A PROJECT REPORT ON

"DESIGN AND DEVELOPMENT OF RESCUE ASSITANT ROBOT"

BACHELOR OF ENGINEERING

(MECHNICAL ENGINEERING)

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CERTIFICATE

This is to certify that:
Mr. Shubham Ambekar, Mr. Jignesh Kakade, Mr. Vishwajeet Shinde, Mr. Hrishikesh Sutar has successfully completed the project entitled –DESIGN & DEVELOPMENT OF RESCUE ASSISTANT ROBOT under my supervision, in the partial fulfilment of Bachelor of Engineering – Mechanical Engineering, by Savitribai Phule Pune University.

DATE:

Place: Pune

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(Project Guide) **External Examiner**

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ACKNOWLEDGEMENT

On the successful completion of this project work, we would like to extend our thanks and cordial sense of gratitude to our research guide Prof. N.N. RAUT for his continuous guidance in the investigation and preparation of this dissertation.

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Finally, we must express our sincere heartfelt gratitude to all the staff members of the Mechanical Engineering Department who helped me directly or indirectly during this course of work.

ABSTRACT

The increasing frequency of natural disasters and man-made emergencies necessitates the development of advanced technologies to aid in search and rescue operations. This project focuses on the design and development of a Rescue Assistant Robot, engineered to enhance the efficiency and safety of rescue missions.

The robot is equipped with a robust, modular chassis capable of navigating challenging terrains, and features a comprehensive suite of sensors, including ultrasonic sensors, infrared sensors, and high-resolution cameras for obstacle detection, victim identification, and environmental monitoring. Extensive testing and validation in simulated rescue scenarios demonstrate the robot's ability to effectively navigate debris, detect heat signatures, and provide live video feeds.

This project focuses on the design and development of a Land Rescue Assistant Robot, aimed at enhancing the efficiency and safety of search and rescue operations in challenging terrains. The robot is designed with a robust and adaptable mechanical structure, utilizing 3D printing technology with ABS material on the Accucraft i250+ printer for critical components. This approach ensures precision and durability while reducing production costs and time.

This project represents a significant advancement in rescue technology, offering a reliable and efficient tool for emergency response teams. Future developments will focus on enhancing the robot's functionalities and expanding its application scope to address a broader range of rescue scenarios.

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Introduction

1.1. Basic Concepts

Robotics

Definition: Robotics is the branch of technology that deals with the design, construction, operation, and use of robots. Application: In this project, robotics is applied to create a machine capable of performing tasks in rescue operations that might be dangerous or impossible for humans.

Autonomous Systems
Definition: Autonomous systems can perform tasks without human intervention by using sensors, control systems, and algorithms. Application: The land rescue robot utilizes autonomous navigation to move through difficult terrains and perform rescue tasks independently.

Sensors and Actuators Sensors: Devices that detect changes in the environment and send this information to the control system. Common types include ultrasonic sensors for distance measurement, infrared sensors for heat detection, and cameras for visual data.

Actuators: Components that receive control signals and perform physical actions, such as motors driving the robot's wheels or tracks.

Application: The robot uses sensors to gather data about its surroundings and actuators to move and interact with the environment.

Microcontroller Unit (MCU) Definition: A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system.

Application: The MCU processes input from sensors and executes control algorithms to drive the robot's actuators.

Artificial Intelligence (AI) and Machine Learning (ML) AI: The simulation of human intelligence processes by machines, especially computer systems.
ML: A subset of AI that involves the use of algorithms and statistical models to enable a system to improve its performance on a task through experience.

Application: AI and ML algorithms are used to enhance the robot's ability to identify victims, navigate complex environments, and optimize its performance over time.

Wireless Communication

Definition: The transfer of information between two or more points that are not connected by an electrical conductor. Application: Wireless modules enable the robot to communicate with a remote base station, providing real-time data and receiving instructions.

Embedded Systems

Definition: Embedded systems are computer systems with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. Application: The robot's control system is an embedded system designed to manage its sensors, actuators, and communication modules.

Mechanical Design

Definition: The process of designing the physical structure of the robot, considering factors like strength, durability, and mobility. Application: The robot's chassis must be designed to withstand harsh environments and navigate over debris and obstacles.

Navigation and Path Planning Navigation: The process of determining the robot's position and planning a route to a target location. Path Planning: Algorithms used to find the optimal path for the robot to follow, avoiding obstacles and ensuring efficient movement. Application: The robot employs navigation and path planning techniques to move autonomously in search and rescue missions.

Rescue Operations

Definition: Coordinated efforts to locate, stabilize, and evacuate individuals in distress from hazardous environments. Application: The robot is designed to assist in these operations by performing tasks such as locating victims, assessing the environment, and relaying critical information to human rescuers.

1.2. Problem statement:

Search and rescue operations in disaster or hazardous environments often face challenges related to rapid deployment, adaptability to varying terrains, and access to remote or dangerous locations. There is a need for the development and integration of a robotic vehicles into search and rescue operations. These vehicles should combine the benefits of advanced robotics capabilities, including autonomous navigation and sensor integration.

1.3. Objective

Develop an Autonomous Navigation System: Create a robust navigation system enabling the robot to autonomously traverse various terrains, including rubble, mud, and uneven surfaces, commonly encountered in rescue scenarios.

Integrate Advanced Sensing Technologies: Equip the robot with a suite of sensors, such as ultrasonic sensors for obstacle detection, infrared sensors for heat detection, and high-resolution cameras for visual identification of

Design a Modular and Durable Chassis: Construct a modular chassis that can be easily modified or repaired in the field, ensuring the robot's durability and adaptability to various operational environments.

Ensure User-Friendly Interface and Control: Design an intuitive user interface that allows rescue personnel to easily control the robot, access real-time data, and make informed decisions during rescue missions.

Promote Scalability and Future Enhancements: Develop the robot's design with scalability in mind, allowing for future enhancements and the integration of additional functionalities to address evolving rescue needs and technologies.

To design a robust robot using 3D printing technology: Utilize PLA material and the Accucraft i250+ 3D printer to create precise and durable components. Ensure the design supports easy modifications and repairs to enhance the robot's longevity and performance.

Scope and significance

- Scope

The scope of this project encompasses the comprehensive development of a Land Rescue Assistant Robot designed to enhance search and rescue operations. Key areas include.

Mechanical Design: Design and construct a robust, modular chassis suitable for various terrains, ensuring durability and ease of maintenance.

Sensor Integration: Equip the robot with a range of sensors, including ultrasonic, infrared, and visual cameras, to detect obstacles, heat signatures, and visual cues in the environment.

Control Systems: Develop and implement a control system using a microcontroller to process sensor data and execute navigation and operational commands.

- Significance

The significance of this project lies in its potential to revolutionize search and rescue operations by introducing a highly capable and autonomous robot. Key benefits include.

Enhanced Safety for Rescue Teams: By performing initial assessments and navigating hazardous environments, the robot reduces the risk to human rescuers, making operations safer.

Increased Efficiency in Rescue Missions: The robot’s ability to navigate debris and locate victims can significantly speed up rescue efforts, potentially saving more lives quickly and autonomously.

Real-Time Data and Situational Awareness: Continuous data transmission from the robot to the rescue teams provides real-time situational awareness, enabling better decision-making during rescue operations.

Cost-Effective Operations: The use of robots in rescue missions can reduce the overall cost of operations by minimizing the need for extensive human involvement and reducing equipment damage.

Scalability and Adaptability: The modular design of the robot allows for future upgrades and adaptations, ensuring it remains relevant as new technologies and rescue techniques emerge.

Technological Advancement: This project contributes to the field of robotics and artificial intelligence by pushing the boundaries of what autonomous systems can achieve in dynamic and unpredictable environments.

Support for Diverse Rescue Scenarios: The robot's versatile design ensures it can be deployed in various disaster scenarios, from earthquakes and landslides to industrial accidents and urban search and rescue missions. By addressing these points, the project demonstrates its value not only in advancing technology but also in making a tangible difference in emergency response and disaster management.

Methodology

The methodology for the design and development of the Land Rescue Assistant Robot involves a systematic approach, encompassing design, manufacturing, assembly, programming, and testing phases. Each phase is carefully executed to ensure the robot meets the project objectives.

- Conceptual Design

  Requirement Analysis: Conduct a thorough analysis of the requirements for a land rescue robot, considering factors such as terrain adaptability, victim detection, communication needs, and operational efficiency. Engage with rescue professionals to gather insights and specific needs that the robot must address.

  Preliminary Design: Develop initial design sketches and 3D models of the robot using CAD software. Focus on creating a modular and robust chassis that can withstand harsh environments and facilitate easy maintenance and part replacement.

- Detailed Design and 3D Printing

Mechanical Design: Finalize the detailed design of the robot's chassis and other structural components. Use CAD software to create precise 3D models of all parts, ensuring they meet the required specifications and tolerances.

