variables and cannot be changed by the program code like variables. This syntax is generally used when creating constants that represent numbers, strings or expressions.

```
#define ECHO_PIN A0         // Echo pin connected to pin A0 of Arduino Uno
#define TRIGGER_PIN A1      // Trigger pin connected to pin A1 of Arduino Uno
#define RIGHT A2            // Right IR sensor connected to pin A2 of Arduino Uno
#define LEFT A3             // Left IR sensor connected to pin A3 of Arduino Uno
#define MAX_DISTANCE 200    // Maximum ping distance
```

Figure 25. Define sensors' pins

```
//create motor objects
AF_DCMotor Motor1(1,MOTOR12_1KHZ);
AF_DCMotor Motor2(2,MOTOR12_1KHZ);
AF_DCMotor Motor3(3,MOTOR34_1KHZ);
AF_DCMotor Motor4(4,MOTOR34_1KHZ);
```

Figure 26. Register 4 wheels in turn

```
void setup()
{
  Serial.begin(9600); //initailize serial communication at 9600 bits per second

  myservo.attach(10); // servo attached to pin 10 of Arduino UNO
  {
    for(pos = 90; pos <= 180; pos += 1) //goes from 90 degrees to 180 degrees
    {
      myservo.write(pos);
      delay(15);
    }
    for(pos = 180; pos >= 0; pos-= 1)   //goes from 180 degrees to 0 degrees
    {
      myservo.write(pos);
      delay(15);
    }
    for(pos = 0; pos<=90; pos += 1)     //goes from 0 degrees to 90 degrees
    {
      myservo.write(pos);
      delay(15);
    }
  }
```

Figure 27. Servo motor code

```
//Move Forward
if(distance>=10 && distance<=30)
{
  Motor1.setSpeed(120);
  Motor1.run(FORWARD);
  Motor2.setSpeed(120);
  Motor2.run(FORWARD);
  Motor3.setSpeed(120);
  Motor3.run(FORWARD);
  Motor4.setSpeed(120);
  Motor4.run(FORWARD);
}
```

Figure 28. Move forward code

```
//Turn Left
else if((Right_Value==0) && (Left_Value==1))
{
  Motor1.setSpeed(200);      //left side move backward
  Motor1.run(BACKWARD);
  Motor2.setSpeed(200);
  Motor2.run(BACKWARD);
  Motor3.setSpeed(150);      //right side move forward
  Motor3.run(FORWARD);
  Motor4.setSpeed(150);
  Motor4.run(FORWARD);
}
```

Figure 29. Turn Left code

```
//Turn Right
else if((Right_Value==1)&&(Left_Value==0))
{
  Motor1.setSpeed(150);      //left side move forward
  Motor1.run(FORWARD);
  Motor2.setSpeed(150);
  Motor2.run(FORWARD);
  Motor3.setSpeed(200);      //right side move backward
  Motor3.run(BACKWARD);
  Motor4.setSpeed(200);
  Motor4.run(BACKWARD);
}
```

Figure 30. Turn Right code

If the robot is too close to the object – the distance between the ultrasonic sensor is less than 10 centimetres. All the motors will stop.

```
//Stop
else if(distance > 1   && distance < 10)
{
  Motor1.setSpeed(0);
  Motor1.run(RELEASE);
  Motor2.setSpeed(0);
  Motor2.run(RELEASE);
  Motor3.setSpeed(0);
  Motor3.run(RELEASE);
  Motor4.setSpeed(0);
  Motor4.run(RELEASE);
}
```

Figure 31. Stop when the object is too close

```
else if((Right_Value == 1)&&(Left_Value == 1))
{
  Motor1.setSpeed(0);
  Motor1.run(RELEASE);
  Motor2.setSpeed(0);
  Motor2.run(RELEASE);
  Motor3.setSpeed(0);
  Motor3.run(RELEASE);
  Motor4.setSpeed(0);
  Motor4.run(RELEASE);
}
}
```

Figure 32. Stop when the object is too close

4.3 Difficulty

Suppose there are two targets like **Figure 33**, target A and target B. First, the robot is 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. Finally the 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 (Ahn et 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 (Skydio, 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).

