SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING

A SKILL DEVELOPMENT REPORT

ON

"DESIGN AND DEVELOPMENT OF HAND FOLLOWING ROBOT"

Submitted in fulfillment of the requirements for the award of the Degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMPUTERS ENGINEERING

Submitted by

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DECLARATION

We, Mr. / Ms. **Bhagya V** (R22EP031), **Jayanth BV** (R22EP038), **Shreyas M Shanbhag** (R22EP055), **Rahul P** (R22EP046), **Bhagya V** (R22EP031), **Shravan** (R22EP053), student of B. Tech, belongs to the School of Electronics and Communication Engineering, REVA University, declare that this Project Report / Dissertation entitled "**Design and Development of Hand Following Robot**" is the result of the of project/dissertation work done by me under the supervision of Prof. Tauseef, Asst. Prof., School of ECE REVA University.

I am submitting this Project Report / Dissertation in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electronics and Communication Engineering award by the REVA University, Bengaluru, during the academic year 2022-23.

I declare that this project report has been tested for plagiarism and has passed the plagiarism test with a similarity score of less than 25%. It satisfies the academic requirements regarding the Project work prescribed for the said Degree.

I further declare that this project/dissertation report or any part of it has not been submitted for the award of any other Degree / Diploma of this University or any other University/ Institution.

(Signature of the Student)

Signed by us on 10th January 2024.

Certified that this project work submitted by Mr/Ms. Bhagya V (R22EP031), Jayanth BV (R22EP038), Shreyas M Shanbhag (R22EP055), Rahul P (R22EP046), Shravan (R22EP053)has been carried out under my / our guidance and the declaration made by the candidate is true to the best of my knowledge.

Signature of Guide
Date: 10th January 2024

Signature of Director
Date: 10th January 2024
Official Seal of the School

SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the project work entitled "**Design and Development of Hand Following Robot**" carried out under my guidance by ***Mr/Ms. Bhagya V (R22EP031), Jayanth BV (R22EP038), Shreyas M Shanbhag (R22EP055), Rahul P (R22EP046), Shravan (R22EP053),*** a bonafide student of REVA University during the academic year 2022-2023, is submitting the project report in partial fulfillment for the award of Bachelor **of Technology in Electronics and Communication Engineering** during the academic year **2022–23**. The project report has been tested for plagiarism and has passed the plagiarism test with a similarity score of less than 25%. The project report has been approved as it satisfies the academic requirements regarding the Project work prescribed for the said Degree.

Signature with date	Signature with date
Prof. Suraj **Guide**	**Dr. K M Sudarshan** **Director**

External Examiner

	Name of the Examiner with affiliation	Signature with Date
1.		
2.		

ACKNOWLEDGEMENT

This satisfaction and euphoria that accompany the successful completion of any task would be but complete without the mention of the people who made it possible with constant guidance and encouragement and crowned our efforts with success.

We thank our Honorable **Chancellor**, **Dr. P. Shyamaraju** for his support and encouragement and wonderful infrastructure/resources.

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Last but not least we would like to thank our beloved parents for their blessings, love and encouragement to successfully complete the task by meeting all the requirements.

Bhagya V (R22EP055)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

Qty	Name	Abbreviation
1.	IC	Integrated Circuits
2.	3D	3 Dimensional
3.	IoT	Internet Of Things
4	ESP	Espressif
5.	CAD	Computer aided Drawing
6.	DC	Direct Current
7.	PLA	Polyactic Acid
8.	STEM	Science,Technology,Engineering,Mathematics

LIST OF TABLES

ABSTRACT

The IoT-based Hand following robot is a cutting-edge system that combines IoT technology, robotics, and computer vision algorithms. The robot is equipped with various sensors, drivers, and Microcontrollers all connected through the internet, enabling it to perceive and respond to human hand with remarkable accuracy.

This project introduces a budget-friendly autonomous hand-following robotic car, showcasing the integration of a 3D-printed sensor holder and casing alongside minimalistic hardware, including an ultrasonic sensor, L293D motor driver, and ESP32 microcontroller. The design emphasis lies in providing an accessible and cost-effective solution for enhancing human-robot interaction.

The 3D-printed sensor holder and casing play a pivotal role in this project, serving as a customized and efficient enclosure for housing the essential components. The holder accommodates the ultrasonic sensor in a strategically positioned manner, optimizing its field of view for accurate hand detection. Additionally, the casing provides protection to the internal components, ensuring durability.

The ultrasonic sensor, as the primary distance measurement device, enables the robotic car to maintain a safe and consistent distance from the user's hand. The L293D motor driver, controlled by the ESP32 microcontroller, facilitates precise motor control for responsive and smooth movements. The 3D-printed design adds a layer of customization, allowing for adaptations to different robotic car models and user preferences.

The hand-following algorithm, interprets the ultrasonic sensor data to adjust the robotic car's direction autonomously. Through experimentation and testing, the 3D-printed model's impact on the system's performance and adaptability is evaluated, demonstrating its versatility for various robotic applications.

This project not only presents a functional autonomous hand-following robotic car but also underscores the significance of accessible design through the incorporation of 3D printing technology. The low-cost nature of this solution, coupled with the customizable 3D-printed components, makes it an ideal platform for educational purposes, hobbyist exploration, and further innovation in human-robot interaction.

Chapter 1

INTRODUCTION

Embarking on a transformative journey aimed at redefining user experience and accessibility, our project introduces an IoT-Based Hand-Following Robot, seamlessly integrating natural and instinctive control mechanisms. At the core of this innovation lies the indispensable L293D motor driver, empowering the robot with precision in its movements and articulation of physical mechanisms. Notably, the project's distinction is further emphasized by the incorporation of a meticulously designed 3D-printed sensor holder case.

