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DESIGN AND DEVELOPMENT OF A SMART ROUGH TERRAIN BEETLE ROBOT

Senior Design Project Report

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2023

Wah Engineering College

DESIGN AND DEVELOPMENT OF A SMART ROUGH TERRAIN BEETLE ROBOT

Senior Design Project Report

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ABSTRACT

As the globe gets bigger, technology gets better because of effective attempts to develop robots and practical initiatives. People and animals can move almost everywhere, whereas wheeled and tracked vehicles can only cover around 50% of the planet's surface. This situation led to the development of robot vehicles that mimic nature's method of propulsion by using specially designed wheels. The goal is to traverse challenging terrain with animal-like movement. With the aid of specially made wheels, an extremely light design known as the "Rough Terrain Robot" can move through rocky terrain. After using Creo Software for self-design, the robot is built. They used wheels designed specifically for rocky terrain. The circuit, hardware, and software were all integrated to complete the project. The robot is assessed and tested on a variety of surfaces/ terrains, including grassy, muddy, pebbled based, bushy, bricks oriented, etc., in the subsequent testing rounds. Obstacle detection for autonomous mode and live navigation has also been tested using live video streaming. Robotics testing shows that the constructed robot is capable of navigating a range of difficult terrains. The results show how useful this robot mechanism is for a number of applications, particularly in military surveillance and espionage.

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Chapter 1: INTRODUCTION

1.1 Motivation

The world makes tremendous technological progress every year. Our objective is to maneuver a robot on surfaces that are inaccessible to people or that could endanger their safety. It's always a good idea to use humans instead of robots and to save human life. To choose wheels that are specifically developed for travelling on uneven surfaces, robotic wheels and legs have been studied. Robots navigate uneven terrain with difficulty yet travel smoothly on flat surfaces. This research displays the flexible capabilities of wireless robots. Today, a wide range of technologies, such as WiFi modules, RF modules, touch displays, and Zigbee protocols, are used to control and build robots. Using information from several research, we examined recent developments in robotics in this essay, focusing notably on the field of difficult terrain robots [13].

1.2 Problem description

Developing robots that can successfully traverse challenging terrain has a variety of challenges. One crucial consideration is making sure there is stability and balance. Robots working in these circumstances must be able to adapt to uneven surfaces and maintain stability despite unexpected shocks. Additionally, efficient locomotion systems that provide traction and maneuverability are necessary for successful navigation.

Machines are quickly replacing human work in numerous industries, thus manufacturers are looking for machinery that can do its job well. Robots are machines that humans can control and take the place of insecure individuals in professions or surroundings. Robots are little computers that carry out commands. People will not perform as well as robots. Cost-effective production is another benefit of robotics. Numerous international businesses have fully automated [14]

Additionally, advanced technology must be added into the robot's design in order to improve its functionality and autonomy. The combination of sensors, communication modules, and processing units enables the robot to gather up-to-date knowledge about its environment, make sensible decisions, and communicate with other systems. The ESP32 microcontroller, ESP32 camera, Antenna 2.4GHz for wireless connection, 16x2 LCD for information display, Motors for locomotion, Motor Driver Monster Motor Shield for motor control, and GPS Neo 6M for localization can all be used to significantly increase the RTR's capabilities. We examined the developments in robotics related to rough terrain and robots through a range of researches in this article, as well as our recommended work for the following paper.

There are a number of difficulties that must be overcome in the design and development of robots that can successfully navigate difficult terrains. These difficulties can be divided into the following main categories:

1.2.1 Consistency and Flexibility:

Uneven surfaces, variable slopes, and unanticipated obstacles are common in rough terrains. A robot must ensure stability and adaptability in order to successfully navigate such settings. To avoid falling over or being trapped, the robot must keep its balance, shift its centre of gravity, and dynamically respond to changes in the terrain.

1.2.2 Locomotion:

A rough terrain robot needs efficient locomotion technologies to negotiate challenging terrain. The inability of traditional wheeled robots to gain grip on slick or rough ground may limit their capacity to move ahead or climb barriers. The robot must be equipped with appropriate locomotion mechanisms that provide sufficient grip, traction, and maneuverability to allow it to traverse difficult terrain and travel over multiple obstacles.

1.2.3 Identifying and avoiding obstacles:

Rugged terrain frequently has obstructions like rocks, downed trees, ditches, and other debris. The robot needs to be able to identify these obstructions and plan suitable pathways to get around them in order to navigate safely and efficiently. The robot needs sensors and perception systems that can instantly identify and classify obstacles. It should be capable of making quick decisions to avoid collisions or choose alternative paths when presented with obstacles.

1.2.4 Integration of Cutting-edge Technologies:

The autonomy and functionality of the rough terrain robot must be enhanced by the application of cutting-edge technologies. A few of these technologies are motor systems, motor driver modules (like the Motor Driver Monster Motor Shield), cameras, wireless communication modules (like the Antenna 2.4GHz), display systems (like the 16x2 LCD), microcontrollers (like the ESP32), and localization systems (like the GPS Neo M6). Making sure that these technologies work as intended, that they are seamlessly included into the robot's design, and that their capabilities are utilized to enhance the robot's performance in difficult terrain navigation is the challenge.

These difficulties must be resolved in order to develop and build a reliable rough terrain robot that can successfully negotiate challenging terrain. The research makes an effort to overcome these difficulties in order to improve the robot's stability, mobility, obstacle avoidance, and overall performance in uneven terrains. The robot will be more applicable in a wider range of real-world situations as a result.

1.3 Objectives of the work

Main aims for this project are:

- To Design a Robotic Platform capable of moving on specific rough terrains.
- To Fabricate a Robotic Platform.
- To Develop System for locomotion of Robot on a Rough Terrain.

The major objectives of the work are to design, construct, and produce a robotic platform that can successfully traverse several challenging terrains. The primary objective is to build a robotic platform that is trustworthy and flexible enough to traverse challenging terrain. Planning the platform in accordance with the various hard terrains the robot will encounter is required for this. Stability and maneuverability are important components of the robot's locomotion.

The second objective is to construct the planned robotic platform. This procedure comprises turning the idea design into a real robot. It entails selecting and procuring the materials, components, and supporting systems needed for the robot's assembly. The fabrication process may involve assembling mechanical parts, integrating electronic parts, and including sensors and actuators.

The development of a method for traversing treacherous terrain is the third objective. In order to accomplish this, mechanisms and programme codes must be created and implemented so that the robot can maneuver across challenging terrain. This system may include novel loco-motional elements like specific wheels. Sensor technology must also be included into the robot in order for it to perceive obstacles, respond to them, modify its locomotion approach, and maintain stability on uneven terrain.

The created and produced robot will be capable of navigating difficult areas within its range on its own or with remote control thanks to its sophisticated locomotion mechanism. By attaining these objectives, the group hopes to develop a useful robotic platform that can successfully traverse particular difficult terrains. This platform is useful for a wide range of operations, including search and rescue missions, hazardous area investigations, infrastructure inspections, and supporting operations in challenging terrain. The overarching objective of the work is to improve robotics technology and practical applications in tough terrain.

1.4 Scope of Study:

Following are the project's specific study goals for the rugged terrain robot with the necessary features:

1. Examine the mechanical design and mobility potential of the four-wheeled off-road robot.
2. Evaluate the utility of a mobile app interface for remote control of the robot.
3. Consider the robot's autonomous mode, which identifies and avoids obstacles using an ultrasonic sensor.
4. Consider the robot's limitations, such as its inability to climb stairs or climb on walls or to move on things higher than a certain height or distance.
5. Conduct tests for performance evaluation to assess the robot's accuracy in spotting and dodging hazards as well as its mobility on various surfaces.
6. Keep in mind potential applications for the off-road robot within the constraints that have been established.
7. Discuss possible enhancements and modifications to address the discovered limits and boost the robot's functionality.
8. Consider how the research results might influence recent and upcoming advances in challenging terrain robots.
9. This reduced scope of study, which also provides a clear research plan for the specified rough terrain robot, highlights the crucial areas of investigation.

1.5 Technological importance of the project:

The significance of the rough terrain robot project technologically is highlighted by the following primary factors:

1. ***Advancement of robotics technology:*** The project makes strides in robotics technology by examining the design, control architecture, and sensor integration of the rough terrain robot.
2. ***Sensor Integration:*** By integrating an ultrasonic sensor for obstacle detection and avoidance, the robot is better able to autonomously navigate challenging terrain.
3. ***Remote Control Interface:*** A practical and user-friendly control system that permits precise robot maneuvering in hazardous situations may be developed by using a mobile app interface for remote control.
4. ***Movement and Versatility:*** By examining the mechanical structure and movement capabilities of the robot, the project aims to improve the robot's ability to negotiate

challenging terrains and expand its range of applications.

5. ***Problem Solving:*** Finding solutions to the robot's limitations, such as its inability to cross water, climb stairs, or mount walls, promotes inventive problem-solving, which could lead to future design modifications and advancements.
6. ***Efficiency and Safety:*** The project contributes to efficiency and safety by enabling the robot to operate autonomously and securely in challenging environments. This autonomous mode has obstacle recognition and avoidance capabilities.
7. ***Potential Uses:*** Gaining insight into the rough terrain robot's technological capabilities lays the path for potential usage in fields including agriculture, military operations, exploration, and search and rescue in the future.
8. ***Future Research and Collaboration:*** By defining its methods and findings, the project serves as a manual for future research and development. This promotes new collaborations and advancements in the field of challenging terrain robotics.

The technological contributions of your project include the development of robotics, the incorporation of sensors for improved autonomy, the development of a remote control interface, the improvement of mobility and versatility, the resolution of specific issues, the improvement of efficiency and safety, the identification of potential applications, and the promotion of additional research and collaboration.

Chapter 2: LITERATURE REVIEW

2.1 Details of relevant theory

Even though rough terrain robots are much more practical and easy to operate when using a secondary multimedia device like Bluetooth connectivity or digital displays, a close examination of the research papers that have already been published reveals that there is still room for improvement in their accessibility and usability. There is always opportunity for more automation in the vast field of robotics. There are four different types of these robots: tracked, legged, wheeled, and reconfigurable robots. Because they are more affordable and complex, wheeled robots with specific designs are used because they enable movement without the need for specialized control algorithms.

2.1.1 Four types of robots:

Legged robots, reconfigurable robots, wheeled robots, and tracked robots are compared and described, along with the rationale for the project's use of specially designed airless wheels.

2.1.1.1 Legged Robots:

Legged robots are capable of navigating a range of surfaces and overcoming obstacles by mimicking the movement of animals or people using their legs. Titan VIII and Parawalker are legged robots made to move through outdoor areas with debris or obstructions, while Robot III was made to study the gait of insects and other animals. There are commercially available robot hobby kits, such as the Hexapod III.

Advantages: Legged robots excel at navigating challenging environments, climbing stairs, and navigating rough and uneven terrain, where wheels or tracks can struggle.

Limitations: Legged robots usually require complex sensor systems and control algorithms in order to maintain stability and balance. Additionally, they could be more advanced and consume more energy than other types [1].

