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Terrain Vehicle using Rocker-Bogie Arm Mechanism

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ABSTRACT

The need to develop a highly stable suspension system capable of operating in multi terrain surfaces while keeping all the wheels in contact with the ground. To design a mechanism that can traverse terrains where the left and right rockers individually climb different obstacles. It has the specialty of being able to climb over obstacles twice the diameter of the wheel, that too without compromising the stability of the rover as a whole.
A four wheeled manual wired rover capable of traversing rough terrain using an efficient high degree of mobility suspension system. The primary mechanical feature of the rocker bogie design is its drive train simplicity, which is accomplished by using only two motors for mobility. Both motors are located inside the body where thermal variation is kept to a minimum, increasing reliability and efficiency. A series of mobility experiments in the agriculture land, rough roads, inclined, stairs and obstacles surfaces concluded that rocker bogie can achieve some distance traverses on field.

Key words: Rocker bogie; All terrain Rover; obstacle climbing; rover ;wheels

1. INTRODUCTION

The Rocker-Bogie system has no springs and stub axles for each wheel allowing the rover to climb over obstacles , such as rocks that are upto twice the wheel's diameter in size while keeping all six wheels on the ground. The rocker-bogie system is the suspension arrangement developed in 1988 for use in NASA's Mars rover Sojourner and which has since become NASA's favoured design for rover.[1]
The rocker-bogie suspension system is good at dealing with obstacles and excellent traversability. However, the rocker-bogie based robots must move at a very low average speed to ensure the stability of traveling . In some situations, mobile robots mostly face slightly uneven terrain with rarely significant obstacles on it. This is why we proposed a configuration modification, expanding the span of the rocker-bogie system support polygon to increase the traversability. Nevertheless, when it needs to deal with obstacles, it can switch to its original configuration without losing its native robust capability.
It has been used in the 2003 Mars Exploration Rover mission Robots Spirit and Opportunity the 2012 Mars Science Laboratory (MSL) mission's rover Curiosity and the Mars 2020 rover Perseverance.

The “rocker” part of the suspension comes from the rocking aspect of the larger body-mounted linkage on each side of the rover. The “bogie” part of the suspension refers to the smaller linkage that pivots to the in the middle and which has a drive wheel at each end.[1]

2. LITERATURE REVIEW

2.1 Their robot is built on the Arduino platform for data processing and its software counterpart helped to communicate with the robot to send parameters for guiding movement. For

obstacle detection, three ultrasonic distance sensors were used that provided a wider field of detection. The robot is fully autonomous and after the initial loading of the code, it requires no user intervention during its operation. When placed in unknown environment with obstacles, it moved while avoiding all obstacles with considerable accuracy.[2]

2.2 Autonomous Intelligent Robots are robots that can perform desired tasks in unstructured environments without continuous human guidance. The minimum number of gear motor allows the walking robot to minimize the power consumption while construct a program that can produce coordination of multi-degree of freedom for the movement of the robot. It is found that two gear motors are sufficient to produce the basic walking robot and one voltage regulators are needed to control the load where it is capable of supplying enough current to drive two gear motors for each wheel.[3]

2.3 A robot is a machine that can perform task automatically or with guidance. The project proposes robotic vehicle that has an intelligence built in it such that it directs itself whenever an obstacle comes in its path. This robotic vehicle is built, using Arduino. An ultrasonic sensor is used to detect any obstacle ahead of it and sends a command to the Arduino. Depending on the input signal received, the Arduino redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver. At the same time, we can control steering gear to release the obstacle avoidance function. The robot car uses front axle steering, rear wheel drive arrangement.[4]

2.4 The artificial potential fick (APP) is a relatively mature algorithm that is widely used for its math calculations. However, due to the local minimum problem in this algorithm, the robot cannot achieve the target, so in order to solve this problem, a new method is proposed to remedy this algorithm. The proposed method is simulated in the MATLAB environment. The results of simulation evaluations show that in the modified artificial potential field algorithm, the robot can pass obstacles around the target without collision and reach the target.[5]