This 3D-printed sensor holder case assumes a pivotal role as a customized and efficient enclosure for crucial components, demonstrating a commitment to both optimal functionality and user-friendly design. Its strategic placement accommodates the ultrasonic sensor, ensuring an optimal field of view for precise hand detection. This addition not only enhances the overall efficiency of the robot but also underscores the project's dedication to meticulous engineering.

As the L293D motor driver facilitates dynamic responses to gestures captured by the ultrasonic sensor, translating them into seamless movements such as forward, backward, and intricate object manipulation, the 3D-printed sensor holder case complements this functionality, contributing to the robot's overall efficiency and aesthetic appeal.

Elevating the project to unparalleled connectivity heights is the ESP32 microcontroller, serving as the central processing unit and communication hub. Equipped with Wi-Fi and Bluetooth capabilities, the ESP32 establishes seamless connections to the internet and other smart devices.

Our IoT-Based Hand-Following Robot stands as a testament to the convergence of cutting-edge technologies, robotics, and IoT. By harmonizing the precise detection capabilities of the ultrasonic sensor, the motor control finesse of the L293D, and the processing prowess coupled with connectivity features of the ESP32, this robotic system, complemented by the meticulous addition of the 3D-printed sensor holder case, delivers an unparalleled, intuitive, and interactive user experience.

- **Applications:**

1) Interactive Exhibits in Museums:

The hand/object-following robot can be used as an interactive exhibit in museums, science centers, or educational institutions to engage visitors and demonstrate the principles of robotics and sensor technology.

2) Assistive Technology for Individuals with Disabilities:

Adapted for assistive technology, the robot can assist individuals with limited mobility, allowing them to control the robot's movement through hand gestures.

3) Educational Workshops and STEM Programs:

Deployed in educational settings for robotics workshops and STEM programs to teach students about robotics, programming, and technology in a hands-on and interactive manner.

4) Entertainment Events and Parties:

Used as entertainment at events, parties, or shows to captivate audiences with a dynamic and interactive robot that responds to hand movements.

5) Research and Development in Human-Robot Interaction:

Applied in research and development projects focusing on human-robot interaction, exploring ways to enhance collaboration and communication between humans and robots.

6) Autonomous Guided Vehicles (AGVs):

Modified for industrial applications as a prototype for autonomous guided vehicles (AGVs) used in manufacturing or warehouse environments, demonstrating the potential for automated material handling.

- ## Challenges:

1. Precision and Accuracy:

Achieving precise and accurate hand detection and tracking poses challenges, as variations in lighting conditions and hand gestures can impact the reliability of the system.

2. Sensor Calibration:

Calibrating sensors, especially the ultrasonic sensor, for accurate distance measurement and gesture recognition can be challenging due to environmental factors and sensor sensitivity.

3. Integration of Components:

Integrating various hardware components, such as the ultrasonic sensor, motors, and the 3D printed sensor holder case, requires careful consideration of space, weight distribution, and overall system compatibility.

4. Mechanical Design:

Designing a 3D printed sensor holder case that is both functional and robust can be challenging. Ensuring proper fit, structural integrity, and ease of assembly are critical aspects.

5. Real-Time Processing:

Implementing real-time processing for gesture recognition and motor control demands efficient algorithms and a powerful microcontroller, introducing challenges in terms of computational resources.

6. Material Selection for 3D Printing:

Choosing suitable materials for 3D printing the sensor holder case involves considering factors such as durability, weight, and the ability to withstand environmental conditions.

7. Cost Constraints:

Balancing the integration of advanced features and capabilities with cost constraints can be challenging, especially if certain technologies or materials are expensive.

- **Advantages:**

1) Intuitive Interaction:

The hand/object-following robot offers an intuitive way of interacting with a robotic system. Users can control the robot's movement through simple hand gestures, providing a natural and user-friendly interface.

2) Hands-Free Operation:

Users can control the robot without the need for physical controllers or devices, offering a hands-free operation that can be useful in scenarios where manual control is not practical.

3) Accessibility and Inclusivity:

The technology can be adapted for individuals with mobility challenges, making it more accessible and inclusive. It has potential applications in assistive technology to assist people with disabilities.

4) Educational Value:

The project provides an educational platform for learning about robotics, sensor integration, and programming. It can be used in STEM education to engage students in hands-on learning experiences.

5) Entertainment and Engagement:

The robot has applications in entertainment, providing an engaging and interactive experience for users. It can be used in events, exhibitions, or as a unique form of entertainment in various settings.

6) Demonstration of Technology Integration:

The project demonstrates the integration of different technologies, such as ultrasonic sensors, microcontrollers (like the ESP32), and motors, showcasing the potential of combining these elements for practical applications.

Chapter 2

Methodology

We worked on the systematic approach to solve the problem statement and advance our project towards completion and excellence.

The Systematic Approach to complete the project is called Methodology.

The Flowchart in figure 3 represents the ideal steps to be followed to complete a project/ research paper

