Chapter-1

1.1-Introduction

In the realm of robotics and autonomous systems, the development of intelligent and adaptive robots capable of navigating complex environments has become a focal point of research and innovation. This project focuses on the design, implementation, and evaluation of a Lane Tracking and Obstacle Avoidance vehicle, a sophisticated robotic system that combines advanced sensor technologies, precise control mechanisms, and intelligent decision-making algorithms.

The motivation behind this project stems from the increasing demand for intelligent robotic systems that can operate seamlessly in real-world scenarios. Lane Tracking and Obstacle Avoidance are critical functionalities for autonomous vehicles and robots, contributing to enhanced safety and efficiency in various applications, including transportation, surveillance, and industrial automation.

The primary objectives of the project are as follows:

Lane Tracking: Implement a robust system for tracking lanes in dynamic environments, allowing the robot to follow predefined paths or navigate through marked lanes autonomously.

Obstacle Avoidance: Develop an obstacle detection and avoidance mechanism to ensure the robot can dynamically react to its surroundings, avoiding collisions and stop before hitting the obstacles.

Sensor Integration: Integrate sensors such as ultrasonic sensors, and infrared sensors to provide the robot with comprehensive environmental awareness.

Control Algorithms: Implement control algorithms that allow the robot to make informed decisions based on sensor inputs, enabling it to adjust its trajectory in real-time.This report details the Lane Tracking and Obstacle Avoidance vehicle project, covering design, implementation, testing, and performance. It discusses methodology, challenges, solutions, and outlines future enhancements. Aim is to autonomous navigation in robotics, addressing complexities in lane tracking and obstacle avoidance.

Chapter-2

2.1- Material Required

(a) Arduino UNO: The Arduino Uno is a versatile microcontroller board built around the ATmega328P microcontroller, functioning as the core processing unit. Equipped with a set of digital and analog input/output pins, it facilitates connections to sensors and devices. The board features a USB interface for easy programming and power supply, making it accessible for beginners and experienced users alike. With a reset button, LEDs for visual feedback, and connectors for seamless interfacing, the Uno is a user-friendly platform for prototyping and electronic projects. Operating on open-source principles, both the hardware schematics and software (IDE) are freely available, fostering a thriving community and enabling a vast array of applications. Its popularity stems from its simplicity, versatility, and widespread use in educational settings and DIY electronics projects