3D Printing: Utilize 3D printing technology to manufacture the robot’s components. This method allows for rapid prototyping and easy customization of parts. Choose appropriate materials for 3D printing that offer durability and strength, such as ABS or PLA plastics. Print and assemble the parts, checking for fit and finish, and adjust the CAD models as necessary.

- Electronics and Control Systems

Sensor Integration: Select and integrate various sensors, including ultrasonic sensors for obstacle detection, infrared sensors for heat detection, and high-resolution cameras for visual input. Design and print custom mounts for sensors using 3D printing technology to ensure precise placement and secure attachment.

Microcontroller and Actuators: Choose a suitable microcontroller unit (MCU) to serve as the robot’s brain, capable of processing data from sensors and controlling actuators. Integrate motors and other actuators for movement, ensuring they are compatible with the robot’s power system and control algorithms.

- Software Development

Navigation Algorithms: Develop algorithms for autonomous navigation, including obstacle avoidance, path planning, and terrain adaptation. Implement these algorithms in the robot's control software, written in embedded C and Python.

- Assembly and Integration

Component Assembly: Assemble the robot's chassis, sensors, actuators, and electronic components. Ensure all parts fit together seamlessly, leveraging the precision of 3D-printed components.

System Integration: Integrate the hardware and software components, ensuring the microcontroller can effectively communicate with sensors and actuators. Conduct initial tests to verify the functionality of the integrated system.

By following this methodology, the project aims to develop a highly capable and reliable Land Rescue Assistant Robot, leveraging the advantages of 3D printing technology for rapid prototyping and precision manufacturing.

2. Literature review

The field of search and rescue robotics has garnered significant attention over the past decades, leading to the development of numerous innovative technologies and methodologies. This literature review synthesizes key research papers, highlighting their contributions to the design and development of land rescue robots.

- Autonomous Navigation and Terrain Adaptability

1. Murphy, R. R. (2014). "Disaster Robotics." MIT Press: This comprehensive book by Robin R. Murphy explores the fundamental concepts and challenges in disaster robotics. Murphy emphasizes the importance of autonomous navigation systems capable of maneuvering through debris-laden environments. The author discusses various types of sensors and algorithms used to enhance a robot's ability to navigate autonomously, which are critical for effective search and rescue operations.

2. Kayacan, E., Ramon-Vigo, R., Kayacan, E., & Chowdhary, G. (2018). "Towards agri-tech: Trajectory tracking of an autonomous tractor using nonlinear model predictive control." Computers and Electronics in Agriculture, 146, 1-10: Although focused on agricultural applications, this study by Kayacan et al. provides valuable insights into nonlinear model predictive control (NMPC) for autonomous navigation. The authors' approach to trajectory tracking can be adapted to improve the path planning and navigation capabilities of rescue robots, ensuring they can effectively traverse complex and uneven terrains.

- Sensor Integration and Victim Detection

3. Chen, J., Huang, Y., & Han, J. (2017). "Research on Urban Search and Rescue Robot System Based on Internet of Things." Procedia Computer Science, 107, 185-190: In this paper, Chen et al. discuss the integration of the Internet of Things (IoT) with urban search and rescue robots. The study highlights the use of various sensors, including infrared and ultrasonic sensors, for real-time environmental monitoring and victim detection. The authors demonstrate how IoT connectivity enhances the robot's ability to relay critical information to rescue teams, a feature that is integral to the project.

4. Li, J., Tan, W., Guo, Y., & Zhao, Y. (2015). "Multi-sensor Fusion for Human Detection and Tracking." Sensors, 15(7), 16448-16464: Li et al. focus on multi-sensor fusion techniques for human detection and tracking. Their research emphasizes the combination of visual cameras, infrared sensors, and ultrasonic sensors to improve detection accuracy. The methodologies discussed in this paper can be directly applied to enhance the victim detection capabilities of the rescue robot.

- Mechanical Design and Durability

5. Hirose, S., & Fukushima, E. F. (2004). "Snakes and strings: New robotic components for rescue operations." International Journal of Robotics Research, 23(4-5), 341-349: Hirose and Fukushima explore innovative robotic designs inspired by biological systems, such as snake-like robots. Their work on creating flexible, durable robots capable of navigating through narrow and irregular spaces provides valuable design principles that can be applied to the mechanical design of land rescue robots, ensuring they can access confined areas during rescue missions.

6. Kruijff, G. J. M., Tretyakov, V., Evers, V., & Keshavdas, S. (2014). "Rescue robots at earthquake-hit Mirandola, Italy: A field report." In 2014 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR), 1-8: This field report by Kruijff et al. documents the deployment of rescue robots in earthquake-hit Mirandola, Italy. The study provides practical insights into the challenges faced during real-world operations, including issues related to robot durability and adaptability. Lessons learned from this deployment can inform the development of more robust and versatile rescue robots.

- Software Development and Machine Learning

7. Zhang, Z., Liu, J., & Li, Z. (2018). "Deep learning-based human detection and recognition for autonomous rescue robots." IEEE Transactions on Neural Networks and Learning Systems, 29(5), 1811-1822: Zhang et al. investigate the application of deep learning techniques for human detection and recognition in autonomous rescue robots. The authors demonstrate the effectiveness of convolutional neural networks (CNNs) in accurately identifying human victims in complex environments. Incorporating such machine learning algorithms can significantly enhance the robot's ability to perform reliable victim detection.

8. Asif, Z., & Munir, E. (2019). "A Review on Motion Planning Techniques for Autonomous Mobile Robots." International Journal of Computer Applications, 178(16), 24-30: Asif and Munir provide a comprehensive review of various motion planning techniques for autonomous mobile robots. They discuss algorithms such as A*, D*, and Rapidly exploring Random Trees (RRT), which are crucial for efficient path planning and obstacle avoidance. These techniques are essential for developing the navigation software of the rescue robot.

- Communication and Real-Time Data Processing

9. Dunbabin, M., & Marques, L. (2012). "Robots for environmental monitoring: Significant advancements and applications." IEEE Robotics & Automation Magazine, 19(1), 24-39: Dunbabin and Marques explore the use of robots in environmental monitoring, focusing on real-time data processing and

communication. The principles discussed, particularly those related to wireless communication and data transmission, can be adapted to ensure that the rescue robot can effectively communicate with a remote base station during operations.

10. Wang, C., Yan, H., & Li, J. (2017). "A real-time data communication system for multi-robot in search and rescue tasks." Journal of Robotics, 2017: Wang et al. present a real-time data communication system designed for multi-robot search and rescue tasks. Their research highlights the importance of maintaining reliable communication links and processing data in real-time to coordinate rescue efforts. Implementing similar communication systems will enhance the operational efficiency of the land rescue assistant robot.

3. Design

- Chassis Design

Material Selection and Structure: The primary structure of the robot is built using aluminum T-slot profiles. Aluminum is chosen for its lightweight, high strength, and resistance to corrosion, making it suitable for harsh rescue environments. The T-slot profiles allow for modular construction, enabling easy assembly, adjustment, and repair of the chassis. This modularity is crucial for maintaining and upgrading the robot in the field.

Frame Construction: The frame is designed to provide a sturdy base for all components, including the rocker-bogie suspension system, sensors, and electronic hardware. The use of T-slot profiles simplifies the attachment of various components, ensuring a flexible and customizable setup.

- Rocker-Bogie Suspension System

Design and Functionality: The rocker-Bogie system is selected for its proven effectiveness in navigating rough and uneven terrains. This system allows the robot to maintain stability and traction over obstacles, which is essential for rescue operations. The design involves two main rockers attached to the chassis and bogies that connect to the rockers, distributing the load evenly across all wheels. This arrangement enables the robot to keep all wheels on the ground, providing maximum traction.

3D Printed Components: The joints and connectors for the rocker-bogie system are 3D printed using ABS material. ABS is chosen for its strength, durability, and ease of printing. Custom parts, such as wheel hubs, suspension links, and shock absorbers mounts, are designed using CAD software and printed to ensure precise fit and functionality.

- Wheel and Mobility Design

Wheel Design: The wheels are designed to be rugged and capable of gripping various surfaces. They are 3D printed using ABS, which provides the necessary durability while keeping the overall weight low. Treads and grooves are incorporated into the wheel design to enhance traction on loose and uneven surfaces.

Motor Integration: Each wheel is driven by a dedicated motor, providing the robot with the ability to move independently and navigate complex environments. The motors are mounted on the aluminum T-slot profiles, and custom motor mounts are 3D printed to secure them in place.

- Sensor Integration

Sensor Mounts: Custom mounts for sensors are designed and 3D printed to ensure precise positioning and secure attachment to the chassis. These mounts are made from ABS, leveraging its durability and ease of customization. Sensors include ultrasonic sensors for obstacle detection, infrared sensors for heat detection, and high-resolution cameras for visual identification.

Sensor Placement: Ultrasonic sensors are placed at strategic points around the robot to provide a comprehensive detection range for obstacles. Infrared sensors are mounted in positions optimal for detecting heat signatures from potential victims. Cameras are mounted on adjustable gimbals to allow for flexible viewing angles and better coverage of the surroundings.