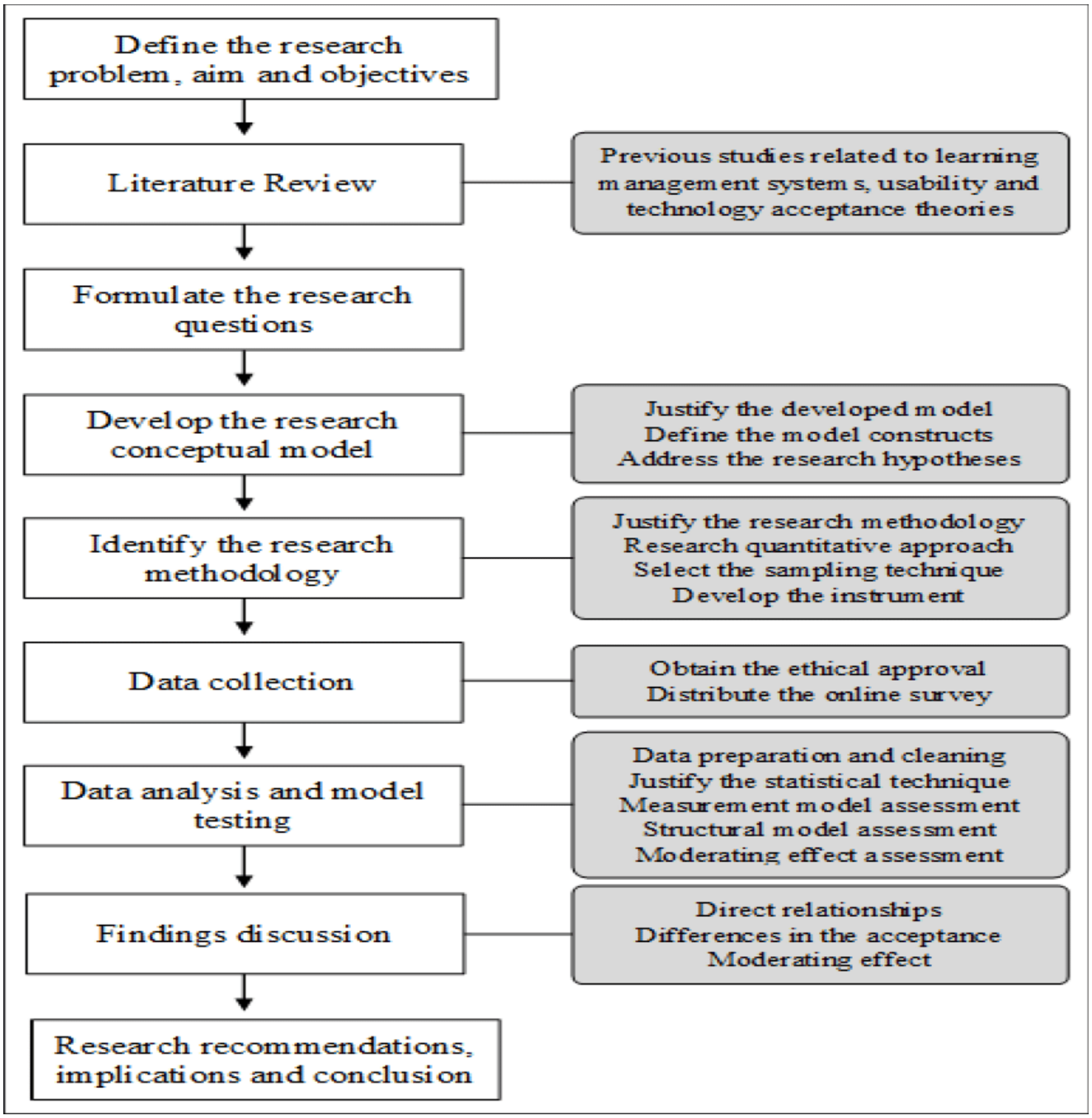


figure 3 Flowchart of Methodology

1. Literature Review:

Conducting an extensive literature review to comprehensively understand the existing research and technologies related to hand-following robots, gesture recognition, and 3D printing applications in robotics.

2. Define Objectives:

Develop a robust gesture recognition system using an ultrasonic sensor to accurately capture and interpret hand movements.
The main objective of the project and the course of Skill Development Program is to give a versatility of making a Robotic system and integrating it with a 3D printed Model

3. System Design:

The Robot System is simulated to work in TinkerCAD for the information of circuit Diagram and components requirement. System software used to simulate the robotic system is TinckerCAD software but the main software used to make the 3D model with the schematics of the Robotic systems is the CATIA software. The figure 3.1.1 represents the circuit of the robot simulated in TinkerCAD.

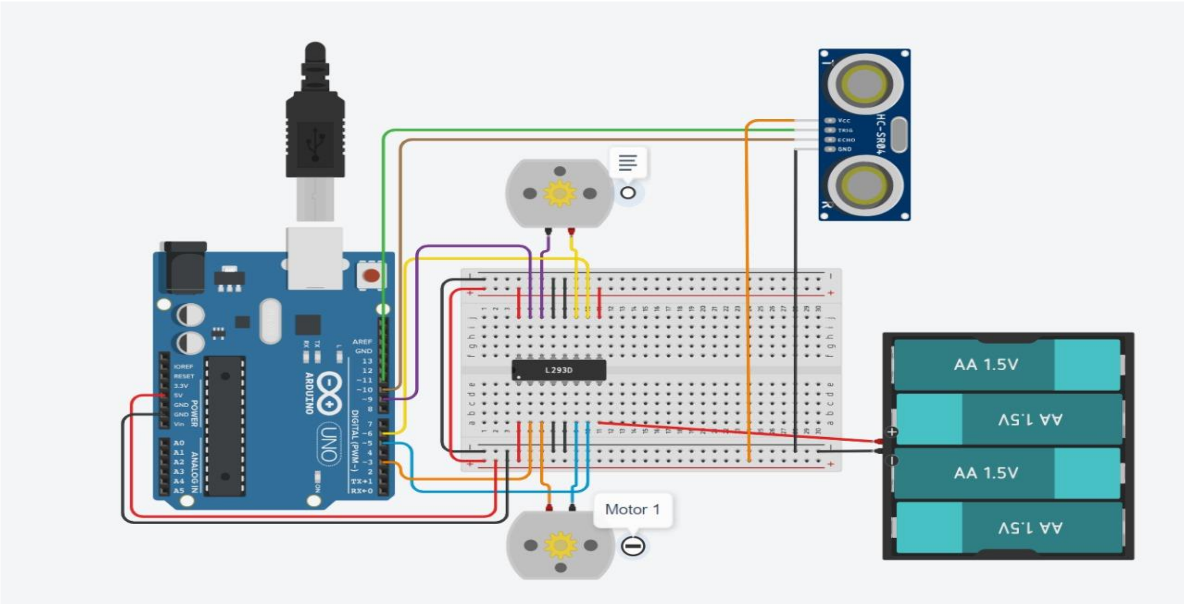


figure 3.1.1 Circuit Diagram

4. Components Collection [Electronics]:

Components required for the robotic system circuit is [Lists below are only electronic components]:

