DESIGN AND FABRICATION OF AUTONOMOUS ROVER

A PROJECT REPORT

SUBMITTED BY

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In partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

MECHATRONICS ENGINEERING

SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY
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SUSTAINABLE DEVELOPMENT GOALS

The Sustainable Development Goals are a collection of 17 global goals designed to blueprint to achieve a better and more sustainable future for all. The SDGs, set in 2015 by the United Nations General Assembly and intended to be achieved by the year 2030, In 2015, 195 nations agreed as a blueprint that they can change the world for the better. The project is based on one of the 17 goals.

QUESTIONS	ANSWERS
Which SDGs does the project directly address?	The project supports SDGs 9 (Industry, Innovation, and Infrastructure) and 11 (Sustainable Cities and Communities).
What strategies or actions are being implemented to achieve these goals?	The project leverages AI-driven navigation, environmental monitoring, and efficient resource usage to meet SDGs 9 and 11.
How is progress measured and reported in relation to the SDGs?	Progress is tracked via indicators that measure waste reduction and efficiency gains.
How were these goals identified as relevant to the project's objectives?	The goals align with the project's objectives, addressing critical environmental needs and sustainability challenges integral to its purpose.
Are there any partnerships or collaborations in place to enhance this impact?	No, there isn't any partnerships or collaborations in place to enhance this impact currently.

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BONAFIDE CERTIFICATE

Certified that this project report**"DESIGN AND FABRICATION OF AUTONOMOUS ROVER"** is the bonafide work of **"ALAN X (727722EUMT011), KAMES A S (727722EUMT055), KHARTHIC S J (727722EUMT061), HAYAKKIRI M (727723EUMT506)"**who carried out the project work under my supervision.

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Submitted for the Project viva-voce examination held on________________

INTERNAL EXAMINER EXTERNAL EXAMINER

ACKNOWLEDGEMENT

At this juncture, we take the opportunity to convey our sincere thanks and gratitude to the management of the college for providing all the facilities to us.

We wish to convey our gratitude to **Dr.K.Porkumaran**, Principal, for supporting us to do our project and offering adequate duration to complete our project.

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We extend my gratitude to our beloved guide **Dr. S. Dinesh**, Assistant Professor Department of Mechatronics Engineering for his constant support and immense help at all stages of the project.

ABSTRACT

This project investigates the development and integration of an autonomous driving system for rovers, designed for obstacle detection, Bluetooth manual control, and voice control applications in dynamic environments. Autonomous rovers represent a shift from traditional manually controlled machines, providing enhanced adaptability for complex tasks like exploration and remote navigation.

The project focuses on the limitations of conventional autonomous systems, particularly in rugged and unpredictable terrains, prompting the exploration of merging autonomy with advanced sensor technology. This research integrates an obstacle avoidance system, supported by real-time camera feedback, to enhance the rover's navigation capabilities. Additionally, the implementation of voice and Bluetooth control provides the rover with a flexible, user-friendly interface for diverse applications, including cave exploration, lunar, and Martian missions.

Key benefits of this project include improved efficiency, operational flexibility, and the ability to perform automated tasks in challenging environments. The study also highlights potential future improvements, such as the use of machine learning for smarter decision-making and scalability challenges for larger rovers. Ultimately, the project emphasises the transformative impact of autonomous rovers, contributing to advancements in remote exploration and paving the way for more robust autonomous systems in a variety of fields.

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LIST OF ABBREVIATIONS

ACRONYM	ABBREVIATION
ADS	AUTONOMOUS DRIVING SYSTEM
FPV	FIRST PERSON VIEW
RTN	REAL TIME NAVIGATION
ODS	OBSTACLE DETECTION SYSTEM
AMR	AUTONOMOUS MOBILE ROBOT
BT	BLUETOOTH
VC	VOICE CONTROL
EDR	ENHANCED DATA RATE
RPM	REVOLUTION PER MINUTE
DC	DIRECT CURRENT

CHAPTER 1

INTRODUCTION

Autonomous rovers are versatile, computer-controlled systems used for various tasks such as exploration and obstacle avoidance in challenging environments. Traditional remote-controlled vehicles often face limitations in dynamic terrains, where adaptability is essential. This project integrates an autonomous driving system (ADS), featuring Bluetooth and voice control technologies, providing a user-friendly interface for remote and automated operations. The system also includes real-time video feedback through a First-Person View (FPV) camera, enhancing the rover's navigation capabilities in complex environments.

The project emphasises the integration of obstacle detection and avoidance mechanisms, making the rover suitable for applications such as industrial site inspection, hazardous material handling, and remote monitoring in agriculture. The use of Bluetooth and voice commands enables flexible and efficient control, while the rover autonomously adapts to obstacles. This project seeks to showcase the rover's potential for overcoming limitations found in traditional autonomous systems, ensuring its applicability in diverse fields, from industrial automation to agricultural innovation.

The integration of advanced technologies such as obstacle detection and autonomous navigation allows this rover to adapt seamlessly to real-world applications where manual intervention is often challenging or unsafe. For example, in industrial site inspections, the rover can be deployed to navigate confined or hazardous areas where human presence might be limited. Additionally, it can be used for remote monitoring in agriculture, allowing farmers to survey large areas of farmland autonomously while avoiding obstacles like irrigation systems or crops. These features enhance the rover's practicality, making it a valuable tool for industries requiring remote or automated operations.

1.1 OBJECTIVE OF THE PROJECT WORK

Develop comprehensive documentation outlining the design and fabrication of an autonomous rover system with integrated obstacle detection and autonomous navigation. Featuring Bluetooth and voice control, the system will ensure efficient remote operations and enhanced mobility in applications such as industrial inspections and agricultural monitoring. The goal is to improve operational flexibility, safety, and automation, with a user-friendly interface and real-time video feedback for optimised control.

