A Mini Project Report

On

HUMAN FOLLOWING ROBOT CAR USING ARDUINO

Submitted for partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND COMMUNICATION ENGINEERING

SUBMITTED BY

P.AMULYA	**(21271A0405)**
K.BHAVANI	**(21271A0408)**
D.JAHNAVI	**(21271A0417)**
N.SATHWIK	**(21271A0440)**

Under the guidance of

Mr.J.Ramesh
Assistant Professor

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

JYOTHISHMATHI INSTITUTE OF TECHNOLOGY AND SCIENCE (AUTONOMOUS)

(Approved By AICTE, accredited with NAAC ‘A’ Grade, NBA and Affiliated to JNTUH)

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CERTIFICATE

This is to certify that the project work entitled **"Human Following Robot Car"** is a bonafide work carried out by **P.Amulya(21271A0405), K.Bhavani(21271A0408), D.Jahnavi(21271A0417), N.Sathwik(21271A0440)** in partial fulfillment of the requirements for the degree of "**BACHELOR OF TECHNOLOGY**" in "***Electronics and Communication Engineering"*** from the Jyothishmathi Institution of Technology and Science,(Autonomous) during the academic year 2021-25.

No part of this report has been submitted elsewhere for award of any other degree

Submission for mini project viva voce examination held on__________

Project guide	**Head of the Department**
Mr.J.RAMESH	**Dr.N.UMAPATHI**
Assistant Professor	**Professor & Head**

INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLEDGEMENT

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P.Amulya (21271A0405)

K.Bhavani (21271A0408)

D.Jahnavi (21271A0417)

N.Sathwik (21271A0440)

<u>DECLARATION</u>

This is to certify that the work reported in the present project entitled **"Human Following Robot Car"** is a record of work done by us in the partial fulfillment for the award of the degree of ***Bachelor of Technology*** in ***Electronics & Communication Engineering, Jyothishmathi Institute of Technology and Science (Autonomous),*** affiliated to JNTUH, Accredited By NAAC and NBA, under the guidance of **Mr.J.Ramesh, Assistant professor**, ECE Department. We hereby declare that this project work bears no resemblance to any other project submitted at Jyothishmathi Institute of Technology and Science (Autonomous) or any other university/college for the award of the degree. The conclusion and results in this report are based on our own.

P.Amulya	**(21271A0405)**
K.Bhavani	**(21271A0408)**
D.Jahnavi	**(21271A0417)**
N.Sathwik	**(21271A0440)**

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ABSTRACT

The Human-Following Robot Car, an innovative project driven by an Arduino microcontroller, demonstrates the potential of autonomous robotics in real-world applications. This intelligent vehicle utilizes a combination of ultrasonic and infrared sensors to accurately detect and track a designated human target. The system continuously analyzes sensor data, allowing the robot to adjust its speed and direction in real-time to maintain a safe following distance. Integrated obstacle detection mechanisms, such as ultrasonic sensors, enable the robot to navigate its surroundings safely, avoiding collisions with any obstructions. Motor drivers, controlled by the Arduino microcontroller, precisely regulate the speed and direction of each wheel, ensuring smooth and controlled movement. This versatile system has the potential to revolutionize various fields, including personal assistance for individuals with mobility limitations, providing companionship and assistance to the elderly, and streamlining delivery services through efficient and contactless operations. Furthermore, the Human-Following Robot Car serves as an invaluable educational tool, providing hands-on experience in robotics, electronics, programming, and sensor technology. By incorporating advanced features like sensor fusion, machine learning algorithms for adaptive behavior, and intuitive human-robot interaction interfaces, this project paves the way for a future where autonomous robots seamlessly integrate into our daily lives, enhancing efficiency, safety, and overall quality of life..

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CHAPTER 1

INTRODUCTION

Human-following robots are a significant innovation in robotics, aimed at creating systems capable of autonomously detecting, tracking, and following a target individual. These robots find applications in various fields, including personal assistance, healthcare, and logistics. This project focuses on designing a human-following robot using cost-effective components such as an Arduino Uno microcontroller, IR sensors, ultrasonic sensors, and an L298N motor driver. The IR sensors are used to detect the presence of a human or a marker, while ultrasonic sensors measure the distance between the robot and the target, ensuring precise tracking and safe operation. Additionally, the ultrasonic sensors help in obstacle detection, allowing the robot to navigate safely in its environment. The Arduino Uno serves as the central processing unit, processing sensor data and controlling the robot's movement. The L298N motor driver is employed to regulate the speed and direction of the motors, enabling smooth and accurate navigation.

This project highlights the integration of basic electronic components and sensors to create an autonomous robot. The system is designed to follow a target while maintaining a safe distance and avoiding obstacles, making it suitable for controlled environments. Its cost-effective design and simplicity make it an excellent platform for educational purposes, prototype development, and further research. With future advancements, the robot can be enhanced with more sophisticated technologies for improved functionality and adaptability in complex environments.

1.1 Problem Statement

The development of autonomous robots capable of navigating dynamic environments while reliably following a human subject presents significant challenges. The primary goal of this project is to design and implement a human-following robot that can operate in real-time, ensuring precise tracking, obstacle avoidance, and adaptability to environmental changes. This involves leveraging sensor fusion and computer vision techniques to create a system that is not only efficient but also robust in diverse scenarios.

The robot must be equipped with the ability to:

1. Navigate Dynamic Environments:

The robot should navigate seamlessly in environments that are constantly changing, such as hospitals, shopping malls, public spaces, or warehouses. It must dynamically adjust its path in response to moving obstacles, unpredictable human behavior, and environmental constraints, ensuring smooth operation without manual intervention.

2. Follow a Human Subject in Real-Time:

The robot must be capable of reliably detecting and tracking a specific human target. This requires advanced detection mechanisms that can differentiate the target from other individuals or objects in the environment. The tracking system should work consistently even in the presence of occlusions, distractions, or varying distances, maintaining an appropriate and safe following distance at all times.

