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Research Paper

PORTABLE TRACK SUSPENSION ROBOT WITH ARM

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Tracked locomotion offers superior mobility characteristics over wheeled or legged vehicles for locomotion in unstructured environment. Design of track suspension robot with arm deals with a tracked robot with suspension capable of moving on any terrain specially designed for military purpose and rescue operations in remote areas.

Keywords: Track, Suspension, Arm

INTRODUCTION

Tracked robots have great importance in the field of robotics. Tracked robots have a larger ground contact surface than wheeled vehicles and are more stable than bipeds due to their low centre of gravity. Derived the fundamental dynamics of the stair-climbing process for a tracked robotic element, analyzing the different phases of riser climbing, nose crossing, nose line climbing and the effects of grouser. A mechanism is a combination of rigid or restraining bodies so shaped and connected that they move upon each other with definite relative motion. A machine is a collection of mechanics. The robot that we have designed comes under wheeled robot with two modes of running which are specified below, most of them are confined to certain application or terrain, the track robot we designed is capable of moving in any field with suspension system and an arm which is used to pick and place objects.

Table 1: Specifications

1.	Robot Mass	2500 g
2.	Load Mass	750 g
3.	Effective Leg Stiffness	6000 N/m
4.	Effective Load Suspension Stiffness	21 N/m

ROBOT FRAME

The robot frame design was based on materials that were readily available. The main hull construction was made with HIGH-LAM sheet joint having bolts like the one shown below. The benefit of these is the multiple holes that allow adjustments to be made on the fly. Flat jointers along with angled brackets form

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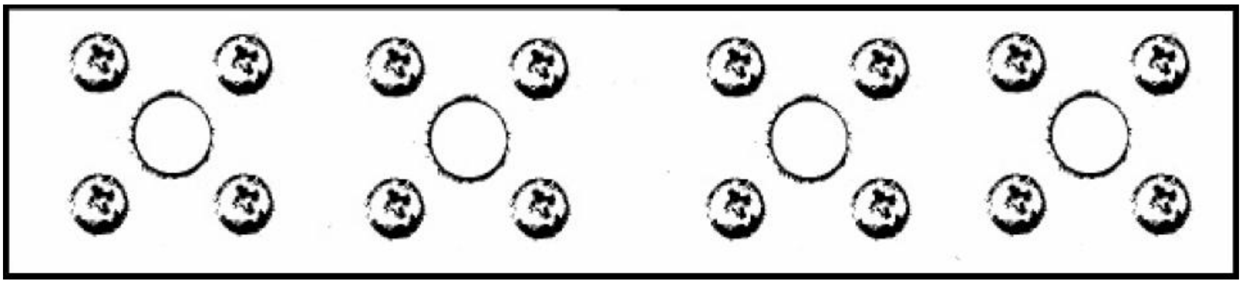
Figure 1: Robot Frame



the rectangle shape of the hull that is strong enough to support the motors, tracks and electronics. The frame size is 28 x 47 cm while the complete robot footprint is 40 x 47 cm. The robot has a layer of high-lam sheet built on top. The layer accommodates the motors, electronics and batteries. The camera is attached on its own raised support bracket.

To join the two hylam sheets on both sides we used three pieces of aluminum by fixing them with bolts and nuts. The dimensions of bolts are 30 mm long and 6 mm diameter.

POWER TRANSMISSION

The power required for the motion of robot is drawn from a battery and transmitted to a D.C motor and and tracked belt. 6 motors with 12V 2A rating and 5 kg torque are used on either sides for linear motion.Belts are the cheapest utility for power transmission between shafts that may not be axially aligned. Power transmission is achieved by specially designed belts and pulleys. The demands on a belt drive transmission system are large and this has led to many variations on the theme. They run smoothly and with little noise, and cushion motor and bearings against load changes, albeit with less strength than gear or chains. However, improvements in belt engineering allow use of belts in systems that only formerly allowed chains or gears. Power transmitted between a belt and a pulley is expressed as the product of difference of tension and belt velocity:

