

Multipurpose Rocker Bogie Robot

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ABSTRACT

The rocker-bogie robot is a highly stable and efficient mobile robotic system designed to traverse rough, uneven, and obstacle-filled terrains. Originally developed for planetary exploration, this mechanism uses a unique suspension system that allows all wheels to remain in contact with the ground, thereby enhancing traction and stability without the need for complex spring-based suspensions. The rocker-bogie configuration consists of two main rockers connected to a central differential, which evenly distributes load and enables the robot to climb obstacles nearly twice the diameter of its wheels. This makes the robot particularly suitable for applications such as space exploration, search and rescue operations, military surveillance, agricultural monitoring, and industrial inspection in hazardous environments. The robot can be powered using electric motors and controlled through wired or wireless communication systems, often integrated with sensors, cameras, and microcontrollers for autonomous or semi-autonomous operation. Due to its simplicity, reliability, and superior terrain adaptability, the rocker-bogie robot has become a widely researched and implemented mobility platform in modern robotics.

Keywords: - Rocker-Bogie Mechanism, Mobile Robot, Rough Terrain Navigation, Suspension System, Obstacle Climbing, Autonomous Robotics etc.

1. INTRODUCTION

The Rocker-Bogie Robot is a specialized type of mobile robotic system designed to move efficiently over rough, uneven, and challenging terrains. The rocker-bogie mechanism was originally developed by NASA for its Mars rovers, where reliable mobility over rocky and unpredictable surfaces is critical. Unlike conventional wheeled robots that use springs or complex suspension systems, the rocker-bogie design employs a simple yet effective mechanical arrangement that ensures stability, traction, and smooth movement even on highly irregular ground. The rocker-bogie system consists of two symmetrical rocker arms connected to a central differential, with each rocker linked to a bogie that holds multiple wheels. This configuration allows the robot to maintain continuous contact between all wheels and the ground, distributing the load evenly and preventing tipping during obstacle climbing. As a result, the robot can climb obstacles up to nearly twice the diameter of its wheels without losing balance. The absence of traditional suspension springs reduces mechanical complexity and increases durability, making the system suitable for long-term and harsh environment operations. Rocker-bogie robots are widely used in applications such as planetary exploration, search and rescue missions, military surveillance, agricultural field monitoring, and inspection of hazardous or inaccessible areas. With the integration of sensors, cameras, microcontrollers, and wireless communication technologies, these robots can operate autonomously or be remotely controlled.

Due to their high stability, strong obstacle-handling capability, and reliable performance on uneven terrain, rocker-bogie robots continue to play a significant role in advanced robotic research and real-world applications.

1.1 OBJECTIVE

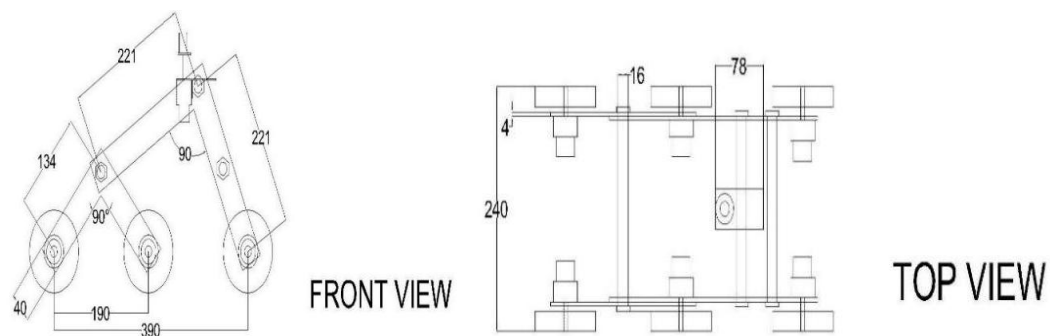
- To design and develop a rocker-bogie based robotic system capable of traversing rough, uneven, and obstacle-filled terrains with high stability.
- To study and implement the rocker-bogie suspension mechanism for effective load distribution and improved traction without using conventional springs.
- To enable the robot to climb obstacles of significant height relative to wheel diameter while maintaining balance and preventing rollover.
- To integrate suitable motors, controllers, and power sources for smooth and efficient locomotion.
- To incorporate sensors and control systems for autonomous or remote operation of the robot.
- To evaluate the performance of the rocker-bogie robot in terms of mobility, stability, and obstacle-climbing capability.
- To demonstrate the applicability of the rocker-bogie robot in real-world scenarios such as space exploration, search and rescue, surveillance, and inspection tasks.