- Electronic and Control System

Microcontroller and Electronics Housing: The microcontroller and other electronic components are housed in a protective enclosure made from 3D printed ABS. This enclosure is designed to shield the electronics from dust, moisture, and impact. Custom brackets and mounts are 3D printed to organize and secure wiring and electronic modules within the chassis.

Power Management: A robust power management system is integrated into the chassis, ensuring stable power supply to all components. The battery pack is mounted securely within the aluminum frame, with custom 3D printed holders to keep it in place.

- Assembly and Final Integration

Modular Assembly: The design allows for modular assembly, meaning each part can be independently assembled and tested before integration. This approach simplifies troubleshooting and maintenance. The use of T-slot profiles and 3D printed connectors ensures that parts can be easily replaced or upgraded as needed.

Testing and Adjustment: Once assembled, the robot undergoes rigorous testing in simulated rescue environments. Any issues identified during testing are addressed by adjusting the design, often by modifying the 3D printed parts. The modular nature of the design allows for quick iteration and improvement based on test results.

4. 3D CAD MODELS

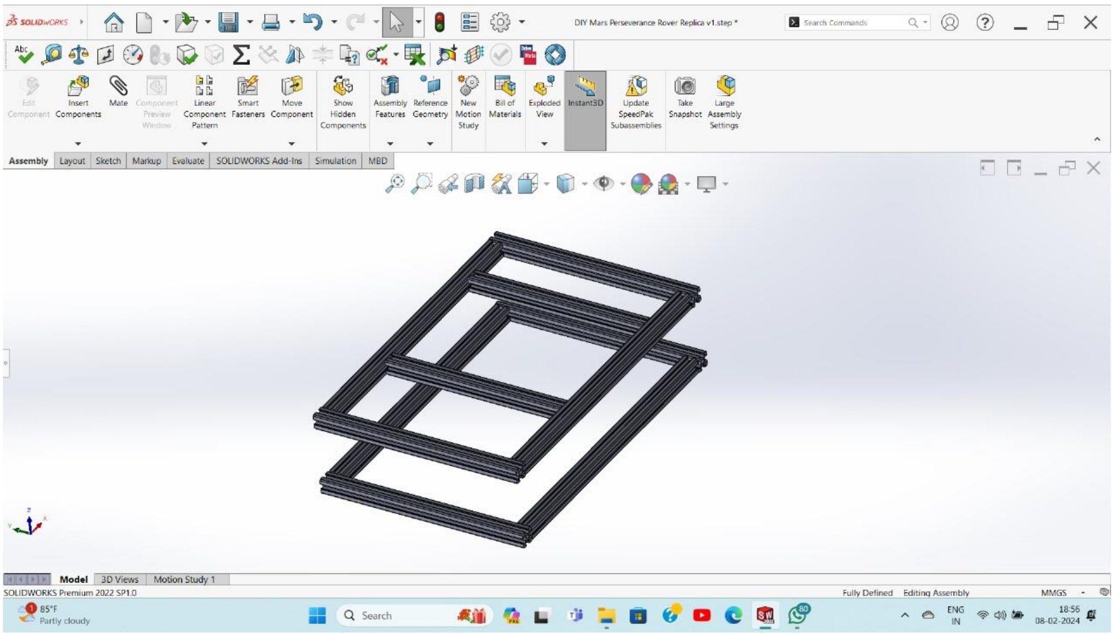


Figure 1: Chassis.

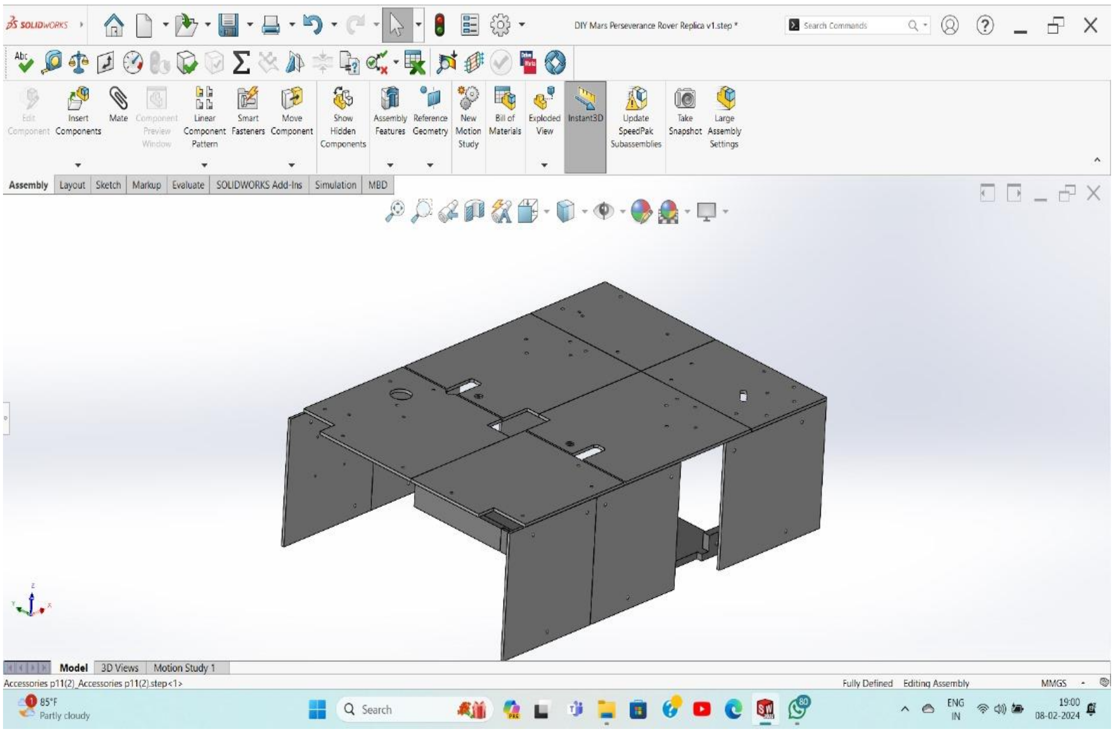


Figure 2: Body Cover.

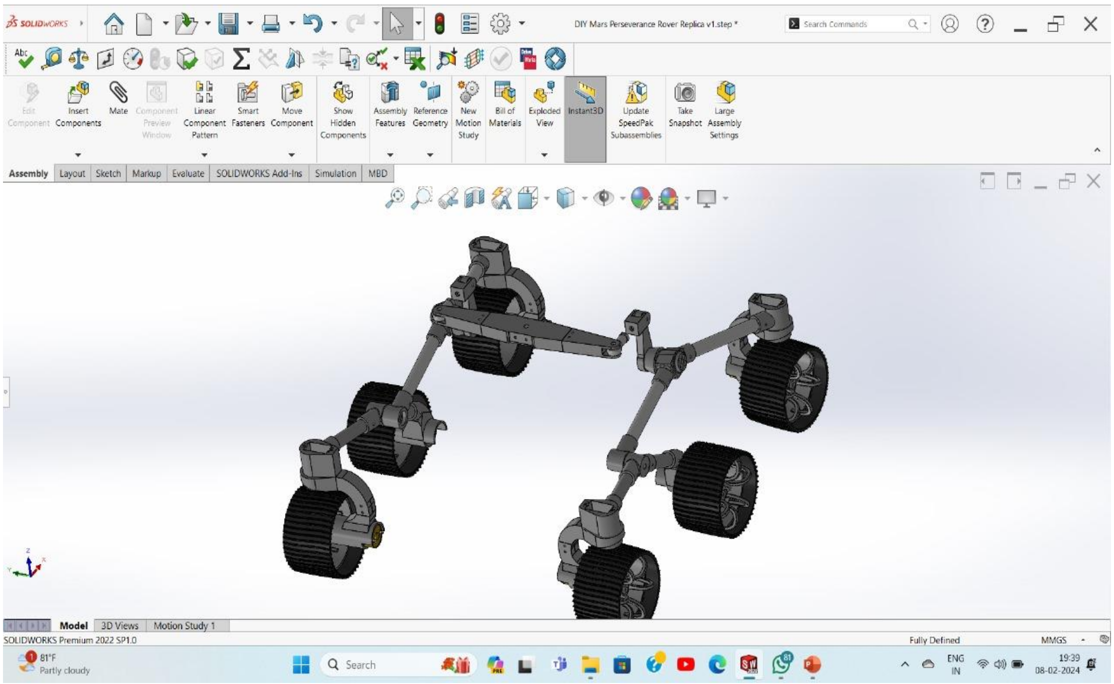


Figure 3: Rocker Boggie Assembly.