1.2 METHODOLOGY

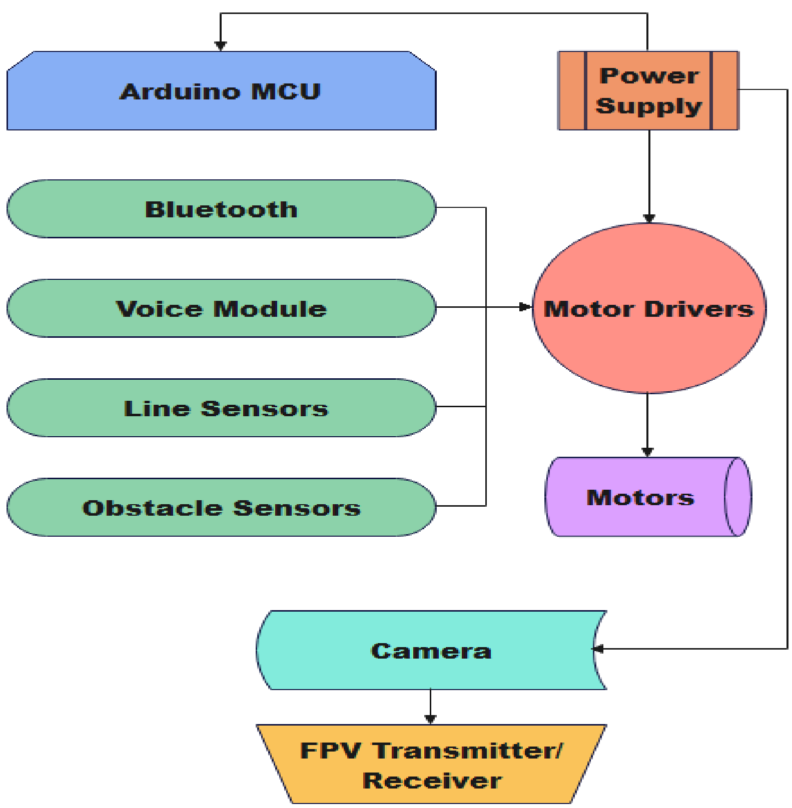

Fig 1.1 Methodology

1.3 ORGANISATION OF CHAPTERS

Chapter 1 introduces the autonomous rover project, its objective to create a flexible, efficient rover with Bluetooth and voice control. It also outlines the project methodology, covering system design and testing approaches, followed by a brief organisation of the chapters.

Chapter 2 presents a survey of previous work on autonomous rovers, focusing on key technologies like obstacle detection and navigation systems. The review helps identify existing gaps and how this project addresses them with advanced solutions.

Chapter 3 provides the design calculations, including motor power requirements, wheel selection based on torque and force, and structural analysis through shear force and bending moment diagrams for the baseplate.

Chapter 4 describes the components used in the rover, such as the DC gear motor, Arduino Uno, ultrasonic sensor, Bluetooth module, and FPV camera. Each component's specifications and role in the system are briefly outlined.

Chapter 5 includes a visual representation of the circuit diagram, illustrating the wiring of all components. A detailed 3D model of the rover is also presented, highlighting the assembly and layout of the design.

Chapter 6 provides an estimation of the costs involved, including all components and materials. It includes a breakdown of costs for each part used in the fabrication of the rover system.

Chapter 7 concludes with the successful implementation of the autonomous rover, discussing its capabilities and performance. Future scopes, including the addition of advanced sensors and scalability improvements, are briefly mentioned.

