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DESIGN AND FABRICATION OF MULTI TERRAIN ROVER FOR MONITORING

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ABSTRACT

The ability to automate monitoring in challenging terrains, especially at high altitudes, has become a crucial component of future developments in remote area exploration. Recent advancements in mobile robotics, particularly with the progress in sensor technology and cost-effective rover designs, have led to increased interest in such applications. Mobile robotics stands out as a key technology for both domestic and industrial purposes due to its adaptability in diverse environments, leveraging a combination of heterogeneous sensors. The rover design presented here draws inspiration from NASA's Perseverance rover, employing a rocker-bogie suspension system for terrain adaptability and Ackerman steering for precise turning.

Keyword: Mobile Robotics, Rover, Rocker-Bogie, Ackerman steering geometry.

INTRODUCTION

Recent innovations in robotics have revolutionized the development of machines capable of performing complex tasks with high precision. These robots have become increasingly sophisticated, with sensors and mechanical components designed to replicate human capabilities. Today, robots can be deployed to explore areas that are otherwise inaccessible or too dangerous for humans. They are crucial in collecting data from remote or hostile environments, providing valuable insights that would be difficult to gather otherwise. The role of robots is becoming more prominent as they are equipped with advanced technology, enabling them to operate in extreme conditions. These autonomous systems can perform repetitive and intricate tasks with high accuracy, leading to increased productivity and cost efficiency in various industries. The integration of human-robot collaboration further enhances their capabilities, especially in scenarios that require both precision and reliability.

Rovers, which are specialized vehicles designed to explore distant terrains such as Mars, have been instrumental in exploring uninhabitable environments. They are equipped with high-end technology, including various sensors and mechanical components, to navigate and conduct experiments across rocky and uneven surfaces. The rocker-bogie suspension system is a key component of many rover designs, providing stability and ensuring that all wheels maintain contact with the ground, even over challenging landscapes.

The first notable Mars rover, Sojourner, was launched with the Pathfinder mission in 1997 and provided valuable data about the Martian surface. Subsequent missions, such as Opportunity and Curiosity, have used rovers to explore Mars, collect data on soil and rocks, and search for signs of past water activity. The Perseverance Rover, launched in 2020, is the most advanced rover to date, aiming to investigate signs of ancient microbial life and study the geology of Mars' Jezero crater.

In this work, we propose the design of a six-wheeled rover that combines a four-wheeled rocker system with two bogie wheels, forming an effective rocker-bogie suspension mechanism. The design ensures that the rover can

Date of Article Publishing: 2024 November 24

travel over rough terrain without losing balance, even when navigating inclines. The rover is equipped with various sensors to enable semi-autonomous operation, ensuring safety and precision during its journey.

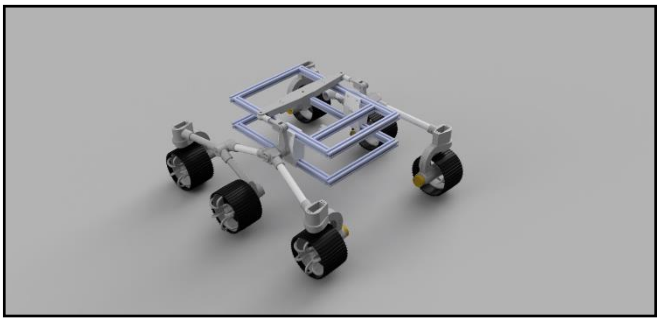

Figure 1: Final design of the rover with Ackermann steering

To empower the rover to work in a semi-autonomous mode various sensors have been utilized in the framework. To stay away from catastrophic harm to the rover because of generally differing landscapes, an ultrasonic sensor is used. Like the impact of a reflex activity in the human body, the sensor distinguishes the oddity and sends the information to the microcontrollers for halting the rover and deflecting any risk.

DESIGN AND CALCULATION

The proposed rover design integrates a rocker-bogie suspension system, which consists of a series of linked components that allow the wheels to adjust independently to uneven surfaces. This design is well-established and provides excellent terrain handling, ensuring that all wheels maintain constant contact with the ground, even on slopes.

The Ackerman steering geometry used in the rover ensures that the inside wheels turn more sharply than the outside wheels during turns. This is crucial for enhancing the rover's stability and maneuverability, particularly when navigating tight corners. By employing this geometry, the rover can maintain stability while turning on rugged terrain.

To ensure the rover operates effectively in semi-autonomous mode, it is equipped with an array of sensors. One of the key sensors is the **ultrasonic sensor**, which detects nearby obstacles and prevents the rover from colliding with them. This sensor is connected to the microcontroller, which processes the data and issues commands to halt or change the rover's path.

