MARS WEATHER MONITORING ROBOTIC SYSTEM USING ROCKER BOGIE MECHANISM

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ABSTRACT: The exploration of Mars has been a subject of immense scientific interest, prompting the development of advanced robotic systems capable of traversing the challenging Martian terrain. The Rocker Bogie mechanism has emerged as a reliable and efficient mobility system for Mars rovers, allowing them to navigate over rough and uneven surfaces with enhanced stability and manoeuvrability. This paper presents, Mars Weather Monitoring Robotic System using Rocker Bogie Mechanism. The proposed Mars robot employs a six-wheeled configuration with a Rocker Bogie suspension system, enabling the robot to maintain stability while traversing obstacles and uneven terrain. The robot's ability to negotiate obstacles, climb slopes, and traverse loose or rocky surfaces is assessed, providing insights into its operational capabilities and limitations. The robot will be equipped with cameras, spectrometers, and other scientific instruments to analyze the Martian environment and gather valuable data for further exploration and research. The objective of this project is to examine the temperature, humidity and water molecules on the surface of the mars and to send the observations to the operators.

KEYWORDS: Rocker Bogie mechanism, robot, Weather Monitoring, Mars, temperature, humidity.

I. INTRODUCTION

The type of locomotion used by a mobile robot is crucial for the robot to perform its task and reach its goal in a given environment [1]. This work focuses on the optimization of the design of a planetary rover's wheel suspension system subject to optimizing well defined mobility metrics. As robots evolve from industrial fixed base robots to autonomous mobile platforms, the concept of locomotion in robotics becomes

much more important. Similar to nature, also robot locomotion must be adapted to the given terrain or task [2].

The term "rocker" describes the rocking aspect of the larger links present each side of the suspension system and balance the bogie as these rockers are connected to each other and the vehicle chassis through a modified differential [3]. As the Mars Rover is a mobile robot, the wheel suspension system of the rover is most crucial. It allows for movement, mobility and stability of the robot while it is travelling through a Mars environment. The rover must be able to traverse over obstacles of at least half its wheel diameter and keep its stability on slopes or other rough or hazardous terrain [4].

In the system, "bogie" refers to the conjoining links that have a drive wheel attached at each end. Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain [5]. Bogies were also quite commonly used on the trailers of semitrailer trucks as that very time the trucks will have to carry much heavier load [6]. As accordance with the motion to maintain centre of gravity of entire vehicle, when one rocker moves upward, the other goes down. The chassis plays vital role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation [7]. The physics of these rovers is quite complex. To design and control these analytical models of how the rover interacts with its environment are essential [8]. Models are also needed for rover action planning. Simple mobility analysis of rocker-bogie vehicles have been developed and used for design evaluation in the available published works [9].

The proposed Mars robot employs a six-wheeled configuration with a Rocker Bogie suspension system, enabling the robot to maintain stability while traversing obstacles and uneven terrain. The design process involves the selection of appropriate materials and components that can withstand the harsh Martian environment, including extreme temperatures, low atmospheric pressure, and dusty conditions [10].

II. LITERATURE SURVEY

L. Tang and P. Abplanalp, [11] presents GPS guided farm mapping and waypoint tracking mobile robotic system. With the rapid development of automated farm facilities such as auto-weather report, crops growing monitoring, soil testing, etc. a future-focused autonomous real time farm environment monitoring mobile robot platform is in need. Such a system will provide a base for integrating automated farm tools and facilities and maximize the use of modern farm technologies. The system provides potentials for further development that could bring more significant contributions to intelligent farming machines and agricultural automation. M. A. Hsieh, E. Forgoston, T. W. Mather and I. B. Schwartz, et. al. [12] presents a collaborative robotic control strategy designed to track stable and unstable manifolds. The technique does not require global information about the fluid dynamics, and is based on local sensing, prediction, and correction. The collaborative control strategy is implemented on a team of three robots to track coherent structures and manifolds on static flows as well as a noisy time-dependent model of a wind-driven double-gyre often seen in the ocean. We present simulation and experimental results and discuss theoretical guarantees of the collaborative tracking strategy.

