

Medical Robotics for Pandemic Crisis: A Rover-Inspired Solution for Contactless Healthcare Logistics

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Abstract

This research presents an innovative application of rover technology, namely in the medical sector during pandemic scenarios like as COVID-19, when reducing physical contact among individuals is essential. The suggested device, a Medical Transportation Robot (MTR), employs a Rocker-Bogie mechanism to guarantee stability and provide smooth navigation across diverse terrains. The MTR is engineered to convey medical supplies, food, and necessities between patients and healthcare professionals, therefore decreasing the possibility of viral transmission.

The MTR boasts a six-wheeled rover design with advanced attributes, including spider-leg wheels for improved mobility. The system functions via a line-following mechanism and may be remotely operated by a smartphone application utilizing Bluetooth technology, therefore obviating the necessity for direct human participation. A collection of sensors, comprising ultrasonic and infrared types, facilitates obstacle identification and secure navigation, guaranteeing dependable operation in semi-autonomous mode. The rover's control system is constructed using Arduino and Raspberry Pi platforms, interacting with motor drivers and microcontrollers for accurate functionality.

This study delineates the concept and development of the MTR, emphasizing its practical implications in alleviating the burden of frontline healthcare professionals and enhancing safety in medical settings. The design is economical, user-friendly, and can accommodate a weight of up to 5.2 kg, rendering it a practical choice for medical transportation within hospitals. The report also examines current rover technology and explores prospective advancements in medical robots.

Keywords - Mars Rover, Rocker Bogie Mechanism, Rover Technology, Six-wheel robot

1. INTRODUCTION

A rover, or planetary rover, is a vehicle developed for space exploration, intended to traverse the surface of a planet or other celestial body. Certain rovers are engineered to convey human spaceflight crew members, while others function as partially or completely autonomous robots. Rovers often reach the planetary surface using a lander-type spacecraft. Rovers are designed to land on other planets to gather

information and collect samples. They are capable of collecting dust, pebbles, and capturing images. They are highly beneficial for investigating the cosmos. [5]. During this decade, we face pandemic situation like covid-19, which are very dangerous for human survival. This type of infectious diseases mostly transferred by human physical interactions as per survey. Most of time, the transmission has done by front line health workers like nurses, pharmacists, cleaners, Ward boys etc. Their work is also important for health of patient. Health of front-line health worker and patient health are also important [9]. Considering this need, we have proposed Medical Transportation Robot (MTR), which is based on Rocker Bogie system. Rocker bogie system is suspension less system and it can resist mechanical failure so for base frame rocker bogie system is good [9]. In the era where we are facing pandemics like covid 19, viral in nature. We need a robotic system which can overcome physical interaction between humans. Considering this need, we are proposing MTR which is Medical Transportation Robot. As our system based on line path follower mechanism with the ability to operate from safe distance using mobile app with help of Bluetooth Technology, it can perfectly work without human interaction, without transmission of diseases. Also, will help to reduce the workload of frontline health workers. It is beneficial for both patient as well as health worker. This paper proposes 6-wheeled rover which combines the rocker wheels which form the rocker bogie mechanism along with the spider-leg wheels. The figure 1 shows growth of surgical or medical robots worldwide. It seems that there is 40% growth expected till 2025 in use of medical robots in all around the world. This is a significant improvement to the existing rocker bogie mechanism. The integration of the four-bar linkage, spring-damper, and linear actuator facilitates the rover's ability to navigate minor obstacles. A component is attached to the chassis via a hinge. One end of the member is affixed to the actuator, while the outer end connects to a four-bar linkage, resulting in a system that is both stable and flexible [1].