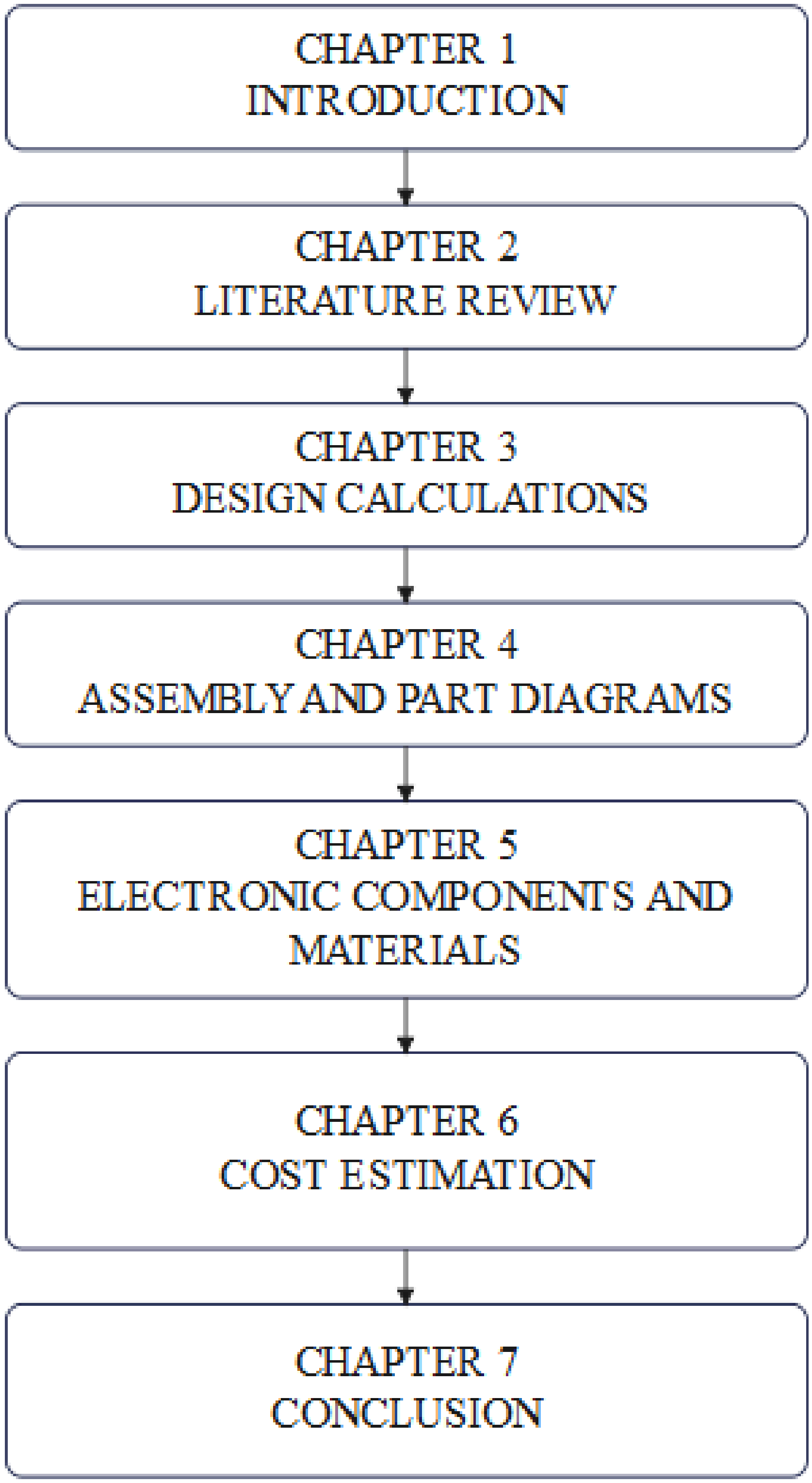

Fig 1.2 Organisation of Chapter

CHAPTER 2

LITERATURE REVIEW

Autonomous rovers are evolving as flexible and efficient mobile robotic systems, offering a new level of versatility for a variety of applications, such as industrial site inspections and agricultural monitoring. These Autonomous Mobile Robots (AMRs) are equipped with advanced systems for real-time navigation (RTN) and Obstacle Detection Systems (ODS), surpassing traditional, manual systems used in dynamic environments. Unlike conventional vehicles, autonomous rovers use sensor fusion (SF) technology to process data from multiple sources, allowing them to navigate complex terrains efficiently and autonomously. This project integrates technologies like Bluetooth (BT), Voice Control (VC), and First-Person View (FPV) cameras, providing an intuitive and flexible control interface for remote operations.

The project evaluates the effectiveness of ODS and autonomous navigation systems (ANS), which are crucial for performing tasks in environments filled with obstacles or hazardous areas. The rover employs a combination of sensors, such as ultrasonic and infrared (IR) sensors, to detect and avoid obstacles in real time. These are paired with BT and VC modules, allowing for seamless human-robot interaction. The use of FPV camera systems (FCS) further enhances control, enabling operators to receive live visual feedback and navigate the rover with precision.

The integration of these technologies offers several benefits, including improved safety, increased operational efficiency, and reduced human intervention in high-risk environments. Autonomous rovers, equipped with these advanced features, demonstrate superior performance in tasks that require remote monitoring and real-time adaptability. This project aims to showcase the potential of autonomous rovers in enhancing mobility and automation in industrial and agricultural sectors, providing valuable insights into the future of autonomous robotic systems

2.1 LITERATURE SURVEY

A comprehensive literature survey is essential for understanding the current advancements in autonomous rover technology. The following references highlight significant contributions from 2022 to 2024, focusing on design, navigation, control, and real-world applications of autonomous rovers.

1. Gupta, R. N., et al. (2024): This paper discusses recent advances in battery technology for autonomous rovers. The authors highlight how high-capacity lithium-sulphur batteries can extend operational time and reduce weight, improving rover performance for extended missions.
2. Patel, K. R., et al. (2023): This research examines the application of reinforcement learning in autonomous navigation. The authors developed a training framework enabling the rover to learn optimal navigation strategies in various terrain types, showcasing enhanced adaptability through simulated trials.
3. Rahman, H. M., et al. (2022): This study presents a robust path-planning algorithm for autonomous rovers in unknown terrains. The authors propose an enhanced A* algorithm incorporating machine learning techniques, demonstrating reduced travel time and improved safety in complex environments.
4. Singh, A. P., et al. (2024): This study evaluates safety protocols and ethical considerations for deploying autonomous rovers in public spaces. The authors propose a risk assessment framework and mitigation strategies, emphasising regulatory guidelines to ensure safe human-autonomous system interaction.
5. Stauffer, J. L., et al. (2022): This research investigates the use of LiDAR and computer vision for real-time obstacle avoidance in autonomous rovers. A hybrid approach combining LiDAR depth perception with visual recognition algorithms is proposed, leading to enhanced navigation accuracy in dynamic settings.

6. Torres, D. F., et al. (2023): The study focuses on GPS-denied navigation using inertial measurement units (IMUs) for autonomous rovers. The authors introduce a new algorithm fusing IMU data with visual odometry, maintaining accurate positioning in areas with weak or unavailable GPS signals.
7. Wang, T., et al. (2023): This paper provides an overview of AI-driven path planning algorithms for autonomous rovers, emphasising their impact on enhancing navigational precision and adaptability in unfamiliar environments.
8. Wilson, T. J., et al. (2024): This research develops a teleoperated autonomous rover for disaster response. The authors showcase the rover’s navigation capabilities in hazardous environments while under remote control, highlighting the importance of real-time data communication and robust navigation systems.
9. Yu, X., and Jiang, Y. (2023): The authors explore sensor fusion techniques combining IMUs and LiDAR for rovers, particularly for applications requiring high positional accuracy, such as search-and-rescue missions.

CHAPTER 3

DESIGN CALCULATIONS

This chapter will outline the mechanical design and analytical calculations necessary for an autonomous rover utilised in diverse applications. The design process encompasses the selection of materials, structural integrity assessment, and performance optimization to ensure the rover meets operational requirements.

