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Review on Rover with Rocker-Bogie Linkage Mounted with Ultrasonic Sensor and Bluetooth Module with Solar Energy

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Abstract - *The term "BOGIE" refers to the links that have a drive wheel at each end. Bogies were commonly used as load wheels in the tracks of army ranks as idlers distributing the load over the terrain.*

Rocker Bogies are important for conducting in-situ scientific analysis of objectives that are separated by many meters to tens of kilometers. Current mobility designs are complex, using many wheels or legs. They are open to mechanical failure caused by the harsh environment on Mars. A four wheeled rover capable of traversing rough terrain using an efficient high degree of mobility suspension system.

•The need to develop a highly stable suspension system capable of operating in multi terrain surfaces while keeping all wheels in contact with the ground.

•To design a mechanism that can traverse terrain where the left and right rockers individually climb different obstacles.

•To sustain a tilt of over 50deg without tipping over the sideways.

An economical robot which utilizes the Rocker-Bogie linkage, which is also used by NASA's curiosity; to facilitate all terrain movement. The rover has 6wheels with independent motors mounted to the linkage. The electronic components are mounted on a main chassis. The robot also consists of an ultrasonic sensor for obstacle detection and movement commands given through a Bluetooth module. This system is controlled by Arduino chip. The whole system can be run by using a battery connected to a solar plate. It's a working model.

1. INTRODUCTION

A planetary rover is a space exploration vehicle designed to move across the surface of a celestial body. The advantage of a rover over an orbiting spacecraft is its ability to make microscopic observations and conduct physical experimentation. A rover is required to be reliable, compact and autonomous as far as navigation and data acquisition are concerned. NASA's current design uses a two wheeled rocker arm on a passive pivot attached to a main bogie on the opposite side (Bickler, 2004). Miller et al (2002) discussed the need for rovers with higher traversal speeds for future planetary missions. They described a method of driving a rocker bogie linkage which can effectively step over most obstacles instead of impacting them, preventing high dynamic shocks. Barlas (2004) discussed the different types of suspension systems of wheeled locomotion which are required to be simple, lightweight, and have spring-less connections to maintain equal traction and be able to distribute load equally to each wheel and prevent slipping. Tarokh et al. (1999) have described a rigorous method for the kinematic modelling of the Rocky 7 Mars Rover in terms of measured wheel velocities and certain rocker joint angles. Stone (1996) described the design of NASA's Mars Pathfinder and its various subsystems. Patel et al. (2010) have provided the locomotion subsystem analysis of the Exo Mars rover developed by ESA – a 3 bogie concept with flexible metallic wheels, body pose adjustment capability and 6 wheel steering. The paper focused on the suspension mechanism performance and wheel performance with solar energy. Kim et al. (2011) presented an optimal design of a wheel type mobile robot with high stability and excellent adaptability while climbing stairs using the Taguchi model for optimization. Harrington et al. (2004) discussed the design of a lightweight, compact mechanism for the Mars Exploration Rover. It also highlighted the various latch and deployment mechanisms employed.

2. LITERATURE

The concept of our research work is to create a rocker bogie drive system based on those of NASA. NASA developed the rocker-bogie suspension system for their rovers and was implemented in the Mars Pathfinder's and Sojourner rover. The rocker-bogie suspension system passively keeps all six wheels on the robot in contact with the ground even on uneven surfaces. This creates for great traction and maneuverability (Harrington & Voorhees).

The rocker-bogie suspension mechanism which was currently NASA's approved design for wheeled mobile robots, mainly because it had study or resilient capabilities to deal with obstacles and because it uniformly distributes the payload over its 6 wheels at all times. It also can be used for other purposes to operate in rough roads and to climb the steps. It was having lots of advantages but one of the major disadvantages is the rotation of the mechanism when and where is required. The rotation can be possible by providing individual motors to individual wheels which causes arise in cost and complicacy in design. Here an attempt was made to modify the existing design by incorporating a gear type steering mechanism which will be operated by a single motor which simplifies the design as well as the total cost and operating cost of the mechanism.

In this work the proposed steering mechanism was designed and the modeling was done in CATIA (V-5) and the same was analyzed for static analysis for the proposed torque condition of the motor in ANSYS. All the results in the analysis were analyzed for static analysis [1]. The researchers discuss the concept and parameter design of a Robust Stair Climbing Compliant Modular Robot, capable of tackling stairs with overhangs. Modifying the geometry of the periphery of the wheels of our robot helps in tackling overhangs. Along with establishing a concept design, robust design parameters were set to minimize performance variation.