2. LITERATURE SURVEY

- **Yang, J., Dong, M., & Ye, J. (2017)** A Literature Review of the Rocker-Bogie Suspension for the Planetary Rover This paper provides a comprehensive review of the rocker-bogie suspension system used in planetary rovers, summarizing various design configurations and performance improvements adopted by different research works to enhance rover mobility on extremely uneven terrain.
- **V. Bharath Simha Reddy, V. R. Rao & Jathoth Madhukar (2023)** Design and Development of Six-Wheeled Robot with Rocker Bogie Suspension System Discusses the practical implementation of a six-wheeled rocker-bogie robot, including system design, Bluetooth-based control, and ultrasonic sensor integration for obstacle avoidance, showing real-world applicability in exploration tasks.
- **Cosenza, C., Niola, V., Pagano, S., & Savino, S. (2023)** Theoretical Study on a Modified Rocker-Bogie Suspension for Robotic Rovers Presents a theoretical analysis of an improved rocker-bogie suspension, focusing on mechanical adaptations to enhance rover performance on varied terrains and offering insights into advanced rover suspension design strategies.
- **Mongkol Thianwiboon & Viboon Sangveraphunsiri (2006)** Traction Control for a Rocker-Bogie Robot with Wheel-Ground Contact Angle Estimation This conference work introduces kinematics modeling and traction control methods for rocker-bogie robots, emphasizing wheel contact estimation to reduce wheel slip and improve locomotion.
- **I. Dashti & M. R. Elhami (2015)** Kinematics Analysis and Simulation of a Rocker-Bogie Mobile Robot offers a detailed kinematic model of a rocker-bogie system using Denavit-Hartenberg transformation and simulations to validate the robot's motion on rough terrain, laying a foundation for dynamic motion analysis.
- **Anish Pandey et al. (2022)** New Concept-Based Six-Wheels Rocker-Bogie Robot: Design and Analysis Focuses on the design and performance analysis of a six-wheeled rocker-bogie robot, particularly evaluating kinematics and stability on uneven surfaces, highlighting modern design improvements.
- **Zainol, Z., Rafeeq, M., Toha, S. F., & Idris, A. S. (2021)** Locomotion Performance of Amphibious Robot Vehicle using Transformable Rocker-Bogie Mechanism Examines an amphibious robot that incorporates a rocker-bogie mechanism with a transformable configuration, demonstrating adaptability in both land and water environments.