3.1 RESISTIVE FORCES

ASSUMPTIONS

Constraints Measured and Assumed:

Assumed mass of the rover (M) = 856g = 0.856kg

No.of Wheels = 4 so, 856/4 = 214g / wheel

W = M x G = 0.856 x 9.81 = 8.39N

These constraints are assumed based on the minimum requirements of the rover

TOTAL RESISTIVE FORCE

<u>Rolling Resistance:</u>

R.R = F_r x W

R.R = 0.015 x 8.39

R.R = 0.126 N

<u>Air Resistance:</u>

A.R = 0.5 x P x A_f x C_d x V^2

A.R = 0.5 x 1.225 x 0.9 x 0.01 x $(0.5)^2$

A.R = 0.0014 N

Gradient Resistance:

G.R = W x Sin Θ

G.R = 8.39 x Sin 20^0

G.R = 2.87 N

Now Total Resistive Force,

Total Resistive Force = RR + GR + AR

Total Resistive Force = 0.126 + 2.87 + 0.014

Total Force = 2.9974 N

3.2 WHEEL SELECTION

Circumference = π x D

If we assume a motor with 200RPM

Linear speed = RPM x (π x D / 60)

To meet a target speed of 0.5m/s ,

0.5 = 200 x (π x D / 60)

D = 0.5 x 60 / 200 x π

D = 48mm

Thus a 48mm diameter wheel meets the minimum speed requirement, but some higher values > 48mm of diameter is suitable for the rover

A wheel with a radius of 48 mm can produce this amount of torque, and having a wheel with a diameter of 68 mm (which is two times larger) can provide additional advantages.

Additionally, using a larger diameter wheel can improve the rover's ability to traverse uneven terrain by providing better ground clearance. This can also enhance the overall stability and performance of the rover during navigation.

3.3 TORQUE CALCULATION

Torque calculation for 50mm diameter wheel, as the 50mm diameter of wheel has a radius of 0.025m

$T = (F_{total} \times r) / 4$

$T = (2.9974 \times 0.025) / 4$

$T = 0.0187$ Nm

Each motor must deliver 0.0187Nm to overcome the resistance at this wheel size.

3.4 BATTERY CAPACITY

To calculate the sufficient power supply, we calculate the battery capacity sufficient for 2 hour operation,

Assumed voltage = 7.4V

Motor Power Requirement = $F_{Total} \times V = 2.9974 \times 0.5 = 1.4987$W

Each motor's Power Requirement = $P_{total} / 4 = 1.4987 / 4 = 0.3747$W

Current per motor = $P_{motor} / V = 0.3747 / 7.4 = 0.051$A

So, the total current draw would be $0.051 \times 4 = 0.204$A

For a 2 hour runtime,

Battery capacity = 0.204 x 2 = 0.408Ah = 408mAh

A 7.4V, 500mAh battery is sufficient to meet these requirements.

3.5 MOTOR SELECTION

Total Weight of the rover (W) = 8.39N

Total Resistance (R) = 2.9974N

Wheel Diameter (D) = 50mm

Torque (T) = 0.187Nm

Total Power Requirement (P_{total}) = 1.4987W

Power Requirement per motor (P_{motor}) = 0.3747W

Total Load = W + R

$F_{total} = 8.39 + 2.9974$

$\mathbf{F_{total} = 11.3874N}$

Required Torque

$\mathbf{T = F_{total} \times R}$

$R = D / 2 = 50 / 2 = 25mm = 0.025m$

$T = 11.39874 \times 0.025$

$\mathbf{T = 0.2847Nm}$

3.6 SHAFT DIAMETER

Formula for Shear stress $\tau = F / A$

here A is the cross sectional Area of the shaft so using $A = \pi d^2 / 4$

Rearranging this formula for finding the diameter,

$\tau = F / (\pi d^2 / 4)$,

$d^2 = 4F / \pi.\tau \Rightarrow d = \sqrt{(4F / \pi.\tau)}$

So for this,

$\tau = 0.0187$ Nm

$r = d / 2 = 0.025$ m

$F = T. 1000 / r = (0.0187 \times 1000) / 0.025 = 748$N

Substituting this to the diameter formula,

Consider $\tau = 60$Mpa $= 60 \times 10^6$ N/m^2

$d = \sqrt{(4 \times 748 / \pi.(60 \times 10^6)}$

$d = 0.00398$ m

d = 3.98mm

Hence the diameter of the shaft which can handle the needed torque of 0.0187 Nm should be above 4mm.

3.7 SCREW AND SCREW HOLE SPECIFICATIONS

1) **Load Calculation**

   Total mass = 856g = 0.856kg

   Weight (w) = 8.39 N

   Load per motor = 8.39 / 4 = 2.0975 N

2) **Shear stress calculation**

   $\tau = F / A$

   Let's assume that we are using M4 screws so, diameter of this screw is

   $d = 4\text{mm} = 0.004\text{m}$

   $A = \pi (0.004)^2 / 4 = 1.25664 \times 10^{-5}$ m^2

   Shear stress $\tau = 2.0975 / (1.25664 \times 10^{-5})$

   τ = 166793 Pa

3) **Shear strength of the screw material**

Common materials for the M4 screws are usually steel, which has a shear strength of approx 200 Mpa to 600 Mpa.

Safety factor calculation,

$T_{allowed}$ = shear strength / safety factor = 200 / 3 = 66.67 Mpa

Hence, $\tau_{calculated} < \tau_{allowed}$ so, using M4 screw is appropriate for this application.

SCREW HOLE DIAMETER

For M4 screws, the clearance hole diameter is typically around,

Clearance hole diameter = d + tolerance

Here d = 4, tolerance = 0.2,

So, the hole diameter of the screw is 4.2 mm

This 0.2 mm clearance ensures easy insertion and allows for slight misalignments during assembly.

CHAPTER 4

DESCRIPTION OF COMPONENTS

COMPONENTS USED

- ARDUINO UNO
- DC 3-12V DUAL SHAFT GEAR MOTOR
- 9V DC BATTERY
- SERVO MOTOR
- 1200TVL FPV CAMERA
- TS832 FPV TRANSMITTER
- L293D MOTOR DRIVER
- HC-05 BLUETOOTH MODULE
- ULTRASONIC SENSOR

4.1 DC 3-12V DUAL SHAFT GEAR MOTOR

The 200 RPM Dual Shaft BO Motor motor gives good torque and rpm at lower operating voltages, which is the biggest advantage of these motors. It is an alternative to our metal gear DC motors. It comes with an operating voltage of 3-6V and is perfect for building small and medium robots

A small shaft with matching wheels gives an optimised design for your application or robot. Mounting holes on the body & lightweight makes it suitable for in-circuit placement. The motor is ideal for DIY enthusiasts. This motor set is inexpensive, small, easy to install, and ideally suited for use in a mobile robot car.