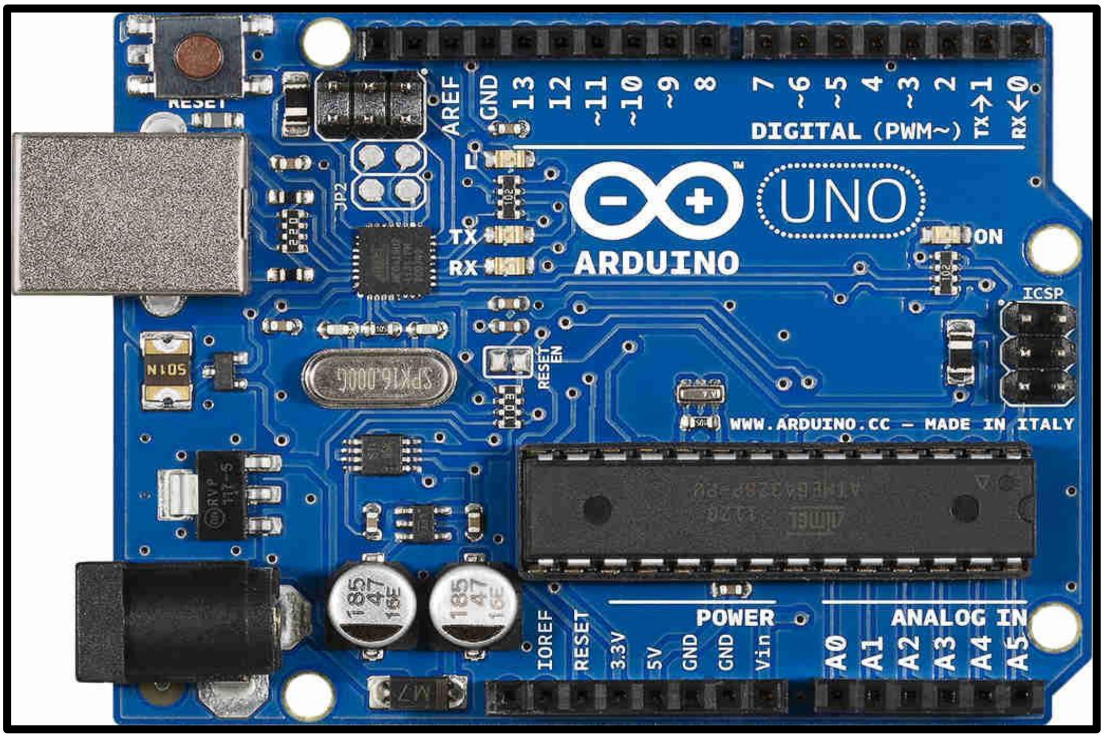

Fig:2.1 Arduino UNO

(b) Ultrasonic sensor Hc-sr04: The HC-SR04 ultrasonic sensor is a widely used distance measuring device that operates on the principle of echolocation. Consisting of a transceiver module, it emits ultrasonic waves and calculates the distance to a target object by measuring the time taken for the waves to return after hitting the object. The sensor contains a pair of ultrasonic transducers—one for sending pulses and the other for receiving them. By triggering the sensor with a pulse and measuring the time until the echo is received, the distance to the object can be accurately determined using the speed of sound. The HC-SR04 is commonly employed in robotics, automation, and proximity detection applications due to its affordability, simplicity, and reliability in measuring distances ranging from a few centimetres to several meters. Integration into projects is straightforward as it requires minimal external components and provides precise and real-time distance information.

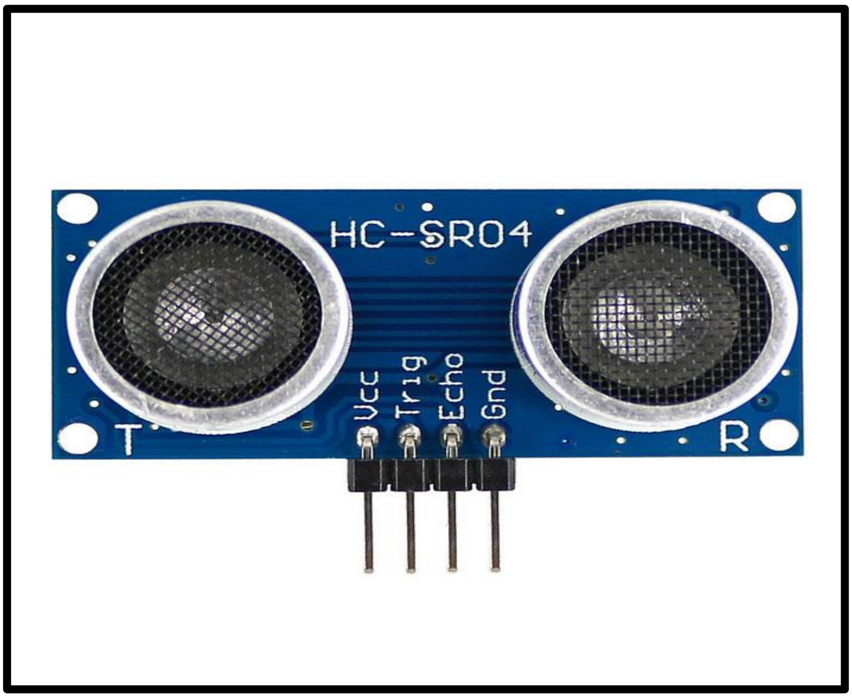

Fig 2.2 Ultrasonic Sensor (HC-SR04)

(c) L293d motor driver shield: The L293D motor driver shield is a versatile and widely used integrated circuit designed to control and drive DC motors, making it a crucial component in robotics and electronic projects. With its H-bridge configuration, the L293D can drive two motors bidirectionally, allowing precise control of motor speed and direction. This shield is compatible with popular microcontrollers like Arduino, offering an easy-to-use solution for motor control without the need for complex circuitry. It provides flexibility for various applications, including robot movements, motorized vehicles, and other electromechanical systems, making it an ideal choice for hobbyists and professionals alike.