3. Avoid Obstacles and Prevent Collisions:

Ensuring safety is paramount. The robot should be equipped with obstacle detection and avoidance capabilities to prevent collisions with stationary or moving objects. This includes dynamic recalibration of its trajectory to account for unexpected obstacles that may appear in its path.

4. Adapt to Environmental Variability:

To be functional across different settings, the robot should adapt to environmental changes, such as fluctuating lighting conditions, uneven surfaces, and crowded areas. Its sensors and algorithms should ensure reliable performance, even in challenging conditions where standard systems may fail.

5. Handle Occlusions and Distractions:

A robust system must address scenarios where the human subject temporarily moves out of the robot's line of sight due to obstacles or environmental clutter. The robot should predictively and intelligently navigate to re-establish visual or sensor contact with the target, minimizing disruption in its operation.

6. Maintain Communication with the Human Subject:

Reliable communication between the robot and the human subject is essential for signalling intentions or responding to commands. The robot should implement a mechanism for receiving and processing input from the user, whether through gestures, voice commands, or other intuitive interfaces, enhancing its interactivity and user-friendliness.

7. Ensure Cost-Effectiveness and Scalability:

The solution should use readily available, affordable components and algorithms to ensure cost-efficiency without compromising performance. Scalability is also crucial; the robot should be easily adaptable to additional functionalities or deployment in larger, more complex environments.

8. Demonstrate Robust Performance in Diverse Applications:

The robot's functionality must extend across various use cases, including assisting patients in hospitals, guiding shoppers in malls, or supporting logistics operations in warehouses. It should showcase reliable performance across these applications, handling varying operational demands and environmental complexities effectively.

1.2 Evaluation Metrics:

The success of the human-following robot will be measured against several key performance indicators:

• **Accuracy:** The robot's ability to correctly detect, identify, and follow the target human subject under different conditions.

• **Safety:** The robot's capability to avoid obstacles, maintain appropriate distances, and operate without posing risks to people or property.

• **Reliability:** Consistent performance in tracking and navigation, even in challenging scenarios involving occlusions, distractions, or dynamic changes in the environment.

• **Cost-Effectiveness:** The overall affordability of the system, including its components, manufacturing, and maintenance costs.

• **Scalability and Adaptability:** The ability to extend or modify the robot’s functionality for broader or more complex applications.

CHAPTER 2

LITERATURE SURVEY

2.1 Existing system

• Simple Motion Planning

The existing system employs a basic motion planning algorithm that is suitable for simple and controlled scenarios but falls short in handling complex environments. This limitation becomes evident when navigating through intricate terrains with irregular paths, narrow passages, or dynamic obstacles. The algorithm's inability to predict and adapt to changes in the environment hinders its performance in real-time applications, making it unsuitable for scenarios with moving objects such as vehicles or pedestrians. Moreover, the system often fails to compute optimal paths in such conditions, leading to inefficiencies in time and energy usage. As a result, the current approach is inadequate for applications that require precision, adaptability, and robust navigation in challenging settings.

• Safety Concerns

The current system lacks essential safety features, which poses significant risks during operation. The absence of a reliable obstacle avoidance mechanism increases the likelihood of collisions, potentially causing damage to equipment, people, and property. Furthermore, the system does not include emergency response protocols, such as an emergency stop function, which are critical in mitigating the impact of unforeseen events like sensor malfunctions or loss of control. This deficiency makes the system hazardous in high-risk scenarios where safety is paramount. Additionally, the lack of fail-safe mechanisms limits the system's reliability and increases the potential for accidents, reducing its suitability for deployment in real-world applications.

2.2 Disadvantages of the Existing System

Limited Scalability: The simple algorithms used cannot be easily scaled to more complex or larger environments.

Poor Real-Time Decision Making: The system cannot react quickly to unexpected changes in the environment, reducing its reliability in dynamic settings.

High Maintenance Risk: The lack of advanced safety features increases the risk of frequent damage and higher maintenance costs.

Low User Confidence: The absence of robust safety and planning features may deter potential users from adopting the system.

Unsuitability for Critical Applications: In industries such as healthcare, transportation, or defense, where precision and safety are non-negotiable, the current system falls short of required standards.

2.3 Proposed system

The proposed system is a Human-Following Robot Car powered by an Arduino microcontroller, designed to autonomously track and follow a human target in real-time. This system leverages ultrasonic and infrared sensors to detect and process the position of a human, enabling smooth and dynamic navigation. By continuously analyzing sensor data, the robot adjusts its speed and direction to maintain a consistent following distance, ensuring seamless operation without manual intervention. Furthermore, obstacle detection mechanisms are integrated to enhance safety by avoiding collisions. This cost-effective solution, built on the Arduino platform, utilizes readily available components, making it accessible and easy to develop.

Compared to existing systems, the proposed solution offers enhanced tracking accuracy, improved motion planning, and increased reliability. Its modular design allows for scalability and future upgrades, such as GPS integration for navigation or machine learning for advanced recognition. The system is highly versatile, finding applications in logistics, healthcare, retail, and construction. For instance, it can assist warehouse workers by carrying goods, aid medical staff in transporting supplies, or enhance the shopping experience by carrying customer items. The proposed system demonstrates significant potential for improving efficiency and automation in various domains, providing a reliable and user-friendly solution for real-world needs

CHAPTER 3

EMERGING TRENDS

Person-following scenarios can be categorized into ground, underwater, and aerial operations based on their mode of functioning. A typical example of ground-based person-following involves service robots that accompany humans while collaboratively completing tasks. These robots find applications across domestic settings, industries, and healthcare sectors. Underwater, diver-following robots play a crucial role in tasks such as inspecting submarine pipelines, exploring shipwrecks, monitoring marine life, and studying the seabed, among other research activities. Similarly, aerial person-following robots, particularly quadcopters, have seen significant growth over the past decade. These aerial systems are widely used for capturing footage of outdoor activities like mountain climbing, biking, surfing, and various other sports.

3.1 Ground Scenario[1]

Unmanned Ground Vehicles (UGVs) designed for person-following are frequently seen in the form of domestic assistant robots and shopping-cart robots. Their application has been steadily expanding, not only in industrial settings but also in healthcare and military operations. These robots are becoming increasingly popular due to their versatility and efficiency in supporting various tasks.