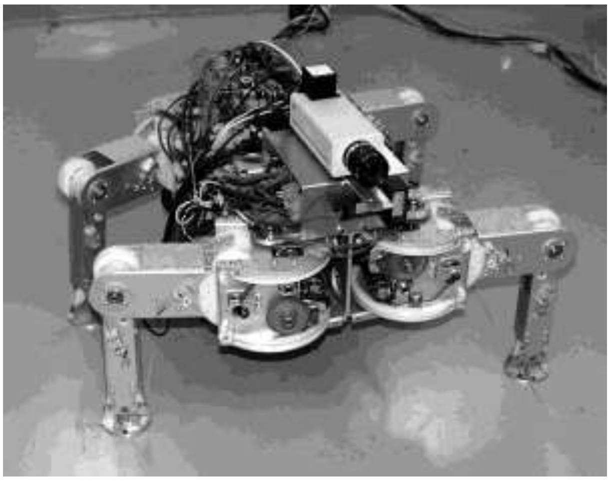

Figure 2-1: Legged Robot; Titan VIII [1]

2.1.1.2 Reconfigurable robots:

Robots that can be modified to perform new functions or navigate through new settings are known as reconfigurable robots. Reconfigurable robots with a wide range of applications, Polybot and Polypod are composed of one or two types of repeated modules, respectively.

Advantages: Reconfigurable robots have the advantage of adaptability, enabling them to work in a variety of locations and for a variety of activities without having to make large hardware changes.

Limitations: Reconfigurable robots must have adaptive mechanisms and intricate control systems, which can make designing and operating them difficult [2].

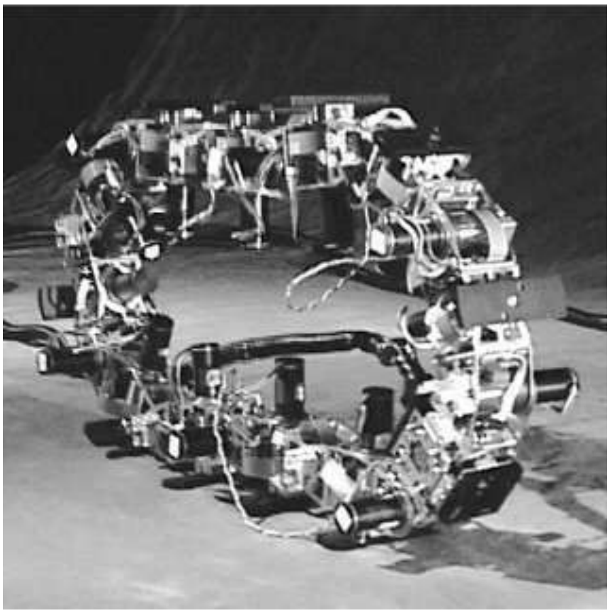

Figure 2-2: Reconfigurable robots; Polybot [2]

2.1.1.3 Tracked Robots:

Using continuous tracks or treads, tracked robots move more steadily and with better traction.

Brat, Cyclops, or Mini Andros II, as examples. Urbie is designed for urban reconnaissance and surveillance, whereas Micro-VGTV is designed for piping inspection and urban search and rescue. The research robot known as Lurch was made for exploring different terrains. One thing all of these tracked robots with stair climbing capabilities have in common is an additional pair or two of articulated tracks.

Advantages: Tracked robots perform best on rocky, sandy, or snowy surfaces where wheels may squeak. Excellent stability, climbing abilities, and maneuverability are all features of these vehicles.

Limitations: Relative to wheeled robots, tracked robots may be more sophisticated, consume more energy, and have slower speeds. They could have trouble on flat or even surfaces because of their huge footprint and higher friction [3].

Figure 2-3: Tracked Robot; Micro-VGTV [3]

2.1.1.4 Wheeled Robots:

Wheeled robots move around on flat, even surfaces with ease, efficiency, and steadiness. The robots Lynx and Hobo that are used to dispose of explosive ordnance.

Advantages: They are simple to operate, consume little energy, and move quickly on flat or smooth surfaces. For uses including logistics, interior navigation, and production settings, they are well suited.

Limitations: Wheeled robots may have difficulty navigating difficult or uneven terrain, which restricts their capacity to move swiftly across such terrain [4].

Figure 2-4: Wheeled Robots; Hobo [4]

2.1.2 Comparison Table:

Table 1: Comparison Table of different Robots

Sr. #	Robot Type	Benefits	Drawbacks
1.	Legged Robots	Can move over difficult terrain being able to climb stairs and get around difficulties.	Complex stability and control needs- More energy is consumed [5].
2.	Reconfigurable Robot	Robots that are adaptable. The capacity to adapt to a variety of work and circumstances.	Complexity management in design [6].
3.	Tracked Robots	Robots with tracks provide superior traction on unlevel or rocky ground.	Limited speed on flat or even ground; increased stability and obstacle climbing; higher energy consumption [7].
4.	Wheeled Robots	Robots on wheels are simple to operate and use little energy.High speed on flat or smooth surfaces.	Limited performance over tairs and vertical obstacles [8].

2.1.3 Arguments in favor of using airless wheels:

1. Enhanced Durability: Airless wheels are strong and made to endure rough surfaces, impacts, and punctures. Compared to conventional pneumatic wheels, which might be vulnerable to flats or punctures in difficult circumstances, they are more resilient and damage-resistant. They are useful for applications where the robot must operate in difficult or uncertain terrain because of their durability.

2. Better Stability: Weight distribution and stability are improved with airless wheels. The sturdy design lowers the likelihood that the robot may topple over or lose stability while in operation by assisting it in maintaining balance on crooked or uneven terrain. This stability is especially useful for activities that need for precise control and stability, such transporting delicate or sensitive payloads.

3. Less Maintenance: Unlike pneumatic wheels, airless wheels don't require inflation, tire pressure monitoring, or potential puncture repairs, therefore they require less maintenance overall. By doing so, the robot may be serviced and maintained more quickly and with less effort, making it more useful in the field.

4. Improved Traction: On a range of surfaces, airless wheels that have been specially developed can provide improved traction. The robust construction and distinctive tire patterns can boost grip and traction, allowing the wheeled robot to navigate across uneven terrain with less sliding. A robot's traction can be quite useful while moving through uneven or slippery surfaces.

5. Flexibility: Specialized airless wheels can be created with characteristics according to the requirements of the robot's intended purpose. The capacity to adapt enables customization in terms of size, tread pattern, material composition, and other elements, enabling the wheeled robot to maximize its performance in certain environments and jobs.

It's significant to note that the decision to employ specially created airless wheels depends on the particular requirements of the robot and the application for which it is intended. If airless wheels are the best option for a wheeled robot in a certain situation, it depends heavily on factors like the terrain, durability requirements, stability requirements, and maintenance considerations.

Figure 2-5: All Terrain Wheels [9]

These wheels can be used as replacement or for custom robots that have to navigate difficult terrain. The plastic hubs are metallic, and the soft, spiky black tyres are designed to boost traction. Wheels are readily mounted to motors with 4mm output shafts using the provided adapters [10].

2.2 Review of past/reported work

The robot described in **Pragati et al.** research study about Rough Terrain with Beetle-like legs employed wheels designed like insect legs to run over the terrain. To communicate and receive data to the microcontroller that directs the movement of motors and the laser shooter, RF modules are employed. The goals included designing a radar idea, an accident-avoidance feature, and depth detection. [11]

BigDog, a Quadrupted Robot, was the subject of another study by **Marc et al.** on uneven surfaces. The objective was to create unmanned legged vehicles with improved rough-terrain mobility to current wheeled and tracked vehicles. Through posture control and terrain detection, the control system adjusts to changes in the terrain [12].

Sahil et al. employed a smart phone to feed live video of the surroundings instead of a wireless camera in their review study on various rough terrains, which also included a defence robot. The aspects that were successfully designed included a radar idea, an accident-avoidance function, depth sensing, a wireless robot, and a human checker [13].

The research was done for rough surfaces to make a robot which can travel on various surfaces by **T. Balachander et al.** in which sensor values were sensed and sent to the controller using Motor sensing and control. The GPS and GSM were used to locate the robot and pass on the information to the user. Video could be transmitted to the user via RF transmitter and receiver [14].

The research conducted by **Debesh et al.** in which two kinds of mechanical structures, namely Rover 1 and 2 were designed and tested through computer simulations. Prototype model of the Rover 1 was manufactured and its performance was tested while navigating among step obstacles [15].

In a study by **Premkumar et al.** on automated multi-purpose robots for defence applications using Zigbee adopter networks, a system is proposed to identify intruders (unknown people) using a low-power Zigbee wireless sensor network, and the robot will then automatically take the appropriate action. This means that the suggested solution, an Intelligent Unmanned Robot (IUR) employing Zigbee, saves human lives and eliminates manual error in the defence side. [16].

A hexapod robot that can search the land was designed by **Talha et al.**, and because of the way its legs are constructed, it was intended to travel over a variety of rough terrain. The computer was used for image control, and the robot-mounted camera was used. The motors are operated simultaneously in this investigation by the programme that was written into the electronic cards. The car is in charge of controlling the control circuit created for the project [17].

Design and Fabrication of a Rough Terrain Robot Using Locally Available Low Cost Materials is a topic that **Nashiyat et al.** explored. The mechanical design of the rough terrain robot is really simple. Its frictional losses have been minimised by the design's straightforward and effective execution [18].

D. A. Carnegie et al. published the mechanical design and construction of a mobile outdoor multi-terrain robot, which outlined the design and building of a low-cost caterpillar-track robot intended for outdoor use in a variety of irregular terrains. The robot has the necessary sensors and processing capability to someday be able to carry out tasks on its own [19].

Semicircular wheels—a unique design—were created by **Kanta et al.** for a mobile robot. We discovered that semicircular wheels performed better than circular wheels in climbing steps. With less surface area in contact with the ground than full circular wheels, semicircular wheels may have less grip on slick or uneven surfaces. The stability may be impacted [20].

In addition to introducing the Traversability Field as a new idea for obstacle avoidance on flat ground, **Cang et al.** offered a revolutionary way for mobile robots crossing rugged terrain to negotiate obstacles [21].

A hexapod robot was implemented by **Jiawang et al.** along with a design methodology. It was created to have six links. An approach for planning tripod and bipod gaits as well as robot single-leg trajectory planning were suggested [22].

Ervin et al. created a robot for control that is outfitted with a high-speed (1 Gbit/s) WiFi connection, a variety of sensors, and the best DSP processor available right now. There was no human interaction with this machine [23].

Before the parts are put together, each component of the hexapod robot has been created and analysed by **S. Rathnaprabha et al.** to determine its strength to withstand a certain amount of force or pressure. Hexapod bodies can move apart from their places of ground contact [24].

Using various objects placed in front of the proximity IR sensor, Buddhika et al. conducted study on the sensor. The findings indicate that a human and flame (fire) can be distinguished using a PIR sensor [25].

The power autonomous legged Rhex vehicle, described by **Martin et al.**, is able to navigate terrain that is similar in complexity and variety to that found in the natural world. Over uneven ground, autonomous leg robot locomotion [26].

With its mechanical, electronic, and software infrastructure for sensorimotor activities, X-RHex was created by **Galloway et al.** The first robot of its size to support a configurable GPU that will serve a variety of sensors' computing needs [27].

Presented by **WEI et al.**, the project entails the experimental development of a small all-terrain robot with good movement capabilities. In this paper, the mechanical design of the numerous mechanical modules and the development of the robot prototypes are fully documented [28].

Shivesh et al. discovered the obstacles and difficulties that a high-performance rover would confront in its planned use in harsh locations. Used product development techniques to determine the best way for the rover to move. Using a fresh multi-body dynamics modeling tool. In the process, a case study about a possible use of the program for space robots was presented. [29].

