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Helix

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ABSTRACT

Helix is a rover based on the principle of a suspension system. The rover is developed with a highly stable suspension system capable of operating in multi-terrain surfaces. The rover can sustain a tilt of over 50 degrees without flipping over the sideways. The rover can be also rotated in left or right direction for better controllability. A six-wheeled rover capable of traversing rough terrain using an efficient high degree of mobility suspension system has been chosen for the purpose. Six motors are located inside the body where thermal variation is kept to a minimum, increasing reliability and efficiency. Six wheels are used because there are few obstacles on natural terrain that require both front wheels of the rover to climb simultaneously. A camera and appropriate sensors are also mounted in the rover. In case of any variation in surrounding of the working area, the rover can alert the authority for the safety of the workers. With the implementation of rover in mining industries, we can surely say that many lives can be saved.

Keywords— Rocker bogie, Terrain, Stair climbing; Rover; Mining, Sensors

1. INTRODUCTION

Mining accidents occur in the process of mining metals or minerals. Thousands of miners die from mining accidents each year, especially in the process of coal mining and hard rock mining. Most of the deaths today occur in developing countries, especially China. China's coal mines are the world's deadliest, killing an average of 13 miners a day. China accounts for the largest number of coal-mining fatalities, about 80% of the world's total, although it produced only 35% of the world's coal. So we aimed to create a rover that is specially used in mining areas to prevent the deaths of miners due to hazardous gas leakage, extremely high temperature, poorest air quality and many more. The rover created to keep in mind the ways to ease the working of miners and to avoid the death of them.

The term "rocker" comes from the rocking aspect of the larger links on each side of the suspension system. These rockers are connected to the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the other goes down. The chassis maintains the average pitch angle of both rockers. One end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie. 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 tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks. When building a robot, you'd like it to be as simple as possible. In most cases, you'd never need a suspension system, but there were several instances when a suspension system cannot be avoided. Both applications now prefer trailing arm suspensions. The rocker-bogie design has no springs or stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that is up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity.

The rover is further enhanced with the automatic lighting system, camera and sensors to look after the changes in the environmental conditions and alert the local authorities about any hazardous conditions like fire, gas leakage, etc. The automatic lighting system is the system where photo resisters are used to sense the luminous intensity of the surrounding area. A camera has also setup in the bogie to live-cast or record the mining area in which the rocker-bogie is being used.

2. LITERATURE REVIEW

The motive the research initiation was to understand mechanical design and the application of Rocker- bogie suspension system in areas of mining. Hence, the concept of our project is to create a rocker-bogie drive system based on those of NASA that can be used in mining. The rocker-bogie suspension system passively keeps all six wheels on the robot in contact with the ground even on uneven surfaces. 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 on 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 has also been implemented to provide the change in the direction of the rocker-bogie. The rocker-bogie suspension-based rovers

has been successfully introduced for the Mars Pathfinder and Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions conducted by apex space exploration agencies throughout the world. The proposed suspension system was currently the most favored design for every space exploration company indulge in the business of space research.

The most common accidents occurring in the mining industry are the result of poisonous or explosive gases or mishaps relating to the use of explosives for blasting operations. Some of them include:

- Methane and coal dust explosions: Methane and coal dust explosions have caused the largest mining disasters in history and frequently kill or trap underground miners. The tragic Courrières accident, the worst ever mine disaster in Europe, was directly caused by methane and dust. It caused the death of 1,099 miners in Northern France on March 10, 1906. Therefore, a gas sensor is used to detect the amount of methane gas present in the atmosphere of mine.
- Mine-Induced Seismicity: Especially dangerous in underground mining areas, mine-induced seismicity also causes slope instability in surface mining, and is a major threat for all miners. Therefore, the rocker-bogie mechanism has been used.

Important fields of application are homeland security, surveillance, demining, reconnaissance in dangerous situations, and agriculture. The design of the locomotion systems of mobile robots for unstructured environments was generally complex, particularly when they were required to move on uneven or soft terrains, or to climb obstacles. The three main categories of locomotion systems (wheeled – W, tracked – T and legged – L) and the four hybrid categories that can be derived by combining these main locomotion systems were discussed about maximum speed, obstacle-crossing capability, step/stair climbing capability, slope climbing capability, walking capability on soft terrains, walking capability on uneven terrains, energy efficiency, mechanical complexity, control complexity, and technology readiness.