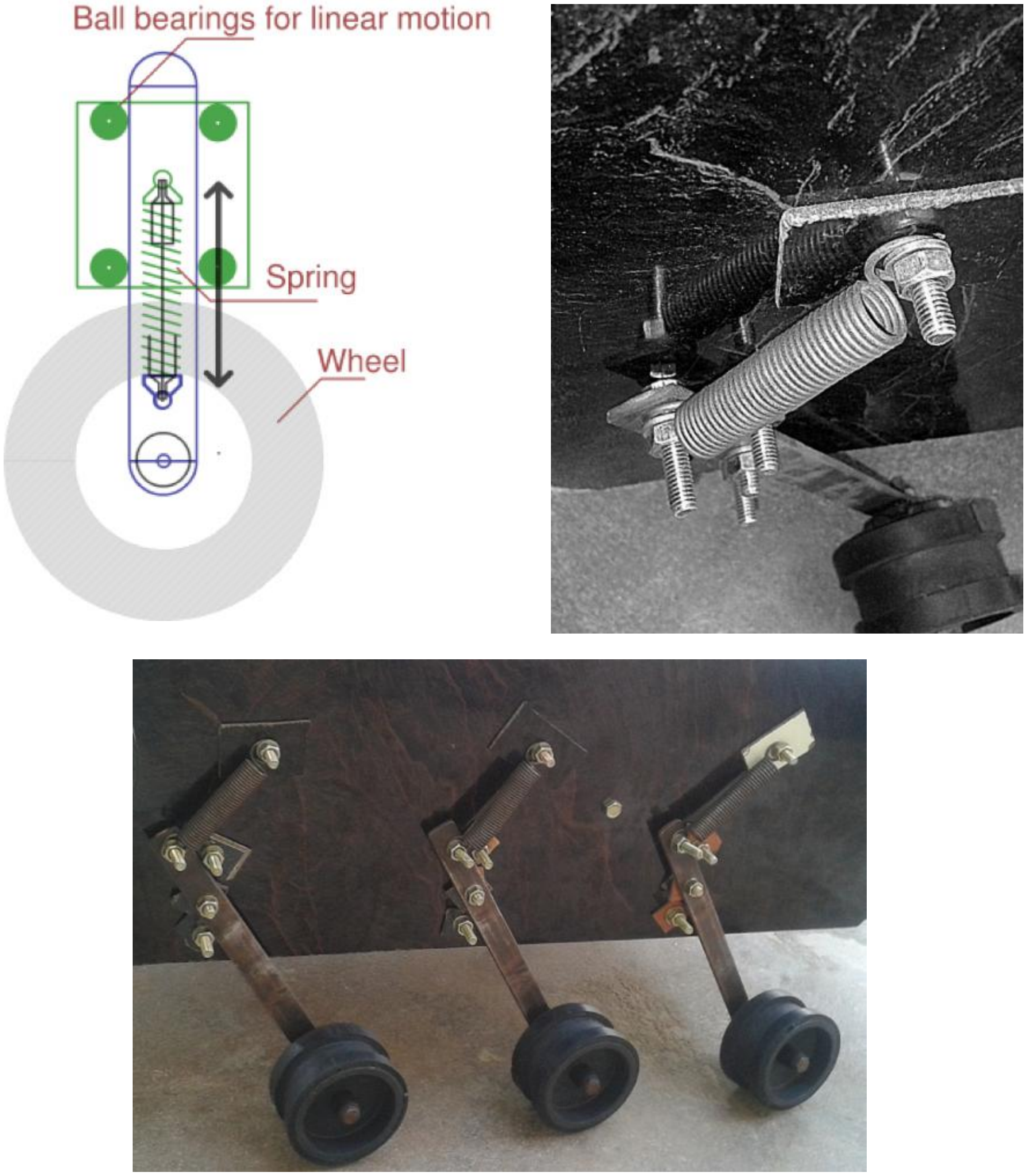
$$P = (T_1 – T_2)v$$

SUSPENSION

Since the first version of the robot design, the parts that underwent the most design iterations were the tracks and the suspension. These two parts define the whole locomotion properties of the robot. Slippage, current draw, vibrations, etc. are heavily dependent on the track pads and tension of the track. Below are the three types of suspensions that were built for the robot. The first one is a CAD representation of what is shown in figure 42 on the left. This

Figure 2: Belt Used for Transmission

Figure 3: Showing Spring Suspension System on the Robot



was the first attempt to equip the robot with a suspension. This implementation, although operational, was not optimal. It had problems such as difficulty dealing with forces applied to the wheel at various angles other than vertically. Another issue was the narrow error margin of the placement of the bearings making it difficult to duplicate the same design and behavior.