Growth of installed surgical robots worldwide

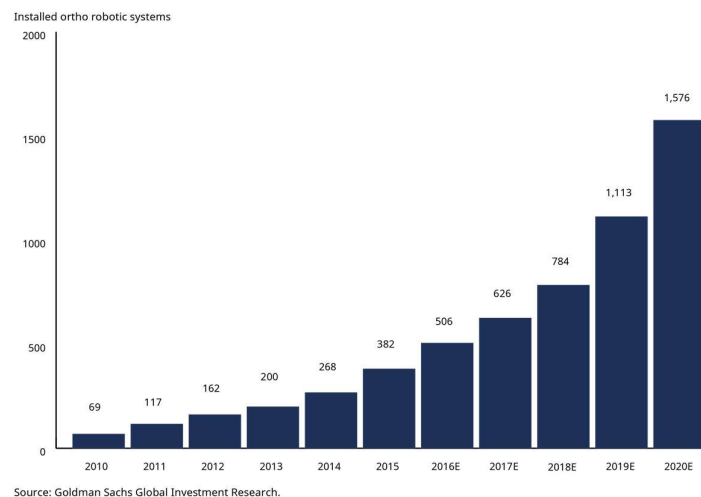


Figure 1 Growth of medical robot worldwide

This work describes a rover mechanism that allows the rover to traverse diverse terrains while maintaining stability and protecting its apparatus. To facilitate the rover's operation in a semi-autonomous mode, several sensors have been included into the system. An ultrasonic sensor is employed to prevent catastrophic damage to the rover caused by diverse terrains. Similar to a reflex movement in the human body, the sensor identifies the abnormality and transmits the data to the microcontrollers to halt the rover and prevent any potential risk. The mechanical system governing the rover's motor apparatus is intricate yet highly efficient. The array of sensors, coupled with a system including several readily accessible microcontrollers and microprocessors, renders the rover's movement and operation very precise and conveniently achievable. The motor drivers and sensors are connected to microcontrollers such as the Arduino UNO. It is operated utilizing advanced microprocessors such as Raspberry Pi. The Rover is equipped with semi-autonomous control, facilitating rapid error correction and effective management. This study elucidates the comprehensive operation and the functionality of the different subsystems within the rover [2].

1.

2. REVIEW OF LITERATURE

Prior to advancing with the project, research was conducted to ensure the project's objectives are met. This literature review encompassed observation and investigation pertaining to the technologies relevant to the project. The subsequent systems were examined during the literature survey: In this project, the stability of the rocker bogie robot was enhanced because to the risks of flipping and suspension damage posed by rugged terrain and uneven surfaces [1].

This study proposes a technique for operating a wireless robot for surveillance using an application developed on the Android platform. The Android is equipped with a visual display for monitoring and buttons for controlling the robot and camera. The Android smartphone and Raspberry Pi board are linked to Wi-Fi. An Android smartphone transmits a wireless command that is received by a Raspberry Pi board, prompting the robot to move appropriately. Raspberry Pi programming is conducted using the Python language [2].

This study proposes a design analysis of the Rocker Bogie Suspension System and evaluates the feasibility of using it in front-loading vehicles. In locations where the gravitational force is less than that of Earth's gravitational coefficient, the current suspension system fails to achieve the expected outcomes due to alterations in the magnitude and mechanism of shock absorption. NASA and the Jet Propulsion Laboratory have collaboratively created a suspension system known as the rocker-bogie suspension system to mitigate anti-gravity effects [3].

This research proposes an ideal design for a wheel-type mobile robot to achieve great mobility stability and superior flexibility when ascending stairs. The Taguchi technique is utilized as an optimization tool owing to its simplicity and cost-effectiveness in generating an objective function and concurrently meeting various constraints. The sensitivity analysis of design parameters is conducted to elucidate their impact on the performance criteria under kinematic limitations, which are established to prevent undesirable interactions between a mobile robot and stairs. To assess the climbing capabilities of the improved rocker-bogie mechanism, the friction requirement metric is selected, defined as the minimal friction coefficient necessary for a mobile robot to ascend a stair without slipping [4].

This study involved the design of the suggested steering mechanism, which was modeled in CATIA (V-5) and subsequently subjected to static analysis under the specified torque conditions of the motor in ANSYS. All outcomes in the analysis underwent static examination [5].

This work examines the kinetic behavior of a planetary rover, focusing on tire-soil traction mechanics and articulated body dynamics, to analyze control during traversal across natural rocky terrain. The correlation between the load-traction factor and the slip ratio is theoretically modeled and subsequently validated via experimentation. Simulations are conducted for comparison with the relevant experimental data and validated to accurately depict the physical behavior of a rover [6].

The researchers examine the idea and parameter design of a robust stair-climbing compliant modular robot, proficient at ascending stairs with overhangs. Altering the design of the wheel perimeter of our robot aids in addressing overhangs. In addition to formulating a conceptual design, stringent design parameters were established to reduce performance variability. The Grey-based Taguchi Method was utilized to determine the ideal configuration for the robot's design parameters. The robot prototype successfully ascended steps of varied dimensions with overhang, hence validating the study conducted [7].

The global market for mobile robots is projected to grow significantly over the next 20 years, exceeding the industrial robotics industry in both unit sales and revenue. Significant areas of use include homeland security, surveillance, demining, reconnaissance in hazardous settings, and agriculture. The design of locomotion systems for mobile robots in unstructured situations is inherently complicated, especially when navigating uneven or soft terrains or ascending barriers. The three primary categories of locomotion systems—wheeled (W), tracked (T), and legged (L)—along with the four hybrid categories formed by their combinations, were analyzed concerning maximum speed, obstacle-crossing ability, step/stair climbing proficiency, slope climbing capability, performance on soft terrains, adaptability to uneven terrains, energy efficiency, mechanical complexity, control complexity, and technological readiness. The present and

forthcoming developments in mobile robots were examined [8].