Figure 3.1 Domestic assistant

3.2 Underwater Scenario

Underwater operations often involve collaboration between human divers and autonomous robots, working together to complete shared tasks. In these missions, divers typically take the lead while robots follow and assist during specific phases of the operation. This approach is crucial in various applications, such as inspecting ship hulls and submarine pipelines, studying marine species migration, conducting search-and-rescue missions, and performing surveillance tasks. Since underwater environments lack radio communication and global positioning capabilities, human-robot interaction becomes essential for navigation. Incorporating human-in-the-loop guidance not only enhances mission efficiency but also eliminates the need for teleoperation or complex pre-mission planning, thereby reducing operational overhead.

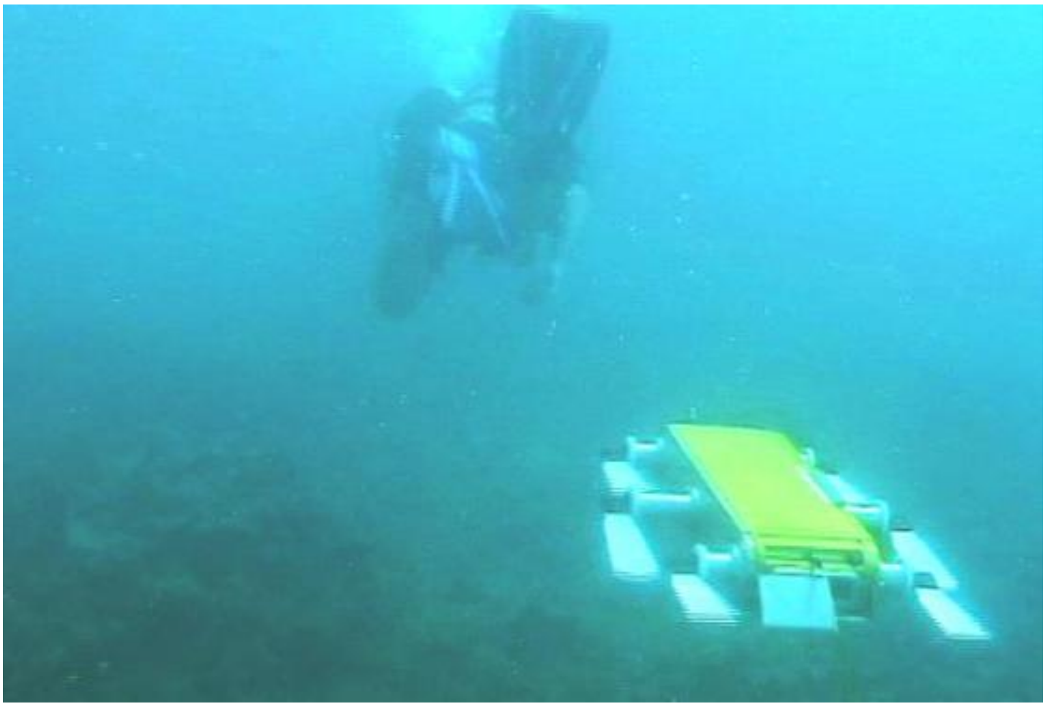

Figure 3.2 An underwater robot is following a diver

3.3 Aerial Scenario

Unmanned Aerial Vehicles (UAVs), commonly referred to as drones, were initially developed for industrial and military applications. In recent years, however, they have become widely available and increasingly popular for recreational activities and use in the film industry. UAVs are particularly valuable for capturing sports such as climbing or skiing from unique perspectives, eliminating the need for teleoperation or traditional manned aerial vehicles. Additionally, person-following UAVs offer an innovative application by providing athletes with external visual feedback, enabling them to analyse and improve their movements. These emerging use cases have driven extensive research and development into cost-effective UAVs, making them a cornerstone of the person-following aerial robotics industry.

While there are many types of robots, this paper focuses on a prototype ground-based human-following robot. This system incorporates an Arduino Uno, equipped with sensors for detection and powered by four DC motors for movement.

Figure 3.3 A UAV is filming a sport activity while intelligently following an athlete

CHAPTER 4

CORE COMPONENTS

4.1 Core

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

4.1.1 Arduino Uno[2]

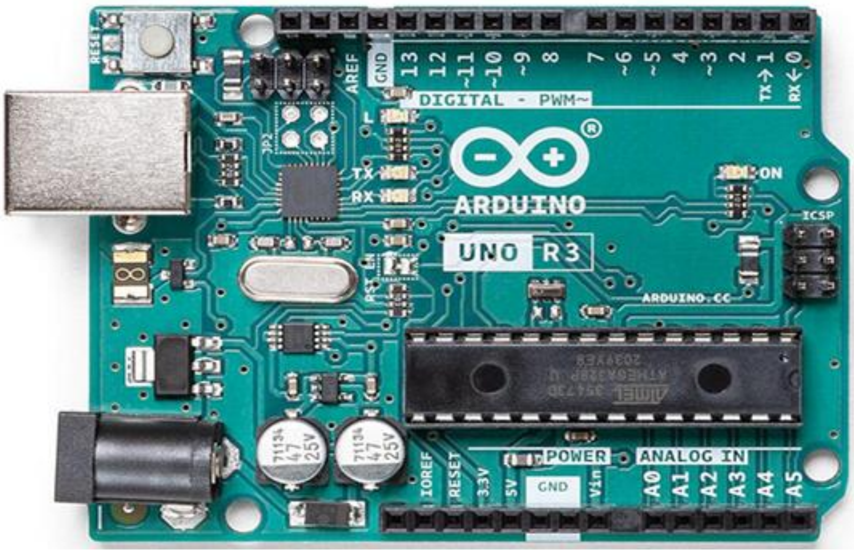

Figure 4.1.1 Arduino Uno

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 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.