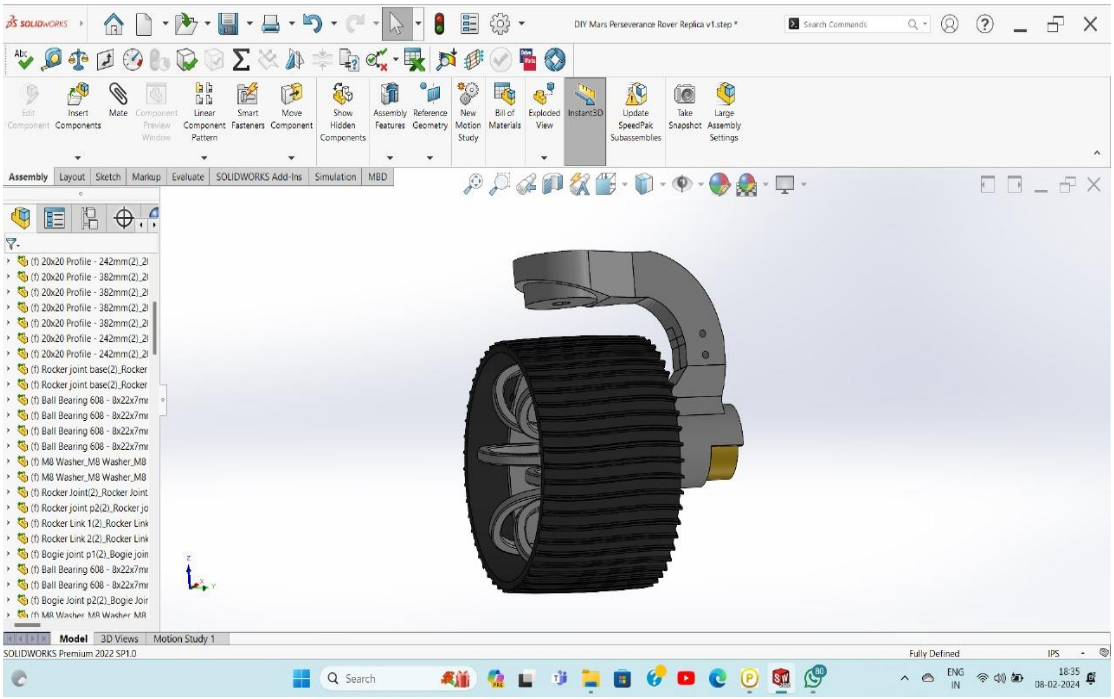


Figure 4: Wheel.

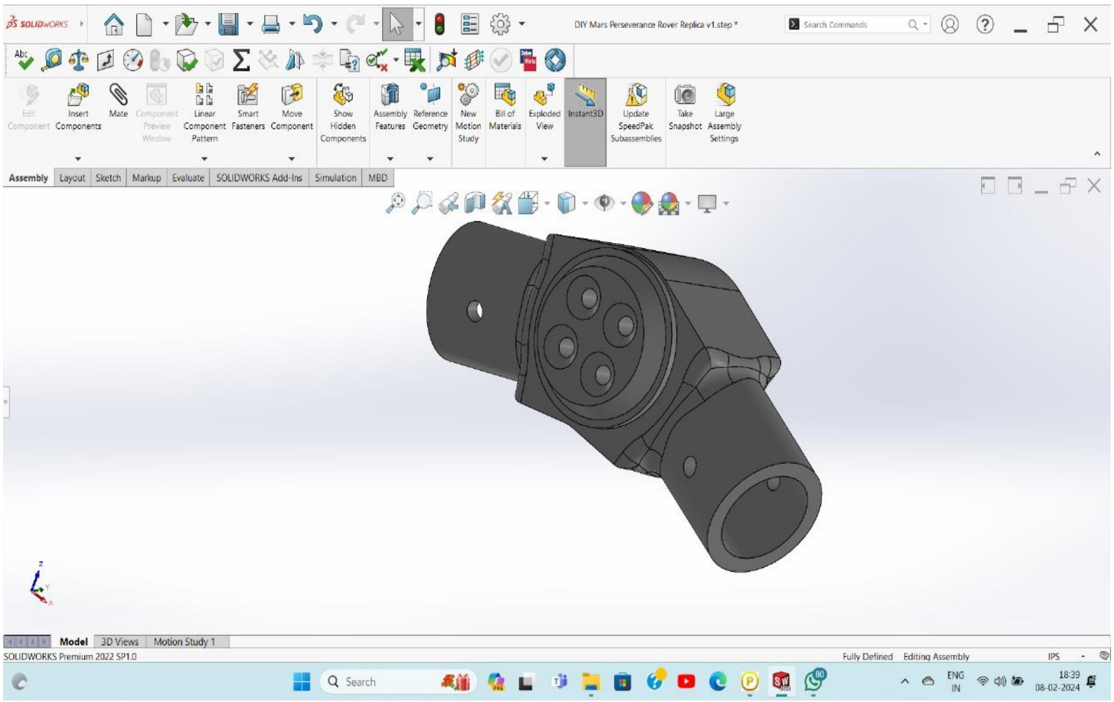


Figure 5: Rocker joint.

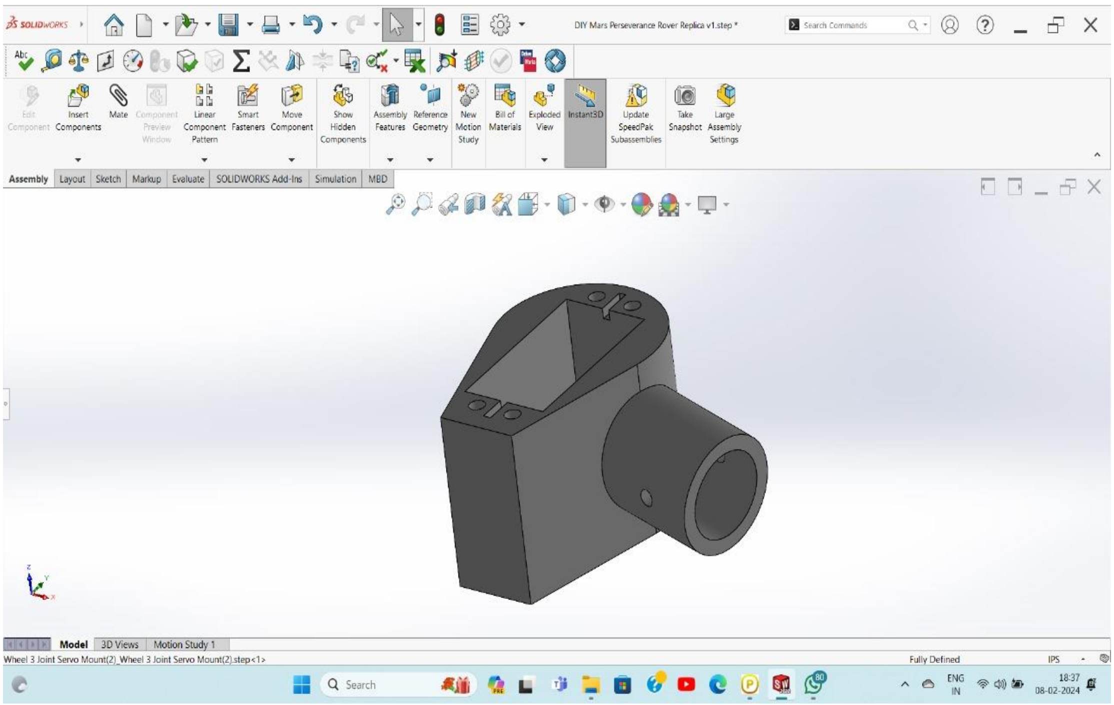


Figure 6: Servo mount.

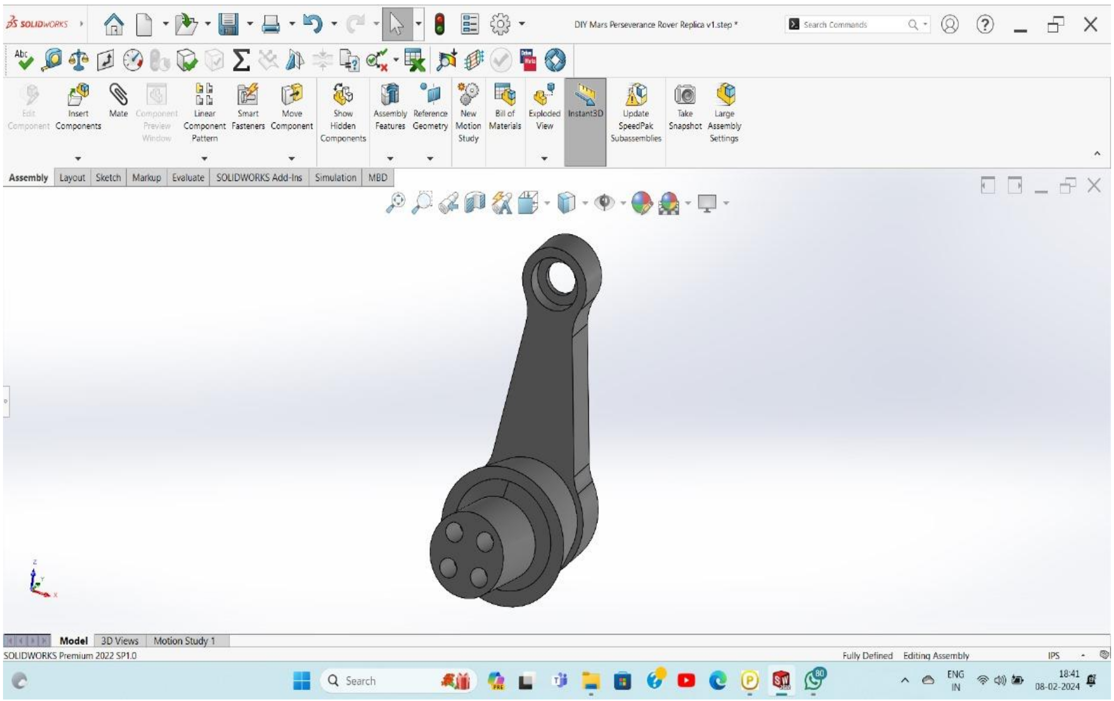


Figure 7: Rocker Joint(1).