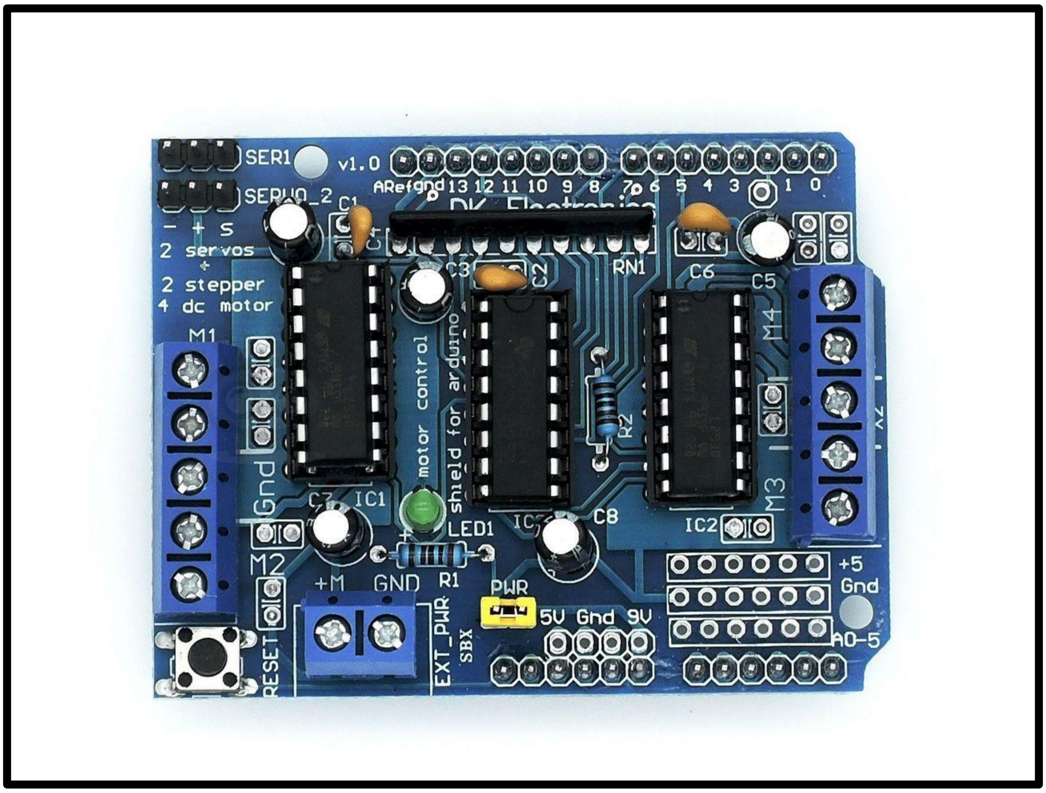

Fig:2.3 Motor Driver (L293D)

(d) 4 DC gear motor: A DC gear motor is a type of electric motor equipped with a gearbox. The gearbox, or gear reduction system, is connected to the motor and consists of gears that control the motor's speed and torque. In the context of robotics or electronic vehicles, a DC gear motor is valuable for its ability to provide controlled and efficient movement. The gear reduction mechanism slows down the motor's high-speed rotation while increasing its torque, allowing for precise control over the motor's output. This makes DC gear motors suitable for applications where a combination of both speed control and strength is essential, such as in obstacle-avoidance and lane-tracking vehicles.

Fig:2.4 DC gear motors (L-shaped)

(e) IR Sensors: In the context of obstacle-avoiding and lane-tracking systems, infrared (IR) sensors are pivotal components used for detecting and responding to the surrounding environment. These sensors emit infrared light and measure the reflected or emitted infrared radiation to determine the presence of obstacles or track lane boundaries. In obstacle-avoidance applications, IR sensors play a crucial role in detecting objects in the vehicle's path, allowing the system to make real-time decisions to navigate around obstacles. For lane-tracking, IR sensors contribute to maintaining the vehicle within designated lanes by continuously monitoring the road boundaries. The data collected by IR sensors enable the system to adjust the vehicle's trajectory and ensure accurate alignment. Overall, IR sensors enhance the awareness and responsiveness of vehicles, making them adept at navigating complex environments with precision.