2.5 Their project proposes an autonomous robotic vehicle. In it no remote is used for controlling the robotic actions. It intelligently detects obstacles present on its path through the sensors, avoid it and take decision on the basis of internal code that we set for it. A micro-controller (AT mega 8) is used to achieve the desired operation. An ultrasonic sensor is used to finds any obstacle ahead of it and sends a command to the microcontroller. Depending on the input signal received, the micro-controller changes the direction of the robot by actuating the motors which are interfaced to it through a motor drive.[6]

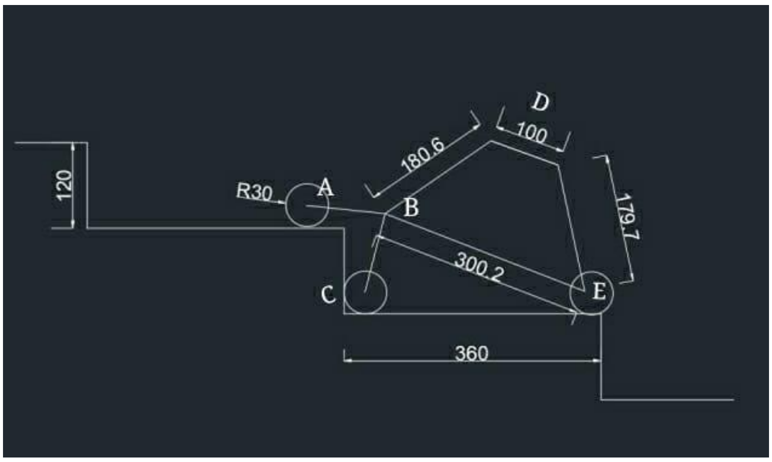
2.6 A robotic vehicle is one that is able to intelligently detect obstacle on its path and avoid it. This was done using the Ultrasonic and proximity sensors to detect obstacles, motor driver for the driving the DC motors, and DC motor is used for the movement of the robot with the help of the Arduino Microcontroller. The Arduino platform for data processing and its software counterpart on C programming language helped to communicate with the robot to send parameters for guiding movement. The result presented an accurate and efficient detection of obstacles and its manuvering in order to assist vehicle driving.[7]

2.7 This paper proposes arobotic Robot with an intelligence built into it that guides itself whenever an obstacle comes along its way by bug algorithm. This robotic Robot is constructed using AT mega 8 families micro-controller (Arduino Uno R3). The ultrasonic sensor is used to detect any obstacle with edges and sends a command to the microcontroller. The micro-controller, based on the received input signal, redirects the robot to push in an alternative direction by actuating the motors that are interfaced with it via a motor driver. Depending on the situation the robot is able to choose the correct path. Decision making process of obstacle avoiding edge detection occurs spontaneously here. This robot was designed to think about its day-to-day potentialities.[8]

2.8 The robot was able to produce the basic walking movements using DC motors with a very good intelligence, capable of sensing obstacle, and perfectly avoid obstacles on its path at a distance range of 30cm. The robot uses the left, right, forward and backward movement to avoid the obstacle, either autonomously or using the control application. The accuracy recorded from several testing trials, showed that the robot performed excellently scoring 87.5%, considering the scope under which it was examined. [9]

3. DESIGN OF ROCER BOGIE

AutoCAD is a computer-aided design (CAD) and drafting software application created by the company Autodesk. A range of professionals like architects, city planners and graphic designers use it. AutoCAD has become one of the most widely used CAD programs worldwide. The software allows you to draw and edit 2D and 3D designs more efficiently. Corrections and edits can be time-consuming while working by hand on a physical medium. You can access easily AutoCAD designs from anywhere as the software also provides cloud integration.
Due to which we decided to make our model in “Autodesk AutoCAD 2022 Software” which really helped