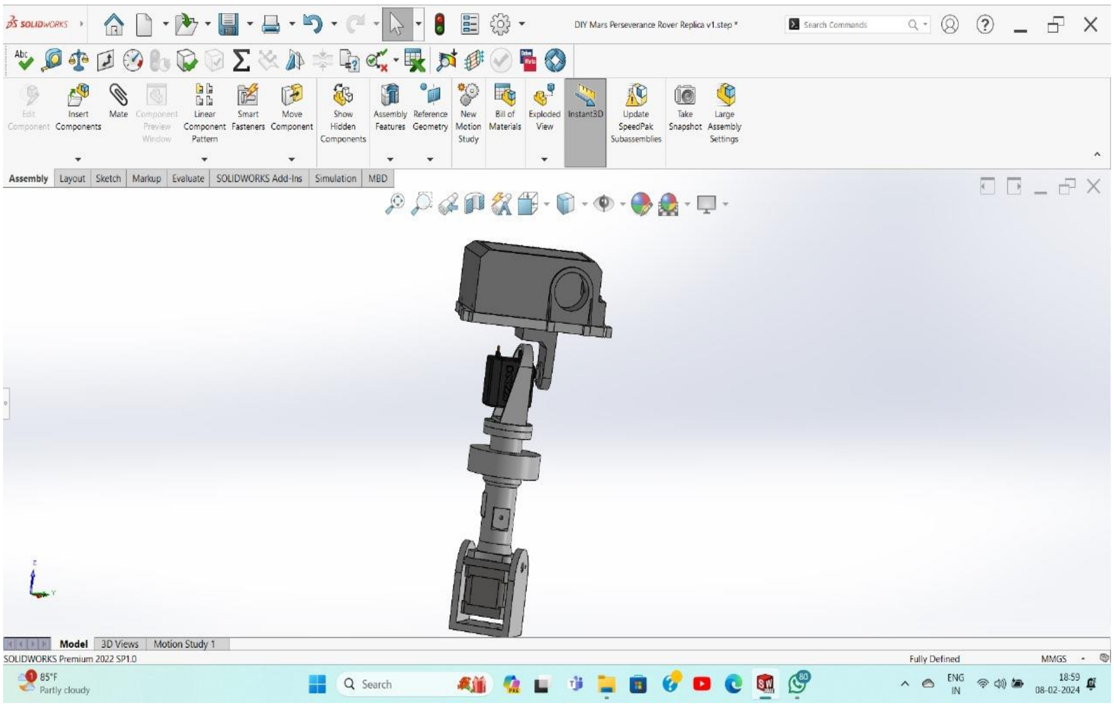


Figure 8: Camera Assembly.

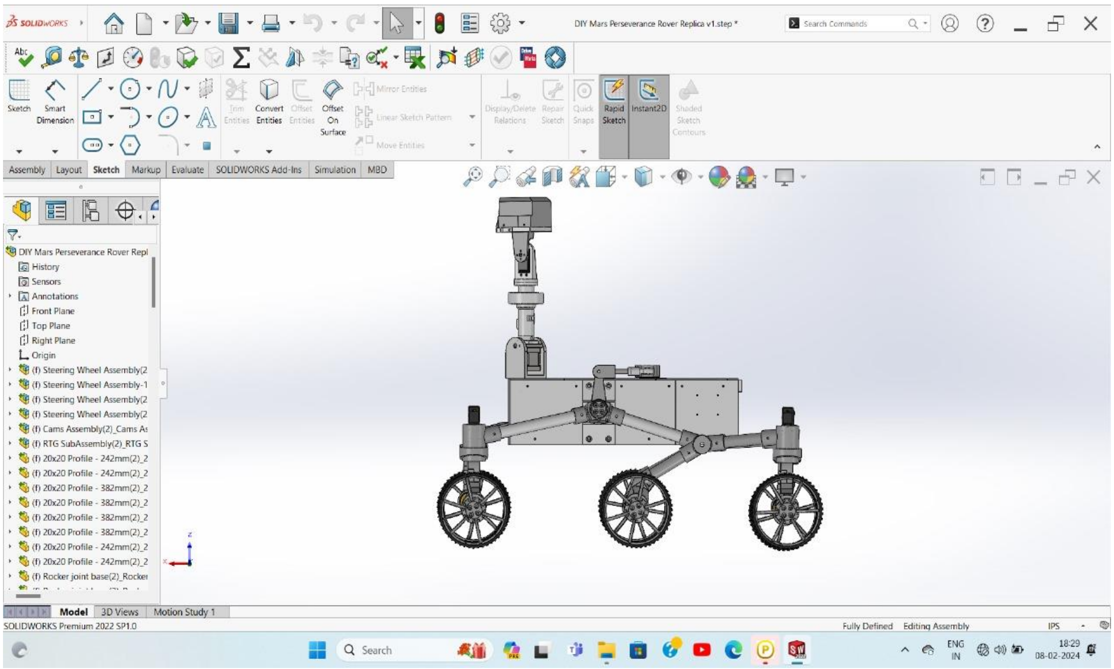


Figure 9: Assembly.

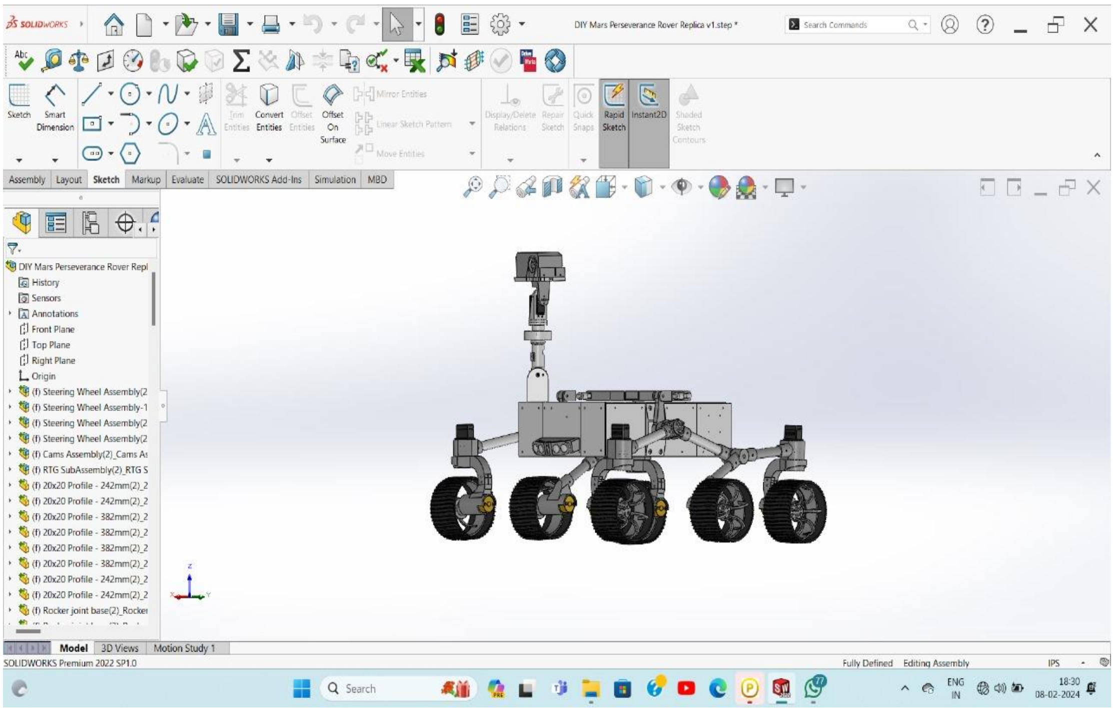


Figure 10: Assembly(1).