- <u>Ultrasonic Sensor:</u>

An ultrasonic sensor comprises a transducer, typically a piezoelectric crystal, serving as the core component. Housed within a protective casing, the sensor incorporates both an emitter and a receiver, which work together to send and capture ultrasonic pulses. The sensor's electronic circuitry processes signals, employing amplifiers, filters, and timers for accurate distance measurements based on the time-of-flight principle. With a control interface allowing adjustments to sensitivity and range, ultrasonic sensors operate on a power supply compatible with common electronic systems. Operating at ultrasonic frequencies and emitting waves within a defined beam angle, these sensors provide output signals reflecting the time taken for pulses to travel, making them valuable for applications such as distance measurement and object detection in robotics and automation. The figure 3.1.2 displays the Ultrasonic sensor which is used in the project.

figure 3.1.2 Ultrasonic Sensor

- <u>L293D:</u>

The L293D motor driver is a crucial integrated circuit (IC) widely employed for motor control in electronics and robotics. Configured as a dual H-bridge, it features four switching transistors arranged to enable bidirectional control of two DC motors or a single stepper motor. The IC incorporates input pins for motor control, with corresponding enable pins to activate or deactivate each motor. Separate power supply pins for the motor and logic components provide flexibility in voltage selection. Output pins are connected to the motor terminals, determining direction and speed based on voltage levels. Notably, the L293D includes built-in diodes for protection against voltage spikes during motor deactivation. Available in a 16-pin DIP or surface-mount package, the L293D's versatility, H-bridge design, and integrated features make it a popular choice for motor control applications in diverse electronic projects. The figure 3.1.3 shows the motor Driver L293D used in making the project. The figure 3.1.3 contains L293D IC and a capacitor to store voltage.

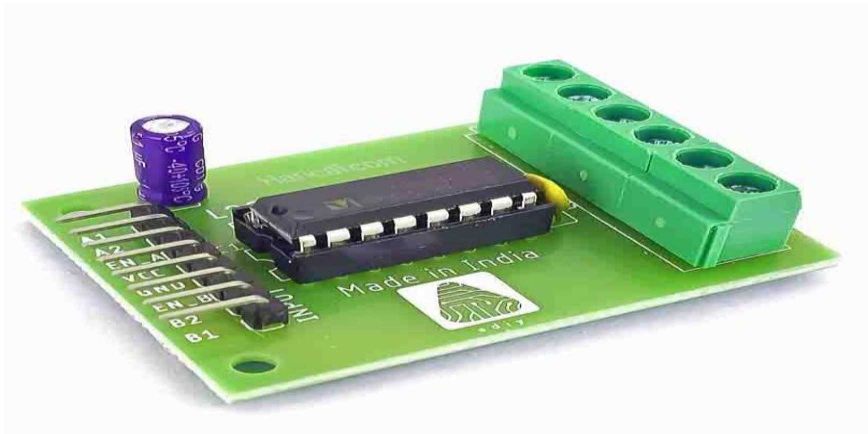


figure 3.1.3 L293D

- <u>ESP32 Microcontroller:</u>

  The ESP32 microcontroller is a powerful and versatile component widely utilized in IoT applications. Featuring dual-core processors, integrated Wi-Fi, and Bluetooth capabilities, the ESP32 serves as a central processing unit and communication hub in electronic projects. Its architecture supports seamless connectivity to the internet and other smart devices, enabling real-time data exchange and remote control. The ESP32's compact design and advanced features make it a preferred choice for IoT applications, providing a robust foundation for the development of connected systems with enhanced processing and communication capabilities. The figure 3.1.4 represents the microcontroller used in our project.

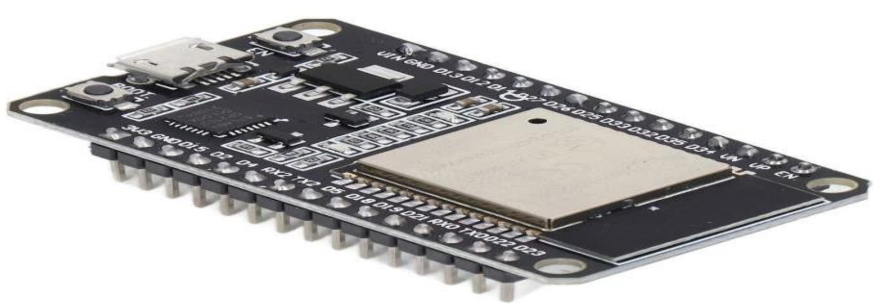


figure 3.1.4 ESP 32 Dev Module

- <u>DC Motors:</u>

  A DC motor with a dual shaft configuration is a specialized electromechanical device commonly used in robotics and automation. This type of motor features two output shafts extending from either side of the motor body, providing enhanced versatility and functionality. The dual shaft design allows for simultaneous power transmission to two different mechanisms or loads, facilitating more complex and synchronized movements in robotic systems. These motors typically have a compact and durable construction, with brushes or brushless technology depending on the application requirements. The dual shaft setup enables precise control over both shafts, making these DC motors suitable for a wide range of applications, including those demanding intricate movements and precise positioning in various industrial and robotic settings. There are 2 DC motors used in the project for spinning the couple of wheels represented in the figure 3.1.5

figure 3.1.5 DC Motors

5. Components Calibration:

Testing each component for its rightful working to proceed in the project to achieve the robotic system.