Jianwei et al. demonstrated WLHR that was created and put into use to adapt to an all-terrain environment. It possesses the flexibility of a wheel robot and the capacity to navigate obstacles like a leg robot. On the prototype robot, tests were conducted to verify the viability and applicability of the WLHR proposed in this study, including obstacle avoidance, fast walking on flat ground, steering, obstacle crossing, and stair climbing. [30]

Chapter 3: MATERIALS AND METHODS

3.1 Methodology

This study's methodology, which consists of numerous crucial elements, is systematic and thorough. The goals of creating and developing the Rough Terrain Robot (RTR) with four wheels and using cutting-edge technology are intended to be attained by following these procedures. The following stages are included in the research methodology:

1. ***Literature Review:***

A thorough study of the body of research on rough terrain robots, locomotion processes, obstacle recognition and avoidance, and the integration of cutting-edge technology is undertaken. The evaluation aids in the identification of pertinent ideas, design tenets, and technology developments in the area.

2. ***Conceptualization and Design:***

A conceptual design for the RTR is created based on the knowledge gleaned from the literature review. Stability mechanisms, movement mechanisms, obstacle detection sensors, and communication modules are among the crucial components incorporated in the design. The design is improved and its viability is ensured through the use of iterative design procedures, which include prototyping and simulation.

3. ***Integration of Components:***

The RTR's successful development depends on the integration of the right components and technology. Microcontrollers (ESP32), cameras (ESP32 Camera), wireless communication modules (Antenna 2.4GHz), display systems (16x2 LCD), motors, motor driver modules (Motor Driver Monster Motor Shield), and localization systems (GPS Neo M6) are the main carefully selected components for the project. The entire system architecture is then built using these components.

4. ***Mechanical Design and Fabrication:***

Chassis and wheels are designed. The mechanical design of the RTR takes into account factors like the wheel mechanics, overall structural integrity, and the chassis design. The robot's parts and assemblies are modelled in fine detail using Creo 6.0 software. The robot is then physically constructed using the proper manufacturing procedures, assuring accurate assembly and sturdy construction.

5. ***Electronic Design and Assembly:***

The integration of the chosen components, circuit design, and wiring are all part of the RTR's electronic design. According to the design requirements, the required connections are made.

6. *Simulations and Testing:*

To improve and optimize the performance of the robot, simulations and iterative testing are carried out. Based on the outcomes, this iterative procedure enables modifications and improvements.

7. Experimental Setup and Evaluation:

To assess the RTR's performance, an appropriate experimental setting is developed. Real-world tests are carried out in controlled locations with rugged terrain that simulate various situations and difficulties. The robot's stability, mobility, capacity to recognize obstacles, and navigational skills are evaluated. Measured and analyzed performance indicators include traversal time, success rate in avoiding obstacles, and path correctness.

8. Results of Data Analysis:

We examine and interpret the data gathered from the experimental tests. Analysis is conducted to analyze the RTR's performance and determine how well it navigates difficult terrain. The results are displayed along with the system's successes and shortcomings.

9. Iterative Enhancements and Modifications:

Iterative enhancements and refinements are made to the RTR based on the study of the experimental findings and the pinpointed constraints. The alterations and improvements made in successive design iterations are based on feedback from the test results as well as knowledge gleaned from the literature review and data analysis.

This thorough methodology will be used in the research to help it reach its goals of building and creating a Rough Terrain Robot that is capable of navigating well in difficult terrains. The technique includes a number of phases, such as a literature research, conception, design, component selection and integration, mechanical manufacturing, electronic assembly, simulations, testing, data analysis, and iterative improvements. A thorough examination of the study objectives and a well-structured development process are both guaranteed by this methodical approach.

3.2 Block Diagram:

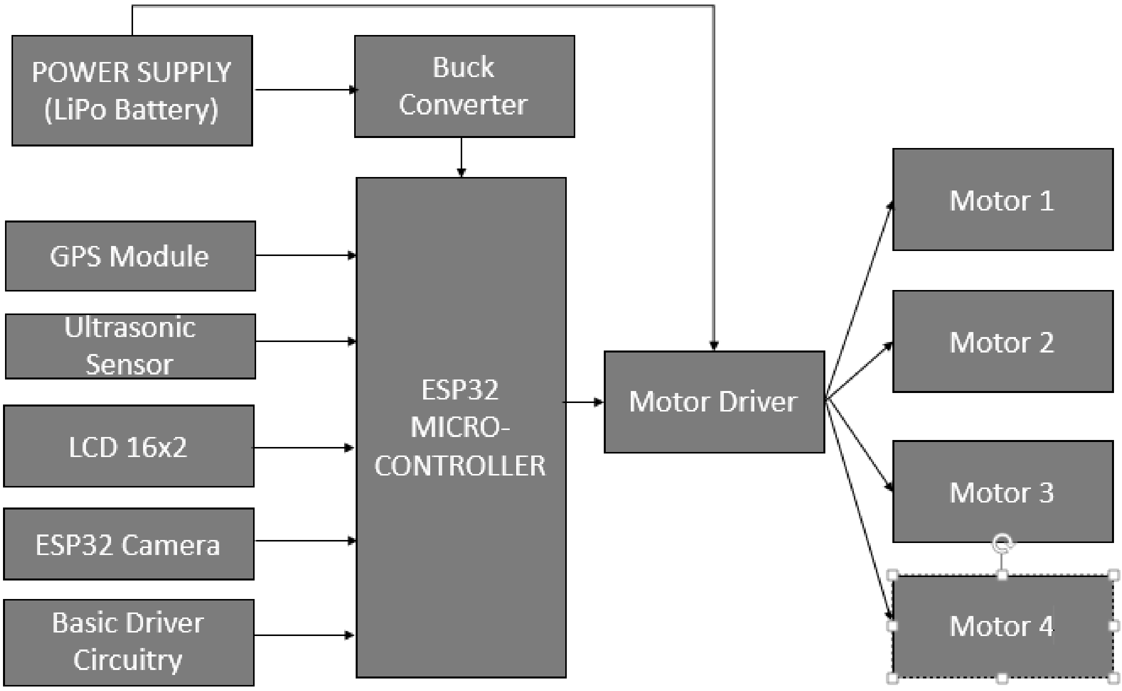

Figure 3-1: Block Diagram

3.2.1 Explanation:

1. The block diagram shows how various system components are connected to one another.
2. The power source (LiPo battery) is linked to the buck converter, which is in charge of converting the battery voltage into a lower, regulated voltage sufficient for the ESP32 microcontroller.
3. Connected to a number of peripherals, the ESP32 microcontroller serves as the system's primary control component.
4. The ESP32 microcontroller is connected to the GPS Neo M6 module, ultrasonic sensor, LCD 16x2, and ESP32 camera, enabling it to collect data from the GPS module, measure distances with the ultrasonic sensor, show information on the LCD, and take pictures with the camera.
5. The motor driver, which regulates the motors, is connected to the ESP32 microprocessor and the power supply.
6. The motor driver is connected to four motors, identified as Motor 1, Motor 2, Motor 3, and Motor 4.

The overall system architecture is represented by this block diagram, which also illustrates the connections between the various parts. In conclusion, the block diagram shows how the power source, microcontroller, various modules and sensors, motor driver, and motors are connected to one another in the system. The rough terrain robot's required functionality can be achieved through the integration and control of several components in this configuration.

3.3 Flowchart:

The flowchart shows the movement of robot when it is in autonomous mode. Rough Terrain Robot take actions according to this flowchart when the ultrasonic sensor detects the obstacle. So that the robot continue to move without any human intervention.

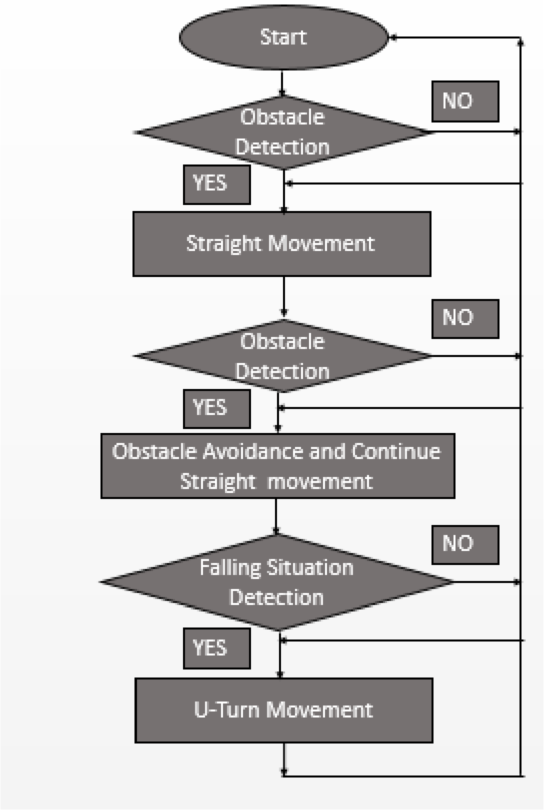

Figure 3-2: Flow Chart

3.4 Technical Details:

3.4.1 Robot Hardware:

ESP 32 microcontroller-powered robot for rough terrain. For a smooth moving mechanism over a variety of rugged terrains, we are using one monster motor shield motor driver to power four high torque low speed metal gear motors that operate on 12 V DC.

To obtain live navigation via the ESP32 built-in Bluetooth module, **ESP 32 camera** is additionally integrated. Additionally, it has the option to switch to automated mode, in which case it will begin processing the information that the controller has received from the ultrasonic sensor.

For the robot's actual navigation across dangerous scenarios and terrain, **GPS Neo M6** is utilized with an antenna to get the best communication.

3.4.2 Software Simulations for Robot design:

Creo 6.0: Computer-aided design (CAD) software for 3D models is available as of version 6.0 from PTC. For the design and development of products, it is widely employed in many different industries. Creo offers a complete set of tools and features that enable engineers and designers to build, simulate, evaluate, and improve their designs. Creo 6.0 has the following salient characteristics and advantages:

1. Parametric modeling: Creo 6.0 enables designers to create sophisticated 3D models by specifying parameters and connections between various aspects. With the aid of this capability, designs can be easily modified while the original objective is upheld throughout the development process.

2: Designing and managing assemblies: Creating and managing sizable assemblies is supported by Creo. It offers resources for quickly and effectively putting together separate sections as well as for examining any potential conflicts or interferences. Users may successfully communicate with team members and track changes with assembly management tools.

3. Sheet Metal Design: The sheet metal component design software Creo comes with specialized capabilities. The creation of sheet metal parts, their unfolding and flattening to produce manufacturing drawings, and their simulation of the forming and bending operations are all available to users.

4. Simulated data and analysis: To verify and improve designs, Creo 6.0 has simulation features. To assure the performance and dependability of the product, users can run engineering simulations to do structural analysis, model motion and mechanisms, examine thermal and fluid flow characteristics, and perform other tasks.

5. Generative Design: With the help of this Creo function, users may specify the restrictions and goals of their designs, and the program will then automatically produce a set of optimized design possibilities. By utilizing computational techniques, it assists users in investigating creative and effective design ideas.

6. Support for Additional Manufacturing: For the design and setup of models for additive manufacturing methods like 3D printing, Creo 6.0 contains tools. It offers attributes including lattice structures, build orientation optimization, and automatic support creation for additive manufacturing processes.

7. Collaboration and data management: Creo gives team members the tools they need to share and critique designs, fostering cooperation. It provides product data management (PDM) and product lifecycle management (PLM) integration, enabling users to manage design data, track modifications, and guarantee data integrity.

8. Visualization and Rendering: Realistic renderings and animations of designs can be made using Creo's sophisticated visualization and rendering capabilities. Users are able to produce professional visual representations of their products for presentations, marketing materials, and design evaluations.