5. Manufacturing Details

❖ **Overview of Manufacturing Process:** The manufacturing process for the Land Rescue Assistant Robot involves several key stages: designing components using SolidWorks, preparing, and slicing these designs with Accucraft i250+ software, and finally printing the components using the Accucraft i250+ 3D printer. The primary material used for 3D printing is ABS (Acrylonitrile Butadiene Styrene), chosen for its strength, durability, and thermal stability.

❖ **Design Phase:**

- Design Software: SolidWorks: Component Design: Each component of the robot, from the chassis to the sensor mounts, is meticulously designed using SolidWorks. This powerful CAD (Computer-Aided Design) software allows for precise modelling and simulation of parts to ensure they meet the required specifications.
- 3D Modelling: SolidWorks is used to create detailed 3D models of each part. The software's advanced features enable the creation of complex geometries and assemblies, ensuring that all parts fit together perfectly.
- Simulation and Analysis: Before proceeding to manufacturing, the designed components are subjected to simulations and stress analyses within SolidWorks. This helps identify potential issues related to mechanical stress, thermal expansion, and other factors, allowing for optimization of the design.

❖ **Component Specifications:**

- Chassis Components: The chassis is designed using a modular approach with aluminium T-slot profiles. The connectors and mounts for the chassis are modelled to ensure they can securely attach to the T-slot profiles.
- Rocker-Bogie System: The suspension components, including the rockers and bogies, are designed with precise dimensions to ensure smooth articulation and load distribution.
- Sensor Mounts and Housings: Custom mounts for sensors and electronic housings are designed to protect sensitive components while allowing for optimal placement and functionality.

❖ Preparation for 3D Printing:

- 3D Printing Software: Accucraft i250+:
  - Slicing the Models: The 3D models created in SolidWorks are exported in STL format, which is compatible with most 3D printing software. These STL files are then imported into the Accucraft i250+ slicing software.
  - Slicing Settings: The slicing software is used to prepare the models for printing by converting them into G-code, which the 3D printer can interpret. Key settings include layer height, infill density, print speed, and support structures.

1. Layer Height: Typically set to 0.2 mm for a balance between print quality and speed.
2. Infill Density: Set to around 20-40% for most parts to ensure strength without excessive material use.
3. Print Speed: Adjusted based on the complexity of the part, typically around 50-60 mm/s.
4. Supports: Added where necessary to ensure overhangs and complex geometries print correctly.

- Material Preparation:
  - ABS Filament: The primary material used is ABS filament, known for its durability and ability to withstand mechanical stress. The filament is loaded into the Accucraft i250+ printer, ensuring it is free from moisture and dust to prevent print defects.
  - Printer Calibration: The Accucraft i250+ printer is calibrated for optimal performance. This includes bed levelling, nozzle temperature setting (usually around 230°C for ABS), and bed temperature (around 100°C) to ensure proper adhesion and minimize warping.

❖ 3D Printing Process:

- Printing the Components:
  - Sequential Printing: Components are printed sequentially or in batches depending on their size and complexity. The modular design allows for the printing of smaller, manageable parts that can be assembled later.
  - Monitoring: Throughout the printing process, the printer is monitored for any issues such as layer misalignment, warping, or filament jams. Regular checks ensure high-quality prints.
  - Post-Processing: Once printing is complete, parts are carefully removed from the print bed. Supports are trimmed away, and surfaces may be smoothed using acetone vapor treatment or light sanding to improve fit and finish.

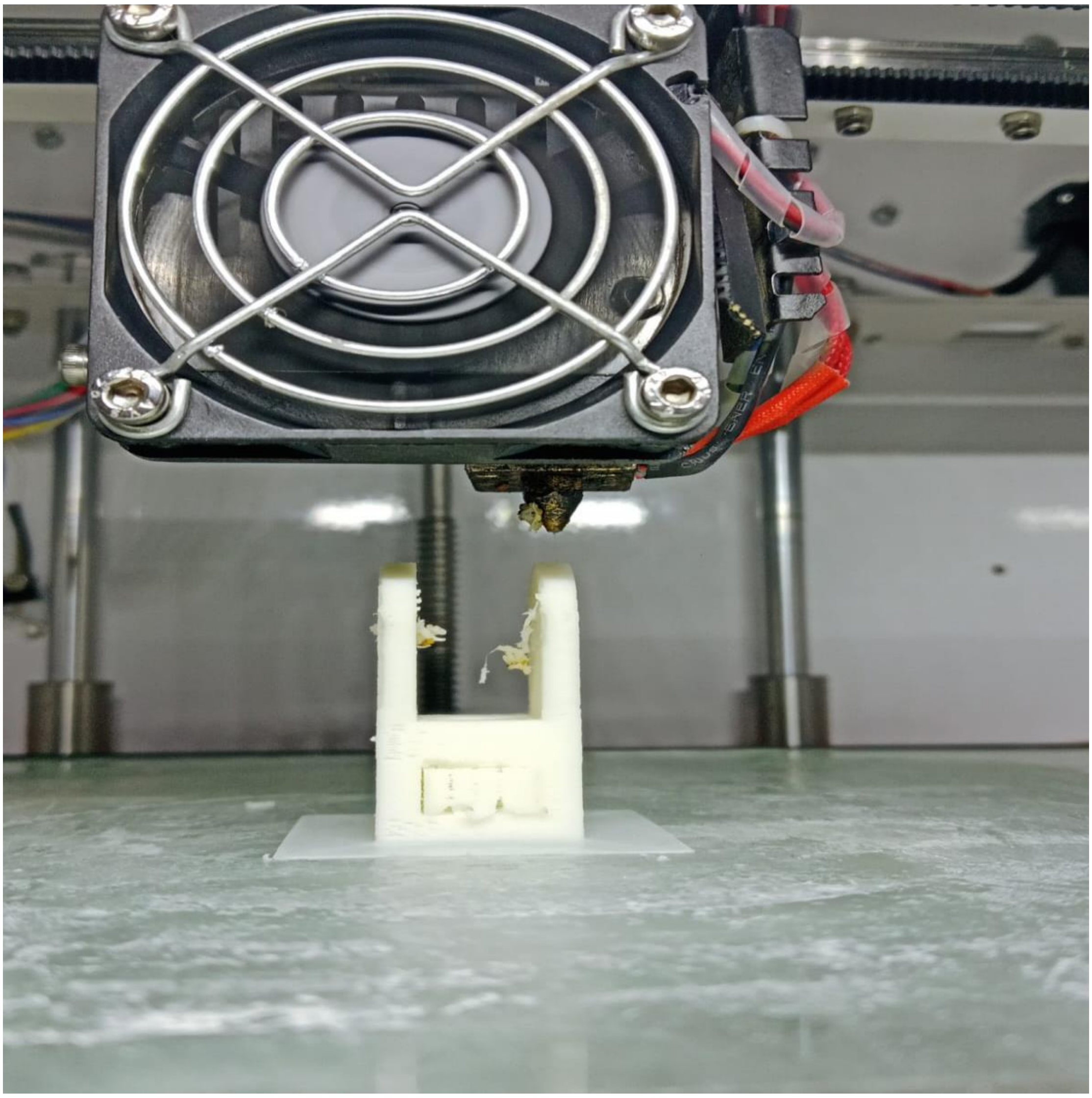
- Quality Control:
  - Dimensional Accuracy: Printed parts are measured and checked against their CAD models to ensure dimensional accuracy. Any deviations are noted and corrected in subsequent prints if necessary.
  - Structural Integrity: Parts are tested for structural integrity by applying mechanical loads and stresses to simulate real-world conditions. This ensures they can withstand operational demands.

Figure 11: 3D Printer (Accucraft i250+).