M. Michini, M. A. Hsieh, E. Forgoston and I. B. Schwartz, et. al. [13] presents a collaborative robotic control strategy that is designed to track stable and unstable manifolds in dynamical systems, including ocean flows. The technique does not require global information about the dynamics, and is based on local sensing, prediction, and correction. The collaborative control strategy is implemented with a team of three robots to track coherent structures and manifolds on static flows, a time-dependent model of a wind-driven double-gyre flow often seen in the ocean, experimental data that are generated by a flow tank, and actual ocean data. We present simulation results and discuss theoretical guarantees of the collaborative tracking strategy. H. Lu, Y. Li, S. Mu, D. Wang, H. Kim and S. Serikawa, et. al. [14] developed an anomaly detection system to prevent the motor of the drone from operating at abnormal temperatures. In this anomaly detection system, the temperature of the motor is recorded using DS18B20 sensors. Then, using reinforcement learning, the motor is judged to be operating abnormally by a Raspberry Pi processing unit. The experimental results confirm that the proposed system can safely control the drone using information obtained from temperature sensors attached to the motor.

S. M. F. Faisal, T. Rahman and M. A. Kabir, et. al. [15] aims to fabricate a low–cost explorer robot with a rocker-bogie mechanism that can run in all sorts of terrains. As the explorer robot is a prototype version of the Mars rover robot, the entire structure's size is confined. Only the mechanism is demonstrated using standard DC motors and wheels. A wireless communication system is implemented using internet of things technology, and a gas sensor is placed in the robot to collect the surrounding environment's gas level data. In the end, performance tests are accomplished to check the rocker-bogie mechanism's stability, and the sensor's data analysis is done. D. Choi, Y. Kim, S. Jung, J. Kim and H. S. Kim, et. al. [16] ensure smooth movement as well as high terrainability on rugged terrain, a new mobile platform (RHyMo) is constructed on the basis of the kinematic and quasi-static analyses. The extensive experiments are carried out by using the RHyMo and the Rocker-Bogie platform on the artificial rugged terrain, which verify that in comparison with the Rocker-Bogie platform, the average and maximum height variations of RHyMo are reduced by 12.72% and 5.96%, respectively.

II. COMPONENTS REQUIRED

ESP32 Microcontroller:

ESP32 is the SoC (System on Chip) microcontroller which has gained massive popularity recently. ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The microcontroller should be able to interface with a variety of sensors. It should support all the common communication protocols required for sensor interface: UART, I2C, SPI. It should have ADC and pulse counting capabilities. ESP32 fulfills all of these requirements. On top of that, it also can interface with capacitive touch sensors. Secondly, the microcontroller should be able to perform basic processing of the incoming sensor data, sometimes at high speeds, and have sufficient memory to store the data. ESP32 has a max operating frequency of 40 MHz, which is sufficiently high. It has two cores, allowing parallel processing, which is a further add-on. Finally, its 520 KB SRAM is sufficiently large for processing a large array of data onboard. For transmitting data, ESP32 has integrated WiFi and Bluetooth stacks, which have proven to be a game-changer. No need to connect a separate module (like a GSM module or an LTE module) for testing cloud communication.

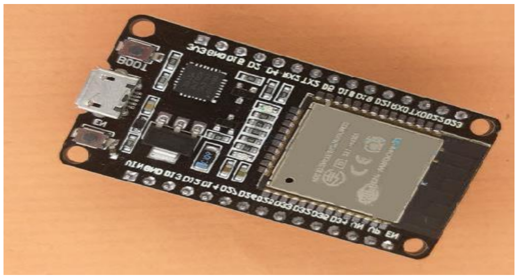

Fig. 1: ESP32 MICROCONTROLLER

DC Motor:

This 12 Volt Metal Gears DC Motor 100 RPM can be used in all-terrain robots and a variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly. These motors are simple DC Motors featuring metal gears for the shaft for obtaining the optimal performance characteristics. They are known as center Shaft DC Geared Motors because their shaft extends through the center of their gearbox assembly.

ISSN PRINT 2319 1775 Online 2320 7876

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Fig. 2: DC MOTOR

Motor Driver:

A microcontroller that normally operates on 5V or 3.3V cannot be directly used to control a DC motor operating on higher voltage and current rating. This is why we commonly use Motor Driver modules like the L293D Motor Driver Module and the L298N Motor Driver Module. While the L293D motor driver module can be used for basic low current application the L298N. Motor driver module is a high current motor driver with some additional features that are commonly used with Arduino and Raspberry Pi for Robotics applications. The motors to be controlled (Motor A and B) are connected to screw terminals.