4.1.2 L298n Motor Driver Shield[11]

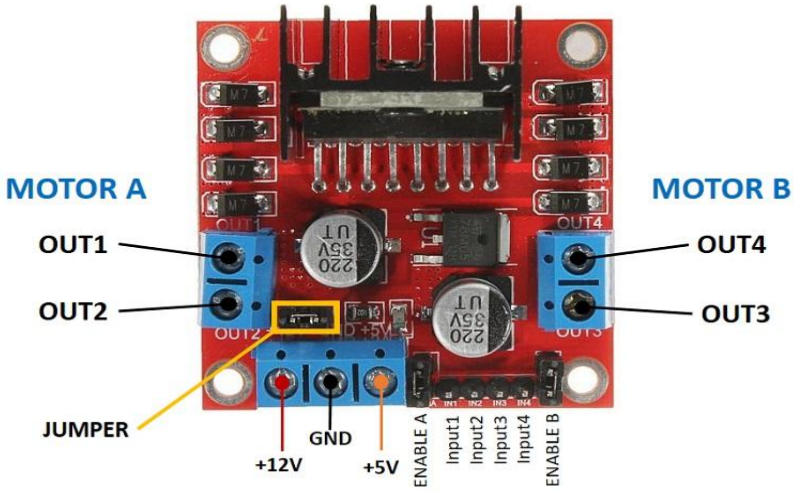

Figure 4.1.2 L298n motor driver

The L298N motor driver is a commonly used dual H-bridge motor driver module that allows you to control the speed and direction of two DC motors simultaneously. It is especially popular for robotics projects due to its simplicity and ability to handle moderate power requirements. Here's an overview of its key features and functionality:

Key Features:

1. Dual H-Bridge Design: Enables independent control of two motors.
2. Wide Voltage Range: Operates at motor supply voltages ranging from 5V to 35V.
3. Current Capacity: Can handle up to 2A per channel with proper heat dissipation.
4. Built-in Heat Sink: Prevents overheating during operation.
5. Logic Voltage: Compatible with logic levels of 3.3V or 5V for microcontrollers like Arduino or Raspberry Pi.
6. PWM Control: Allows for speed adjustment using pulse-width modulation (PWM).

4.2 Detection

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

4.2.1 Ultrasonic Sensor HCSR04[4]

Figure 4.2.1 Ultrasonic Sensor HC-SR04

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.

4.2.2 Infrared Sensor[5]

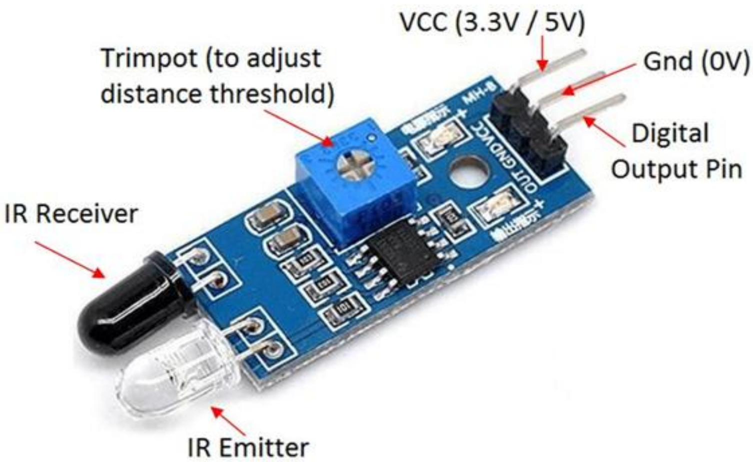

Figure 4.2.2 Infrared Sensor

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.

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.

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.

4.3 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 4.3 Wheel

4.3.1 TT DC Motor[8]

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.

Figure 4.3.1 TT DC motor

4.4 Power

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

4.4.1 18650 Li-on Battery

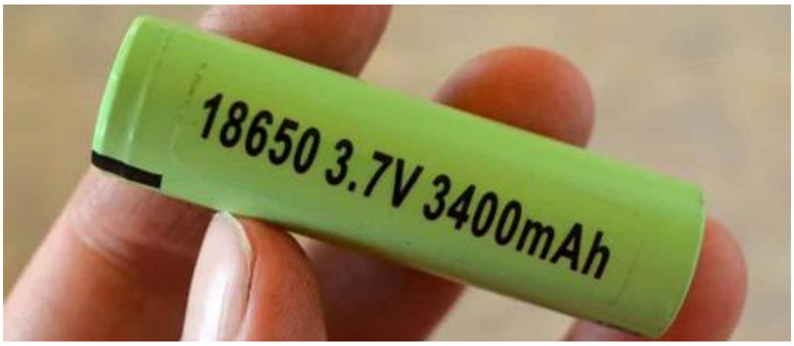

Figure 4.4.1 18650 Li-on Battery

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.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).

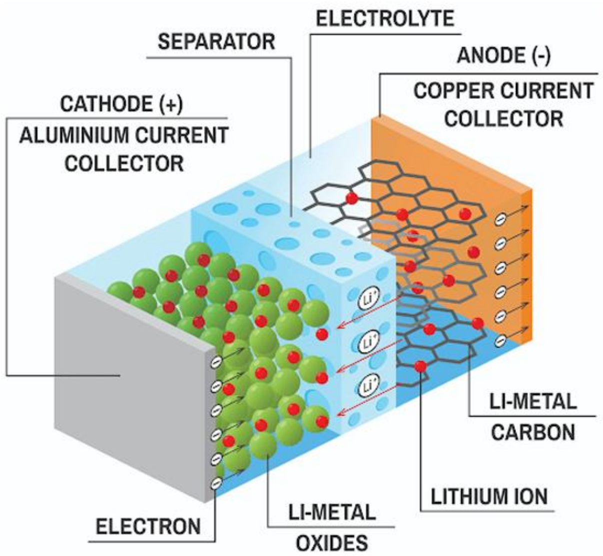

Figure 4.4.2 Inside 18650 Battery

CHAPTER 5

SOFTWARE TOOLS

5.1 Integrated Development Environment (IDE)

The Arduino Integrated Development Environment (IDE) is a versatile, cross-platform application available for Windows, macOS, and Linux, developed using the Java programming language. It enables users to write and upload programs to Arduino-compatible boards and, with the support of third-party cores, to other vendor-specific development boards as well. Released under the GNU General Public License version 2, the source code for the Arduino IDE is open for modification and distribution.