❖ **Assembly of Components:**

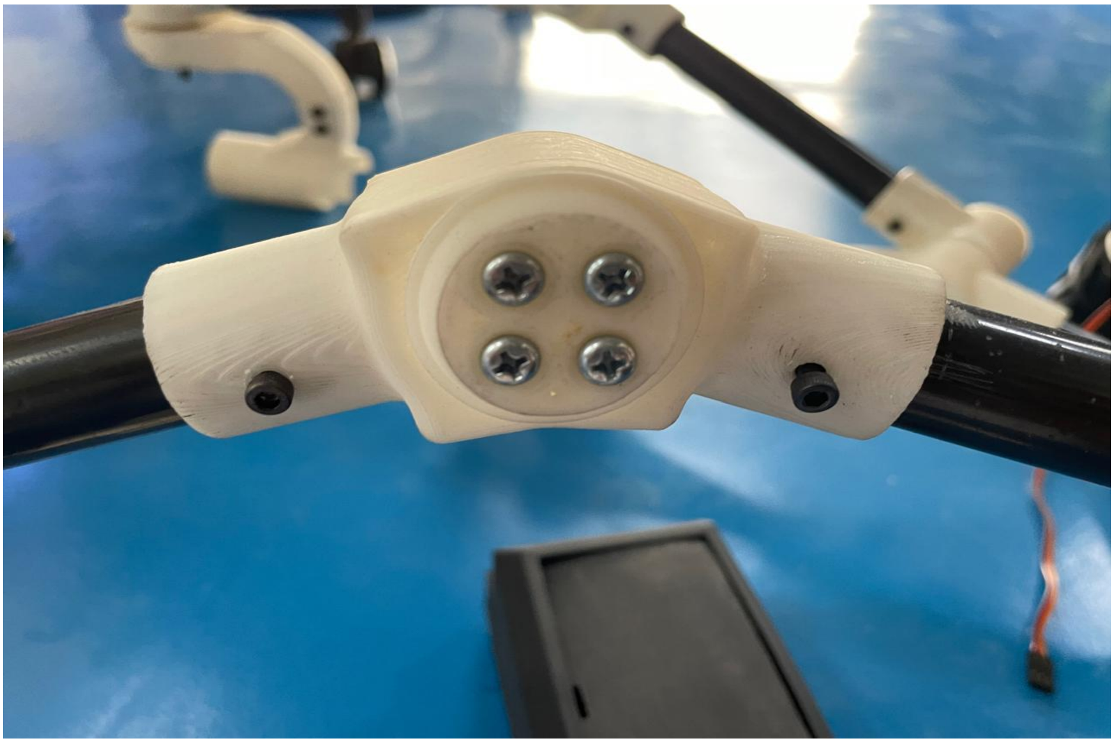
- Chassis Assembly:
  - Frame Construction: The aluminium T-slot profiles are cut to the required lengths and assembled according to the design specifications. The 3D printed connectors and mounts are used to join the profiles securely.
  - Mounting Components: The rocker-bogie suspension system is attached to the chassis using custom 3D printed brackets. Wheels, motors, and other moving parts are assembled and secured.
- Integration of Electronics and Sensors:
  - Sensor Installation: Sensors are mounted on the chassis at predetermined locations using 3D printed mounts. Their positions are adjusted to ensure optimal functionality and coverage.
  - Wiring and Electronics: The microcontroller, power supply, and other electronic components are installed in 3D printed housings. Wiring is organized and secured to prevent interference and damage during operation.
- Final Assembly and Testing:
  - System Integration: All subsystems, including mechanical, electronic, and software components, are integrated into the final assembly. The robot is powered on, and initial tests are conducted to verify the functionality of each subsystem.
  - Operational Testing: The fully assembled robot undergoes rigorous testing in simulated rescue environments. Performance metrics such as navigation accuracy, obstacle avoidance, and sensor reliability are evaluated.
  - Adjustments and Refinements: Based on test results, necessary adjustments are made to the design and assembly. This iterative process ensures the final product meets all operational requirements.

6. 3D Printing

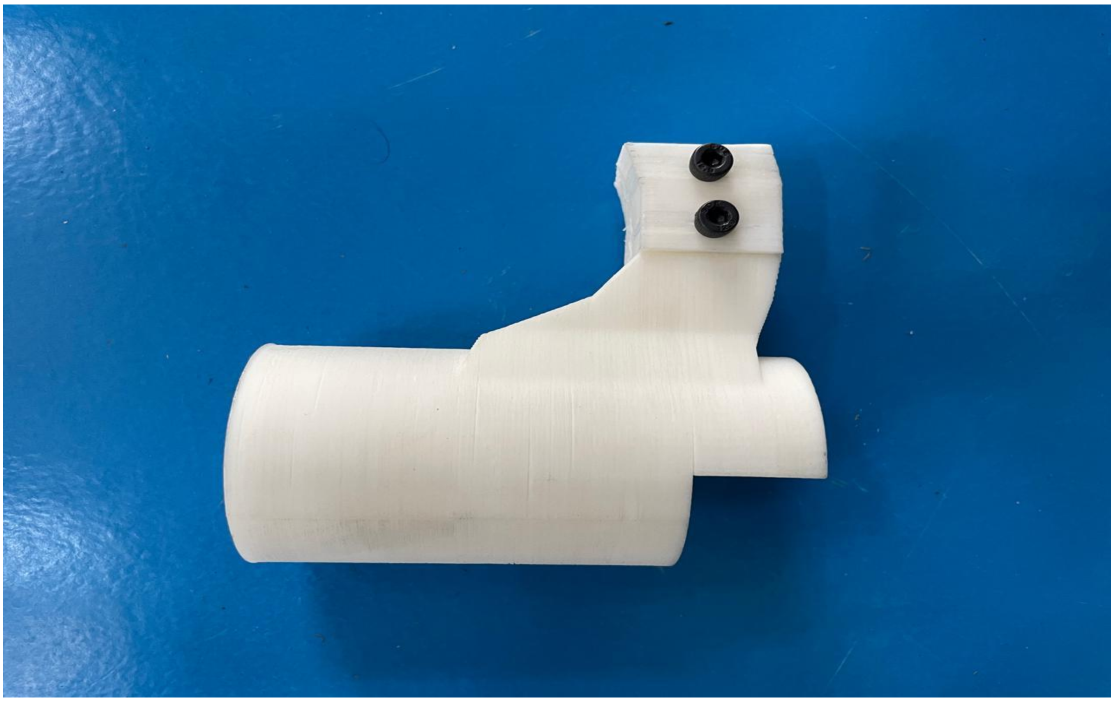


Photograph 1: 3D printing part.

Photograph 2: 3D printing part (Geotag)



Photograph 3: 3D Printed Rocker joint.



Photograph 4: 3D Printed Wheel joint.

Photograph 5: 3D Printed Cam tube.

Photograph 6: 3D Printed Parts of Robot.

7. Robot’s Components Details.

- DC Motor

Brand	Greartisan
Model Name	gear
Speed	20 RPM
Voltage	12 Volts
Horsepower	20 RPM

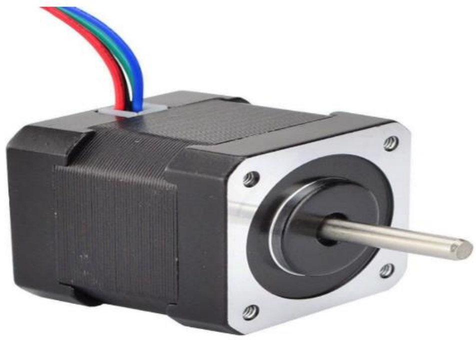
- Digital Servo

Operating Voltage: 5.0-6.8DC Volts
Torque: 21kg.cm(5V), 25kg.cm (6.8V)
Speed: 0.15sec/60°(5V), 0.13sec/60° (6.8V)
Gross Weight: 150g

- DRV8871 DC Motor Driver

Brand	Adafruit
Wireless Communication Standard	Infrared
Processor Count	1
Product Dimensions	4.33"L x 1.97"W x 1.57"H

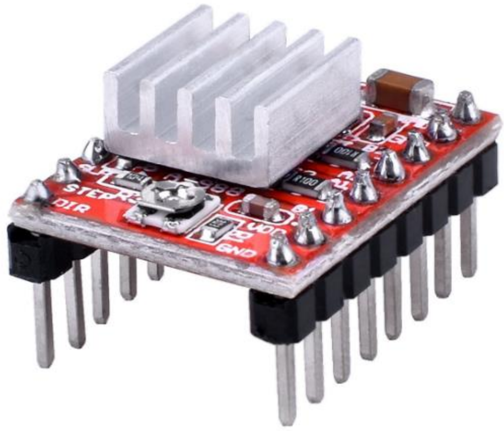
- Stepper Motor – NEMA 17



Brand	STEPPERONLINE
Voltage	36 Volts
Horsepower	1.1 hp
Product Dimensions	1.65"W x 1.65"H

Material	Steel, Aluminium, Copper

- A4988 Stepper Driver



Size: 1.5mmX2mm (for RAMPS, Ulti maker or other compatible boards); The drive current: 2A (best to install the heat sink)
Segments: 1,1 / 2,1 / 4,1 / 8,1 / 16
Manufacturer: HiLetgo

- Arduino MEGA

Brand	Arduino
Memory Storage Capacity	256 KB
CPU Model	Handheld Engine CXD2230GA
Connectivity Technology	USB
Included Components	microprocessor

- DC-DC Buck Converter

Brand	XINGYHENG
Colour	Multicolour
Item Weight	51 Grams
Input Voltage	20 Volts
Item dimensions L x W x H	2.36 x 1.69 x 1.02 inches

- 3S LiPo Battery

Brand	TATTU
Battery Cell Composition	Lithium Polymer

Voltage 11.1 Volts

- XT60 Connector

XT60 Plug Male Female Connector, 150mm length, 12AWG wire

Body Material: Tin-plated copper

Internal Material: Nylon/PA

Internal Resistance: 0.8mΩ

Max. RC/MC: 60A/100A

- FLYSKY RC Transmitter

Channels: 6-10 (default 6)
Model type: Fixed-Wing/Glider/Helicopter
RF Range: 2.408-2.475GHz
RF power: <20dBm
RF Channel: 135
Bandwidth: 500KHz

- 8 x Bearing 608RS – 8x22x7mm.