Fig 4.1 Motor

4.2 ARDUINO UNO

The Arduino Uno R3 Compatible board is an electronic hardware device used to build and program electronic circuits and projects. The board is based on the ATmega328P microcontroller and is designed to be compatible with the Arduino Uno R3 board, which means that it can be programmed using the Arduino software and libraries.

The board features 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and an ICSP header. The digital pins can be used as input or output pins and can be easily controlled using the Arduino programming language. The analog inputs allow the board to read analog signals, such as those from sensors, and convert them into digital signals for processing.

The board also features a power regulator that can accept a range of input voltages, from 7 to 20 volts, and regulate it to a 5-volt output that is used to power the microcontroller and other components on the board. Additionally, the board includes a reset button, which can be used to restart the program running on the board, as well as an LED indicator that can be used for debugging and status monitoring.

The Arduino Uno R3 Compatible board is an excellent choice for hobbyists, students, and professionals who are looking for a low-cost, easy-to-use, and flexible platform for building and prototyping electronic projects. The board is compatible with a wide range of sensors, actuators, and other components, making it ideal for a wide range of applications, including robotics, automation, data logging, and more. Its open-source nature and large community of developers and enthusiasts make it an excellent platform for learning, experimentation, and innovation.

Arduino UNO Specifications:

- ATmega328 Controller
- Digital IO 13
- PWM Channel 6
- Working Freq. 16MHz
- DC current / IO 40mA
- DC current / IO 50mA (3.3V)
- Input Voltage 6V to 20V DC
- Flash 32Kb
- SRAM 2Kb
- EEPROM 1Kb

Fig 4.2 Arduino UNO

4.3 ULTRA SONIC SENSOR

This HC-SR04-Ultrasonic Distance Measuring Sensor is a very popular sensor which is found in many applications where it is required to measure distance and detect the objects.

The module has two eyes like projects in the front which form the Ultrasonic transmitter and Receiver. The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object like bats or dolphins do.

This Ultrasonic Sensor module is a transmitter, a receiver, and a control circuit in one single pack. It has a very handy and compact construction. It offers excellent range accuracy and stable readings in an easy-to-use package. Its operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect).

Fig 4.3 Ultra Sonic Sensor

4.4 HC-05 BLUETOOTH MODULE

HC-05 is a Bluetooth Transceiver Module and has TTL Output. HC-05 6 Pin Wireless Serial Bluetooth Module is a Bluetooth module for use with any microcontroller. It uses the UART protocol to make it easy to send and receive data wirelessly. This Bluetooth module is a completely qualified Bluetooth V2+Enhanced Data Rate (EDR).

The HC-06 module is a slave only device. This means that it can connect to most phones and computers with Bluetooth but it cannot connect to another slave-only device such as keyboards and other HC-06 modules. To connect with other slave devices a master module would be necessary such as the HC-05 version which can do both master and slave.

Fig 4.4 Bluetooth Module

4.5 L293D MOTOR DRIVER

L293D uses a 16 pin DIP package, its internal integration is bipolar H - bridge circuit.

This kind of bipolar pulse width method has many advantages, such as the current continuous, or microcurrent vibration when the motor stops, which has a lubrication effect. It can eliminate the dead zone of static friction when positive and negative.

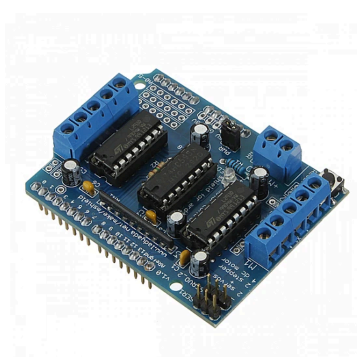

Fig 4.5 Motor Driver

4.6 TS832 FPV TRANSMITTER

TS832 FPV 5.8G 600MW 48CH Wireless AV Transmitter packs a whopping 600mW of ultra clean 5.8GHz power. A must for those looking for longer range and locked-in video. The TS832 is transmitting a full range of 32 channels and uses an easy-to-use 2 button interface, it also comes with a clean pre-wired harness.

Fig 4.6 FPV Transmitter

4.7 1200TVL FPV CAMERA

1200TVL CMOS Camera with 2.8mm Lens FPV Camera for RC Drone Quadcopter adopts 1/3 CMOS SUPER HAD II Image sensor, low illumination reaches up to 0.01Lux/1.2F, easy to set up parameters. It has a wide operating voltage from 7 to 12V power.

It has a CMOS chip inside and Electronic Shutter Speed PAL: 1/50-100.000 it can be a very good choice for your Drone/Multicopter for Video recording and Imaging.

Fig 4.7 FPV Camera

4.8 SERVO MOTOR

The Micro Servo 9G is lightweight, high-quality and lightning-fast. The servo is designed to work with almost all the radio control systems. It is with excellent performance that brings you to another horizon of flight. The SG90 mini servo with accessories is perfect for R/C helicopter, plane, car, boat and truck use

Fig 4.8 Servo Motor

4.9 BATTERY

Two lithium-ion (Li-ion) batteries provide a compact, high-capacity power solution ideal for portable electronics and robotics. With a nominal voltage of 3.7V each, two Li-ion batteries in series deliver a combined 7.4V, offering stable power and the flexibility to meet the needs of a variety of devices. Known for their lightweight design and high energy density, Li-ion batteries ensure reliable, long-lasting performance, making them a preferred choice for applications requiring a dependable and rechargeable power source.

Fig 4.9 Battery

CHAPTER 5

CIRCUIT DIAGRAM AND 3D MODEL

This chapter includes the circuit diagram and 3D model of the project. For proper assembly and implementation, it is essential to have detailed diagrams and models created using appropriate software. The chapter outlines the electrical connections and layout, along with the 3D design of the components, showcasing their dimensions and various views, which are crucial for the accurate construction and functioning of the system.