Calculating the Diameter of the wheel and RPM by selecting the velocity of 100 mm/s

Using the formulae,

$v = \pi DN/60$.

Wheel Diameter – 70mm

RPM – 30

Calculating the links of Rocker-Bogie using Pythagoras theorem as shown in the figure.2

Date of Article Publishing: 2024 November 24

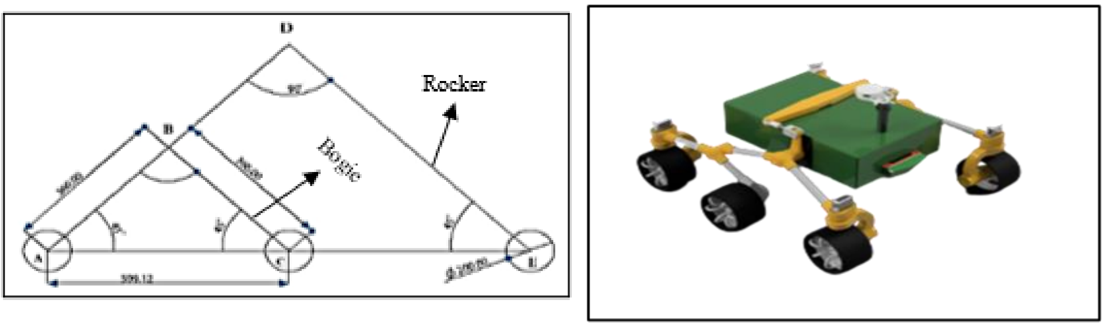

Figure 2: (a) skeleton of the rocker-bogie mechanism. (b) CAD model of the rocker-bogie mechanism

Links of Rocker: -

$AE^2 = DA^2 + DE^2$

DA = 28.2 cm

DA = DE = 28.2 cm = 282 mm

Links of Bogie: -

$BE^2 = DB^2 + ED^2$

AB = 14.14 cm

DB = ED = 14.14 cm = 141 mm

Material Selection

We have used the aluminium for chassis and joining the joints of the Rocker and Bogie. We designed the joints of Rocker-Bogie and 3d printed it with ABS material. As shown in figure.3.

Aluminium material property is shown in Table.1

Table1: Tabulation of material selectiomn and its mechanical properties

Material	Aluminum
Grade	6105-t5
Finish	anodize
strength-to-weight ratio	moderate

Tilt Angle-Angular motion of Rocker-Bogie while climbing.

The surface to be 100mm in length and 400 mm in breadth

so,

$\theta = Tan^{-1} (y/x)$

$\theta = Tan^{-1} (100/400)$

$\theta = 14.03°$

Wheel Base (Chassis)

Date of Article Publishing: 2024 November 24

Let's assume the Total Length = 400 mm
Wheel Base = Total Length – (RFW + RRW)
Wheel Base = 400 – (35 + 35)
Wheel Base = 330 mm

*RFW: -Right Front Wheel *RRW: - Right Rear Wheel

CONTROL SYSTEM

The rover is controlled through a Microcontroller (Arduino Mega ATmega2560), which manages six DC motors and four servo motors for driving and steering, respectively. The microcontroller requires a 5V DC power supply, while the DC motors require a 12V 1A power source. To drive the motors, we use an L298 H-bridge to provide sufficient power.

The rover is powered by a DC-DC buck converter, which steps down the 12V DC to 5V to power the microcontroller and sensors. The system also includes a 7805-voltage regulator to ensure stable voltage supply and protect components from back EMF.

The Control System Consists of 3 Parts (A) Main Frame Circuit (B) Power Supply (C) App IoT,

Main Frame Circuit

The Main Frame Circuit consists of Microcontroller-Arduino Mega ATmega2560, to control the 6-DC Motor, 4-Servo Motor, and 1-Camera for monitoring. The Microcontroller requires a 5v DC supply to work, and the DC motors required 12v 1A to work, but the insufficient output of the controller can't drive the motor, so we are using the L298 H-bridge to provide sufficient power to drive the motor through the controller. The Four servo motors are for the steering of the rover which uses the Ackerman steering geometry which is explained in

In summary, Ackermann's steering geometry is a design that enables the inside wheel of a vehicle to turn more sharply than the outside wheel during a turn, resulting in improved handling and stability. [9-10]

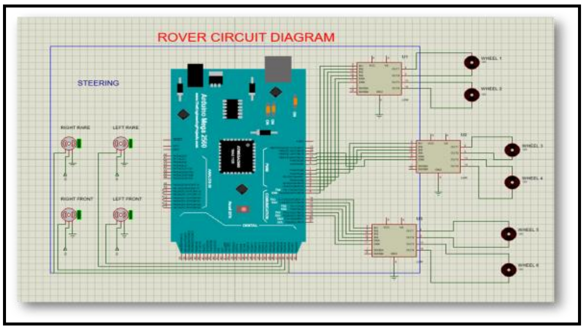

Figure 3: Schematic of the main frame circuit.