6. Circuit Combination:

The ultrasonic sensor is connected to the ESP32 DEV module microcontroller. The microcontroller is programmed to receive the signals of the ultrasonic sensor and command the Motor Drivers to rotate the wheels connected to the motors which are powered by batteries through the L293D motor driver. The Figure3.1.6 explains the circuit diagram which was successfully stimulated in TinkerCAD software. The Figure 3.1.6 constitutes the circuit diagram of the project. The project is executed with Esp32 microcontroller not the Arduino Board

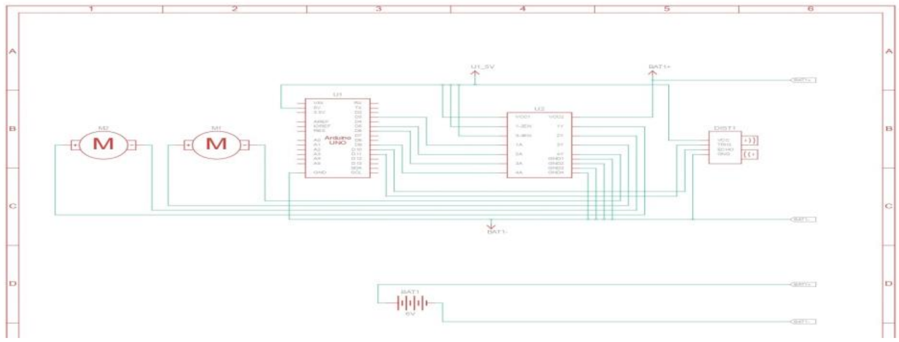


figure 3.1.6 Circuit Diagram

7. Mechanical Components collection:

A robotic system contains 3 major course components: Electronic, Mechanical, Computer[Coding].The Mechanical components used in the project are:

- <u>Chassis:</u>

The robot's body is called the chassis of the robot. The project has 2 wheel drive chassis with the castor wheel. Chassis is designed in the CATIA software with appropriate views and measurement which is used in our project represented by figure 3.1.7. The chassis has an inbuilt castor wheel.

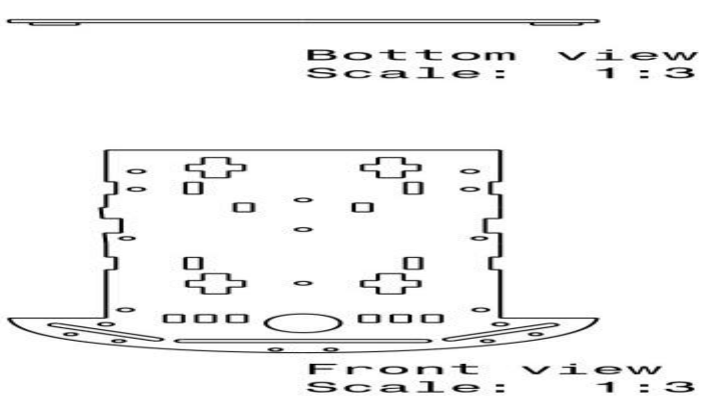


figure 3.1.7 CATIA software design of chassis

- <u>Wheels:</u>

  Wheels are the mechanical parts which are connected to The DC Motors and to display the output of the Robo car. Wheels used in our project are represented in figure 3.1.8:

figure 3.1.8 Wheels

7. IoT Integration:

Leverage the IoT capabilities of the ESP32 for connectivity. Implement features such as remote control, real-time monitoring, and data exchange with cloud servers to enhance the robot's functionality using coding with the platform ARDUINO IDE.

8. 3D Model Design:

Designing the 3D model for the sensor holder case. Utilization of CAD software known as CATIA to create a customized and ergonomic design that accommodates the ultrasonic sensor securely while ensuring ease of assembly. The 3D model is designed with appropriate measurements as in figure 3.1.9 to hold the ultrasonic sensor and to be placed perfect in the chassis. The 3D model with perfect dimensions has to be in a 3D printer

figure 3.1.9 3D model design [Casing]

9. External Parameters:

Parameters where the weight distribution of the Car Robot is to noted for efficient use of the robot. Which is why weight distribution of the entire robot is calculate using the Density Chart with the motor calculations for effective understanding of working of the Robot with the 3D model is done below for the reference.

<u>MOTOR CALCULATION:</u>

RPM OF THE MOTOR =150RPM

Shaft -DUAL

Load Current=40-180mA

Rated torque=0.35kgcm

Weight of the motor=30g

Torque of the motor=0.035NM

Diameter of the Wheel=067.5mm=0.0675m

Radius of Wheel=0.0337

$$TORQUE\ OF\ THE\ WHEEL + FORCE \times PERPENDICULAR\ DISTANCE$$

$$FORCE = TORQUE \div RADIUS = \frac{0.035}{0.0337} = 1.038N$$

$$FORCE\ IN\ TERMS\ OF\ kg = \frac{1.038}{9.81} = 0.1058kg$$

NUMBER OF WHEELS=2

$$TOTAL\ PULLING\ FORCE = 2 \times FORCE\ IN\ kg = 2 \times 0.1058kg = 0.2116kg = 211.6G$$

- Density Chart

Components	Mass	Volume	Density
BO DC Motor	30g	7.46× $10^{-7}m^3$	40214.47kg/m^3
ESP32	31g	2.10× $10^{-6}m^3$	14761.9kg/m^3
Ultrasonic Sensor	0.08g	2.29× $10^{-6}m^3$	34.93kg/m^3
L293D Motor Driver	4g	4.39× $10^{-6}m^3$	911.1kg/m^3
Chassis	56g	5.638× $10^{-5}m^3$	993.26kg/m^3
Wheels	34g	6.6× $10^{-5}m^3$	515.15kg/m^3
Castor wheels	13g	1.256× $10^{-5}m^3$	1035.03kg/m^3
Total mass	235.08g		