5.1 CIRCUIT DIAGRAM

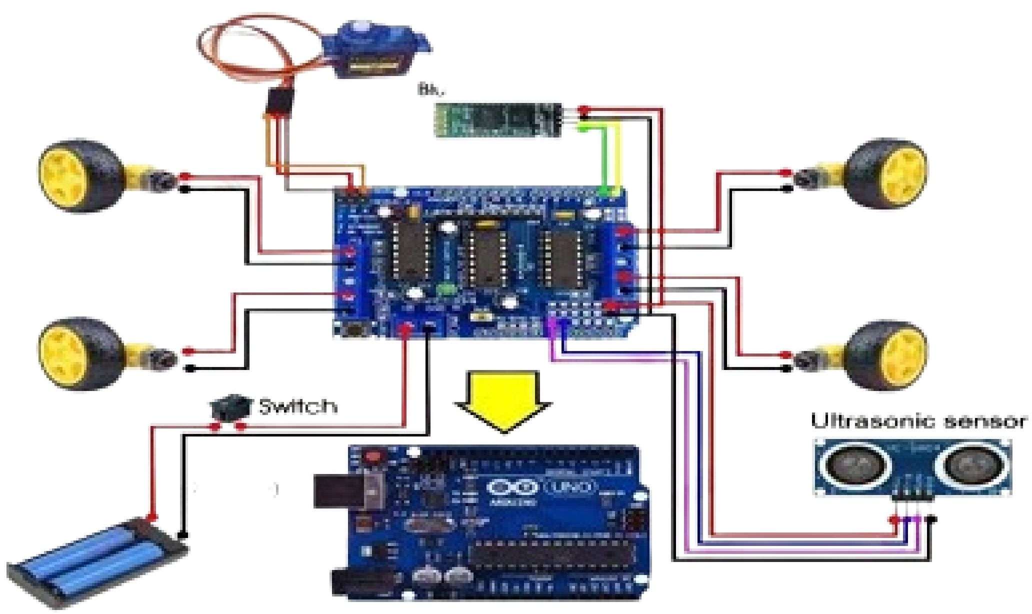

Fig 5.1 Circuit Diagram

5.2 3D CAD MODEL

The 3D CAD model provides comprehensive insights into the design through various views. The front view displays the height and width of the structure, while the top view offers a bird's-eye perspective, showcasing the overall layout and component positioning. The left and right views give a side profile, detailing the depth and side dimensions of the model. Lastly, the bottom view reveals the underside of the design, focusing on the base structure and any mounting points for better understanding and analysis.