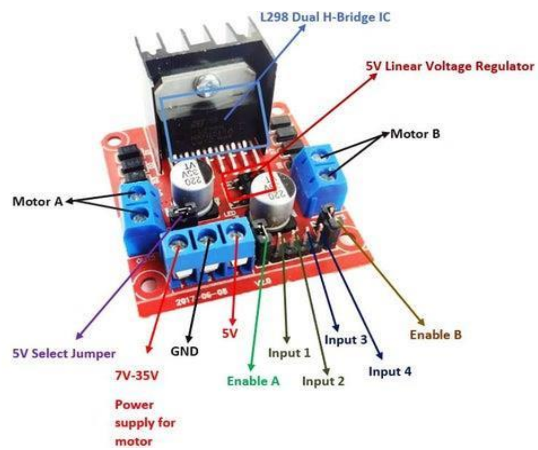

Fig. 3: DC MOTOR DRIVER

MQ-7:

Carbon monoxide gas is a very dangerous, harmful, and toxic gas for the normal environment. Since the gas has no color and is odorless, so it cannot be smelt or seen. So, if there is carbon monoxide gas in the surroundings, the person really would get no idea that they are breathing in CO until he/she feels not safe. So, it is necessary to have detected that toxic gas. Hence, there is an MQ7 gas detector sensor that can detect this harmful gas. The MQ7 alcohol sensor comprises a tin dioxide (SnO2), a perspective layer inside aluminium oxide micro-tubes (measuring electrodes), and a heating element inside a tubular casing. There is an enclosed stainless steel net at the end face of the sensor and the backside holds the connection terminals.

Fig. 4: MQ-7 CARBON MONOXIDE SENSOR

DHT11:

DHT11 is a part of DHTXX series of Humidity sensors. The other sensor in this series is DHT22. Both these sensors are Relative Humidity (RH) Sensor. As a result, they will measure both the humidity and temperature. Although DHT11 Humidity Sensors are cheap and slow, they are very popular among hobbyists and beginners. The DHT11 Humidity and Temperature Sensor consist of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal.

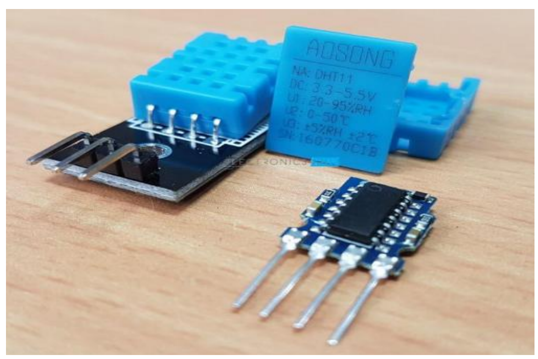

Fig. 5: DHT11 SENSOR

Water Sensor:

The water level sensor includes 3 pins:

S (Signal) pin: This pin outputs analog voltage that is in proportion to the water level. This pin should be connected to an analog input pin of ESP32.

Fig. 6: WATER SENSOR

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12V Battery:

12V 1.3Ah Rechargeable Lead Acid Battery is normally use for robots in competition. Wired or Wireless Robots runs for a long time with high speed with this type of battery. Seal Lead Acid (SLA) Rechargeable battery is the most common general purpose battery. Low cost, robust and less maintenance required are the advantages of SLA. But it is considered heavy weight for certain robotic application. To charge SLA batteries, you can use any general DC power supply as long as it provides the correct voltage to your battery.

Fig. 7: 12V RECHARGEABLE LEAD ACID BATTERY

LM2596:

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed frequency oscillator. The LM2596 series operates at a switching frequency of 150 kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

Fig. 8: LM2596

III. DESIGN AND WORKING PRINCIPLE

The block diagram of Mars Weather Monitoring Robotic System using Rocker Bogie Mechanism is represented in below Fig. 9.

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ISSN PRINT 2319 1775 Online 2320 7876

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Principle:

The front wheels are forced against the obstacle by the rear wheels. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle. The middle wheel is pressed against the obstacle by the rear wheel and pulled against the obstacle by the front, until it is lifted up and over. Finally, the rear wheel is pulled over the obstacle by the front two wheels. These rovers move slowly and climb over the obstacles by having wheels lift each piece of the suspension over the obstacle one portion at a time.