The second design was of an angled short arm carrying the wheel and 90 degrees away, a coil spring was placed to push the wheel down. The spring used was an extension spring that was perfect for absorbing most vibrations. This design was adequate for the task. The only minor issue was that the extension of the spring could not be adjusted more than a few Newton per meter. So we used stoppers on both sides of the arm to restrict it.

DEGREES OF FREEDOM AND MOBILITY

In mechanics, the Degree Of Freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration. It is the number of parameters that determine the state of a physical system and is important to the analysis of systems of bodies in mechanical engineering. The mobility and degrees of freedom for our track robot design

$M = 6n = 6(N - 1)$

$n = 1, N = 2$

$M = 6 \times 1 = 6$

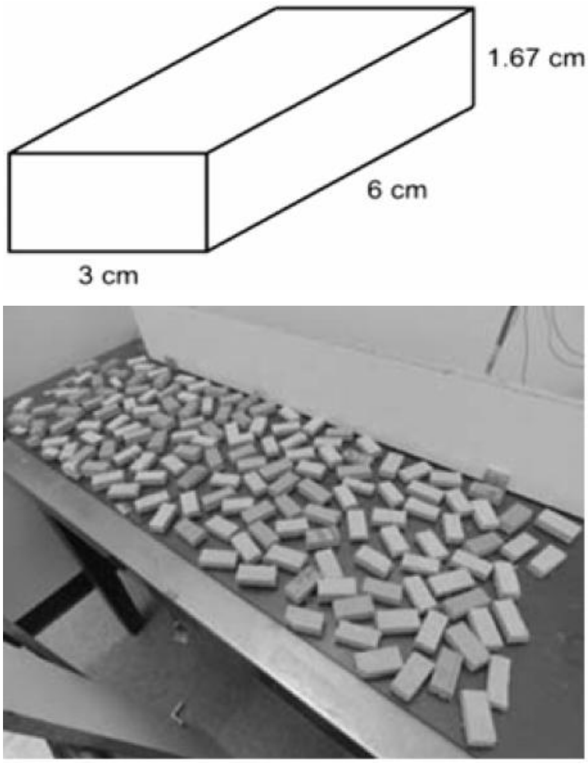
Which are one degree of freedom joints, have $f = 1$ and therefore $c = 6 - 1 = 5$.

EXPERIMENTAL METHODS

Rough Terrain

Rough terrain was simulated by randomly distributing and fixing about 150 foam pieces on a plastic track that measured 142 cm long by 47 cm wide . Each foam piece was about 3cm wide by 6 cm long by 1.67 cm high. Since the highest clearance of the robot was about 1.5 cm, these pieces were chosen to represent significant obstacles for the robot to surmount. The foam pieces were cut from a large foam block and each piece was quite stiff so no significant deformation occurred while the robot ran over the track.

Figure 4: Experimental Setup Rough Terrain



EXPERIMENTAL SETUP

The power and speed of the robot with a rigidly-attached load versus an elastically-suspended load was measured to compare the relative mobility of the robot in each configuration. To determine power, the voltage across the motor terminals of the robot was measured with an ADC and the current flowing through the motor was measured with a hall-effect sensor. An analog low pass filter was used to reduce measurement noise and the robot was powered by a regulated power supply at a constant voltage during each trial. The data was sampled at 1 kHz using a USB4 DAQ. The first 0.75 seconds of data were ignored to remove the initial power spike from the comparison. The robot was started from the same point and the legs were checked for the proper alternating tripod configuration before every trial. To measure the speed of the robot in each configuration, a laser trip wire at the end of the track was used to stop the data collection, yielding the time the robot took the traverse the known track distance. High-speed video was also taken at 240 fps to qualitatively observe the dynamics of the system in each configuration. We also sought to determine the effect of the rough terrain height on themobility of the robot over rough terrain. The average power and speed of the robot was measured while running it for 10 trials over a short track with flat ground and varying obstacle heights. Multiple thin books were stacked on top of each other to simulate increasing rough terrain height (Figure 3). Although the track length was shorter, thepowerandspeed of the robot was measured using the samemethod discussed previously.