The IDE supports programming in C and C++, following specific rules for code structuring. It also includes a software library from the Wiring project, which provides a wide range of functions for handling common input and output tasks. Users need to define only two core functions: one for initializing the program (setup) and another for the main execution loop (loop). These user-defined functions are compiled and linked with a pre-written main() function into a cyclic executive program, using the GNU toolchain that comes bundled with the IDE.

To upload code to an Arduino board, the IDE utilizes a tool called avrdude, which converts the compiled code into a hexadecimal text file. This file is then uploaded to the board using a loader program pre-installed in the board's firmware.

5.2 Libraries

1.Including the NewPing Library

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

The NewPing library is included to simplify working with ultrasonic sensors. It provides easy-to-use functions for measuring distances with ultrasonic sensors like the HC-SR04.

2. Ultrasonic Sensor Pin Definitions

```
#define ULTRASONIC_SENSOR_TRIG 11
#define ULTRASONIC_SENSOR_ECHO 12
```

ULTRASONIC_SENSOR_TRIG (Pin 11): The trigger pin of the ultrasonic sensor is connected to pin 11 of the microcontroller (e.g., Arduino). This pin sends out sound pulses.

ULTRASONIC_SENSOR_ECHO (Pin 12): The echo pin is connected to pin 12. This pin receives the reflected sound pulses, allowing the microcontroller to calculate distance.

3. Motor Speed Configurations

```
#define MAX_FORWARD_MOTOR_SPEED 75
#define MAX_MOTOR_TURN_SPEED_ADJUSTMENT 50
```

MAX_FORWARD_MOTOR_SPEED (75): This defines the maximum speed at which the robot can move forward. The speed is likely a percentage of the maximum motor power (e.g., 0–100 or 0–255, depending on the motor driver setup).

MAX_MOTOR_TURN_SPEED_ADJUSTMENT (50): This value sets the maximum adjustment to motor speed for turning. For instance, when the robot turns, one motor might slow down or stop while the other continues at full or reduced speed.

4. Distance Thresholds for Ultrasonic Sensor

```
#define MIN_DISTANCE 2
#define MAX_DISTANCE 30
```

MIN_DISTANCE (2): The minimum distance, in centimeters, the robot should maintain from an obstacle. If the distance is less than this, the robot will likely stop or change direction.

MAX_DISTANCE (30): The maximum distance (in centimeters) within which the ultrasonic sensor actively detects objects. Objects farther than this distance are ignored.

5. IR Sensor Pin Definitions

```
#define IR_SENSOR_RIGHT 2
#define IR_SENSOR_LEFT 3
```

IR_SENSOR_RIGHT (Pin 2): The right IR sensor is connected to pin 2 of the microcontroller. This sensor may detect objects, follow lines, or determine direction.

IR_SENSOR_LEFT (Pin 3): The left IR sensor is connected to pin 3 of the microcontroller, performing similar functions on the left side.

CHAPTER 6

METHODOLOGY

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

6.1 Hardware[2][3][4]

Our system consists of a four-wheel robotic vehicle equipped with an onboard microprocessor and control unit. It incorporates various sensors and modules, including ultrasonic and infrared sensors, which enable the robot to track people and objects in its environment. These sensors work together to assist the robot in navigating its path by avoiding obstacles and maintaining a predetermined distance from surrounding objects. Ultrasonic sensors are utilized for obstacle avoidance and ensuring objects remain at a safe distance. Additionally, two infrared sensors, positioned on either side, are used to detect the robot's orientation.

6.2 Hardware Block Diagram

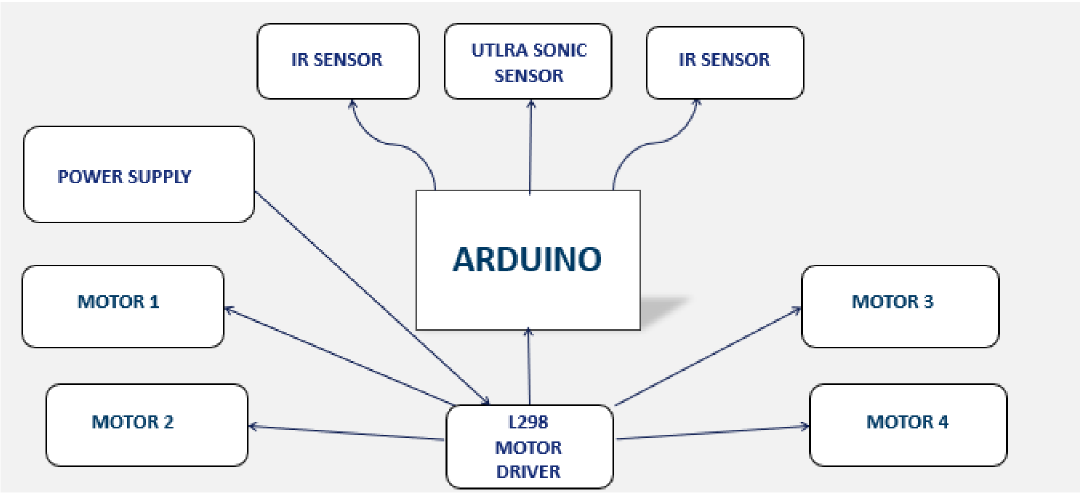

Figure 6.2 block diagram

The block diagram represents an Arduino-based robotic system designed for tasks like obstacle avoidance or autonomous navigation. At its core, the Arduino serves as the central controller, receiving input from sensors and controlling the output devices. The system utilizes IR sensors and an ultrasonic sensor to detect obstacles, measure distance, or follow a line. These sensors send input signals to the Arduino, which processes the data and decides the appropriate actions. The Arduino communicates with an L298 motor driver, which acts as an interface to control the motors. The motor driver amplifies the control signals from the Arduino and drives four motors (Motor 1, Motor 2, Motor 3, and Motor 4) to enable movement in different directions, such as forward, backward, or turning. The entire system is powered by a power supply, ensuring smooth operation of the Arduino, sensors, motor driver, and motors. This setup is commonly used in robotic applications for efficient and autonomous operation.