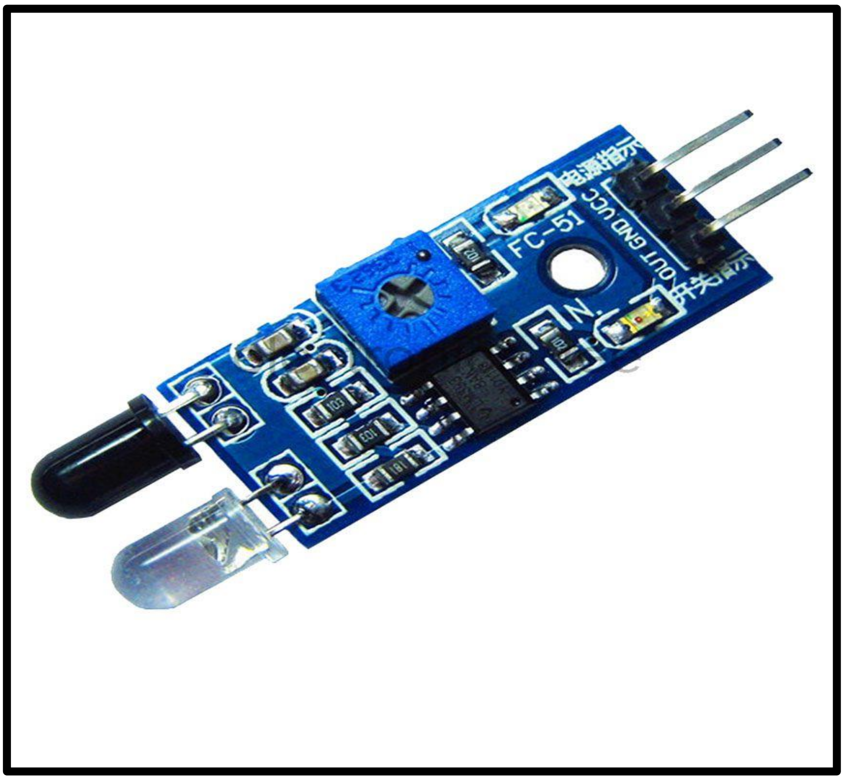

Fig:2.5 IR sensors

(f) 9V Battery: In electricity, a battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Since the invention of the first battery (or "voltaic pile") in 1800 by Alessandro Volta and especially since the technically improved Daniel cell in 1836, batteries have become a common power source for many household and industrial applications. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year, with 6% annual growth There are two types of batteries: primary batteries (disposable batteries), which are designed to be used once and discarded, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. Batteries come in many sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for exchanges and computer data centres.

Fig:2.6 9V Battery

(g) Jumper wires: For connections between components

Fig:2.7 Jumper Wire

(h) Wheels: 4 wheels are required that gets attached to the motor

Fig:2.8 Wheels

(i) Doubled layer cardboard base: Instead of spending money on a chassis kit for our vehicle base, we chose a more affordable option—cardboard. Knowing that a single layer of cardboard wouldn't be strong enough for the stress from the motors and wheels, we joined two cardboards together to create a stronger yet lightweight base.