5.2.1 DETAILED VIEW

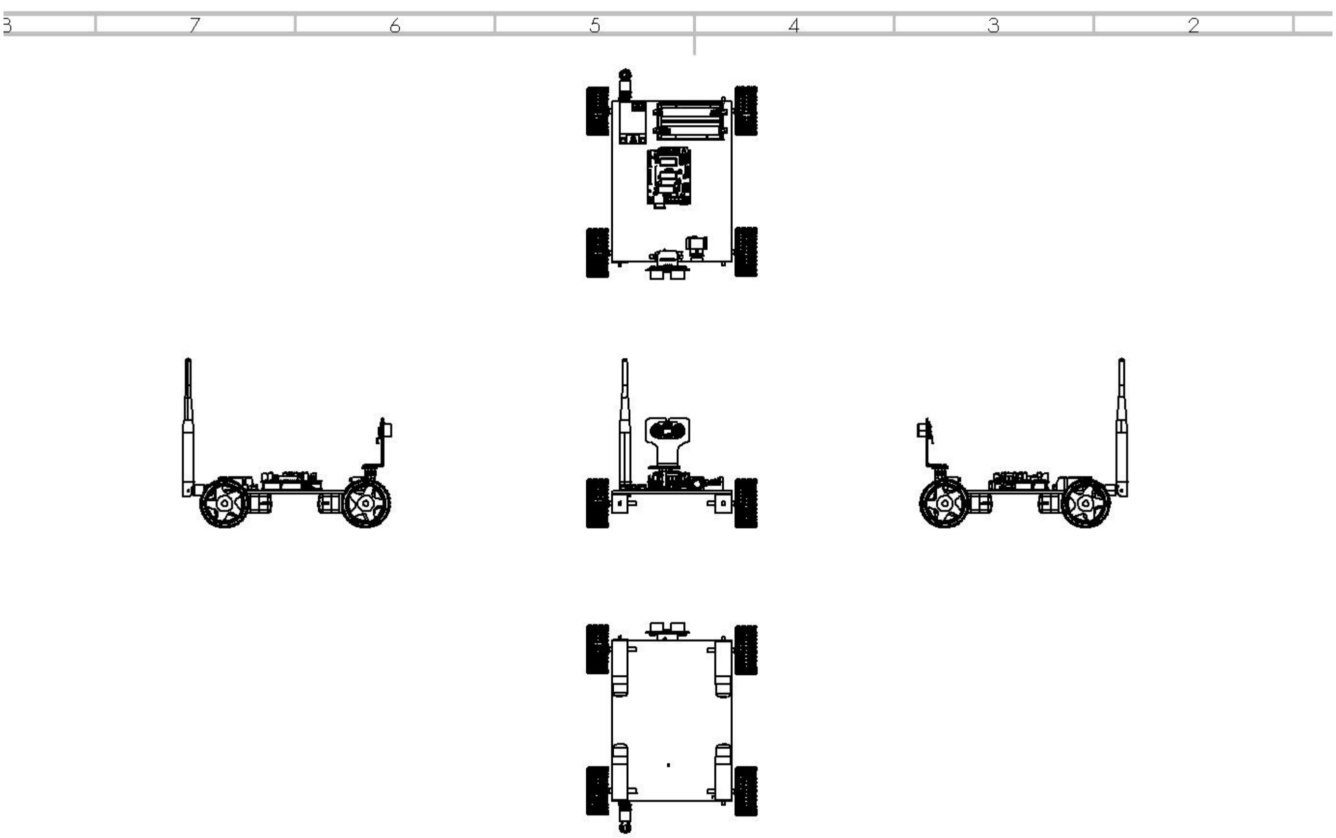

Fig 5.2 Detailed View

5.2.2 3D MODEL OF ROVER

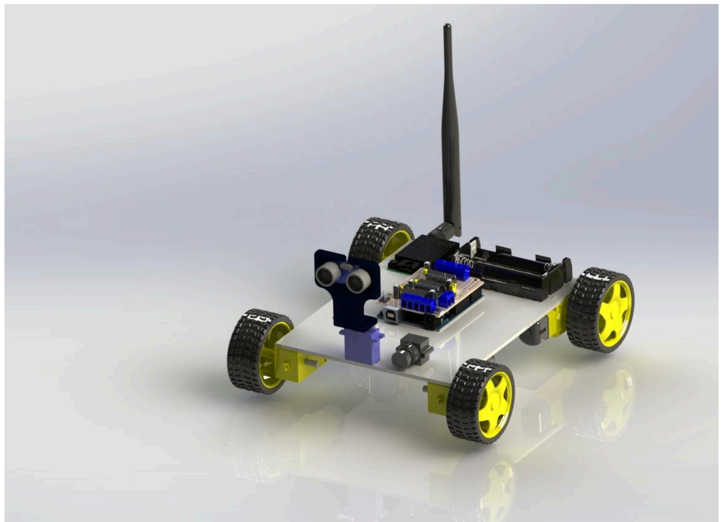

Fig 5.3 3D View of Rover

Table 5.1 Assembly Parts

S.NO	NAME	MATERIAL	QUANTITY
1	Base	Ply Wood	1
2	DC Motors	-	4
3	Wheels	Plastic	4
4	Servo Motor	-	1

CHAPTER 6

COST ESTIMATION

Estimating and costing serves the number of purposes in the construction process including preparation and finalisation of bids and cost control. The main purpose is to provide a volume of work for cost control and to see that the adequate options of materials are explored during the execution of the project.

6.1 COST REPORT

TABLE 6.1 Bill of Materials

S.No	COMPONENT NAME	COST	QUANTITY	TOTAL COST
1	ARDUINO UNO	700.00	1	700.00
2	GEARED DC MOTOR	60.00	4	240.00
3	ROBOT CAR WHEEL	30.00	4	120.00
4	SERVO MOTOR	100.00	1	100.00
5	ULTRA SONIC SENSOR	80.00	1	80.00
6	L293D MOTOR DRIVER	120.00	1	120.00
7	TS832 FPV TRANSMITTER	1400.00	1	1400.00
8	1200TVL FPV CAMERA	1600.00	1	1600.00
9	SOLDERING AND TOOLS	1000.00	1	1000.00
10	9V DC BATTERY	30.00	1	30.00
11	MISCELLANEOUS	1500.00	-	1500.00

THE TOTAL COST SPENDED ON THE PROJECT AMOUNTED TO : **Rs. 6,890**

CHAPTER 7

CONCLUSION

In conclusion, the development of an autonomous rover with integrated obstacle detection, Bluetooth, and voice control technologies marks a significant advancement in mobile robotics for diverse applications. This project explored the transformative potential of autonomous rovers, highlighting their superiority in comparison to traditional, manually operated systems. The integration of real-time obstacle detection and navigation systems, coupled with First-Person View (FPV) camera feedback, allows for precise and efficient operation in dynamic environments such as industrial inspections and agricultural monitoring.

The combination of Bluetooth (BT) and voice control (VC) provides a user-friendly interface that enhances the flexibility and adaptability of the rover in executing tasks that require remote control or hands-free operation. These features not only improve the rover's efficiency but also ensure safe operation in hazardous or inaccessible areas. The ability of the rover to autonomously detect and navigate obstacles in real-time is a game-changer, offering a layer of functionality that surpasses traditional remote-controlled systems.

The advantages of these integrated technologies are numerous, from increased operational efficiency to improved safety and reduced human intervention. By addressing the limitations of conventional systems, this project provides a comprehensive overview of how autonomous rovers can contribute to innovation in fields such as industrial automation and remote exploration. The findings of this project offer valuable insights into the future of autonomous systems, showcasing the potential of such rovers to revolutionise mobility and automation across various industries.

7.1 OUTCOME OF THE PROJECT

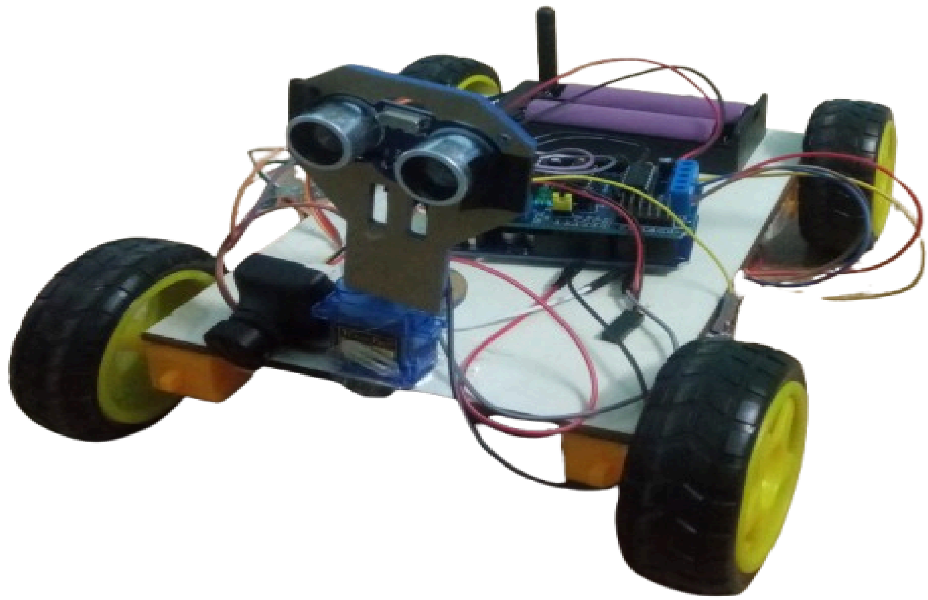

Fig 7.1 Prototype of the Rover

7.2 FUTURE SCOPE

The autonomous rover project opens up numerous possibilities for future advancements in fields such as industrial automation, agriculture, and exploration. One promising area of research is the integration of advanced machine learning (ML) algorithms to improve the rover's decision-making processes. By incorporating sensor fusion (SF) with artificial intelligence (AI), the rover could autonomously learn to navigate more complex environments, adapting in real-time to dynamic obstacles and changing terrains.