3. DESIGN

3.1 Design of rocker-bogie

The important factor in the manufacturing of the rocker-bogie mechanism is to determine the dimensions of rocker and bogie linkages and angles between them. The lengths and angles of this mechanism can be changed as per requirement. In the work, the aim is to manufacture the rocker-bogie mechanism which can overcome the obstacles of 15 cm height (like stones, wooden blocks) and can climb over stairs of height 15 cm. Also, another target is to climb any surface at an angle of 45˚. To achieve the above targets we had design the rocker-bogie model by assuming stair height 15 cm and length 37 cm. Using the Pythagoras theorem, find the dimensions of the model. It has both angles of linkages are 90˚.

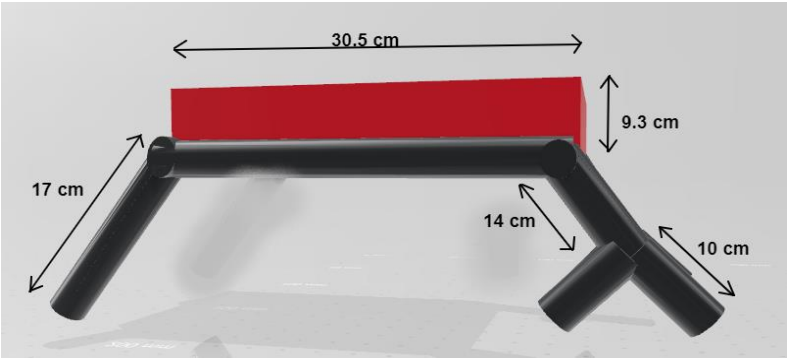

Fig. 1: Dimensions of rocker-bogie

3.2 Design of Wheels

The design of the wheel is required at velocity up to 0.5m/s. Assume speed is 60-100 rpm motor. Using velocity relation velocity is calculated for assumed speed. Using the calculated velocity value need to find out the diameter of the wheel is 95.35 mm. Hence, we select the wheel of 100 mm diameter (standard wheel). The selection of rubber tread bonded to the wheel makes it lightweight and durable, provides excellent traction friction. These plastic wheels (as shown in Fig. 5.) 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.

Wheel Diameter: 100 mm
Wheel width: 20 mm
Shaft Diameter: 6mm

4. COMPONENTS

The following sensors have been used in the rocker-bogie:

4.1 Flame sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection. It is much more efficient than a smoke or heat sensor. It is used for detecting the flame or fire outbursts in the workplace in any condition. It is enhanced with a buzzer to alert the authorities in case of fire outburst.

4.2 Gas sensor (MQ-4)

This is a sensor, suitable for sensing natural gas (composed of mostly Methane [CH4]) concentrations in the air. In our rover MQ-4 can detect natural gas concentration of 400 ppm; if concentration increases beyond this the red light will glow indicating the increased concentration.

4.3 Temperature and Humidity (DTH-11) sensor

DHT11 is a low-cost digital sensor for sensing temperature and humidity. The temperature range of DHT11 is from 0 to 50 degrees Celsius with 2-degree accuracy. The humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz. i.e. it gives one reading for every second.

4.4 LDR (Light Dependent Resistor)

It is used to enhanced rover with the automatic lighting system. LDR is connected to lights of the rover; it turns on and off the lights by sensing the luminous intensity of the surrounding with the help of relay.

4.5 Bluetooth module (HC-05)

The Bluetooth module has been used to provide the readings of the sensors directly on the smartphone. This module helps in providing readings to the operator rather than on an LCD screen which was mostly seen in older rocker-bogies.

These entire sensors are interfaced with the Arduino (Atmega-326) and are also used to show the readings of these sensors directly on any connectable device, such as smartphones, laptops, etc. The rover is also backed with a camera for monitoring the activities in the workplace and guiding the rover to the desired location.