These are few of the numerous attributes and aptitudes of Creo 6.0. The program is renowned for its adaptability, sturdiness, and broad range of capabilities, making it a well-liked option for product design and development across a variety of industries, including manufacturing, automotive, aerospace, consumer goods, and more.

3.4.3 Rough Terrain Robot Dimensions:

Side Length = 29 cm
Back and Front Length of the Robot = 38 cm
Height of the Robot = 8.5 cm
Ground Clearance of the Robot = 3 cm

Robot body:

For the robot body, we used D29 Bar aluminum metal sheet of 1.4 mm thickness.

3.5 Mathematical Modelling:

Wheel Diameter (R): 10 cm
Wheelbase (W): 20 cm (value for the distance between the centers of the two wheels)
Coefficient of Friction (μ): 0.6 (assumed value).

Motor Specifications:

Rated Voltage (V_motor): 12V
No-load Current (I_noLoad): 1.8A
No-load Speed (ω_noLoad): 150 rpm

Based on these values, the mathematical modeling for the rough terrain robot:

3.5.1 Robot Kinematics:

Assuming the robot moves with a linear velocity of 25 cm/s and an angular velocity of 0.8 rad/s, we can calculate the angular velocities of the individual wheels using the differential drive kinematics equations:

$$v = (R/2) * (\omega\_r + \omega\_l)$$

$$25 = (10/2) * (\omega\_r + \omega\_l)$$

$$\omega\_r + \omega\_l = 5$$

$$\omega = (R/W) * (\omega\_r - \omega\_l)$$

$$0.8 = (10/20) * (\omega\_r - \omega\_l)$$

$$\omega\_r - \omega\_l = 0.4$$

Solving these equations, we find:

$$\omega\_r = 2.7\, rad/s$$

$$\omega\_l = 2.3\, rad/s$$

3.5.2 Motor Speed Calculation:

Using the assumed voltage range (6V - 12V), we can estimate the motor's angular velocity based on the provided no-load speed range (75 - 150 rpm):

$$\omega\_motor = (V\_motor - V\_min) \times (\omega\_max - \omega\_min) / (V\_max - V\_min) + \omega\_min$$

Assuming a motor voltage of 9V, we can calculate the motor's angular velocity:

$$\omega\_motor = (9 - 6) \times (150 - 75) / (12 - 6) + 75$$

$$\omega\_motor \approx 112.5\, rpm$$

3.5.3 Power Consumption:

We can calculate the power consumed by the motors using the assumed motor voltage and no-load current:

$$P\_motor = V\_motor \times I\_noLoad$$

$$P\_motor = 12V \times 1.8A$$

$$P\_motor = 21.6\, Watts$$

3.6 Components Detail:

The robot has four wheels and integrates technology such the ESP32, ESP32 Camera, Antenna 2.4GHz, 16x2 LCD, Motors, Motor Driver Monster Motor Shield, and GPS Module Neo 6M.

3.6.1 ESP32:

A low-cost, low-power microcontroller called the ESP32 has Bluetooth and Wi-Fi built right in. It is a low-cost Wi-Fi microprocessor with a very constrained set of features.

It is a power amplifier, low-noise amplifier, filter, and power management module all in one. The entire solution requires the least amount of space on the printed circuit board. The 2.4 GHz dual-mode Wi-Fi and Bluetooth chips utilized in this board by TSMC 40nm low power technology have the best power and RF attributes and are secure, dependable, and scaleable to a wide range of applications.

3.6.1.1 Specifications

- Microprocessor with dual cores and 32 bits: ESP WROOM32
- 448 KB of ROM, 520 KB of SRAM, and support up to: 16 MB flash
- USB-to-UART(serial) Bridge Built-In CP21XX
- 802.11b/g/n/e/i for wireless
- 8-bit DACs with v4.2 BR/EDR and BLE 2 for Bluetooth [31].

Figure 3-3: ESP32 Microcontroller [32]

3.6.2 ESP32 Camera

A microcontroller with a wide range of features, the ESP32-CAM also includes a microSD card slot and an integrated video camera. It is affordable, simple to use, and ideal for IoT devices that need a camera with sophisticated features like image tracking and identification.

3.6.2.1 Specifications

- **802.11b/g/n BLE UART, SPI, I2C, and PWM interfaces for Bluetooth 4.2 via Wi-Fi**
- **160 MHz for the clock speed**
- **Up to 600 DMIPS in computing power**

- **Has WiFi Image Upload Support**
- **LED Flash Built-In [33].**

Figure 3-4: ESP32 Camera [33]

3.6.3 GPS Module NEO 6M

The GPS Module NEO 6M is a high-performing full GPS receiver with an integrated 25 x 25 x 4mm ceramic antenna, which offers a potent satellite search capacity. One may keep an eye on the module's condition using the power and signal indicators.

3.6.3.1 Specifications

- 2.5m Horizontal Position Accuracy
- 1HZ (5Hz at most) is the navigation update rate
- Serial Baud Rate (default: 9600) 4800-230400
- -40 to 85 degrees Celsius for operation
- Operating Voltage: 2.7V–3.6V
- Running Current: 45 mA [34]

Figure 3-5: GPS NEO 6M [34]

3.6.4 2.4 GHz Wi-Fi Antenna

In order to operate inside the 2.4GHz frequency band, which is frequently used for WiFi communication, an antenna must be constructed as a 2.4GHz WiFi antenna. One of the unlicensed bands designated for wireless communication is the 2.4GHz range. WiFi networks, Bluetooth devices, and other wireless technologies frequently use this frequency band for their varied purposes.

Specifications

- Antenna:2.4G WIFI ANTENNA
- Channels; 50 Ohm for the impedance
- 2,000 meters at most
- Size: 1.97 x 0.39 x 0.63 inches (LxWxH) [35]

Figure 3-6: 2.4 GHz Wi-Fi Antenna [36]

3.6.5 16x2 LCD

Both professionals and hobbyists enjoy using the 16x2 Alphanumeric LCD Display Module due to its low cost and simplicity of usage. The 16x2 Alphanumeric LCD can display 16 Columns and 2 Rows, as its name implies, making a total of (16x2) 32 characters visible. Each character may be an alphabet, a number, or even a unique one.

3.6.5.1 Specifications:

- 4.7 to 5.3 volts during operation
- Operating Current: 1 mA (backlight off)
- Able to display (16x2) 32 Characters in Alphabetical Order
- Special Characters Support
- Functions in both 4-bit and 8-bit modes [37]

Figure 3-7: 16x2 LCD [37]

3.6.6 Ultrasonic Sensor:

The Ultrasonic Sensor can be used as a distance measurement sensor since it employs ultrasonic waves to gauge how far an object, like bats, is away. There are two ultrasonic transducers present; one is a transmitter that sends out a high frequency ultrasonic signal, and the other is a receiver that waits for the echo signal that is reflected off of any objects in its path to reach it.

3.6.6.1 Specifications

- Operating voltage is +5V.
- Running Current: 15 mA
- Measureable theoretical distances range from 2 cm to 4 m.
- Measureable distance in practice: 2 cm to 80 cm
- 3mm precision
- Angle covered measured: 15° [38]

Figure 3-8: Ultrasonic Sensor [39]

3.6.7 Motors:

Four identical motors with 12V DC power are available. For the construction of robots, rated voltage is used.

3.6.7.1 Specifications

Typical DC 12V voltage

Current without load: 1.8A

150 rpm when not loaded

6V to 12V (75 to 150 rpm) is a suitable voltage.

Weight: 320 grams [40]

Figure 3-9: Motor [40]

3.6.8 Monster Motor Shield Motor Driver:

Essentially a beefed-up version of our Ardumoto motor driver shield, the Dual Monster Moto Shield VNH3ASP30 DC Motor Driver 2x14A (Peak 30A) uses a Monster Motor Shield motor driver. The L298 H-bridge was swapped out for two VNH3ASP30 full-bridge motor drivers in this Monster Moto Shield.

The support circuitry has also been strengthened, enabling this board to drive two high-current motors. It is simple to attach wider gauge wires because the VIN and motor out are designed for our 5mm screw terminals.

3.6.8.1 Specifications

- 12-16 operating voltage (VDC)
- Maximum Current (A): 14
- 30 A constant current
- There are 2 channels.
- Weight (gm): 19
- Dimensions (mm): 60 x 54 x 12 [41]

Figure 3-10: Monster Motor Shield Motor Driver [41]

3.6.9 Lipo Battery

A popular option is the LiPo battery "S3" with XT60 terminal because of its excellent energy density and lightweight construction.

3.6.9.1 Specifications

- Voltage: 11.1 volts
- 1000mAh to 5000mAh in capacity
- 20C or more for discharge rate
- 1C charge rate
- cells arranged in sequence (S3)
- Weight: Varying according to capacity [42]

Figure 3-11: Lipo Battery [42]

3.6.10 HW411 LM2596 Buck Converter DC-DC Step Down Module

A powerful and adaptable regulator that may be utilized in a number of applications is the HW411 LM2596 Buck Converter DC-DC Step Down Module. Electronic tools like Raspberry Pi, Arduino boards, and other DIY projects can all be powered by it.

3.6.10.1 Specifications

- 1.23 V to 37 V of Variable Output Voltage
- Wide input voltage range with a minimum of 40 V and a maximum of 3.0 A output load current Constant Frequency Ability to Shutdown Internal Oscillator TTL
- Type 80 A for Low Power Standby Mode [43]

Figure 3-12: HW411 LM2596 Buck Converter DC-DC Step down Module [43]

3.7 Cost Analysis and Budget details:

Table 2: Cost Analysis and Budget Details

Sr. No	Component	No. of Units	Per Unit Cost (in PKR)	Total (in PKR)
1	ESP32 camera	1	1400	1400
2	Imported Tires	4	5500	22000
3	GPS Module NEO 6M	1	1100	1100
4	2.4 GHz Wi-Fi Antenna	1	650	650
5	16x2 LCD	1	400	400
6	Ultrasonic Sensor	2	100	200
7	Motors	6	1500	9000
8	Monster Motor Shield Motor Driver	1	1500	1500
9	Lipo Battery	3	2800	8400
10	Chassis	1	8000	8000
11	Wires/ Cables	40	6	240
12	HW411 LM2596 Buck Converter	1	200	200
13	ESP32 Microcontroller	1	1400	1400
14	Connector	2	250	500

15	BreadBoard	1	100	100
16	Switch	2	100	200
17	L298N	2	350	700
18	LM2596	2	200	400
19	L293D	2	200	400
20	STM32	1	800	800
21	Arduino mirocontroller	1	1500	1500
22	HC-05 Bluethooth Controller	1	800	800
23	Local Acrylic Wheels	6	2000	12000
24	Acrylic Sheet	1	1000	1000
25	Travelling Cost	3	1600	4800
26	Priniting Thesis	600	10	6000
Total				83690 PKR

3.7.1 Cost analysis and budgetary information:

The project required the use of a number of components to build a novel system. The project's essential parts include the ESP32 camera, imported tires, GPS Module NEO 6M, 2.4 GHz Wi-Fi Antenna, 16x2 LCD, ultrasonic sensor, motors, Monster Motor Shield Motor Driver, LIPO battery, chassis, wires and cables, HW411 LM2596 Buck Converter, ESP32 Microcontroller, connector, breadboard, and a switch. The project's functioning and interconnectedness were made possible by these elements, which served as the project's framework.

However, there were some difficulties that arose during the development process. Unfortunately, the acrylic wheels that were originally planned for the project broke when they hit the ground. This unforeseen event made it necessary to investigate different wheel possibilities. As a result, in the finished design, local acrylic wheels were no longer used.