10. System Architectural Design:

Assembly of the entire robot with electronic and mechanical components with 3D model designed is done in CATIA software to ensure the appropriate to accurate measurements. The figure represents 3D assembly and simulation in the software

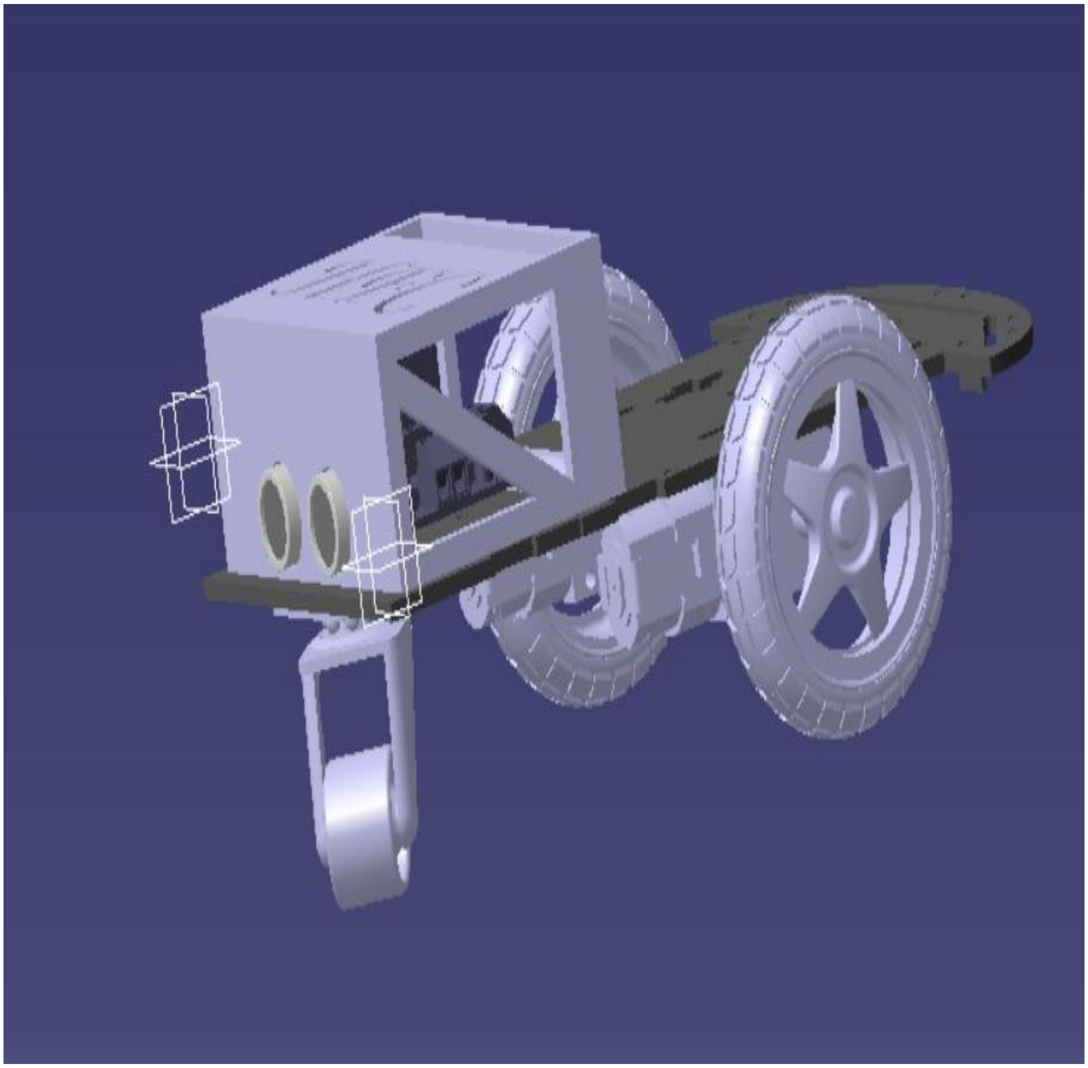


figure 3.1.10 Assembly in CATIA Software

11.3D Printing:

Printing the 3D Model designed in CATAI with effective 3D printer with 80% infill which we have used in our project for the strength of the case.
Figure Represents the 3D model used in our project.
Material: PLA