Power Supply

We have a DC-DC buck converter to step down 12 V DC to 5 V DC to Power up the microcontroller and other peripherals and sensors. To step down we used 7805 regulator IC and Diode for controlling the back emf.

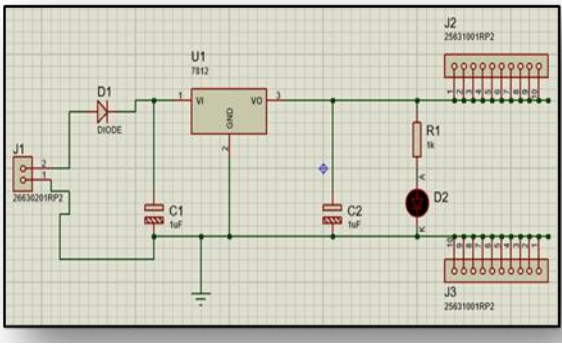

Figure 4: Schematic of the power supply unit.

App-IoT

All the Commands which are given to the rover, are by the app for the motion control of the rover. When the button is pressed the command will be sent through the cloud to the brain of the rover which is a microcontroller then there is action in the rover. With this App only we can have the rover vision with the help of a camera, the signals are received through the cloud.

CONCLUSION

This rover, equipped with a rocker-bogie suspension and Ackerman steering, offers a robust solution for navigating rugged and uneven terrains. By combining advanced mechanical design with sensor integration and IoT control, the rover can perform remote monitoring tasks autonomously, making it a valuable tool for various applications, including space exploration, environmental monitoring, and disaster response.

REFERENCES

[1] Chinchkar, Dhananjay, et al. "Design of rocker bogie mechanism." *International Advanced Research Journal in Science, Engineering and Technology* 4.1 (2017): 46-50.

[2] Chinchkar, Dhananjay, S. Gajghate, R. Panchal, R. Shetenawar, and P. Mulik. "Design of rocker bogie mechanism." International Advanced Research Journal in Science, Engineering and Technology 4, no. 1 (2017): 46-50.

[3] Chandu, K.H., Narayana, P.H., Teja, K.C., Sai, B. and Mohan, Y.M., 2018. Design and Fabrication of Rocker Bogie Mechanism. Int. J. Sci. Eng. Technol. Res, 7, pp.781-784.

[4] Murambikar, R., Omase, V., Nayak, V., Patil, K., & Mahulkar, Y. Design and Fabrication of Rocker Bogie Mechanism using Solar Energy. HISTORY, 6 (04) (2019).

[5] Vigneshwaran, M., Siddharthaa, R., Vijay, G., & Pravin Kumar, S. Design of All Terrian Vehicle Using Rocker Bogie Mechanism. International Journal of Mechanical Engineering and Technology, 10 (3) (2019).

[6] Lindemann, Randel, and Chris J. Voorhees. "Mars Exploration Rover mobility assembly design, test and performance." Systems, Man and Cybernetics, 2005 IEEE International Conference on. Vol. 1. IEEE, 2005.

Date of Article Publishing: 2024 November 24

[7] Muirhead BK. Mars rovers, past and future. In2004 IEEE aerospace conference proceedings (IEEE Cat. No. 04TH8720) 2004 Mar 6 (Vol. 1). IEEE.

[8] Balaram, J., MiMi Aung, and Matthew P. Golombek. "The ingenuity helicopter on the perseverance rover." Space Science Reviews 217, no. 4 (2021): 56.

[9] Flippo, D., Heller, R., & Miller, D. P. (2010). Turning efficiency prediction for skid steer robots using single wheel testing. In Field and Service Robotics: Results of the 7th International Conference (pp. 479-488). Springer Berlin Heidelberg.

[10] Choi, M. W., Park, J. S., Lee, B. S., & Lee, M. H. (2008, October). The performance of independent wheels steering vehicle (4WS) applied Ackerman geometry. In 2008, the international conference on control, automation and systems (pp. 197-202). IEEE.

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