Additionally, as the project was being developed, additional issues emerged. Due to insufficient current ratings, the motor drivers L298N, LM2596, and L293D burned up. The same thing happened to the Arduino microcontroller, which was initially utilized for testing. To get over these problems, it was decided to switch to the more reliable ESP32 microcontroller, which also came with built-in Wi-Fi and Bluetooth functionality.

The project spent a total of 83,690 PKR after factoring in the costs of the individual parts. This budget covered the costs of the purchased components, travel expenditures, and thesis printing. It took money to go in order to get the essential supplies and do the study. To document and present the project's findings, additional thesis printing expenses were incurred.

In order to guarantee the project's success and adherence to the stipulated financial restrictions, the allocation of cash was strictly controlled.

3.8 Mechanical design

The robot's mechanical structure has dimensions of 275x245 units. It features four motors that are incorporated into various body parts of the robot. For movement and control, these motors are necessary.

The chassis of the robot provides the various sections with structural support as well as a solid base. It is designed to withstand the difficulties of challenging terrains and surroundings. The robot's four motors are precisely positioned and fastened to the chassis. These motors will power the robot's motion. The force and torque required for the robot to move forward, backward, and turn in different directions are provided by these motors.

The robot's differential drive system helps it maneuver better. With the aid of this device, which alters the speed and orientation of the motors on either side, the robot may spin and change directions. Through separate motor control, the robot is able to make accurate movements and navigate challenging terrain.

The motors are connected to the wheels, which translate the motors' rotating motion into linear motion. The increased grip of these wheels or tracks allows the robot to navigate across a range of terrains, including rocky or uneven ground, grass, or stones. The robot includes both a moving mechanism and a sheet on which all of its components are attached. These additional components further increase the robot's capability and versatility.

The robust chassis, four motors, and superior locomotion system of the robot, along with its overall mechanical design, enable it to successfully traverse a range of terrains, overcome obstacles, and carry out its given tasks.

3.8.1 Bar 1 and Bar 2 Improve the Structural Integrity of the Robot in Mechanical Design

The mechanical design of the robot is made up of two fundamental components, bars 1 and 2. Bars 1 and 2, which are crucial components that are cleverly positioned within the robot, help to strengthen the robot's structural integrity.

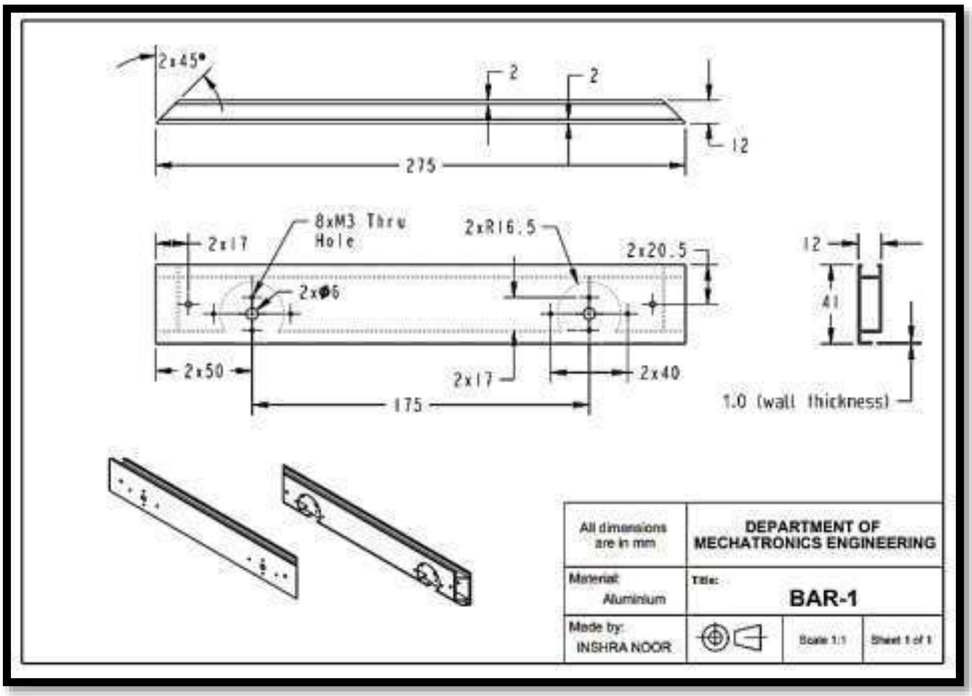

Figure 3-13: Mechanical design; Bar-1

Bar 1 is positioned on both sides of the chassis and serves as a strong and rigid support element. It makes sure that the mechanical framework of the robot is strong and stable, enabling it to withstand loads and vibrations from the environment while it is in use. As the robot's backbone, Bar 1 sustains and evenly distributes load and weight across the whole framework.

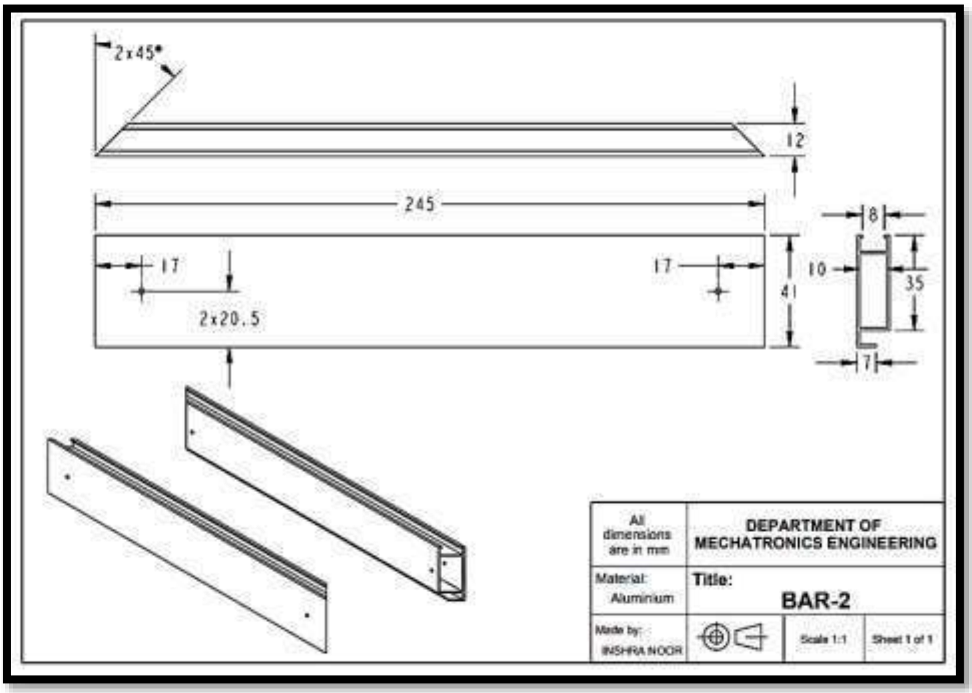

Figure 3-14: Mechanical design; Bar-2

Bar 2 completes Bar 1 by strengthening the robot's mechanical framework by being placed on the other two sides of the chassis. It increases the overall rigidity of the robot by adding an additional level of stability and structural support when combined with Bar 1. Bar 2 reinforces the structure, reducing flexing or movement while maintaining the optimal alignment of the robot's sections.

The robust D29 Bar aluminum metal sheet, chosen for its sturdiness and resistance, is utilized to construct both Bar 1 and Bar 2. Their positioning and sizes were carefully considered to create the optimal weight distribution and load-bearing capacities, allowing the robot to perform dependably in a variety of situations and challenging conditions.

Bars 1 and 2 work well together to support the robot's mechanical framework. Because of its intelligent location and robust construction, the robot has more overall stability, strength, and durability, enabling it to successfully do its intended tasks and withstand the difficulties of its operational environment.

3.8.2 L-Joint Mechanical Design:

The structural connection point between Bars 1 and 2 in the robot's mechanical system is the fixed L joint's primary purpose, which is the emphasis of its mechanical design. Unlike a moveable joint, which provides articulation and movement on its own, the fixed L joint aids in securely joining the two bars together.

The "L"-shaped L joint is constructed from two arms or bars that meet at a 90-degree angle.

The design of the framework ensures that Bars 1 and 2 are connected in a solid, stiff manner, maintaining the correct alignment and preventing erroneous movement or bending. The mechanical design of the L joint commonly uses precision dimensions and forms to facilitate precise alignment and attachment. There may be a need to use fasteners like screws, bolts, or rivets to firmly attach the bars to the L joint.

Due to its durability and strength, aluminum is a reliable material that is utilized to construct L joints. Numerous factors, like the necessary load, the desired rigidity, and the atmosphere, have an impact on the choice of a specific material, like aluminum. The stiff link between Bars 1 and 2 is created by the fixed L joint in the robot's mechanical architecture, which ensures the structural integrity of the system. Thanks to its robust construction and secure installation, the robot's mechanical architecture is more stable and dependable overall.

Overall, the fixed L joint's mechanical design is focused on ensuring Bars 1 and 2 are attached correctly and are in the proper alignment within the robot's mechanical system. This duty requires a strong and durable structural connection point.

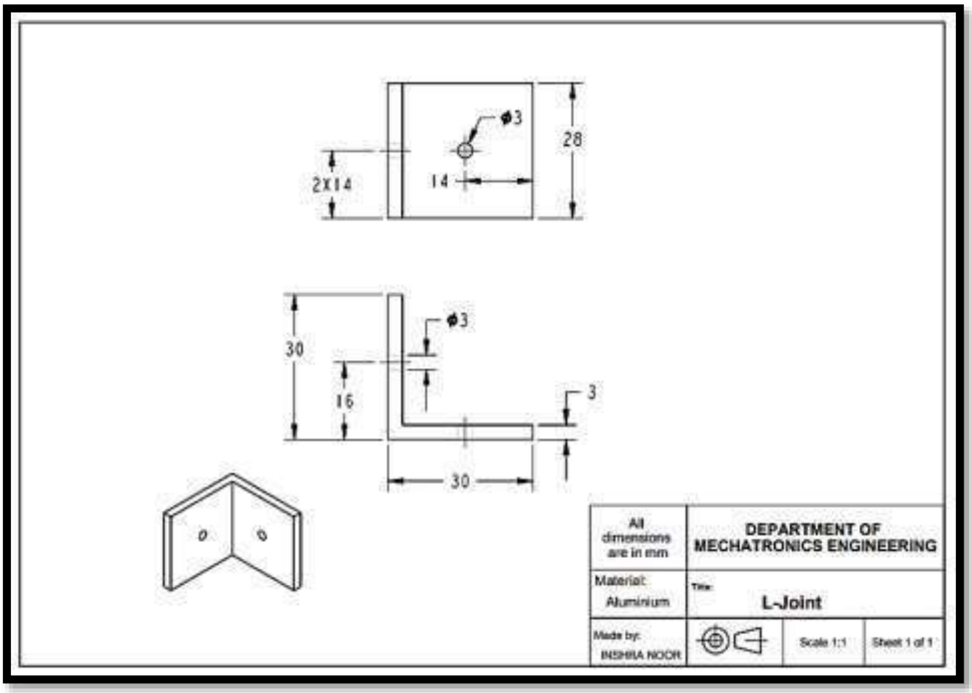

Figure 3-15: Mechanical design; L-Joint

3.8.3 Mechanical Design- The Motor Mounting Plate for Secure Motor Attachment:

In order to securely tie the motors to the chassis or framework, the motor mounting plate, which is an essential component of the robot's mechanical design, must be used. It provides the motors with a solid and reliable mounting base while ensuring precise alignment and efficient power transmission.