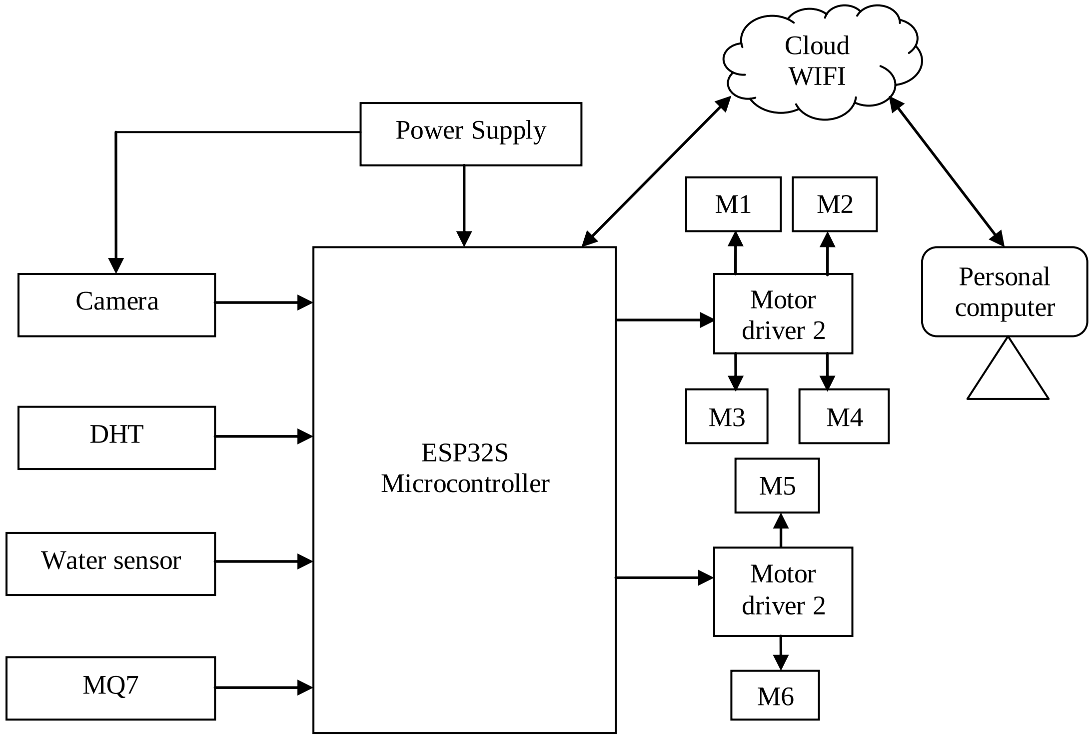

Fig. 9: SYSTEM ARCHITECTURE

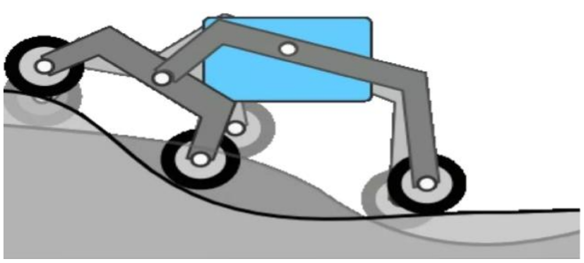

Fig. 10: WORKING PRINCIPLE OF ROCKER BOGIE MECHANISM

Working:

Mars rovers are sophisticated robotic vehicles designed to explore the Martian surface, conduct scientific experiments, and transmit data back to Earth. These rovers use a combination of advanced technologies to operate in the challenging Martian environment. Mars rovers use a rocker-bogie suspension system for stability and flexibility to traverse uneven terrain. The wheels are often individually motorized, allowing precise control over movement.

The motor we are using here is a DC motor which is of 100 rpm. The wheels part is made up of iron and the upper part is made up of acrylic. As we know that the rover consists of water, temperature, humidity and gas sensors. It also consists of a camera. The gas sensor, DHT11 sensor provides analog values where as water sensor provides digital values. As we know that the analog values ranges up to maximum values. The operating voltage range of ESP32 is 3.3V to 5V. Whereas the motor voltage is 12V. So to reduce the motor voltage with respect to ESP32 we are using DC to DC convertor. The motor driver works on H-Bridge principle. The motor driver consists of 2 H-Bridges. The battery we are using is of voltage 12V. The ESP32 provides power to the motor drivers through the battery. And the motor driver decides the moment of the wheels. The ESP32 is controlled by mobile which is connected. And the software we are using to control is the BLYNK app. The sensors examines the particular conditions and provides us the values. We can also watch the surface with the help of the camera.