6.3 Circuit Diagram

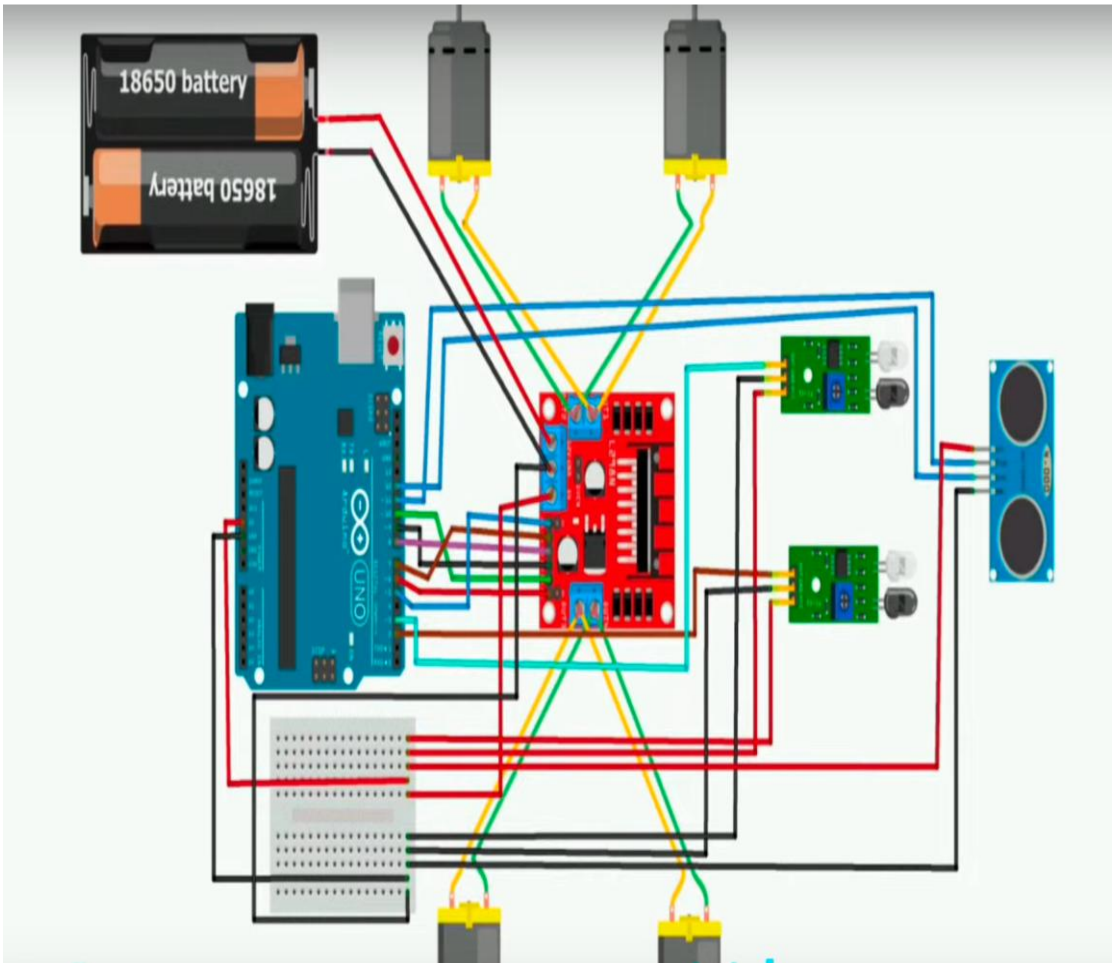

Figure 6.3 Circuit diagram

6.4 Operation

6.4.1 Ultrasonic and IR Sensor Principle[4][5]

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 detects the obstacle and stops the motors.

6.4.2 L298N Motor Driver[11]

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.

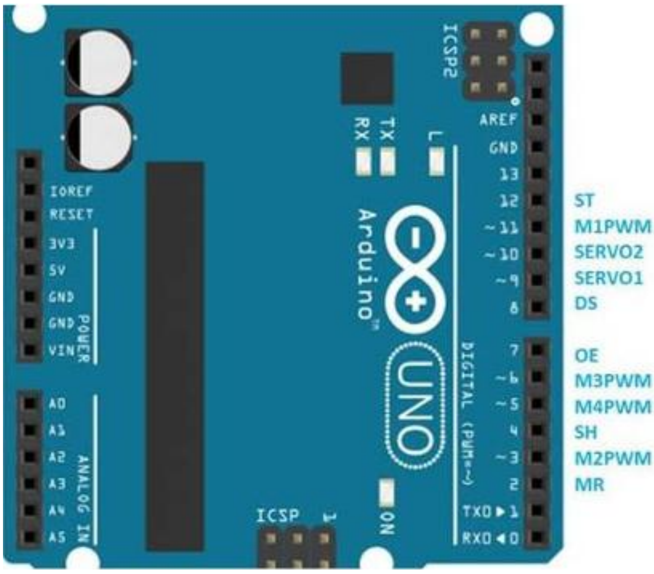

Figure 6.4.1 Pin mapping

Those pins in APPENDIX 1 connect follow the above figure 13.

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.