3. HARDWARE PARTS OF SYSTEM

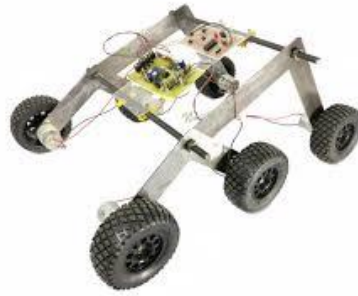
The design, construction, and parts of the Rocker-Bogie robot project are focused on achieving stable and reliable movement over rough and uneven terrain. The rocker-bogie mechanism is a unique suspension system originally developed for planetary exploration rovers, where maintaining traction and balance on irregular surfaces is critical. The primary goal of the design is to allow the robot to climb obstacles efficiently while keeping all wheels in contact with the ground. Unlike conventional wheeled robots that use spring-based suspension, the rocker-bogie system relies on a purely mechanical arrangement of links and joints, which simplifies construction and improves durability. The robot typically uses a six-wheeled configuration, where three wheels are mounted on each side. These wheels are connected through rocker arms and bogie links, which articulate independently to adapt to the terrain. The mechanical design begins with the chassis frame, which serves as the backbone of the robot. The chassis is usually fabricated from lightweight yet strong materials such as aluminum, mild steel, or acrylic sheets, depending on cost and application requirements. Aluminum is often preferred due to its high strength-to-weight ratio and corrosion resistance. The rocker arms are attached to the main chassis through a central differential mechanism that allows equal rotation of both sides, ensuring that the robot body remains relatively balanced even when one side encounters an obstacle. Each rocker arm is connected to a bogie link, which holds two rear wheels, while the front wheel is directly mounted on the rocker. This configuration allows the robot to climb obstacles that are nearly twice the diameter of the wheels without causing excessive tilt or loss of stability. Wheel selection plays a crucial role in the overall design of the rocker-bogie robot. The wheels are generally fitted with rubber or high-friction material to provide better traction on loose or rocky surfaces. The diameter and width of the wheels are selected based on the expected terrain conditions and load-carrying capacity. Larger wheels improve obstacle-climbing ability, while wider wheels enhance stability and reduce slippage. Each wheel is independently driven by a high-torque DC geared motor, which ensures sufficient pulling power at low speeds. Speed is not a primary concern in rocker-bogie robots; instead, smooth and controlled movement is emphasized to prevent mechanical stress and slipping during obstacle traversal. The construction phase of the rocker-bogie robot involves careful assembly of both mechanical and electrical components. The rocker arms and bogie links are cut and drilled according to design specifications and assembled using nuts, bolts, and bearings. Bearings are placed at the joints to reduce friction and allow smooth rotational movement.



Shafts are used to connect the motors to the wheels, ensuring proper alignment and efficient power transmission. During construction, special attention is given to the alignment of wheels and joints, as misalignment can lead to uneven load distribution and reduced performance. The central differential, which is a key component of the rocker-bogie system, can be implemented mechanically using gears or through electronic control logic, depending on project complexity. The electrical system of the rocker-bogie robot is designed to provide reliable power and precise control of motors. A rechargeable battery, such as a lithium-ion or lithium-polymer battery, is used as the primary power source. The battery is usually placed at the center of the chassis to maintain a low and balanced center of gravity. Motor driver modules, such as L298N or BTS7960, are used to control the direction and speed of the DC motors. These drivers receive control signals from a microcontroller, which acts as the brain of the robot. Popular microcontrollers used in this project include Arduino UNO, Arduino Mega, and ESP32, chosen for their simplicity, flexibility, and ease of programming. Control and sensing components are integrated to enhance the robot's functionality. Ultrasonic sensors are commonly used to detect obstacles in front of the robot, while infrared sensors can assist in short-range detection. In more advanced designs, inertial measurement units (IMU) consisting of accelerometers and gyroscopes are added to monitor the robot's orientation and stability. Wireless communication modules such as Bluetooth or Wi-Fi enable remote control and monitoring, allowing the robot to be operated from a safe distance. A camera module may also be mounted on the chassis for real-time visual feedback, which is particularly useful in surveillance and exploration applications. The parts used in the rocker-bogie robot project can be broadly classified into mechanical, electrical, and control components. Mechanical parts include the chassis frame, rocker arms, bogie links, wheels, bearings, shafts, and fasteners. Electrical parts consist of DC gear motors, motor drivers, batteries, voltage regulators, switches, and connecting wires. Control and sensing parts include the microcontroller, sensors, wireless modules, and optional camera systems. Each component is selected carefully to ensure compatibility, reliability, and ease of integration. Overall, the design and construction of the rocker-bogie robot emphasize stability, durability, and efficient obstacle-handling capability. By combining a well-engineered mechanical structure with reliable electrical and control systems, the rocker-bogie robot becomes a versatile platform suitable for applications such as search and rescue, surveillance, agricultural monitoring, and planetary exploration.