IV. RESULTS

Schematic of Mars Weather Monitoring Robotic System using Rocker Bogie Mechanism is represented in below Fig. 11.

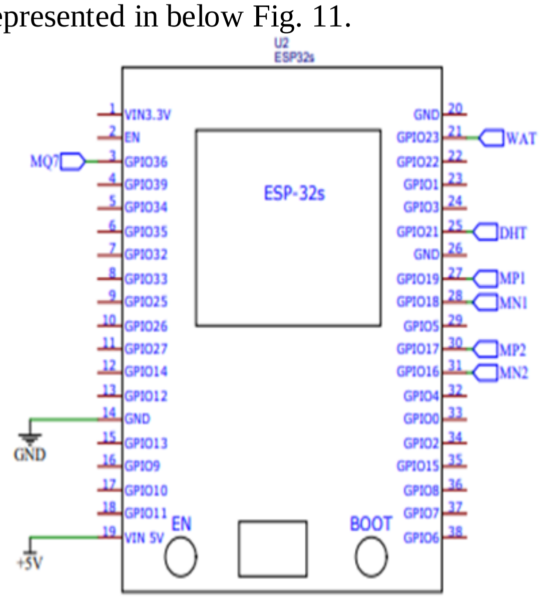

Fig. 11: SCHEMATIC OF SYSTEM

Power supply unit of system is represented in Fig. 12. Layout diagram is represented in below Fig. 13. Mars Weather Monitoring Robotic System is represented in Fig. 14.

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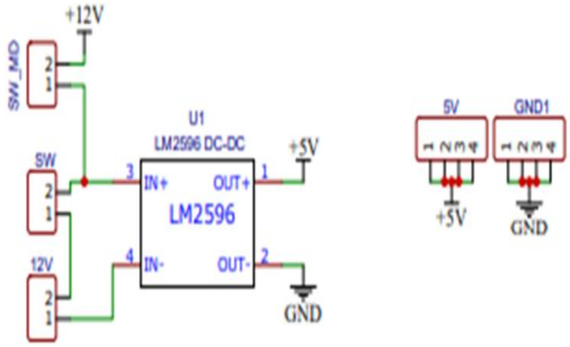

Fig. 12: POWER SUPPLY UNIT

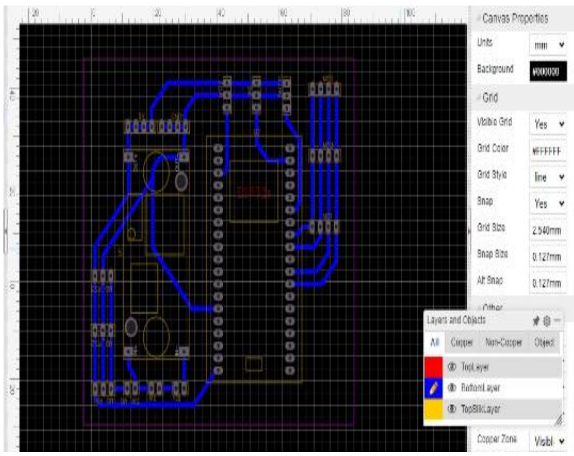

Fig. 13: LAYOUT DIAGRAM

Fig. 14: MARS WEATHER MONITORING ROBOTIC SYSTEM

V. CONCLUSION

In this paper, Mars Weather Monitoring Robotic System using Rocker Bogie Mechanism is described. The use of the rocker-bogie mechanism in Mars rovers has proven to be a highly effective and reliable means of mobility for exploring the challenging Martian terrain. This mechanism offers several key advantages, including exceptional stability, adaptability to uneven landscapes, obstacle-traversal capabilities, redundancy, and precise control. These qualities are instrumental in ensuring the safety, longevity, and successful mission execution of Mars rovers. These considerations must be carefully managed by mission planners and engineers to optimize rover performance on the Red Planet. Overall, the rocker-bogie mechanism has played a pivotal role in expanding our understanding of Mars and its potential for past or present habitability. As technology continues to advance, future Mars rover designs may build upon this mechanism's strengths while addressing its limitations, further enhancing our ability to explore and unravel the mysteries of our neighboring planet.

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