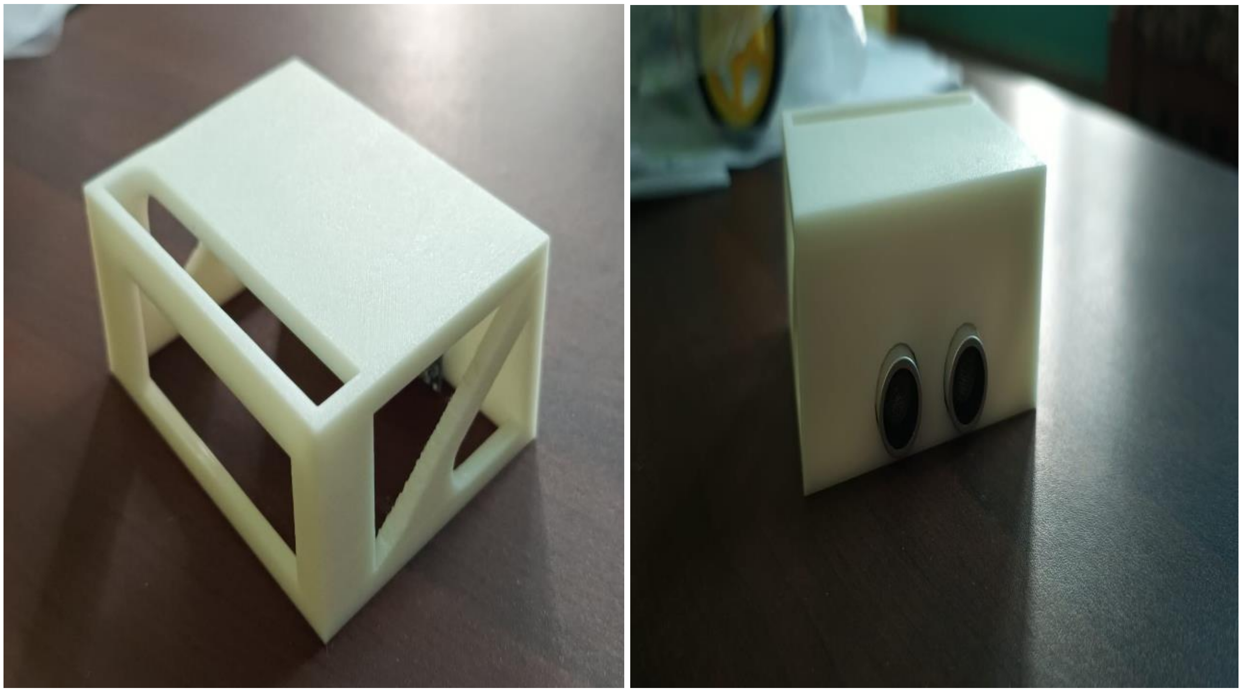


figure 3.1.11 3D Model Printed

12. Performance Evaluation:

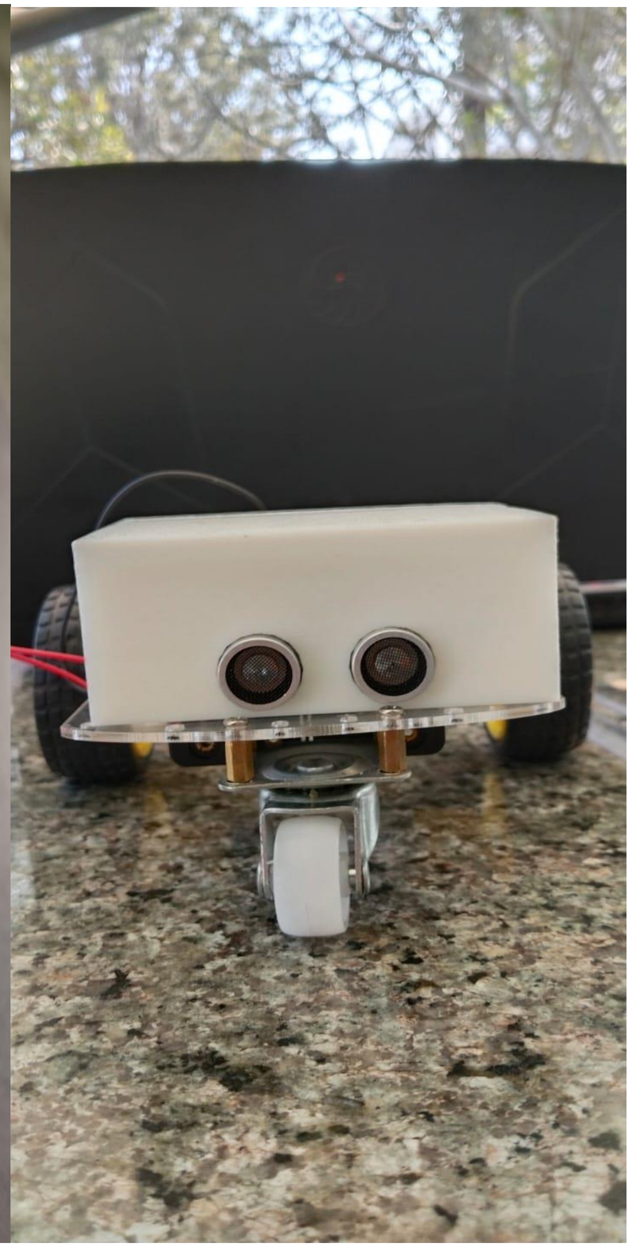
After the 3D printing, assembly of all components physically to be executed.
The working of the "Hand Following Robot" is tested, debugged (if any error) and validated

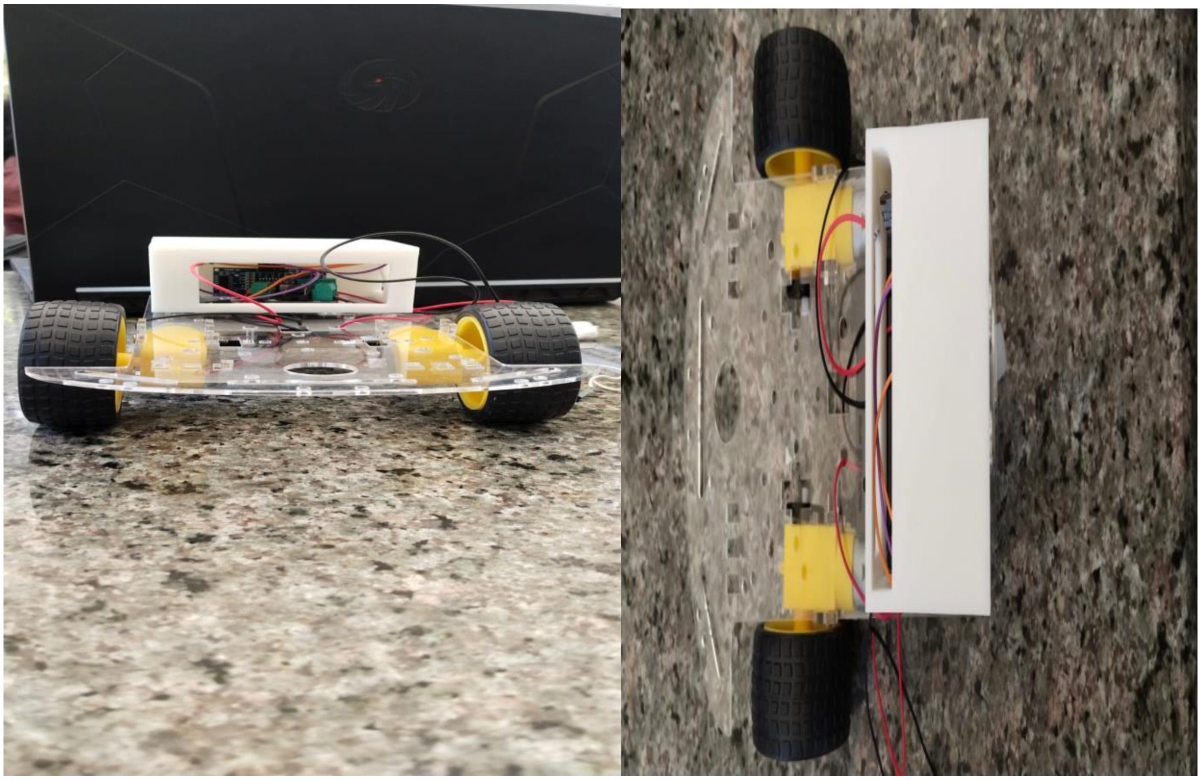
13. Documentation and Presentation:

Document the entire project, including design choices, implementation details, challenges faced, and solutions devised. Prepare a comprehensive report highlighting the innovation and contributions of the project and present against the suitable audiences.

Chapter 3

Result





The results are proven to be positive and working.

The working of the Hand Following robot is smooth with its operation and is working with accuracy.

Chapter 4

Appendix

- Day 1:

    1. Introduction to 3d printing via a Software called CATIA.
    2. CATIA introduction and installation.
    3. Basics and usage of CATIA software.

- Day 2:

    1. Usage of Software for making beginner mini designs.
    2. Brief detailed Introduction of CATIA software.
    3. Selection of the Project Title.

- Day 3:

    1. Designing the components of the project.
    2. Designing the basics of the 3D Model Sensor holder case.
    3. Robot weight Distribution and Density Chart Calculation.

- Day 4:

    1. Completion of the Sensor holder case 3D Design in CATIA.
    2. Assembly of the schematics of the robot in CATIA.
    3. Discussions on report making and 3D printing the designed case.
    4. Internals exam.

Chapter 5

CONCLUSION & FUTURE SCOPE

- **Conclusion**

In summary, the hand/object-following car robot project has successfully demonstrated a user-friendly and intuitive interaction through hand gestures. It has proven to be an effective educational tool, showcasing versatility in applications from entertainment to potential use in assistive technology. The integration of technologies, challenges faced, and lessons learned contribute to a foundation for future developments in the field of interactive robotics. Overall, the project has achieved its goals, providing valuable insights and setting the stage for continued innovation in this domain.

- **Future Scope**

Future improvements for the hand/object-following car robot project include enhancing precision in hand/object detection algorithms for more accurate movements. Exploring additional sensors like cameras and infrared sensors can improve perception and obstacle avoidance. Integrating machine learning enables adaptability to various gestures and environmental conditions. Wireless communication modules (Bluetooth or Wi-Fi) can extend functionality for remote control or device communication. Developing autonomous navigation, expanding gesture recognition, and exploring multi-robot collaboration are avenues for advanced capabilities. Implementing energy-efficient components and customizable features, along with a mobile application for user-friendly control, adds versatility to the robot's functionality.

REFERENCES

1) "A Review on the Role of Internet of Things (IoT) in Robotics" (Pandey, S., & Kalita):

   This review provides insights into the role of IoT in robotics, emphasizing the impact on communication and remote control capabilities. It discusses how IoT technologies contribute to creating more intelligent and autonomous robotic systems, ultimately improving their functionality in diverse applications.

2) "A Survey of Gesture Recognition Techniques and Applications" (Rautaray, S.S., & Agrawal, A.):
   This comprehensive survey provides an overview of gesture recognition techniques and their applications across different domains, including robotics. It explores methods such as computer vision, machine learning, and sensor-based approaches. While not specifically focused on ultrasonic sensors, it provides a valuable understanding of the broader landscape.
3) "Motor Driver Selection Criteria for Educational Robotics Platforms" (Smith, A., Jones, B., & Davis, C.):
   This paper addresses the selection criteria for motor drivers in educational robotics platforms. It discusses the significance of the L293D motor driver in providing an accessible and user-friendly solution for beginners. The study explores how the L293D simplifies motor control, making it suitable for educational purposes.
4) "ESP32: A Comprehensive Survey" (Kumar, A., & Pandey, S.):
   This comprehensive survey provides an in-depth exploration of the ESP32 microcontroller. It delves into its architecture, features, and applications across various domains, including IoT. The study highlights the ESP32's role as a central processing unit and communication hub, showcasing its capabilities in managing sensor data and facilitating communication in IoT projects.
5) Customization in Robotics: A 3D Printing Perspective" (Chowdhury, S., & Das, A.):
   This literature examines the role of 3D printing in enabling customization in robotics. It specifically delves into the creation of sensor holder cases tailored to the unique requirements of robotic systems. The study highlights how 3D printing empowers designers to address specific spatial and functional constraints in the design of sensor enclosures.
6) Real Time applications of hand Following Robot is referred from An AI website known as Chat GPT.
7) IOT Reva Lab Manual
8) Google

Bill of materials

ESP32 Dev Module:1

Ultrasonic sensor:1

L293D:1

Car chassis:1

Wheels:2

DC Motors:2

Castor wheels:1

3D Model:1

Jumper Wires