4. WORKING & IMPLEMENTATION

The working of the Rocker-Bogie robot is based on a unique mechanical suspension system that enables smooth and stable movement over rough, uneven, and obstacle-filled terrain. When the robot is powered on, electrical energy from the battery is supplied to the microcontroller and motor driver circuits. The microcontroller generates control signals that regulate the speed and direction of the DC gear motors through the motor driver module. Each wheel is independently driven, allowing controlled and synchronized motion of the robot. As the robot moves forward on a flat surface, all six wheels rotate at the same speed, and the rocker-bogie mechanism remains in a neutral position, keeping the chassis level. When the front wheel encounters an obstacle such as a rock or step, it begins to climb over it due to the torque provided by the motor. This causes the rocker arm to rotate upward. The motion of the rocker arm is transferred to the bogie link, allowing the rear wheels to follow smoothly without lifting off the ground. During this process, the central differential plays a key role by allowing equal rotation of the left and right rocker arms, thereby maintaining balance and preventing the robot body from tilting excessively. As the obstacle is further climbed, the second and third wheels on the same side sequentially engage with the obstacle.



The articulated joints in the rocker and bogie links adjust automatically according to the terrain profile, ensuring that all wheels remain in contact with the ground. This continuous ground contact improves traction and distributes the robot's weight evenly across all wheels. Because of this design, the rocker-bogie robot can climb obstacles nearly twice the diameter of its wheels without losing stability or requiring complex control algorithms. If sensors such as ultrasonic or infrared sensors are integrated, the robot continuously monitors the environment for obstacles. When an obstacle is detected within a predefined distance, the microcontroller processes the sensor data and decides the appropriate action, such as slowing down, stopping, or changing direction. In advanced configurations, an IMU sensor provides real-time information about the robot's tilt and orientation, helping maintain stability during steep climbs. When operated in remote-control mode, wireless modules like Bluetooth or Wi-Fi receive commands from the user, which are then interpreted by the microcontroller to control motor movement accordingly. Overall, the working principle of the rocker-bogie robot relies on the effective coordination between mechanical articulation and electronic control. The absence of traditional suspension springs reduces mechanical complexity while still providing excellent adaptability to uneven surfaces. This working mechanism makes the rocker-bogie robot highly suitable for applications such as exploration, search and rescue operations, surveillance, and inspection in hazardous or inaccessible environments.

5. CONCLUSIONS

The Rocker-Bogie Robot project successfully demonstrates a stable and efficient mobile robotic system capable of navigating rough and uneven terrains. By using a simple yet effective rocker-bogie suspension mechanism, the robot achieves excellent obstacle-climbing ability without complex suspension systems. The integration of suitable mechanical design, high-torque motors, and basic control electronics makes the system reliable and adaptable for various applications such as exploration, surveillance, and search-and-rescue operations. Overall, this project highlights the practical importance of innovative mechanical design in enhancing robotic mobility in challenging environments.

6. REFERENCES

- [1] Yang, J., Dong, M., & Ye, J. (2017). A Literature Review of the Rocker-Bogie Suspension for the Planetary Rover. Atlantis Press.
- [2] Reddy, V. B. S., Rao, V. R., & Madhukar, J. (2023). Design and Development of Six-Wheeled Robot with Rocker Bogie Suspension System. Journal of Science and Technology.
- [3] Cosenza, C., Niola, V., Pagano, S., & Savino, S. (2023). Theoretical Study on a Modified Rocker-Bogie Suspension for Robotic Rovers. Robotica.
- [4] Thianwiboon, M., & Sangveraphunsiri, V. (2006). Traction Control for a Rocker-Bogie Robot with Wheel-Ground Contact Angle Estimation. Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems.
- [5] Dashti, I., & Elhami, M. R. (2015). Kinematics Analysis and Simulation of a Rocker-Bogie Mobile Robot. Proceedings of the ASSET International Conference.
- [6] Pandey, A., et al. (2022). New Concept-Based Six-Wheels Rocker-Bogie Robot: Design and Analysis. International Journal of Robotics and Automation.
- [7] Zainol, Z., Rafeeq, M., Toha, S. F., & Idris, A. S. (2021). Locomotion Performance of Amphibious Robot Vehicle using Transformable Rocker-Bogie Mechanism. Elekrika Journal.