3. MOBILITY

Rocker Bogie Mechanism

The mechanism of the rover is based on a 6 wheeled rocker bogie suspension system. The mechanism allows the rover to traverse different kinds of terrains like rocks, sand and fine dust. The mechanism consists of a pair of rigid linkages on either side of the chassis attached to each other via a passive rotary joint. This joint is constructed by using two tubes, with internal and external threads respectively which allows the links to rotate about the tube's axis. Each linkage consists of two rigid links attached to each other by pivot joint. The front and middle wheels of are attached to the ends of the forward linkage known as the bogie. The rear wheel is attached to the rear end of the rear linkage known as the rocker. The forward end of the rocker is attached to the middle of the bogie and serves as a pivot point. The rocker is attached to the chassis ahead of the rear wheel by the tube arrangement. The advantage of the mechanism is the high degree of mobility. As the rover moves, the wheels are free to move up and down independently of the other wheels and hence can follow the contours of the terrain. It also maintains an almost equal weight distribution on each wheel (Stone, 1996). The bogie only passes a portion of its displacement to the rocker due to the pivot. When the rover encounters an obstacle, the front wheels are pushed against it by the rear wheels. The rotation of the front wheel lifts it up and over the obstacle. The other wheels move similarly. As a wheel encounters an obstacle, it comes to a dead stop. The rover must be operated at very low speeds; otherwise this shock would damage the vehicle frame and/or flip the vehicle (Miller et al., 2002). An important phenomenon observed while testing, was the lifting off of one of the wheels when it slipped and the other wheels maintained traction. This had to be checked otherwise it would flip over a bogie and disable the rover. Mechanical stops were added to limit the maximum rotation of the bogie. For the stability of the mechanism, the center of gravity must lie below the platform.

Obstacle Capability

Obstacle capability is usually compared in terms of wheel diameter. The rover can climb obstacles up to 1.5 times its wheel diameter and climb slopes within 3 degrees of the angle of repose of the soil.

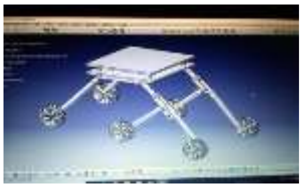


Fig. 1.Catia designed model Fig. 2.Main Assembly of designed model

Material

Initially a flexible plastic was used to construct the links which did not perform well as it deformed excessively when the rover was in motion. It was replaced by a stiffer acrylic board. The tube joint was made of PVC. Wood was used for the platform because of its strength and light weight.

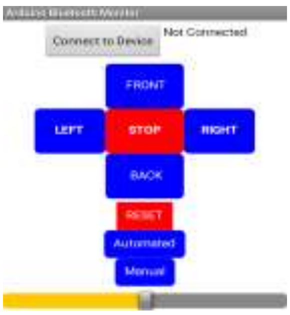
Navigation and Control

The rover's motors and ultrasonic sensors were controlled using an Arduino Uno. Arduino is an open source platform that comes with its own IDE and is significantly simpler to code than many other microcontrollers, as it already has a vast set of libraries available. Hence an Arduino Uno board was preferred over an MSP 430 or other similar microcontrollers.

The motors were controlled using motor driver ICs. The motor driver works on the principle of a dual H-bridge. If the inputs to the motor driver are LOW and HIGH, the shaft rotates in a direction such that the rover moves forward, and vice versa. If both the inputs are LOW (or HIGH) the motor stops, since there is no current flowing through the motor. To turn the rover to the right, the wheels on the right side are made to rotate in the reverse direction and the ones on the left are moved forward. In the opposite manner, the rover is turned left. So the Rover turns about its geometric centre. Due to limited availability of pins on an Arduino Uno board, the controls for the motors on each side were common. The motor controls were lumped so as to reduce the code size and adhere to the code limit of a Uno, which is 16KB.

Autonomous control was the default control state of the rover and can be manually controlled by an override via the app. An Ultrasonic sensor HC-SR04 was used to detect obstacles. The sensor has four pins – trig, echo, Vcc and

GND. Trig emits ultrasonic pulses for 10 microseconds when the pin is set to HIGH. The echo pin is set to HIGH when it receives a pulse. The duration between two successive instances of echo becoming HIGH is measured; and the distance of the obstacle calculated. The rover moves forward by default. When it detects an obstacle in front, it again triggers the left and right sensors, measures the distances of the obstacles to its left and right, and finally moves in the direction in which it has more space. An Android app was used to remotely control the rover via Bluetooth. The app was created using MIT App Inventor, an open source, web based platform. Communication between the rover and the app was established using the Bluetooth module, HC-05. Once the device's Bluetooth is turned on and the 'Connect to device' button is pressed, the app presents a list of visible devices. Upon successful connection, the buttons on screen can be used to control the rover's motion. The slider is used for speed control and is set to a default value, when the app is started up. When a button click is recognized, a string is sent to the serial buffer of the Uno, where it is received by the inbuilt function serial Event. A set of characters is used to detect a button click as well as a termination character to indicate the end of the string. The character corresponding to the button click, say 'F' for front is extracted and the appropriate function is called in the Arduino code. Solar Panel is used to extract the energy from sun even in Mars Rover. It can be run at any place.



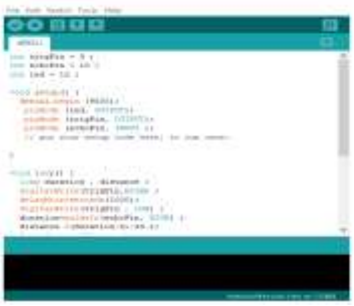


Fig. 3.Bluetooth control Fig.4. Arduino programming

3. CONCLUSIONS

Thus the various subsystems were integrated to construct a fully functional and robust rover.

Future plans for the rover include:

- A more robust design with double bogie arrangement
- Installation of temperature and pressure sensors
- Implementation of path planning algorithms
- Improve path plotting performance for quicker response
- Solar Energy is utilized for running motors.

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