3. METHODOLOGY

2.

3.1 Establishment of Design Concept

The lengths of the connections are determined based on the initial assumption of vehicle speed. The varying lengths of the linkages are computed accordingly. The vehicle's frame was constructed using SolidWorks 2022 according to the specified design calculations. The components for constructing the rover include PVC pipes, 450 and 900 degree elbows, a 12V 60 rpm DC motor, a 12V 12A DC battery, a 2.4 GHz multi-channel remote control, as well as nuts, bolts, and washers. C-PVC pipes were accurately cut to the specified lengths with a hacksaw blade. Holes with a diameter of 6 mm were bored to secure the different pipes in accordance with the design specifications. A narrow incision was created at the ends of the pipes where the wheels are positioned. Each motor terminates with a 6 mm shaft with an aperture. The wheels were secured into the shafts and fastened with bolts. The RC unit was affixed to the upper frame of the rover to mitigate vibrations. The wiring is connected from the RC control unit and soldered to the motor at the other end. The battery is affixed to the frame using clamps and is linked to the control unit. The rover has been prepared and tested using the remote control.

3.2 Development of Device Prototype

A) Mechanical Components :-

- PVC pipes
- Nut and bolts
- Wheels
- Acrylic Sheets
- Circuit Box
- Lead Screw with backlash nut

B) Electrical Components:-

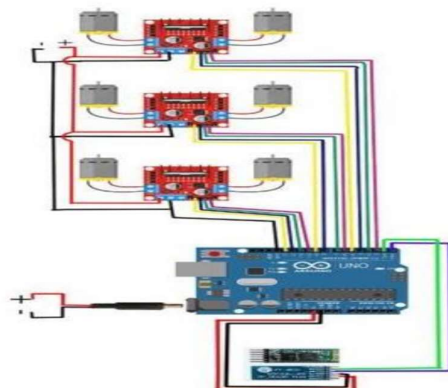
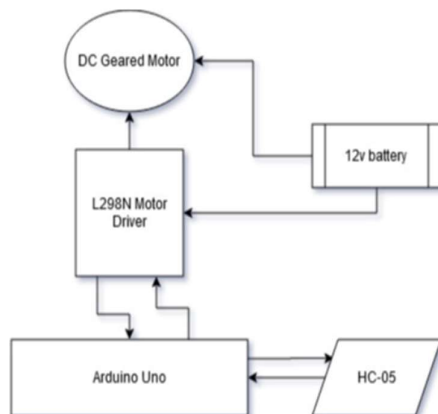
- IR sensors
- Arduino Uno
- Dc motors
- Male female jumper cables
- L298 Motor Driver
- Stepper motor
- Sg 90 Servo Motor
- Ultrasonic sensor
- Tb6600 Stepper motor driver

C) Operational Block Diagram: -

This is operational block diagram of MTR in which Dc motor driver is connected to 6 driving dc motors which runs on the command of Arduino Uno as shown in figure 2. Bluetooth drivers send signal to Arduino Uno and according to that L298 motor driver behaves and drives MTR.

D) Circuit Diagram to Control the MTR Machine

HC05 Bluetooth module gives command to Arduino circuit and Arduino circuit then execute it through L298 motor driver which is connected to dc motors. L298 motor driver drives the dc motor according to requirements as shown in figure 3.