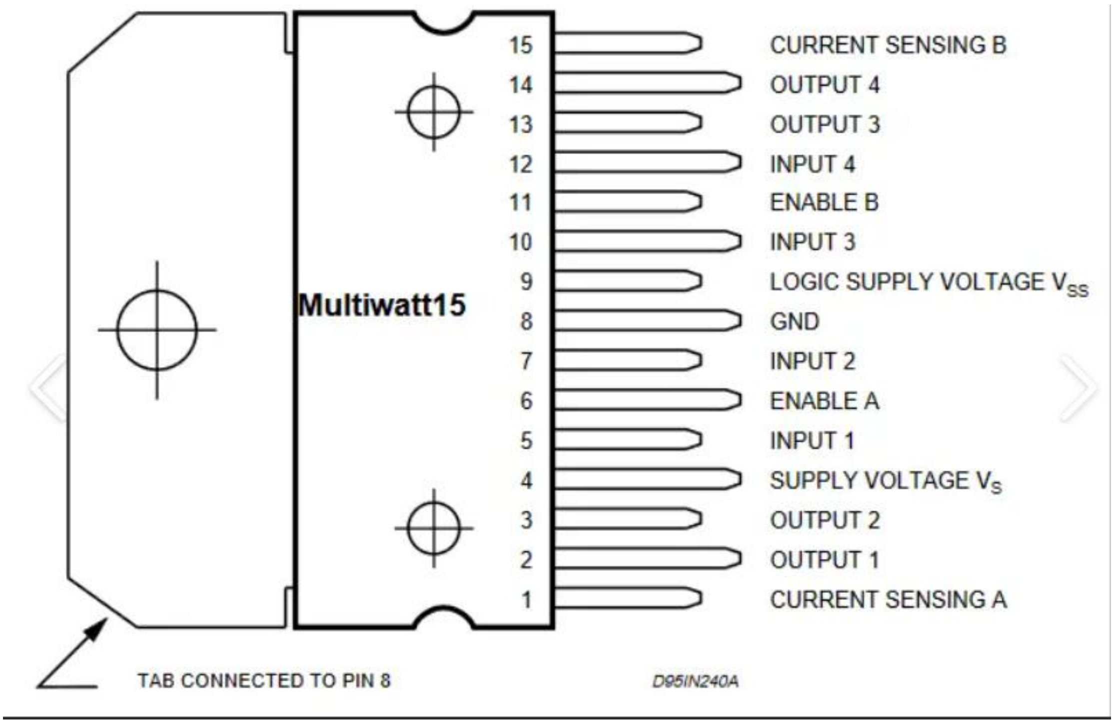

Figure 6.4.2 L298N pin function

Table 6.1 Pin Function

Pin	**Label**	**Function**
1	ENA	Enables and controls the speed of Motor A using a PWM signal.
2	IN1	Input pin for Motor A: Controls the direction of rotation (High/Low).
3	IN2	Input pin for Motor A: Controls the direction of rotation (High/Low).
4	OUT1	Output pin connected to one terminal of Motor A.
5	OUT2	Output pin connected to the other terminal of Motor A.
6	GND	Ground pin (shared between logic and motor power).
7	GND	Ground pin (shared between logic and motor power).
8	VSS	Motor power supply input (5V to 35V for motor operation).

9	VS	Logic power supply input (typically 5V for control circuit operation).
10	GND	Ground pin (shared between logic and motor power).
11	OUT3	Output pin connected to one terminal of Motor B.
12	OUT4	Output pin connected to the other terminal of Motor B.
13	IN3	Input pin for Motor B: Controls the direction of rotation (High/Low).
14	IN4	Input pin for Motor B: Controls the direction of rotation (High/Low).
15	ENB	Enables and controls the speed of Motor B using a PWM signal.

6.4.3 PWM for Speed Controlling

The speed of a DC motor can be controlled by adjusting its input voltage. One common method for achieving this is through Pulse Width Modulation (PWM). PWM is a technique that controls the average value of the input voltage by sending a series of ON-OFF pulses. The average voltage is determined by the duration of the ON pulses, referred to as the Duty Cycle. A higher duty cycle means a greater average voltage applied to the DC motor, resulting in higher speed. Conversely, a lower duty cycle leads to a smaller average voltage, resulting in lower speed.

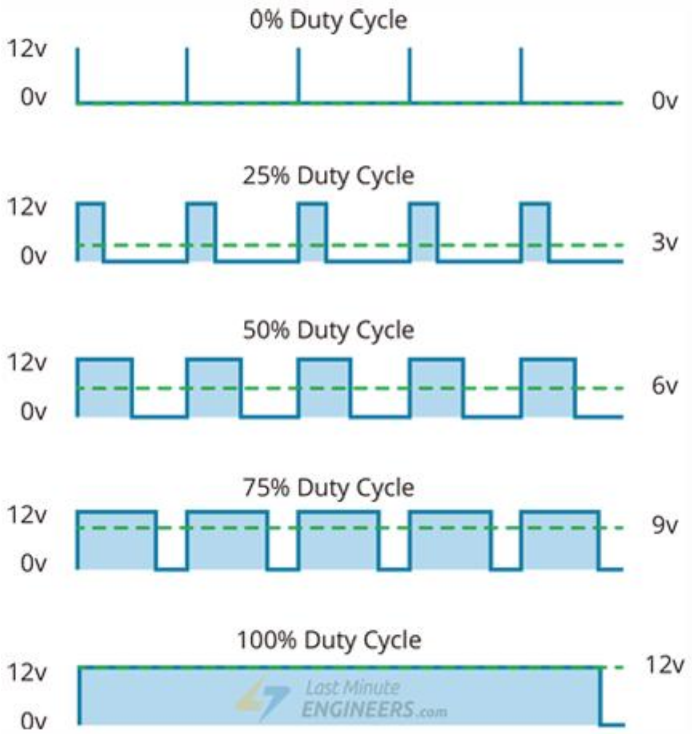

Figure 6.4.3 Pulse Width Modulation (PWM) Technique

CHAPTER-7

RESULT ANALYSIS

7.1 project output

Several experiments were conducted to evaluate the performance of the human-following robot. The ultrasonic and infrared sensors were thoroughly tested and found to be accurate within a range of 4 meters. Subsequently, tests were performed to ensure that the robot maintained a specific distance from the target object. The serial communication between the Arduino, motor shield, and various motors was also examined. Based on the results of these experiments, necessary adjustments were made to the processing and control algorithms. Upon completing the evaluations, it was observed that the robot performed exceptionally well, successfully following the target person wherever they moved. Thus, the objective of achieving effective Human-Robot interaction was accomplished.