Additionally, exploring the scalability of autonomous rovers for larger industrial applications, such as automated inspections or precision agriculture, will be crucial. This involves studying the coordination of multiple autonomous rovers and developing communication protocols to enable these rovers to work in a synchronised manner.

Further research could focus on improving the rover's hardware, such as integrating long-range and high-resolution sensors, more robust power systems, and enhanced obstacle detection mechanisms. Collaborations with industry partners for real-world testing and validation would ensure that the advancements are practically viable for commercial use.

By pushing the boundaries of automation, navigation systems, and sensor technologies, this project can contribute to the growing landscape of autonomous systems, offering solutions for a variety of complex applications in the near future.

Future advancements in this autonomous rover project could also focus on enhancing energy efficiency and power management systems. Integrating solar panels or other renewable energy sources would allow for longer operation times, especially in remote or off-grid environments. Optimising the battery management system (BMS) and developing algorithms that dynamically adjust power usage based on real-time task demands could further improve the rover's sustainability. This would be particularly beneficial for applications requiring extended missions, such as environmental monitoring or disaster relief operations.

Moreover, the rover's communication and control systems could be further advanced through the implementation of edge computing and cloud-based AI. By leveraging edge devices for real-time data processing, the rover could respond to immediate challenges autonomously, while more complex computations and data analysis are offloaded to the cloud. This hybrid approach would increase the rover's intelligence and responsiveness, while maintaining efficiency in resource use. The future of this project lies in continual technological upgrades, aiming to make the rover more autonomous, scalable, and applicable to a wider array of industries.

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ANNEXURE

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

// Define motors on the motor shield
AF_DCMotor motor1(1);  // Left side front
AF_DCMotor motor2(2);  // Left side back
AF_DCMotor motor3(3);  // Right side front
AF_DCMotor motor4(4);  // Right side back

#define Echo A0
#define Trig A1
#define motorPin 10
#define Speed 170
#define spoint 90
#define THRESHOLD 30  // Distance threshold in cm for stopping

int distance;
int LeftDistance;
int RightDistance;

Servo servo;
```

```
void setup() {
  Serial.begin(9600);
  servo.attach(motorPin);

  pinMode(Trig, OUTPUT);
  pinMode(Echo, INPUT);

  Serial.println("Ultrasonic Obstacle Avoiding Robot Initialized");

  forward(); // Start moving forward by default
}

void loop() {
  distance = readUltrasonic();

  if (distance > 0) {  // Only print valid distances
    Serial.print("Distance: ");
    Serial.print(distance);
    Serial.println(" cm");
  }
```

```
 if (distance <= THRESHOLD && distance > 0) { // Obstacle detected within 30 cm
    Stop();
    delay(100); // Stabilize stop
    scanAndMove();
  }
}

int readUltrasonic() {
  digitalWrite(Trig, LOW);
  delayMicroseconds(2);
  digitalWrite(Trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(Trig, LOW);
  long duration = pulseIn(Echo, HIGH);

  if (duration == 0 || duration > 38000) { // Check for timeout
    return -1;
  } else {
    int cm = duration * 0.034 / 2;  // Convert time to distance in cm
    return cm;
  }
}
```

```
void scanAndMove() {
  LeftDistance = checkLeft();
  RightDistance = checkRight();

  if (LeftDistance > RightDistance && LeftDistance > THRESHOLD) {
    left();
    delay(500);
  } else if (RightDistance > LeftDistance && RightDistance > THRESHOLD) {
    right();
    delay(500);
  } else { // Both sides blocked or too close, move backward
    backward();
    delay(500);
  }

  Stop();
  delay(200);
  forward(); // Resume forward movement
}

void forward() {
  motor1.setSpeed(Speed);
```

```
motor2.setSpeed(Speed);
  motor3.setSpeed(Speed);
  motor4.setSpeed(Speed);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}

void backward() {
  motor1.setSpeed(Speed);
  motor2.setSpeed(Speed);
  motor3.setSpeed(Speed);
  motor4.setSpeed(Speed);
  motor1.run(BACKWARD);
  motor2.run(BACKWARD);
  motor3.run(BACKWARD);
  motor4.run(BACKWARD);
}

void right() {
  motor1.setSpeed(Speed);
```

```
motor2.setSpeed(Speed);
  motor3.setSpeed(Speed);
  motor4.setSpeed(Speed);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(BACKWARD);
  motor4.run(BACKWARD);
}

void left() {
  motor1.setSpeed(Speed);
  motor2.setSpeed(Speed);
  motor3.setSpeed(Speed);
  motor4.setSpeed(Speed);
  motor1.run(BACKWARD);
  motor2.run(BACKWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}

void Stop() {
  motor1.run(RELEASE);
```

```
motor2.run(RELEASE);
  motor3.run(RELEASE);
  motor4.run(RELEASE);
}

int checkRight() {
  servo.write(20); // Look right
  delay(500);
  int rightDistance = readUltrasonic();
  if (rightDistance > 0) {
    Serial.print("Right side distance: ");
    Serial.println(rightDistance);
  }
  servo.write(spoint); // Reset position
  delay(200);
  return rightDistance;
}

int checkLeft() {
  servo.write(160); // Look left
  delay(500);
  int leftDistance = readUltrasonic();
```

```
if (leftDistance > 0) {
    Serial.print("Left side distance: ");
    Serial.println(leftDistance);
  }
  servo.write(spoint); // Reset position
  delay(200);
  return leftDistance;
}
```