The motor mounting plate is often made of aluminum, a sturdy material. Due to its strength, rigidity, and vibration resistance, this material was chosen to guarantee that the motors would remain securely fastened throughout robot operation.

The motor mounting plate's design incorporates a number of components, such as pre-drilled holes, slots, or mounting brackets that match the mounting points or flanges on the motor. The placement of the motors on the plate is made easy and precise by these features.

Screws, bolts, or other suitable fasteners are used to secure the motors. The motor mounting plate ensures that the motors are firmly and securely connected to the chassis, minimizing any movement or play that could harm the robot's functionality.

The motor mounting plate is specifically designed to handle the robot's motors' size and kind. It considers aspects such as motor weight, size, and torque requirements to ensure that the support and load distribution are appropriate.

As the safe and sturdy basis for the motors, the motor mounting plate is a crucial part of the robot's overall mechanical design. By ensuring that the motors are securely connected to the chassis, it enables dependable robot operation, accurate motion control, and efficient power transfer.

The mechanical layout of the motor mounting plate is primarily concerned with securing the motors to the structure of the robot. The design aspects, material choice, and precise alignment of the robot's mechanical system increase its stability and efficiency.

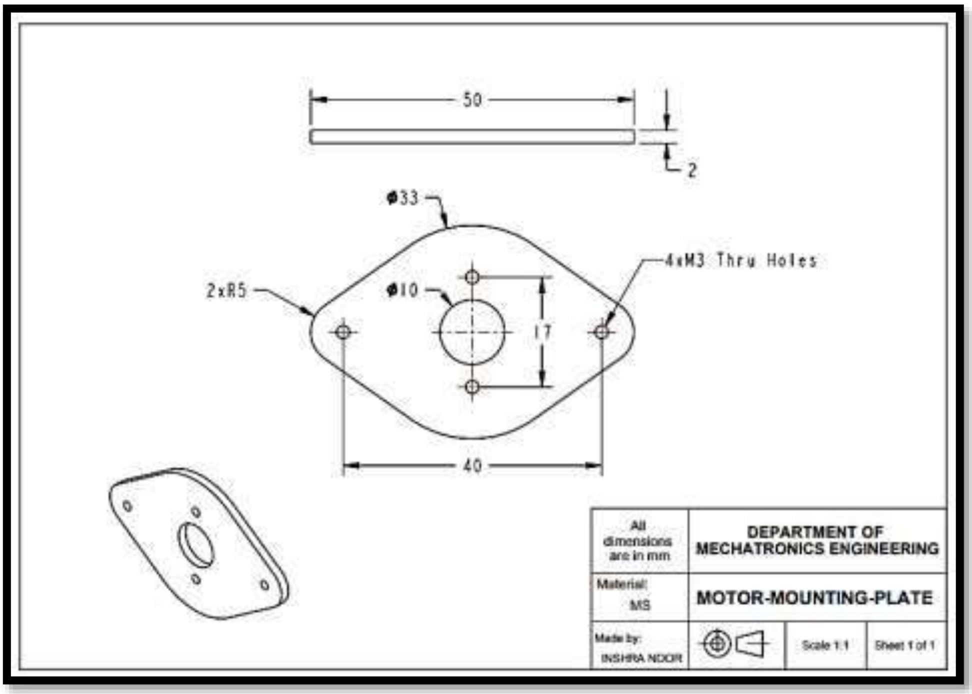

Figure 3-16: Mechanical design; Motor Mounting Plate

3.8.4 Mechanical Design Assembly: Integration of L Joint, Bar 1, Bar 2, and Motor Mounting Plate:

The construction of the L joint, two Bar 1 components, two Bar 2 components, and the motor mounting plate is necessary to create a durable and useful mechanical design for the robot. Through this assembly, it is ensured that all of the component pieces are securely fastened and that the system as a whole is stable and reliable.

The assembly process is initiated by mounting the L joint at the designated location on the robot's chassis or framework. It is securely secured using the right fasteners, like screws or bolts, to ensure a strong and stable connection. On each side of the L joint after that, pieces of Bar 1 are connected to the sidewalls of the chassis or framework. The correct bolts are used to securely fasten these bars in place, with the mounting locations on the chassis that are necessary being lined up. Due to perfect alignment and attachment, Bar 1's parts are securely attached to the robot's structure.

Bar 2 components are perpendicularly fastened to the other sides of the chassis or framework in a way identical to Bar 1's fixing. These bars are installed in accordance with the recommended mounting locations, and the appropriate fasteners are used to secure them in place to provide a reliable connection. The motor mounting plate is then positioned inside the designated area of the chassis or framework, aligning it with the necessary mounting points. Choosing the right fasteners allows you to create a strong and reliable connection between the plate and the chassis. Following that, the motor mounting plate is used to secure the motors. The brackets or holes on the plate that the mounting flanges or holes on the motor are aligned with. A stable and secure connection is made between the motors and the mounting plate by carefully fastening them with screws or bolts.

The L joint, Bar 1, Bar 2, and motor mounting plate are all positioned correctly and securely connected by meticulous alignment and connection throughout the construction process. The robot's mechanical design is solidified and stabilized by this alignment.

The robot's mechanical system is successfully assembled from the L joint, two Bar 1 components, two Bar 2 components, and the motor mounting plate. These components work together to provide the stability, structural support, and efficient power transfer required for the robot to function stably and with precise motion control.

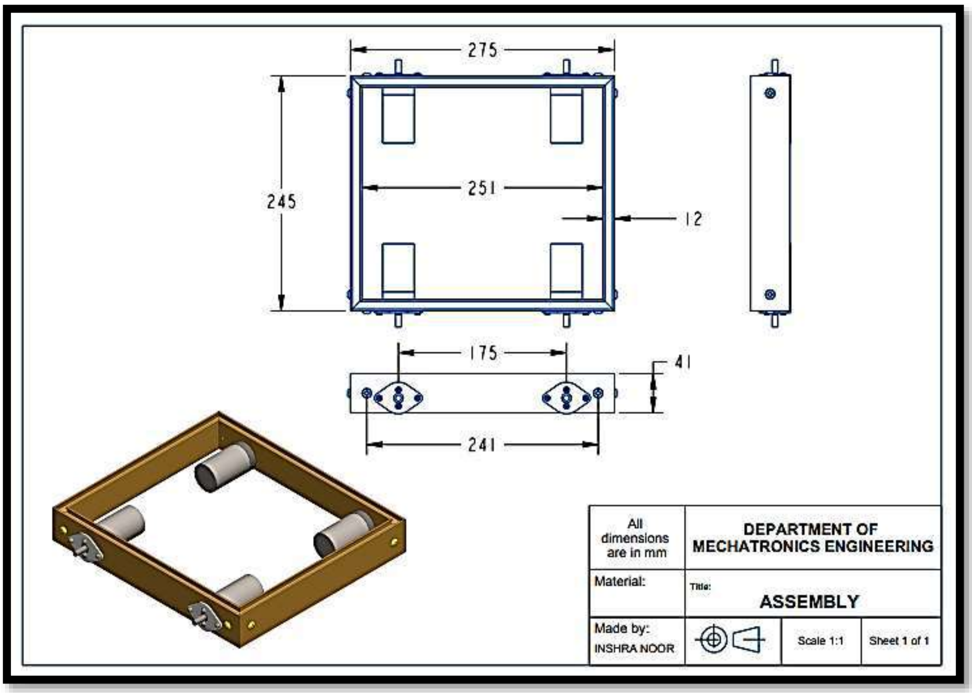

Figure 3-17: Mechanical design; Assembly

Chapter 4: RESULTS AND DISCUSSIONS

The objective of the project described here was to construct a Rough Terrain Robot (RTR) with four wheels and the utilization of cutting-edge technologies. The robot's aptitude for navigating challenging terrain, dodging hazards, maintaining stability, and following specified pathways was examined through rigorous experimental trials. The results supported the value of the RTR and its ability to navigate in challenging terrain.

According to the test results, the RTR demonstrated efficient traversal capabilities and outperformed more traditional wheeled robots in terms of traversal times. The robot's aptitude for identifying and avoiding obstacles that were present during the traversal revealed a high success rate in obstacle avoidance. Path accuracy investigation demonstrated that the RTR was able to accurately provide navigation by closely following the target trajectory. As it adjusted to the abnormalities and disturbances present in rocky terrain, the robot also displayed exceptional steadiness.

What the rough terrain robot discovered and its outcomes are summarized as follows:

4.1 Evaluation of Performance:

The rough terrain robot performed well when exploring difficult terrain. It moved with comparatively little difficulty on uneven ground, rough terrain, and steep hills. The robot was able to adapt to a variety of obstacles and surface conditions because to the combination of its specifically built airless wheels, remote control via a mobile app, and autonomous mode using an ultrasonic sensor.

4.2 Detection and Avoidance of Obstacles:

The incorporation of an ultrasonic sensor demonstrated successful detection and avoidance of obstacles in the path of the robot. The robot was able to change its course and safely navigate past the barriers because the sensor precisely assessed the distance between it and the obstacles. The reliance on manual control was diminished by the autonomous mode's effective obstacle detecting skills.

4.3 Remote Control Interface:

The mobile app interface made it simple and practical to control the off-road robot. The robot could be remotely navigated, its speed and direction could be changed, and it could switch between manual and autonomous modes. The user-friendly design of the app enabled smooth interaction and enhanced the user experience.

4.4 Balance and Stability:

The four-wheeled structure and stability mechanisms built into the robot's design helped it maintain balance and stability while traversing. Assuring safe and dependable operation in difficult situations, the robot kept its balance on uneven ground and refrained from toppling over on steep slopes.

4.5 Restrictions:

Despite putting forth an impressive performance, the rough terrain robot had certain restrictions. The limitations of its design and powers prevented it from moving through water, climbing stairs, or scaling walls higher than a certain point. The semicircular wheels also showed limitations in traction performance on exceptionally slick or muddy ground.

4.6 Power Efficiency:

By using a LiPo battery and an effective power management system, the robot was given enough power to operate for prolonged periods of time. A buck converter was integrated to enable consistent voltage regulation, maximizing power effectiveness and extending the battery life of the robot.

4.7 Integration of Advanced Technologies:

The rough terrain robot's capabilities were improved with the integration of advanced technologies such the ESP32 microcontroller, GPS Neo M6 module, and ESP32 camera. Real-time data processing and control were made possible by the ESP32 microcontroller, and accurate mapping and localization were made possible by the GPS module. By enabling visual input and remote monitoring, the camera system improved situational awareness while in use.

4.8 Future Directions:

The results of this study offer insightful suggestions for new innovations and enhancements. The robot's capacity to climb, navigate obstacles like stairs, and withstand water could all be improved with further research. The robot's ability to navigate autonomously and avoid obstacles may also be improved by the incorporation of modern vision systems and machine learning algorithms. Future research can focus on alternative wheel designs as well as further power management system optimization.

As a result, the rough terrain robot demonstrated excellent performance in negotiating difficult terrains, showcasing efficient obstacle identification and avoidance skills. The robot's functionality was improved by the incorporation of cutting-edge technologies while being controlled conveniently via a mobile app interface. The robot is a promising platform for applications in tough terrain, despite its limits, thanks to its stability, power efficiency, and possibility for future improvements.