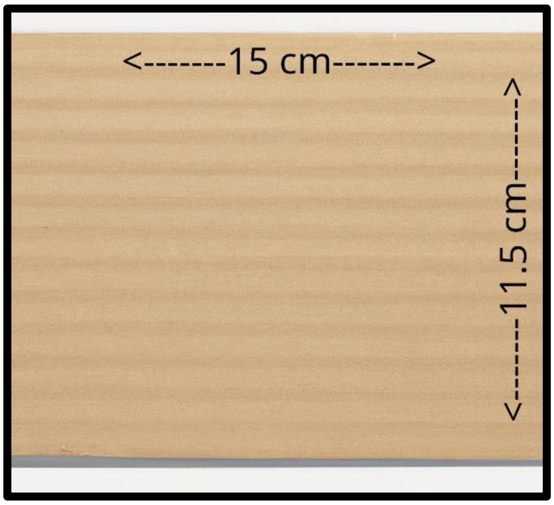

Fig:2.9 Base

Chapter-3

3.1-Circuit Diagram

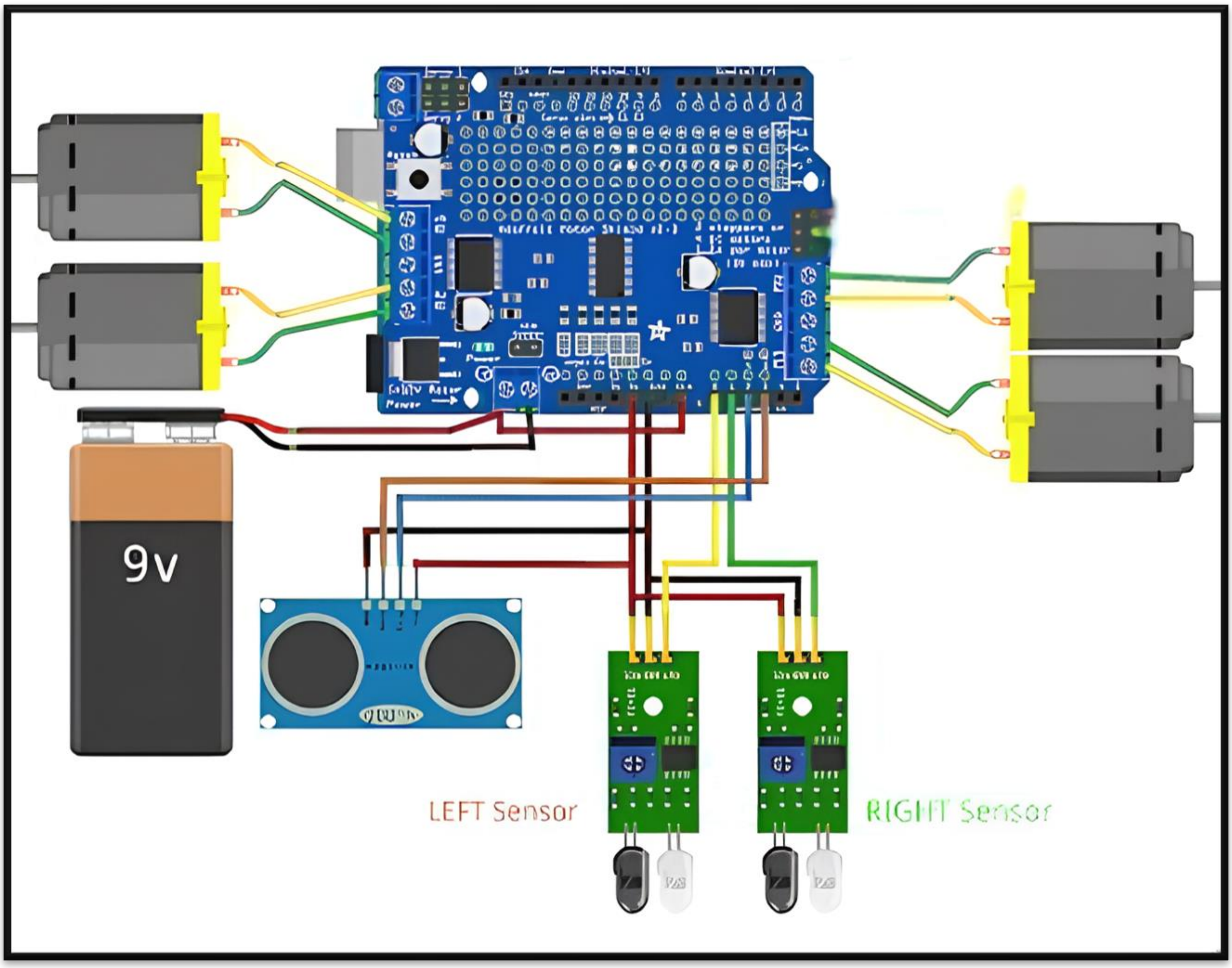

Fig 3.1 Lane tracking and obstacle avoidance circuit diagram

3.2-Pin Connections

Following steps have been performed for the pin connections:

1. First attach a motor driver shield onto the Arduino.
2. Now connect the gear motors to the l293d motor driver shield.
   - Motor 1 to motor driver M1
   - Motor 2 to motor driver M2
   - Motor 3 to motor driver M3
   - Motor 4 to motor driver M4
3. connect the IR sensor to motor driver.
   - IR sensor *OUT* pin is connected to motor driver *A0* pin.
   - IR sensor GND pin is connected to motor driver *GND* pin.
   - IR sensor *VCC* pin is connected to motor driver *5v* pin.

Do the same for other IR sensor but make sure that *OUT* pin is connected to motor driver *A1*.

4. Connect the servo motor to motor driver servo1 slot.
5. Connect ultrasonic sensor to motor driver.
   - Hc-sr04 *TRIG* pin to motor driver *A2.*
   - Hc-sr04 *ECHO* pin to motor driver *A3.*
   - Hc-sr04 *5v* pin to motor driver *5v.*
   - Hc-sr04 *GND* pin to motor driver *GND.*

3.3-Code Documentation

After doing all the connections required connect the Arduino uno to pc via USB cable and open the Arduino IDE, select the Arduino board, and com port from the tool menu after that upload the code.

Here is a brief documentation of the code:

The code is for a robot that uses an HC-SR04 ultrasonic sensor and two IR sensors to avoid obstacles. The robot is driven by four DC motors controlled by an Adafruit Motor Shield.

Libraries Used:

I. - `*NewPing.h*`: This library is used for the HC-SR04 ultrasonic sensor.
II. - `*Servo.h*`: This library is used to control the servo motor which is used to rotate the ultrasonic sensor.
III. - `*AFMotor.h*`: This library is used to control the DC motors using the Adafruit Motor Shield.

Defined Constants:

I. - `*TRIGGER_PIN*` and `*ECHO_PIN*`: These are the pins connected to the ultrasonic sensor.
II. - `*max_distance*`: This is the maximum distance in cm that the ultrasonic sensor will measure.
III. - `*irLeft*` and `*irRight*`: These are the pins connected to the left and right IR sensors.
IV. - `*MAX_SPEED*` and `*MAX_SPEED_OFFSET*`: These are the maximum speed and speed offset for the motors.

Global V*ariables:*

I. - `*distance*`, `*leftDistance*`, `*rightDistance*`: These variables store the distances measured by the ultrasonic sensor.