Figure 5: Experiment Setup 1

Figure 6: Experimental Setup 2

The speed and power of the robot was measured while running over flat ground (not shown), an 8 mm tall obstacle (top left), a 17 mm tall obstacle (top right), a 23 mm tall obstacle(bottom left), and a 31 mm tall obstacle (bottom right) to determine the effect of terrain height on the robot's mobility. The 31 mm tall obstacle proved to be too tall for the robot to reliably surmount.

END EFFECTORS

In robotics, end effectors are a device at the end of a robotic arm, designed to interact with the environment. Gripper is an end effectors or tool to grasp any physical thing that may be a human hand or any instrument. A DC motor is used using spur gears and a threaded shaft arrangement.The gripper can perform the basic function of picking, holding and grasping of irregularly shaped object. Our Project Aims To Build A Prototype of robotic arm with gripper and end effectors for spot welding, the various objectives of the prototype is as follows:

- Having a rigid mechanical structure.
- Ability to move each parts at define angle.
- Optimum power consumption.
- To pick the material in jaws and join itself by means of spot welding mechanism.

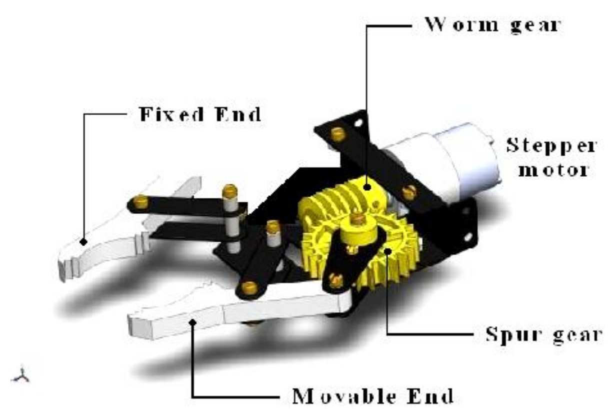
Description of arm manipulator

Material: Plastic

Weight: 30 × 2 = 60 gm for big arm 10 × 2 = 20 gm for small arm.

Length: 60 cm for big arm 20 cm for small

Figure 7: Wrist and End-Effectors



DESCRIPTION

- A spur gear meshing with a worm gear.
- 30 rpm DC motor.
- Two end effectors both are movable.

Their most popular use is the establishment of video links, permitting computers to act as video phones or video conference stations. Other popular uses include security surveillance, computer vision, video broadcasting, and for recording social videos.

Webcams are known for their low manufacturing cost and flexibility, making them the lowest cost form of video telephony. They have also become a source of security and privacy issues, as someXbuilt-in webcams can be remotely activated via spyware.

Design of Gripper Links

The object to be lifted is: Metal Plates Weight of the object: 50-80gm

The link has two parts, Part 1 and Part 2.

The Arm manipulator has length as follows:

Design of Shaft

Length of shaft: 24 mm Torque (T): 42 N-m

Tangential force on gear = 2T/D (D: Diameter of gear)

= (2 x 42)/0.025 = 3360 N

Twisting moment (Te) = 47.18 N-m

Normal load acting on tooth on gear: Ft/cos20 = (3360/0.937) = 3585 N

Maximum bending moment (M) = WL/4 = (3585 x 0.025)/4

= 21.51 N-m

Power and Torque Transmitted

Voltage: 12 v

Current: 7.2 amp

Speed: 10 rpm

Power transmitted VI

P = (12 x 7.2) = 86.4 watt

CALCULATION

Torque = (P60)/2®*N* = (86.4 x 60)/(2® x 20) = 65 N-m

Figure 8: Final Design of Tracked Robot

CONCLUSION

The mobility of Track robot locomotion over rough terrain could be increased by elastically-suspending part of the inherent mass of a legged robot with a compliant suspension system and decoupling the vertical motion of the load from the vertical motion of the robot chassis. This has numerous potential applications for legged robots because batteries, electronics, fuel, vision systems, or sensitive components could be elastically-suspended from the robot body to increase the mobility of tracked robot.

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