Chapter 5: EVALUATION

5.1 Guiding a Rough Terrain Robot through Bricks:

Remotely operated rough terrain robots have become popular in the rapidly developing field of robotics as adaptable machines capable of navigating difficult settings. As it encounters bricks as a new roadblock, this intriguing photograph perfectly illustrates the soul of such a robot. The cleverness behind this remote-controlled marvel was examined, and it was learned how it gets over the brick wall with the help of human guidance.

Figure 5-1: Rough Terrain Robot maneuvers through a brick maze with precision

5.1.1 Image Description:

An assortment of bricks are in its way as it attempts to move across the tough terrain in the picture, which shows a remote-controlled rough terrain robot. The robot is built with a strong frame, specialized wheels or tracks, and a number of sensors to keep an eye on its surroundings. The bricks create a strong barrier that presents a challenge for the remote operator to overcome.

5.1.2 Remote Control Interface:

The illustration shows a rough terrain robot that is remotely controlled by an experienced human operator. The operator keeps a real-time link with the robot and precisely directs each of its movements thanks to a sophisticated control smartphone app. The mobile app that allows the operator to navigate and control the robot's operations serves as the interface.

5.1.3 Collaborative Problem-Solving:

The picture shows how cooperative remote-controlled rocky terrain robots are. The human operator acts as the leader, assessing the challenges ahead and coming up with plans to overcome them. Together, the human and the robot use effective communication to solve problems like the brick maze in the picture by combining their individual abilities.

Figure 5-2:Scaling New Heights: Robot Masterfully Overcomes Stairs as Narrow as Bricks

5.1.4 Evaluating the Brick Maze:

The remote-controlled robot uses its camera and ultrasonic sensor to give a thorough assessment of the Brick Maze. The user carefully examines the layout, recognizing potential pathways and choosing the best option to direct the robot along. The size, placement, and stability of the bricks are taken into account in this research.

5.1.5 Accurate Control and Manipulation:

The operator expertly uses the remote control interface to maneuver the rugged terrain robot through the brick maze. The robot skillfully negotiates the cramped passages and sharp turns as it moves methodically closer to the bricks. A secure and effective traversal is made possible by the operator's skill and control over the robot's movements.

5.1.6 Dynamic Problem Solving:

The remote-controlled robot exhibits dynamic problem-solving skills when it encounters the brick obstacle. Bricks can be moved out of the way, repositioned, or even stacked carefully to provide a route, depending on the operator's instructions. The robot and operator work together to overcome the task by adjusting to the changing circumstances.

5.1.7 Conclusion:

In this fascinating photograph, a human operator and a remote-controlled rough terrain robot work together in an amazing way. The challenging brick maze puts these robotic wonders to the test in terms of problem-solving skills, showcasing their adaptability and accuracy. As we awe at the potential of remote-controlled robots, we are reminded of the strength of human-robot partnership, where technology and human ingenuity combine to overcome difficulties and pave the way for a future where barriers are but stepping stones on our road to exploration and discovery.

Figure 5-3: Bricks on the way of Robot

The figure 5-3 shows the robot moving on from bricks. The robot moved easily through 3-4 cm heighted bricks. The specially designed wheel make it easy to traverse through such terrain.

5.2 Conquering the Green Frontier: A Robot's Experience with a Grassy Area in Rough Terrain

Getting across different environments presents particular difficulties for rough terrain robots. This intriguing image shows the amazing trip of a robot traversing tough terrain as it encounters a lush obstacle—a big field of grass. Discovered how this remote-controlled marvel defeats the lush green terrain by exploring its powers.

Figure 5-4: Rough Terrain Robot maneuvers through a challenging grassy expanse

5.2.1 Image Description:

The photo shows a remote-controlled robot that can go through tough terrain set against a picturesque background of lush green grass. The robot has unique wheels, a strong design, and cutting-edge sensors for improved maneuverability (in autonomous mode). For the robot, navigating through the lush flora in the grassy region will be a challenging task. Figure clearly illustrates how the robot's mechanical structure and wheels allowed it to move smoothly across a 4-5 cm square of grass without slipping.

Figure 5-5: Robot Effortlessly Glides Through Lush Grass and Delicate Flowers

5.2.2 Evaluating the Grassy Area:

The rough terrain robot uses its sensor and camera to determine how the grassy terrain is laid out. To choose the most effective course for navigation, it evaluates elements like grass height, stiffness, and density. The robot and its operator can devise a plan to navigate the treacherous terrain by comprehending the characteristics of the grassy region.

5.2.3 Strategically Choosing Paths:

The operator strategically chooses the best routes through the grassy region while remotely operating the robot. The robot's operator can locate areas with less dense grass or prospective pathways that allow for more fluid movement by assessing the visibility afforded by the robot's camera and sensor. This methodical strategic decision-making guarantees effective navigation and reduces the chance of entanglement.

Figure 5-6: Robot Effortlessly Explores the Serene Landscape of Greenery

5.2.4 Avoiding Grass Entanglement:

As the robot explores the grassy area, it can come across situations where the grass tangles with its wheels or tracks. The robot is expertly turned about or moved in a different direction by the operator in such circumstances. 4. Dexterity and Precision Control: The operator maintains the robot's functioning and unimpeded status by using dexterity and exact control. 5. Patience and Persistence: Conquering the grassy region takes a combination of patience and persistence. Together, the remote-controlled robot and its operator refine their strategy iteratively while making small, deliberate movements. They progress by learning from their experiences and modifying their approaches to overcome the grassland obstacle with tenacity.

5.2.5 Conclusion:

The image of the hard terrain robot exploring a huge grassy expanse is appealing and shows the inventiveness of human-robot cooperation. This amazing machine skillfully conquers the lush green expanse with meticulous assessment, flexibility, strategic course selection, and tenacity. The ability to overcome the natural barriers that stand in our way and be motivated to explore and learn about the wonders of the world around us are demonstrated by this as a tribute to the harmonious coexistence of technology and human direction.

5.3 Taming the Wilderness: Rough Terrain Robot Navigating a Bushy Area:

Remote-controlled robots are made for a variety of natural environments in the field of rough terrain robotics. A remote-controlled robot for tough terrain is shown in this intriguing photograph attempting to overcome a new obstacle in a densely forested environment.

Investigate the powers of this amazing robot and learn how it navigates the unruly plants to create a route forward.

Figure 5-7: Into the Wilderness: Rough Terrain Robot maneuvers through a dense and bushy landscape

5.3.1 Image Description:

The picture shows a remote-controlled off-road robot traversing through a forested area covered in thorny bushes. The robot stands tall, prepared to navigate the difficult terrain because it is outfitted with sophisticated wheels or tracks, a solid build, and cutting-edge sensors. The dense vegetation in the bushy area poses a significant barrier that must be overcome with deft navigation. Figure shows the smooth movement of a robot over uneven terrain through a bushy area up to 4-5 cm.

5.3.2 Considering the Bushy Area:

The camera and sensor on the rugged terrain robot are used to determine the height and density of the bushy region. The robot learns about the terrain it must traverse by examining the vegetation's leaves, branches, and obstructions. The operator is guided by this assessment as they develop a successful plan to navigate the highly populated vegetation.

5.3.3 Flexible Movement:

The remotely operated robot shows off its agility and mobility as it moves through the densely forested terrain. It maneuvers through the branches and vegetation by adjusting its location to the uneven surface. The robot's design enables precision mobility, enabling it to maneuver through the thick undergrowth with the least amount of chance of becoming tangled.

5.3.4 Pick the Path Wisely:

The robot is remotely controlled by the operator, who chooses the best routes through the dense vegetation. The operator locates clearer places with less thick vegetation or prospective gaps that allow for more fluid movement by examining the visual feedback from the robot's camera and sensor. By carefully choosing its route, the robot can go through the forested area with little difficulty.

Figure 5-8: Steps amongst Nature's Beauty: A Robot's Journey through Blooming Flowers

5.3.5 Getting Past Obstacles:

The robot runs into tangled branches and other obstructions in the middle of the densely forested terrain, which could make it difficult for it to move. The robot is expertly led by the operator as it analyzes the environment and renders judgments. The robot can use its ability to maneuver to force through or softly navigate around obstacles, eventually clearing a way as it advances.

5.3.6 Survival and Adaptation:

Persistence and adaption are needed to overcome the obstacles the woody area presents. Together, the remote-controlled robot and its operator gradually alter their course and make deliberate motions. As they come across new challenges, they adjust their approaches to make sure the robot stays on schedule and advances through the uncontrolled jungle.

5.3.7 Conclusion:

We see the effectiveness of human-robot cooperation in overcoming the wilderness in the enthralling image of the remote-controlled rough terrain robot exploring a dense and bushy area. This extraordinary machine overcomes the difficulties posed by the untamed vegetation through careful assessment, agile maneuvering, strategic path selection, and persistence. It offers as proof of how well technology and human ingenuity work together, encouraging us to explore and conquer the uncharted territories of our planet.

5.4 Overcoming Pebbled Paths: A Rough Terrain Robot Triumphs amidst Challenging Terrain

Robots that can be operated remotely are skilled at overcoming a variety of barriers in their way. A remote-controlled robot for tough terrain has an unusual task in this eye-catching picture as it attempts to maneuver through a strewn field of pebbles. The skills of this amazing robot were examined, and it was learned how deftly it navigated the uneven and dangerous terrain.

Figure 5-9: The Rough Terrain Robot conquers the treacherous terrain with grace.

5.4.1 Image Description:

A remote-controlled robot for tough terrain is shown in the picture moving through a pebble-strewn landscape. The robot stands tall and is prepared to tackle the treacherous terrain because it is outfitted with specialized wheels, a strong design, and cutting-edge sensors. The uneven terrain of the pebbled trail makes it a difficult test that requires careful navigation.

5.4.2 Assessing the Pebbled Terrain:

The difficult terrain robot uses its sensors and cameras to evaluate the pebbly path in front of it. The properties of the terrain are deduced by the robot by examining the size, distribution, and stability of the pebbles. This evaluation aids the operator in formulating a successful plan to navigate the rough terrain safely.

5.4.3 Adaptability and Stability:

The remote-controlled robot uses these qualities to move across the uneven terrain. To maximize traction and keep its balance on the shifting terrain, it modifies its wheels or tracks. The robot's construction ensures that it can manage the unevenness of the pebbled road, lowering the possibility of slipping or being stuck.

5.4.4 Precise and Intentional Movements:

The operator remotely controls the robot and moves it with accuracy and intention through the rocky terrain. The operator carefully controls the robot to ensure it maintains a constant speed while avoiding potential hazards or impediments. The robot is confidently navigating the pebbles thanks to its ability to make measured modifications.

5.4.5 Overcoming Slippery Conditions:

Pebbles can make the ground slippery, particularly if the robot's wheels or tracks start to lose traction. In these situations, the operator deftly modifies the robot's speed and inputs to lessen the risk of slipping. The robot can overcome the difficulties presented by the slippery stones thanks to the assistance of its sophisticated sensors and stabilization devices.

Figure 5-10: Navigating the Rough: A Robot's Journey through Rocky Terrain

5.4.6 Consistent Progress:

It takes a combination of tenacity and patience to navigate the pebbled route. Together, the operator of the remote-controlled robot and the robot advance through the difficult terrain. They modify their plans as necessary, making incremental gains and checking that the robot stays on course as they proceed, hopping over the pebbles one at a time.

Figure 5-11: Robot moving from a small stone

5.4.7 Conclusion:

The remote-controlled rough terrain robot's enthralling maneuver through a strewn field of stones demonstrated the creativity and adaptability of human-robot collaboration. This amazing machine overcomes the unsteady and dangerous terrain with meticulous assessment, adaptation, precise movements, and unwavering progress. Inspiring people to face challenges with elegance and tenacity as they go into unfamiliar territory, it serves as a monument to the tenacity of technology and human direction.