II. - `*object*`: This boolean variable is used to determine if there is an object in front of the robot

Functions:

- `*setup()*`: This function initializes the serial communication, sets the pin modes, attaches the servo, and sets the initial speed of the motors.

- `*loop()*`: This function continuously checks the IR sensors and calls the appropriate function based on the sensor readings.

- `*objectAvoid()*`: This function checks the distance to an object using the ultrasonic sensor and decides whether to move forward or turn based on the distance.

- `*getDistance()*`: This function uses the ultrasonic sensor to measure the distance to an object.

- `*lookLeft()*` and `*lookRight()*`: These functions rotate the ultrasonic sensor to the left or right and measure the distance to an object.

- `*Stop()*`: This function stops all the motors.

- `*moveForward()*` and `*moveBackward()*`: These functions move the robot forward or backward.

- `*turn()*`: This function turns the robot based on the `object` variable.

- `*moveRight()*` and `*moveLeft()*`: These functions turn the robot to the right or left.

This code makes the robot move forward until it detects an object within 15 cm. When an object is detected, the robot stops, looks left and right, and then turns in the direction with the most space. If the IR sensors detect an object, the robot will also turn.

Chapter-4

4.1-Working

The Lane Tracking and Obstacle Avoidance Vehicle seamlessly integrates various components to execute its functionalities. Key elements include ultrasonic (HC-SR04) and infrared (IR) sensors, servo motors, and DC gear motors. The four DC motors, denoted as motor1, motor2, motor3, and motor4, are orchestrated for movement control using the AFMotor library, offering a versatile means of propelling the vehicle. Complementing this, a servo motor takes charge of sensor orientation, ensuring precise alignment for effective data collection.

The operational strategy is orchestrated within the *loop()* function, constituting the core control logic of the vehicle. This function continuously monitors inputs from the infrared sensors, namely irLeft and irRight. In the absence of detected lane boundaries by both sensors, the control logic triggers the *objectAvoid()* function. This function, in turn, manages the vehicle's response to obstacles within a proximity of 15 cm. In the presence of such an obstacle, the vehicle halts its movement promptly through the Stop() function, serving as an essential safety mechanism.

Chapter-5

5.1: Advantages

- **Safety First:** The project focuses on safety by making the vehicle stop when it spots an obstacle. This prevents accidental collisions and puts safety at the forefront of its design.
- **Easy Navigation:** Instead of changing direction, the vehicle keeps it simple by stopping when an obstacle is detected. This straightforward approach is useful in situations were going straight is crucial.
- **Predictable Moves:** Stopping upon detecting an obstacle makes the vehicle's behaviour predictable. This predictability is handy in situations where a consistent response is needed, making it easier to integrate into different environments.
- **Less Complicated:** The vehicle doesn't change its course, reducing the overall complexity of how it navigates. This simplicity is beneficial when a straightforward approach is preferred, or when operating within set pathways.
- **Straight to the Point:** The vehicle's design of stopping simplifies how it handles obstacles. This uncomplicated approach can speed up development and troubleshooting, making it accessible for learners and developers.
- **Clear Obstacle Handling:** The focus on halting when an obstacle is detected allows for a focused response. This can be helpful in situations where taking a pause provides an opportunity for further analysis or decision-making.
- **Steady Lane Tracking:** The vehicle's consistent behaviour ensures steady tracking of lanes. By staying still upon detecting an obstacle, it guarantees a continuous and stable path along predefined lanes.
- **User-Friendly:** Stopping when an obstacle is spotted makes the interaction user-friendly. Users can easily understand and control the vehicle, especially in situations where manual intervention is necessary.

5.2: Disadvantages

- **Limited Maneuverability:** The project's stop-only response to obstacles may limit its ability to navigate complex environments with intricate obstacles.
- **Traffic Flow Disruption:** The vehicle's complete halt upon detecting an obstacle could disrupt traffic flow in scenarios involving multiple vehicles, where an adaptive response might be more suitable.
- **Sensor Sensitivity:** Reliance on infrared and ultrasonic sensors makes the vehicle sensitive to changes in lighting conditions or reflective surfaces, potentially affecting obstacle detection accuracy.
- **Static Path Response:** Lack of a mechanism for dynamic path adjustment hinders the vehicle's ability to navigate in real-time, particularly when quick path adjustments are necessary.
- **Simplified Navigation:** While simplicity aids navigation, the project's design may oversimplify responses, potentially limiting its suitability for scenarios requiring more nuanced maneuvering.
- **Sensor Accuracy Dependency:** The project's effectiveness relies heavily on sensor accuracy; any inaccuracies or limitations in sensor performance could lead to false positives or negatives in obstacle detection.
- **Limited User Interaction:** The project's user-friendly design might offer minimal options for user interaction, limiting users' ability to influence the vehicle's behaviour beyond its basic stopping response.
- **Reduced Adaptability:** The straightforward response may limit the vehicle's adaptability in diverse environments, where more dynamic and adaptive navigation is required.
- **Potential for False Stops:** Depending on obstacle detection logic, the vehicle might come to a halt even in the absence of obstacles, leading to unnecessary stops and impacting overall efficiency.
- **Limited Learning Scope:** The project's simplicity may restrict learning opportunities for those seeking to explore advanced robotics concepts or intricate obstacle avoidance strategies.