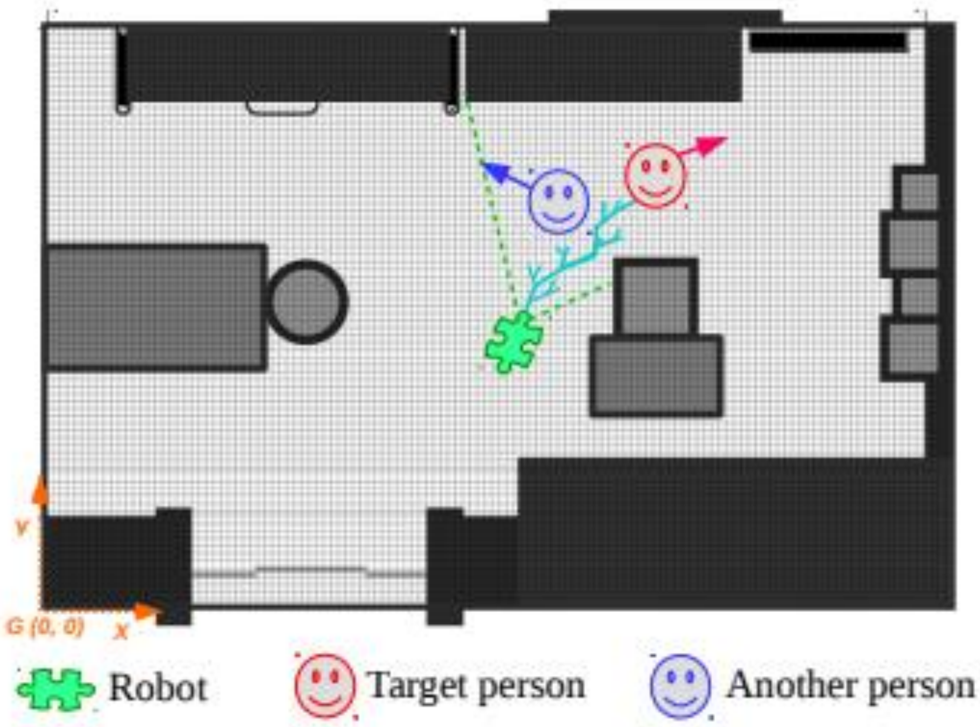
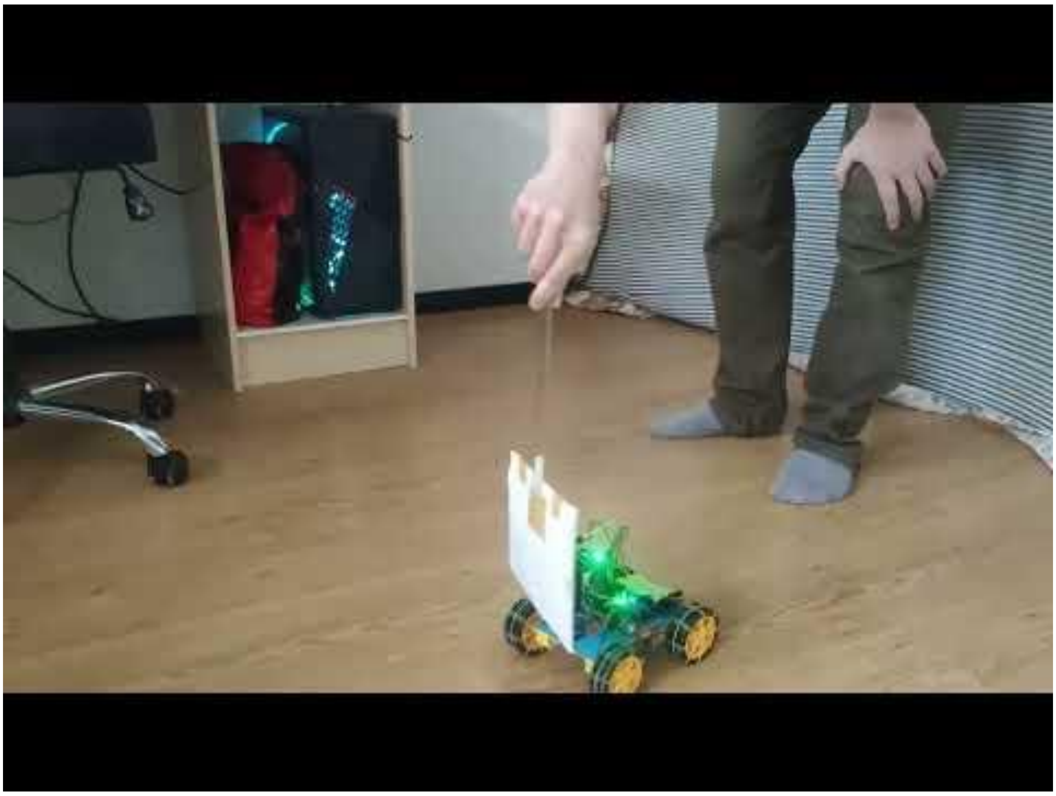


Figure 33. The robot follows the wrong object

4.4 Results

Several experiments were carried out, and the performance of the human following 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.



Video 1. Result video

4.5 Advantages

The robot can work around the clock and be more accurate than humans in order to 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.

4.6 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 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. It is worth noting that the robot will wander around in the weather until it finds the objective 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 model of 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 be made 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 clamours can be inspected later on work.

This research has a variety of interesting applications in several fields, especially military and medical. A wireless communication capability can be added to the robot to increase its versatility and allow it to be controlled from afar. A robot with this functionality might also be exploited for military purposes. We can also add some modifications to the algorithm and structure to make it suitable for a different application. In retail malls, it can correspondingly aid the public. Consequently, it may be used as a luggage carrier, eliminating the need to lift or draw the weights.

Correspondingly, this prototype might be modified in a variety of ways to suit a variety of purposes.

5 CONCLUSIONS

A successful implementation of a prototype of human following robot is illustrated in 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 that the functioning of the robot should be as efficient as possible. Tests were performed on the different conditions to pinpoint the mistakes in the algorithm and to correct them. The different sensors that were integrated with the robot provided 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 with programming.

The significant point of this framework was to plan and develop a devotee automated 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 another 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.

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APPENDIX 1. L293D schematic