us to make 2D designs as following

Fig. 3.1 AutoCAD design dimensions of Rocker bogie

Naming and design of rocker-bogie in 2D are noted in following figure 3.2

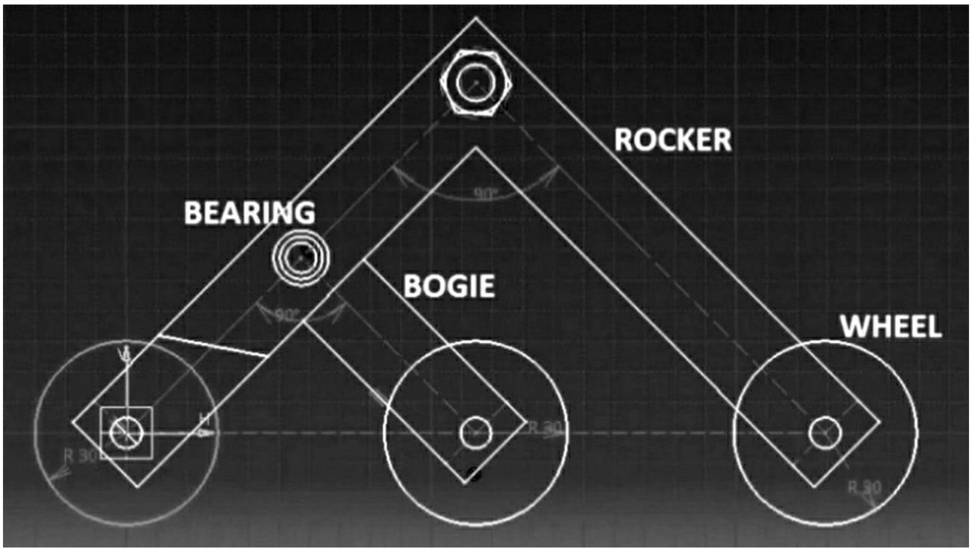


Fig. 3.2 AutoCAD 2D Sketch from side view

The 3D design and fabrication of rocker-bogie from top and front view are as following

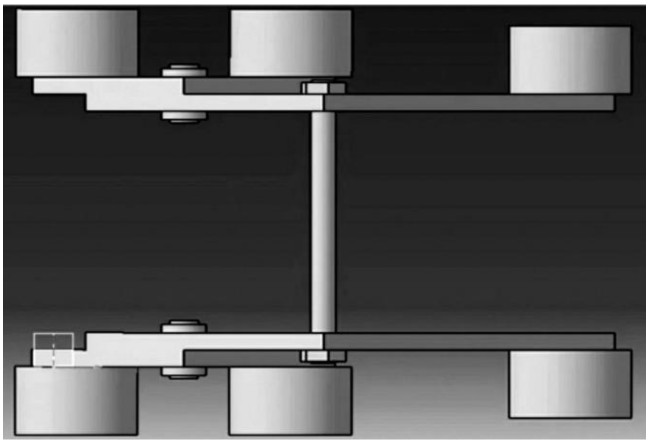


Fig. 3.3 Top view.

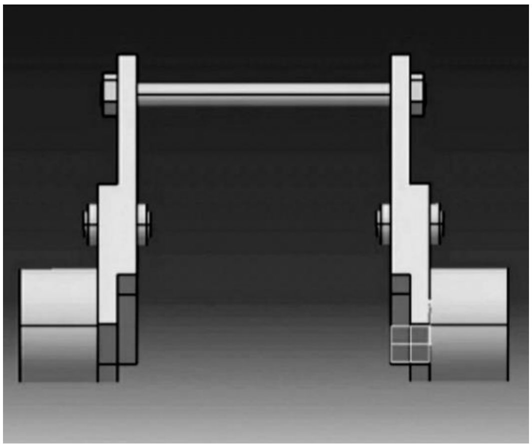


Fig. 3.4 Side view

When engineers design, they have to do 2D drawings to show what the object will look like from each side. These drawings are called plans and elevations.