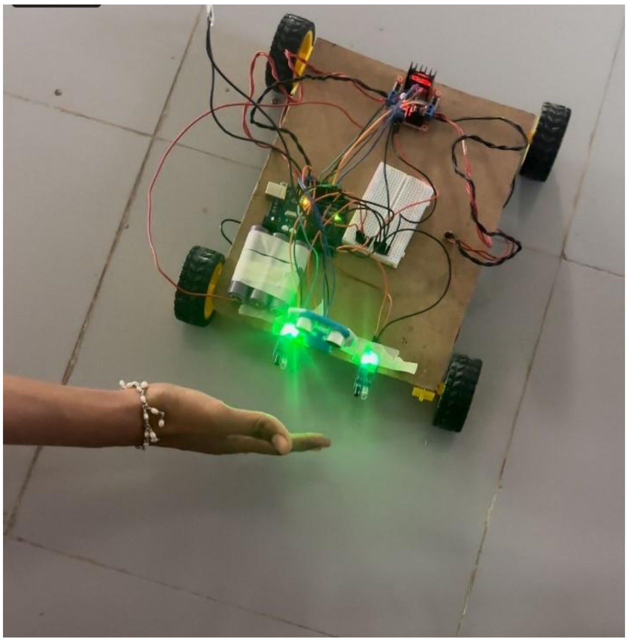

Figure 7.1 Output figure

7.2 Applications

1. Assistive Technology for Elderly or Disabled People
    - These robots can assist elderly or disabled individuals by carrying items like groceries, medical equipment, or personal belongings.

- They act as smart companions that follow their users, reducing physical strain.

2. Warehouse and Logistics Automation
   - In warehouses, human-following robots can be used to transport goods alongside workers, increasing efficiency and reducing manual effort.
   - They can help in tasks such as inventory management and stock replenishment.
3. Retail and Hospitality Services
   - These robots can be deployed in shopping malls or hotels to assist customers by carrying their bags or guiding them to specific locations.
   - In restaurants, they can follow servers to deliver trays or orders to tables.
4. Healthcare Assistance
   - Hospitals can use these robots to follow nurses or doctors, carrying medical supplies, tools, or patient monitoring equipment.
   - They can help during emergencies by transporting essential items like oxygen cylinders or defibrillators.
5. Construction Sites
   - On construction sites, the robot can follow workers to carry tools or heavy materials, reducing fatigue and increasing productivity.
6. Personal Home Use
   - As smart home assistants, these robots can follow their owners to carry items like laundry, groceries, or gardening tools.
   - They can also assist in playing with children by carrying toys or following them around safely.
7. Educational Purposes
   - These robots are excellent tools for teaching robotics, programming, and sensor integration to students.
   - They can be used in STEM projects, workshops, and robotics competitions to promote hands-on learning.
8. Search and Rescue Missions
   - In emergency or disaster situations, these robots can be used to carry equipment or follow rescuers in tight spaces where traditional vehicles cannot operate.

9. Delivery Services
    - Robots can follow delivery personnel in crowded areas to carry packages, enhancing efficiency in last-mile delivery operations.
10. Entertainment and Marketing
    - Human-following robots can be used as interactive promotional tools at events, exhibitions, or malls to attract customers.
    - They can also serve as entertaining gadgets at parties or public gatherings.

CHAPTER-8

FUTURE WORK & CONCLUSION

8.1 Conclusion

This paper presents a successful prototype implementation of a human-following robot. The robot is designed not only with detection capabilities but also with the ability to follow a subject efficiently. During the prototype development, a focus was placed on ensuring the robot's operations are as efficient as possible. Various tests were conducted in different conditions to identify and resolve issues in the algorithm. The integration of multiple sensors into the system provided additional advantages for performance enhancement. The human-following robot functions as an autonomous vehicle that can recognize obstacles, adjust its movement, and follow the subject to maintain its position on the correct path.

This project utilizes components such as Arduino, motors, and various sensors to accomplish its objectives. It required the cooperation of different parts to communicate effectively, which expanded the understanding of electronics, mechanical systems, and programming integration.

The core focus of this framework was to design and develop an autonomous following truck using an ultrasonic sensor, capable of tracking a person in unstructured environments. The autonomous truck uses ultrasonic sensors, motor drivers, and a microcontroller to perform its tasks. This approach offers a new perspective in the field of robotics. The autonomous truck has potential applications in reducing labour in certain tasks, and it holds significant promise for the future development of robotic systems.

8.2 Future work

The ultrasonic positioning system used in implementing a human-following mobile robot is a stable system mounted on the robot. However, the robot may fail to follow the target if the individual intentionally moves out of the sensor's range. Additionally, while the robot is performing obstacle avoidance, the increase in bearing due to the robot’s rotation could pose challenges. It is important to note that the robot may wander aimlessly until it detects the target signal again. An active ultrasonic positioning system could address this issue by maintaining continuous tracking of the target individual, even during the robot's rotation.

Another approach to solving this challenge is to incorporate a motion prediction model for the target individual into the algorithm. One effective method is the use of the Kalman filter, which provides more accurate data about the target's position, especially when the individual moves outside the ultrasonic sensor's detection cone. This approach enables the robot to re-acquire the target signal more quickly, thereby enhancing the overall performance and flexibility of the human-following mobile robot. Both the ultrasonic positioning system and the sonar sensor system operate based on acoustic principles. Therefore, the robustness of these systems in environments with significant noise levels can be investigated in future studies.

This research has numerous applications across various fields, particularly in the military and medical sectors. For instance, wireless communication capabilities can be added to the robot, allowing it to be controlled remotely and enhancing its versatility. Such a robot could also be adapted for military use. Moreover, modifications to the algorithm and structure can make the robot suitable for other applications. In retail environments, for example, it could assist customers by acting as a luggage carrier, eliminating the need to lift or drag heavy items.

With appropriate modifications, this prototype can be tailored for a wide range of purposes, offering significant potential in multiple domains.

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