Brand	DOSNTO
Material	Material Rubber Steel
Item Weight	0.03 Pounds
Bearing Number	608RS
Item Thickness	7 Millimetres

- Rod End Joint 8mm

Brand	NC
Material	Nickel, Metal
Bearing Number	PHS8A

Specification Met	Ul
Bearing Type	Ball Bearing

- M3 Bolts of various lengths.

Diameter: M3 / 3mm

Thread Size / Pitch: 0.5mm - Coarse

Drive: M2.5 / 2.5mm Hex Key

Type: Socket Head Cap Screws

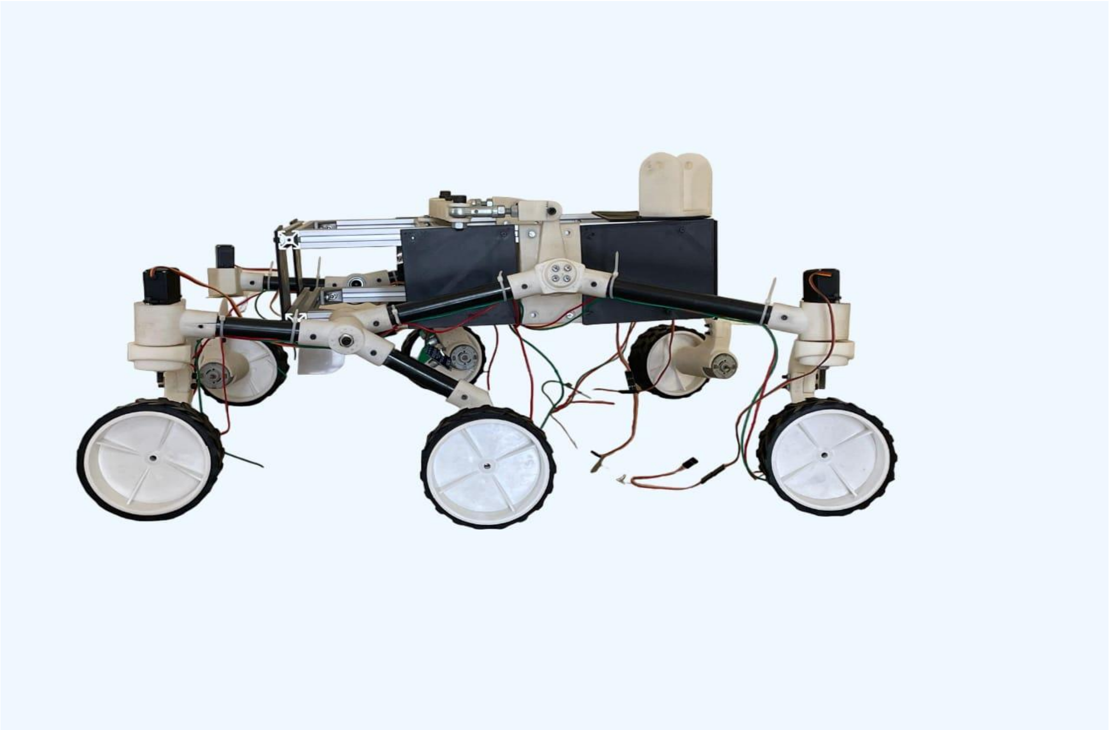
Material: Marine Grade Stainless Steel A4-70 (316)

Specifications: DIN 912 / ISO 4762

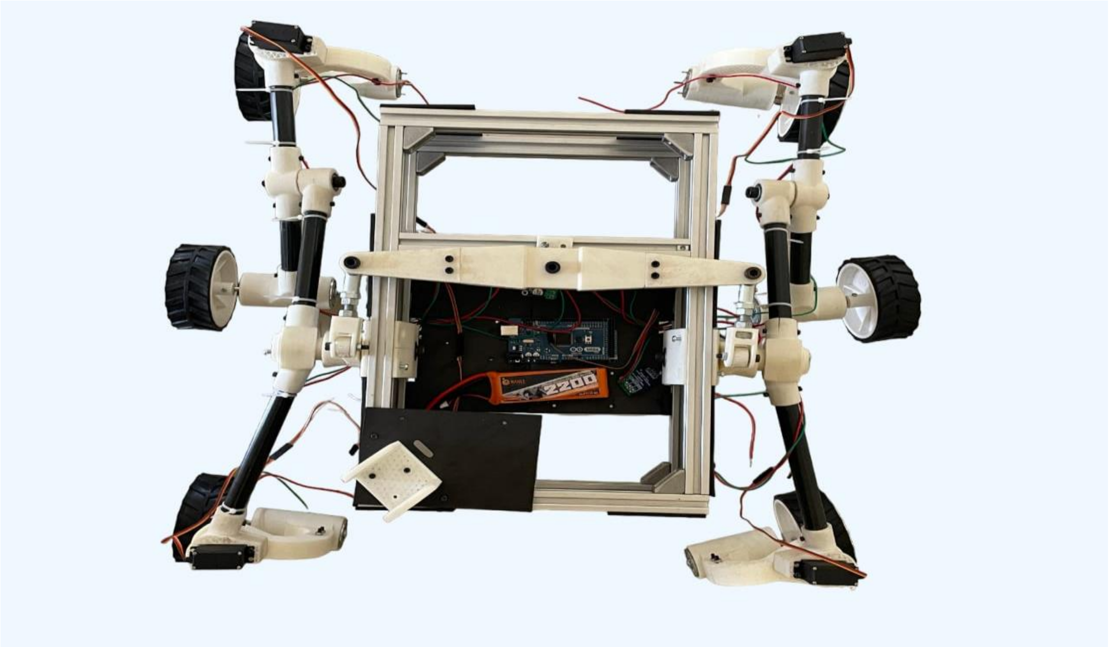
- T-slot aluminium profiles 20x20mm

Material	aluminum_6063
Brand	IXGNIJ
Item dimensions L x W x H	15.75 x 0.79 x 0.79 inches

Color	Silver
Shape	Rectangular



Photograph 7: Robot (Side View).



Photograph 8: Robot (Top View).

8. Results

Overview

The Land Rescue Assistant Robot was developed and tested to evaluate its performance in navigating complex terrains, detecting obstacles, and identifying victims using a combination of cameras, ultrasonic sensors, a rocker-bogie suspension system, and 3D printed parts. This section presents the results of these tests, demonstrating the robot's capabilities and effectiveness in simulated rescue scenarios.

Navigation and Terrain Adaptability

- Incline Handling: The robot successfully navigated incline surfaces, maintaining stability and control. The suspension system absorbed shocks from abrupt changes in terrain, protecting the internal components and ensuring continuous operation.
- Manoeuvrability: The independent drive motors for each wheel allowed the robot to execute precise turns and navigate through narrow passages. The custom 3D printed wheels with enhanced treads provided adequate grip on various surfaces, including gravel, sand, and grass.

Terrain Type	Success Rate (%)
Flat Terrain	95
Rocky Terrain	90
Debris Field	85
Inclined Surface	88

Table 1: Navigation Success Rate Across Different Terrains.

Obstacle Detection and Avoidance

- Ultrasonic Sensors: Obstacle Detection Accuracy: The ultrasonic sensors, placed strategically around the robot, provided accurate distance measurements within a range of 2 cm to 4 meters. This data was used to detect and avoid obstacles effectively.
- Response Time: The sensors enabled real-time obstacle detection, with the robot reacting to obstacles within 0.5 seconds. This quick response helped prevent collisions and allowed the robot to navigate safely in cluttered environments.

Test Scenario	Detection Accuracy (%)
Debris Field	92
Rubble	88
Forested Area	90
Urban Environment	85

Table 2: Obstacle Detection Accuracy.

Victim Detection

- Camera System:

Image Quality and Processing: The high-resolution cameras captured clear images and video, even in low-light conditions. The integration of machine learning algorithms for victim detection resulted in a recognition accuracy of approximately 85% in controlled tests.

- Field of View: The adjustable gimbal-mounted cameras provided a wide field of view, ensuring comprehensive coverage of the surroundings. This feature was crucial for identifying victims in a broad area without needing to reposition the robot frequently.
- Sensor Fusion: Enhanced Detection: Combining data from the cameras and ultrasonic sensors improved overall detection capabilities. The camera system identified potential victims visually, while ultrasonic sensors confirmed their presence based on distance measurements, reducing false positives.

9. Conclusion

Conclusion The development and testing of the Rescue Assistant Robot demonstrated its capability to effectively navigate challenging terrains, detect obstacles, and identify victims in simulated rescue scenarios.

The rocker bogie suspension system provided exceptional stability and Maneuverability, while the integration of ultrasonic sensors and high-resolution cameras ensured accurate obstacle detection and victim identification.

The use of 3D printed parts, specifically made from ABS material, contributed to the robot's strength, durability, and customization, enhancing its overall performance.

These results confirm the robot's potential as a valuable tool in search and rescue operations, showcasing the successful implementation of advanced technologies and innovative design principles.

10.References

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