- •Front view = Elevation (The views from the front and sides are called the elevations)
- •Top view = Plan (The view from the top is called the plan)

Design Calculation of arm -

By pythagoras theorem,

$$AC=155mm$$

AB= x =BC

$$AC^2 = AB^2 + BC^2$$
$$155^2 = x^2 + x^2$$
$$155^2 = 2(x)^2$$
$$x = 109.6 \text{ mm} \sim 110\text{mm}$$

AB=BC=110mm

Again, BD= y =DE

In triangle, BDE

$$BE^2 = BD^2 + DE^2$$
$$300^2 = 2y^2$$
$$y = 212.13$$
$$BD = DE = 212.13\text{mm}$$

We used an 3 meter PVC pipe and 90 degree 6 PVC jointer and 120 degree 4PVC jointer to join the frame of rocker bogie. And six 3-6V geared TT magnetic motor of 200 grams per motor with 30 rpm and Amptex battery with 6V and 4.5 Ah

3.1 DESIGN CALCULATIONS

A. Power required for the motor

$$P = VI \text{ (watts)}$$
$$= 6 \times 1$$
$$= 6 \text{ W}$$

B. Torque required for the motor

$$P = 2\pi NT/60$$
$$T = 60 \times P/2\pi N$$
$$= (60\times6)/(2\pi\times16.55)$$
$$= 3.4619 \text{ N-m}$$
$$= 3461.9 \text{ N-mm}$$

3.2 DESIGN AND SELECTION OF WHEEL

Design of wheel is required at velocity of 0.05 m/s. Speed is 16-30 rpm motor. Using velocity relation velocity is calculated for assumed speed. Using calculated velocity value need to find out diameter of wheel is 65 mm. Hence, we select the wheel of 65 mm diameter (standard wheel). Selection of rubber thread bonded to the wheel makes it light weight and durable, provides excellent traction and friction. These high strength plastic wheels offer a low cost solution that is durable enough for a combat robot yet still light enough to be practical. For robot used six wheels.

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Wheel Diameter: 65 mm

Wheel Width: 30 mm.

Fig 5.1 Rubber coated Wheel

Selection of acceleration for robot. For a typical robot on flat terrain, it's needed to take acceleration about half of maximum velocity. Maximum velocity of robot is 0.05 m/s2. Hence the acceleration of robot will be 0.05/2 means 0.025 m/s2

This means it would take 0.2 seconds to reach maximum speed. If robot is going up inclines or through rough terrain, you will need a higher acceleration due to countering gravity. We needed to climb the angle upto 45˚. Hence,

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Total Acceleration = 0.025+0.121 = 0.046.

4. PERFORMANCE IN DIFFERENT TERRAIN CONDITIONS AND SCOPE

As per the ground level experimentation by rocker bogie arm mechanism manufactured; tests found that the performance of rocker bogie satisfactory .

As modular research platform the rover developed by this project is designed specifically to facilitate future work. With the development in technology the rover can be used for reconnaissance purposes with the cameras installed on the rover and minimizing the size of the rover. With some developments like attaching arms to the rover. It can be made useful for the bomb diffusing squad such that it can be able to cut the wires for diffusing the bomb. By the development of a bigger model it can be used for transporting man and material through a rough terrain or obstacle containing regions like stairs. We could develop it into a wheel chair too. It can be send in valleys, jungles or such places where humans may face some danger.

Following are the result are shown see fig. 6.1 and fig 6.2 on different obstacle and different terrain

environment.

Fig. 6.1 Inclined climbing at 60.

Fig 6.2 Stair climbing

5. CONCLUSION

This work shows how rocker bogie system works on different surfaces. As per the different weight acting on link determines torque applied on it. By assuming accurate stair dimensions, accurately dimensioned rocker bogie can climb the stair with great stability. The design and manufactured model can climb the angle up to 45˚.

It really have a good future scope, one of the main problems of this rover is the limitation offered by the battery power and motor power.When these limitations are answered by using solar panels to charge the battery and mobile data cards for internet connectivity, the rover can be made operational in real time and can be left in a remote terrain for continuous operation. With higher computing electronics, a higher level of autonomy can be given to the rover in navigation by using GPS modules and path planning algorithms. Devices and subsystems like autonomous robotic arm, stereo camera and various useful sensors can also be attached to the rover to further enhance its functionality.

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