5.3: Applications

- **Autonomous Delivery Robots:** Enhance safety in delivery robots by preventing collisions with obstacles and controlled stops upon detection.
- **Warehouse Automation (AGVs):** Improve safety and efficiency in warehouses by using the technology in Automated Guided Vehicles (AGVs) to navigate predefined lanes and halt for unexpected obstacles.
- **Security Surveillance Robots:** Patrol designated areas with security robots, utilizing lane tracking and obstacle avoidance to follow routes and stop when potential security threats are detected.
- **Educational Robotics:** Provide a hands-on and accessible way to teach basic robotics concepts, including sensors, motor control, and obstacle detection.
- **Smart Parking Systems:** Enhance parking efficiency and safety by integrating the technology into autonomous parking systems, guiding vehicles along designated lanes and stopping to avoid collisions.
- **Indoor Navigation for the Visually Impaired:** Assist visually impaired individuals in navigating indoors, ensuring safe travel along predefined paths and stopping in the presence of unexpected obstacles.
- **Industrial Conveyor Systems:** Increase safety in industrial conveyor systems by ensuring vehicles automatically stop when encountering obstacles, preventing collisions and damage.
- **Agricultural Robots:** Utilize the technology in autonomous agricultural robots for precision tasks such as crop monitoring or spraying, ensuring safe navigation along predefined paths.
- **Theme Park Rides:** Implement the technology in autonomous ride vehicles within theme parks to provide a safe and controlled experience, following designated paths and stopping when necessary for passenger safety.
- **Airport Baggage Handling:** Improve safety and efficiency in airport baggage handling systems by integrating the technology into autonomous vehicles, preventing collisions and ensuring efficient movement along