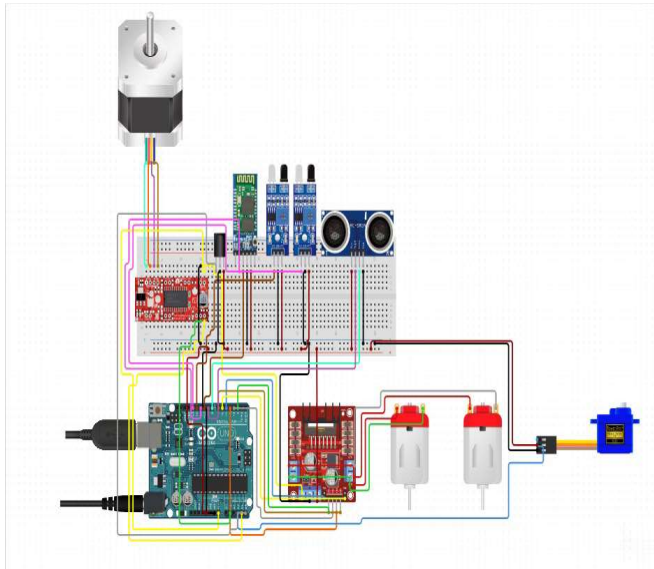


Figure 6 Circuit Diagram of System



Figure 7 APP Interface

3.5 APP Interface

Figure7 shows the APP Interface of the system. In which an application is made with the help of MIT App Inventor-II. It is an application that can be installed on an android-based phone. The app inventor environment contains 2 workplaces where we can create an outer view of the app and can write a block code of the app. The Bluetooth module in the robotic circuit is made to connect with the phone's Bluetooth and exchange commands to operate the rover. Initially a set of code is fed into the Arduino using Arduino IDE by connecting the Arduino board to the computer. The code is written on the basis of the circuit diagram. The buttons in the app are build in such a way that they pass a certain command to the Arduino and the Arduino decodes the received data and sends pulses to the L298N motor driver and makes the motors rotate.

4. CONCLUSION

The Medical Transportation Robot (MTR) we've developed is a cost-effective solution compared to similar products on the market. It is designed to minimize physical contact between patients and healthcare workers by facilitating the delivery of essential items such as food, water, and medication. This reduces the risk of infection transmission and enhances safety protocols in medical environments.

The MTR is user-friendly, with an app interface that's as simple to operate as a remote-controlled toy. Even for those unfamiliar with the app, the MTR can also be controlled via an infrared (IR) remote, ensuring ease of use for all personnel. Additionally, the robot comes equipped with an HC05 Bluetooth module, which allows for operation within a 10-foot range.

In terms of capability, the MTR can carry loads of up to 4kg comfortably, with a maximum capacity of 5.2kg. Its speed is optimized at 12cm/s, taking into account the weight of the robot to ensure stability and efficiency during operation. This combination of features makes the MTR a versatile and practical tool for hospitals and care centres.

3. REFERENCES

- [1] Saraiya P. M., "Design of Rocker Bogie Mechanism" *International Research Journal of Engineering and Technology (IRJET)*, vol.7, no.8, pp. 1544-1550, 2020.
- [2] Bokade A., Ratnaparkhe V. R., "Video Surveillance Robot Control Using Smartphone and Raspberry Pi", *International Conference on Communication and Signal Processing (ICCSP)*, 6-8 April 2016.
- [3] Yadav N., Bhardwaj B. R., Bhardwaj S. et. al., "Design analysis of Rocker Bogie Suspension System and Access the possibility to implement in Front Loading Vehicles" *IOSR Journal of Mechanical and Civil Engineering*, vol. 12, no. 3, pp. 64-67, 2015.
- [4] Hong-an Yang, Kim Dongmok, Luis Carlos Velasco Rojas, " Dynamic analysis and optimization of a wheel-type mobile robot for stair climbing using the Taguchi Technique", *School of Mechanical Engineering, Northwestern Polytechnic University*.
- [5] Panigrahi P., Barik A., Rajneesh R. & R. K. Sahu, "Introduction of Mechanical Gear Type Steering Mechanism to Rocker Bogie", *Imperial Journal of Interdisciplinary Research (IJIR)*, vol. 2, no. 5, 2016.
- [6] Bhole A., Turlapati S.H, Shekhar R. V. S, J. Dixit, "Design of a Robust Stair Climbing Compliant Modular Robot to Tackle Overhang on Stairs" *Robotica*, vol.37, no. 3, 2016.

- [7] Yoshida K. and Hamano H., "Motion dynamics of a rover with slip-based traction model", *IEEE International Conference on Robotics and Automation*, 2002.
- [8] Bruzzone L. and Quaglia G., "Review article: locomotion systems for ground mobile robots in unstructured environments", *Mech. Sci.*, vol.3, pp. 49–62, 2012.
- [9] L. H. Nguyen et al., "Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study," *The Lancet Public Health*, vol. 5, no. 9. pp. 475–483, 2020.
- [10] V. K. Kurkute1, Chaitanya Mate, Jaydeep S. Patil, et. al., "Design Development and Computational Studies on Propeller Shaft of Small Commercial Vehicle", *International Journal of Engineering Trends and Technology*, vol. 71, no. 8, pp. 382-387, 2023.
- [11] K. R. Thilak, S. Ashwinkarthik, Y. Shinde, et. al., "An Investigation on Battery Management System for Autonomous Electric Vehicles," *International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT)*, *IEEE*, pp. 714–718, 2023.