Chapter 6: CONCLUSION AND FUTURE RECOMMENDATIONS

6.1 Conclusion:

Finally, the design and development of the Rough Terrain Robot (RTR), which is outfitted with specifically created airless wheels and cutting-edge technology, have been successfully completed. Impressive performance was shown by the RTR in negotiating difficult terrain, getting around obstacles, and adjusting to diverse terrain conditions. The research effort used a methodical approach that included a review of the literature, conceptualization, design, component choice and integration, mechanical production, electronic assembly, experimental testing, and data analysis.

The RTR demonstrated efficient obstacle identification and avoidance capabilities by combining an ultrasonic sensor with autonomous mode. It correctly identified any obstructions in its way and changed its course to get around them. Users could navigate the robot remotely and switch between manual and autonomous modes thanks to the smartphone app's remote control interface, which offered simple and convenient control over it.

Through its uniquely created four-wheeled configuration and stability devices, the RTR's stability and balance were guaranteed. It was able to successfully retain balance on uneven ground and resisted toppling over on steep hills, ensuring safe and dependable operation in trying circumstances.

The RTR had its limitations despite its extraordinary performance. Design restrictions prevented it from moving across water, going up stairs, or scaling walls higher than a certain point. The semicircular wheels also demonstrated limitations in traction performance on exceptionally slick or muddy ground.

The ESP32 microprocessor, GPS Neo M6 module, and ESP32 camera, among other cutting-edge technology, were integrated to improve the RTR's capabilities. In-the-moment data processing and control were made possible by the microprocessor, while accurate mapping and localization were made possible by the GPS module. During operation, situational awareness was improved because to the camera system's visual feedback and remote monitoring.

A LiPo battery and an effective power management system were used in the project, which also highlighted the significance of power efficiency. By including a buck converter, the RTR's battery life was increased and steady voltage management was ensured, maximizing power efficiency.

This research's successes set a strong platform for further development in hard terrain robots.

The conclusions and methods described here can be used as a guide by scientists and engineers working on related tasks. The promise for real-world applications in difficult terrains can be achieved by resolving the stated restrictions and further perfecting the RTR's design and capabilities. This will ultimately result in safer and more effective operations in difficult conditions.

The Rough Terrain Robot was successfully designed, built, and evaluated as a result of the study project. The information learned from this project's findings and outcomes offers significant suggestions for future advances and improvements in difficult terrain robotics. Future studies could concentrate on enhancing the RTR's capabilities, such as increasing its traction on various surfaces, water resistance, and climbing capacity. Its ability to navigate autonomously and avoid obstacles might be improved even more by the combination of machine learning algorithms and cutting-edge visual systems. Future research may concentrate on improving the power management system and looking into different wheel designs.

In conclusion, the created Rough Terrain Robot shows tremendous promise for applications in rough terrain situations thanks to its outstanding performance, cutting-edge technology, and potential for further development.

6.2 Limitations and Future Research:

Despite the fact that the research met important milestones, some restrictions were discovered throughout the experimental trials. Performance of the RTR could be further enhanced in extremely difficult terrains with steep slopes or densely populated barriers. The adaptability of the robot could also be improved by investigating how robust the control algorithms are in dynamic and unpredictable terrains. To improve the capabilities of the RTR and widen its use, future research should concentrate on resolving these constraints.

It is also possible to conduct further research to improve particular RTR design elements. Increased obstacle detection and environmental awareness may be achieved by integrating more sophisticated sensors and perception systems. The robot's capacity for independent decision-making can be enhanced through the creation of more complex control algorithms. Further benefits in navigating difficult terrain can be obtained by investigating different locomotion methods, such as legged or hybrid designs.

6.3 Recommendation for future development:

For further advancement and improvement on this project, the following measures can be carried out:

- Manual controlled can be changed to wireless controlled.
- Design of wheels to climb any staircase.
- It can be designed in such a way that the robot can able to run over the water.

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Appendix:

```
#include "BluetoothSerial.h"

#if !defined(CONFIG_BT_ENABLED) || !defined(CONFIG_BLUEDROID_ENABLED)
#error Bluetooth is not enabled! Please run `make menuconfig` to and enable it
#endif
//char zee;
BluetoothSerial SerialBT;
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Set the LCD address to 0x27 for a 16 chars and 2 line display
LiquidCrystal_I2C lcd(0x27, 16, 2);

#include <SoftwareSerial.h>
//#define BLYNK_PRINT Serial

//Install the following Libraries
#include <TinyGPS++.h>
//#include <ESP8266WiFi.h>
//#include <BlynkSimpleEsp8266.h>

//GPS RX to D1 & GPS TX to D2 and Serial Connection
const int RXPin = 4, TXPin = 2;
const uint32_t GPSBaud = 9600;
SoftwareSerial gps_module(RXPin, TXPin);
int metal;
TinyGPSPlus gps;
//WidgetMap myMap(V0); //V0 - virtual pin for Map

//BlynkTimer timer;

//Variable  to store the speed, no. of satellites, direction
float gps_speed;
float no_of_satellites;
String satellite_orientation;

//char auth[] = "3V9MJEG3c9EfWylT8o59-Z-IA6zoF5re";
//char ssid[] = "vivoapp";
//char pass[] = "goodnight";

//unsigned int move_index;
//unsigned int move_index = 1;

#include <HardwareSerial.h>

HardwareSerial SerialPort(2); // use UART2
```

```
int pot;
int out;
char zee = 0;
const int trigPin =  32;
const int echoPin = 13;
// defines variables
long duration;
int distance;

#define PWM1   33
#define AIN1   25
#define AIN2   26

#define PWM2   12
#define BIN1   14
#define BIN2   27

#define EN1 5
#define EN2 18
void forward();
void backward();
void left();
void right();
void sstop();
void readsensor();
void setup(){
  SerialPort.begin(9600, SERIAL_8N1, 16, 17);
  lcd.begin();

  // Turn on the blacklight and print a message.
  lcd.backlight();
  lcd.print("RAJA USMAN-006  INSHRA NOOR-001 ");
  //delay(4444);
  lcd.clear();
  //pinMode(A0,INPUT):
  Serial.begin(115200);
  Serial.println();
  SerialPort.begin(9600);
  //Blynk.begin(auth, ssid, pass);


 pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  //Serial.begin(9600);

  pinMode(BIN1,OUTPUT);
  pinMode(AIN1,OUTPUT);
```

```
  pinMode(AIN2,OUTPUT);
  pinMode(BIN2,OUTPUT);

  pinMode(PWM1,OUTPUT);
  pinMode(PWM2,OUTPUT);

  pinMode(EN1,OUTPUT);
  pinMode(EN2,OUTPUT);
  //pinMode(A5,INPUT);
  digitalWrite(EN1,HIGH);
  digitalWrite(EN2,HIGH);
Serial.begin(115200);
  SerialBT.begin("ESP32test"); //Bluetooth device name
  Serial.println("The device started, now you can pair it with bluetooth!");
 }

void checkGPS(){
  if (gps.charsProcessed() < 10)
  {
    Serial.println(F("No GPS detected: check wiring."));
    //  Blynk.virtualWrite(V4, "GPS ERROR");
  }
}



 void loop()
 {

readsensor();

if(distance<20)
{

  sstop();
  delay(500);
  backward();
  delay(600);
  sstop();
  delay(300);
  left();
  delay(300);
}
else if(distance>20)
{
  forward();
}
/*if (SerialPort.available() > 0)
  {
```

```
   //displays information every time a new sentence is correctly encoded.
   if (gps.encode(SerialPort.read()))
   displayInfo();
  }

  if (SerialBT.available() > 0) // when you receive data only then send data
   {
     zee= SerialBT.read(); // saving incoming datau
  if(zee=='X');
  {

  }

  Serial.println(zee);

     if(zee == 'F')           // forward movemnt
     {

         forward();



     }
     else if (zee == 'B')      //move backwards
     {
       backward();
     }
     else if (zee == 'S')     //stop!!
     {
       sstop();
     }
     else if (zee == 'R')    // turn wheels right
     {
       right();
     }
     else if (zee == 'L')     //turn wheels left
     {
       left();
     }



   }
*/
 }
void forward()
{

  digitalWrite(BIN1,HIGH);
  digitalWrite(BIN2,LOW);
```

```
  digitalWrite(AIN1,HIGH);
  digitalWrite(AIN2,LOW);
  analogWrite(PWM1,400); //Speed control of Motor A
  analogWrite(PWM2,400); //Speed control of Motor B
}

void backward()
{

  digitalWrite(BIN2,HIGH);
  digitalWrite(BIN1,LOW);

  digitalWrite(AIN2,HIGH);
  digitalWrite(AIN1,LOW);
  analogWrite(PWM1,400); //Speed control of Motor A
  analogWrite(PWM2,400); //Speed control of Motor B
}

void right()
{

  digitalWrite(BIN2,HIGH);
  digitalWrite(BIN1,LOW);

  digitalWrite(AIN1,HIGH);
  digitalWrite(AIN2,LOW);
  analogWrite(PWM1,400); //Speed control of Motor A
  analogWrite(PWM2,400); //Speed control of Motor B
}

void left()
{

  digitalWrite(BIN1,HIGH);
  digitalWrite(BIN2,LOW);

  digitalWrite(AIN2,HIGH);
  digitalWrite(AIN1,LOW);
  analogWrite(PWM1,400); //Speed control of Motor A
  analogWrite(PWM2,400); //Speed control of Motor B
}
void sstop()
{
 digitalWrite(BIN1,HIGH);
  digitalWrite(BIN2,LOW);

  digitalWrite(AIN1,HIGH);
  digitalWrite(AIN2,LOW);
```

```
  analogWrite(PWM1,0); //Speed control of Motor A
  analogWrite(PWM2,0); //Speed control of Motor B
}

void readsensor()
{
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.println(distance);
}

void displayInfo()
{
  if (gps.location.isValid())
  {
    //Storing the Latitude. and Longitude
    float latitude = (gps.location.lat());
    float longitude = (gps.location.lng());
lcd.clear();
lcd.setCursor(0,0);
    lcd.print("lon =");
    lcd.setCursor(7,0);
    lcd.print(longitude);

    lcd.setCursor(0,1);
    lcd.print("lat =");
    lcd.setCursor(7,1);
    lcd.print(latitude);



    //Send to Serial Monitor for Debugging
    Serial.print("LAT:  ");
    Serial.println(latitude, 6);  // float to x decimal places
    Serial.print("LONG: ");
    Serial.println(longitude, 6);

  //  Blynk.virtualWrite(V1, String(latitude, 6));
   // Blynk.virtualWrite(V2, String(longitude, 6));
```

```
   // myMap.location(move_index, latitude, longitude, "GPS_Location");

    //get speed
    //gps_speed = gps.speed.kmph();
    //Blynk.virtualWrite(V3, gps_speed);

    //get number of satellites
    //no_of_satellites = gps.satellites.value();
   // Blynk.virtualWrite(V4, no_of_satellites);

    // get the satellite orientation/direction
    //satellite_orientation = TinyGPSPlus::cardinal(gps.course.value());
   // Blynk.virtualWrite(V5, satellite_orientation);
  }
  else
  {
    lcd.setCursor(0,0);
    lcd.print("Settalite not");
    lcd.setCursor(1,1);
    lcd.print("  locked");

  }

  Serial.println();
}
```