Chapter-6

6.1: Finished Model

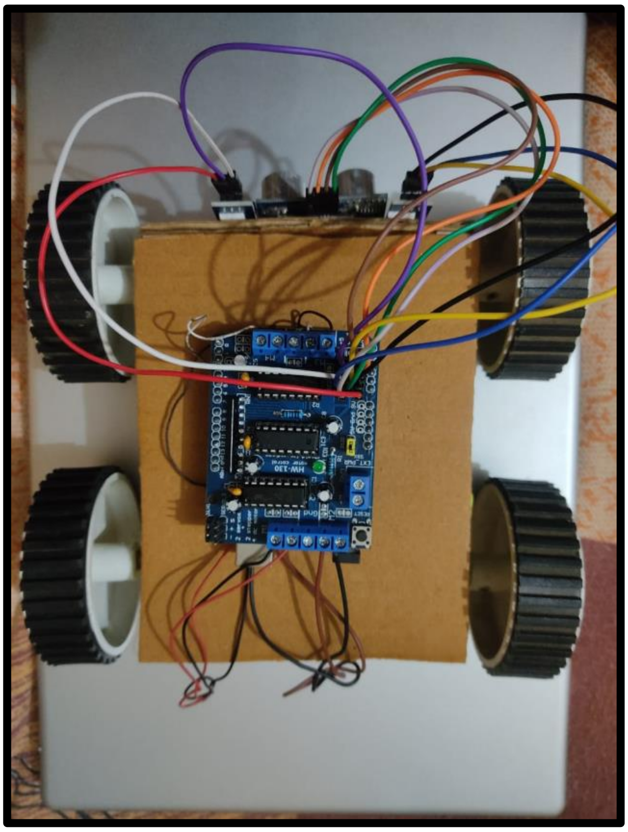

Fig:6.1 Top View

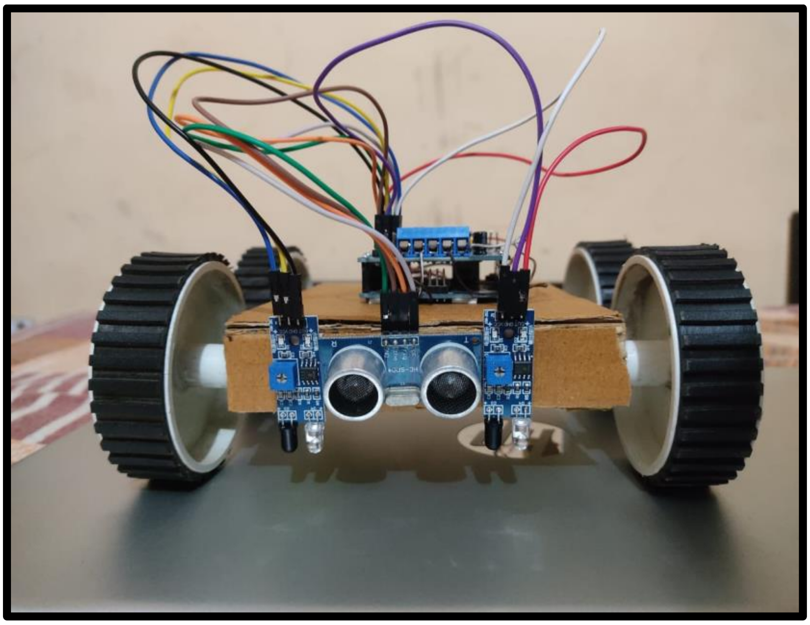

Fig:6.1 Front View

Chapter-7

7.1: Conclusion

In conclusion, the Lane Tracking and Obstacle Avoidance Vehicle project represents a significant stride in the realm of autonomous robotics, offering a simplified yet effective solution for navigating predefined paths while ensuring safety through obstacle detection. By combining ultrasonic and infrared sensors with servo and DC gear motors, the project demonstrates adaptability in various real-life applications, ranging from autonomous delivery systems to educational robotics. The project's user-friendly design and predictable stopping response provide a foundation for learning and customization. However, it's important to acknowledge the project's limitations, such as its static response to obstacles and potential sensitivity to sensor variations. Moving forward, further enhancements could explore dynamic path adjustments and more advanced obstacle avoidance strategies. Overall, this project lays the groundwork for exploring the intersection of simplicity, safety, and adaptability in autonomous systems, contributing valuable insights to the evolving field of robotics.

Chapter-8

8.1: Future Scope

The Lane Tracking and Obstacle Avoidance Vehicle project exhibit promising potential for future enhancements and expansions. The following are key avenues for future development and exploration:

- **Dynamic Path Adjustment:** Integrate a mechanism for the vehicle to dynamically adjust its path when encountering obstacles. This would involve real-time decision-making to navigate around obstacles and resume its course, adding a layer of adaptability to the project.
- **Advanced Obstacle Avoidance Strategies:** Explore and implement more sophisticated obstacle avoidance algorithms, incorporating machine learning or computer vision techniques to enhance the vehicle's ability to recognize and respond to diverse types of obstacles in real-time.
- **User Interaction Features:** Introduce features that allow users to interact with the vehicle, providing commands or influencing its behaviour. This could include a remote-control interface or integration with smart devices for more dynamic user engagement.
- **Multi-Sensor Fusion:** Investigate the use of multiple sensors in combination, such as lidar, radar, or additional ultrasonic sensors, to improve the accuracy and reliability of obstacle detection and enhance the vehicle's overall perception capabilities.
- **Wireless Communication:** Implement wireless communication capabilities to enable the vehicle to communicate with other devices or vehicles. This could be valuable in scenarios where multiple autonomous systems need to coordinate or share information.
- **Integration with Mapping Systems:** Incorporate mapping and localization systems to enable the vehicle to navigate within known environments more efficiently. This

could involve the creation of digital maps that the vehicle references for precise navigation.

- **Energy-Efficient Design:** Optimize the power consumption of the vehicle by exploring energy-efficient motor control strategies, sensor sleep modes, or alternative power sources. This would contribute to prolonged operational durations and sustainability.
- **Human-Robot Interaction:** Explore human-robot interaction aspects, including the development of natural language processing capabilities or expressive interfaces that enable more intuitive communication between the vehicle and users.
- **Real-world Testing and Validation:** Conduct extensive real-world testing in diverse environments to validate the project's performance and identify areas for improvement. This could involve collaboration with industry partners or research institutions to gather valuable insights.
- **Integration with Smart City Initiatives:** Explore opportunities to integrate the project into broader smart city initiatives, contributing to the development of intelligent and efficient urban transportation systems.

Continued exploration and development in these areas would propel the Lane Tracking and Obstacle Avoidance Vehicle project into a more advanced and versatile solution, addressing emerging challenges and contributing to the evolution of autonomous robotics.

References:

1. https://www.mrelectrouino.com/2021/03/Arduino%20obstacle%20avoidance%20line%20follower%20robot.html

2. https://www.youtube.com/watch?v=ZiqAyuLpS3o