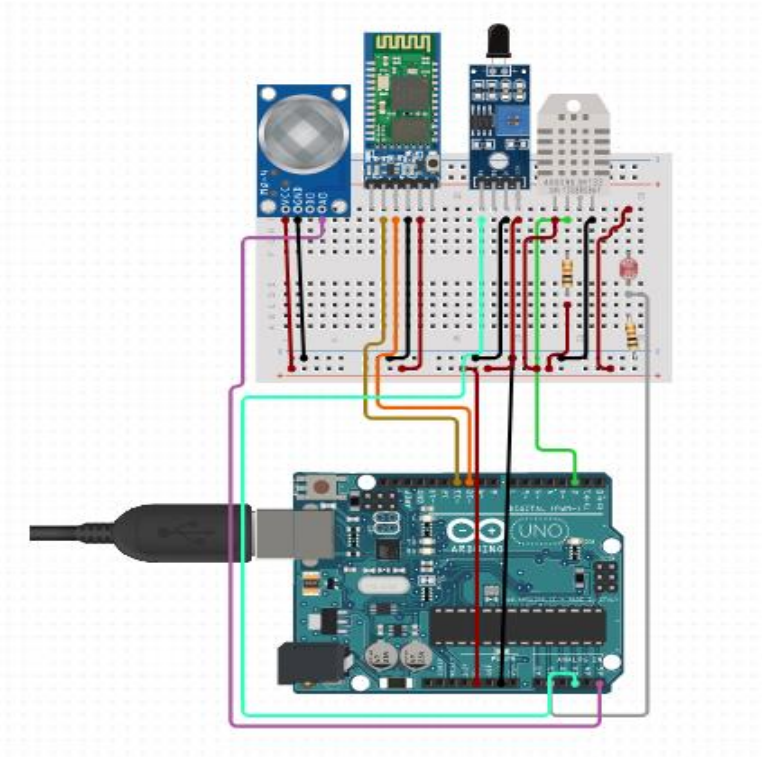

Fig. 2: Circuit Diagram of sensors with Arduino

5. WORKING PRINCIPLE

The rocker-bogie design consisting of no springs and stub axles in each wheel which allows the chassis to climb over any obstacles, such as rocks, ditches, sand, etc. that are up to double the wheel's diameter in size while keeping all wheels on the ground maximum time. As compared to any suspension system, the tilt stability is limited by the height of the center of gravity and the proposed system has the same. Systems employing springs tend to tip more easily as the loaded side yields during the obstacle course. Dependent upon the center of overall weight, any vehicle developed based on Rocker bogie suspension can withstand a tilt of at least 50 degrees in any direction without overturning which is the biggest advantage for any heavy loading vehicle. The system is designed to be implemented in low speed working vehicles such as heavy trucks, Bulldozers which works at a slow speed of around 10 centimetres per second (3.9 in/s) to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

RF technology has been used to control the movements of the rover. By using the push buttons of the transmitter, we can send commands to the receiver for controlling the movement of the wireless robotic vehicle. The receiver and two motors used for movement of the robot are interfaced to the microcontroller of the robotic vehicle. The transmitter encodes the input commands given by the controller and transmits the encoded data using radiofrequency. This encoded data transmitted from the RF transmitter is received by the receiver at the receiving end, which is connected to the robotic vehicle. The receiver consists of an RF antenna designed to work over an adequate range of 20 meters. This, receiver after receiving the data from the transmitter, decodes the data and sends it to another microcontroller for driving the DC motors using a motor-driver IC to move the robotic vehicle.

Moreover, we have assembled some sensors like temperature and humidity sensor (DTH11) for observing the change in the temperature and humidity of the surrounding, Methane gas sensor (MQ-4) is used for detecting the methane content in the air, Flame sensor for detecting of fire. In any sudden increase or decrease in the reading of the sensor, the rover will alert the authorities regarding the conditions of the workplace. The automatic lighting system is the system where photo resisters are used

to sense the luminous intensity of the surrounding area. The rover is also backed with a camera for monitoring the activities in the workplace and guiding the rover to the desired location.

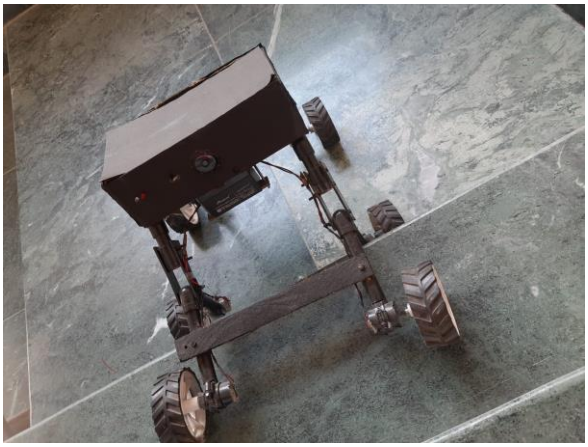

Fig. 3: Helix in action

6. FUTURE SCOPE

According to today's scenario, the artificial intelligence systems are used on a day to day basis in our daily life, it is not wrong to say that our lives have also become advanced with the use of this technology. So we would like to implement this technology in our rover. With the help of artificial intelligence, the rover can work according to the operator as well as on its own. Hence, with this technology, the face of the mining industry can be changed and lots of lives can be saved from the hazardous conditions of this type of industry. 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 rather than in mining fields only. 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.

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