Optimization of Step Climbing Robot

Pratik G. Patil[1], Prof. S.R. Shekokar[2]

[1]Student, Department of Mechanical Engineering, Padmashri Dr. V.B. Kolte College of Engineering, Malkapur, Buldhana Dist, Maharashtra, India

[2]Assistant Professor, Department of Mechanical Engineering, Padmashri Dr. V.B. Kolte College of Engineering, Malkapur, Buldhana Dist, Maharashtra, India

ABSTRACT

According to present scenario robotics is one of the most common technique of atomization to reduce human efforts, as it tends to save time & to increase throughput in several applications. For the robot dedicated to plain surface for controlling the movement in left right & forward backward directions various methods have been developed but for applications such as stair climbing these traditional robots has limitations, so for applications such as stair climbing various techniques are developed like wheeled robots, legged robots and tracked robots. The major shortcoming of these robots is they aren't adjustable according to the structure of stairs. To solve this problem following paper focuses on implementation of an adjustable stair climbing robot. Present mobility designs are complex, using multiple wheels or legs. Rover having six wheels, capable of navigating rough terrain using a mobility suspension system which has high efficiency and is of high degree. The primary mechanical feature of the stair case climbing robot design is its simplicity. This is accomplished by using six motors for mobility. The primary application of these robots is to carry required material on the platform during fire rescue operations.

Keywords: - Stairs climbing robot, Six wheeled rover, Wireless remote, Medical application, Arduino Mega 1280/2560.

1. INTRODUCTION

In manufacturing plants and automated warehouses, automated guided vehicles (AGV) are mainly used. The AGV are vehicles designed primarily to carry pallets with components or products from one place to another during movement on a level floor. In most cases they move along a guided path, however, highly advanced AGV are free ranging, therefore they have a wider range of tasks. In addition, advanced AGV can communicate with one another. Most AGV are three or four wheeled platforms with base dimensions proportional to the height and weight of their maximal load for stability reasons, a fact that puts limits on their ability to travel in crowded areas and narrow corridors and passageways.

The complexity of the modern manufacturing floor needs a robot to have high manoeuvrability while being able to overcome obstacles such as a single step or two, and in some cases an entire staircase. These are ironic requirements, since manoeuvring a crowded and narrow environment requires petty robots, while overcoming obstacles such as stairs requires comparatively bigger robots.

On the basis of a locomotive mechanism to achieve the desired mobility, mobile robots may be subdivided into the following categories: leg-type, track-type, and wheel-type mobile robot, consumption is also an important matter of development. Stair climbing robot is one of the better performances of robot in the category of legged and wheeled robots. Developments have been made in several kinds of stair climbers, considering how to make its climbing ability higher and lower its mechanical complexity and practical. We introduce some solutions to realize stair climbing machines that we developed. Each of them has notable performance as in a category of their similar robots, e.g. various numbers of wheeled shapes. Then, we discuss a development of adjustable high grip mover, which we think as one of the most favourable solutions as the stair climber.
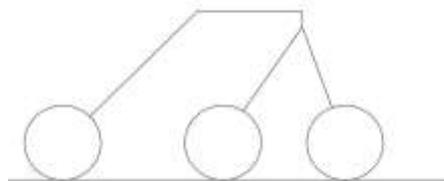
2. WORKING

Fig.1 Line Diagram of Robot (While on a Horizontal Surface)

In the end of riser climbing process, when the vehicle's front part overcomes the stairs nose, the vehicle will cross the riser gradually.

When the front part overcomes the riser nose, the centre of mass will move upward gradually until the limit.

Two kinds of result will come.

1) The centre of the mass overcomes the riser nose and the robot climbs upon the platform or the tread, thus riser crossing has been finished.

2) The centre of the mass rises vertically but cannot overcome the riser nose, which may lead to overturn of the vehicle. Thus riser crossing fails.
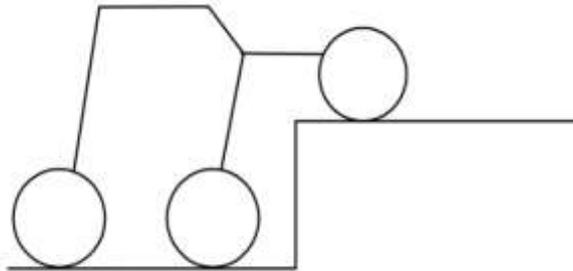

Fig.2 Line Diagram of Robot (While climbing a Step)

The tracked robot's riser climbing is in the same manner as the tank vehicle's vertical wall climbing. Riser climbing is a complicated dynamics process although research in literature has been paid more on the static forces instead of the dynamic forces.

On the other hand, the ground driving friction coefficient changing from 0.6 to 0.95 is larger than the value in standard conditions. So a single module vehicle has limited riser climbing mobility if without extern force.

3. EXPERIMENTAL INVESTIGATION

Fig.3 Four Wheel Robot with Artificial Intelligence

Two Sets of Experiment performed:-

In first, several robots were used to transport a load together similar to which the ants cooperate to carry heavy prey to their nest.

In the second, an automated decision whether the robot can perform a task on its own or needs to cooperate with other robots.
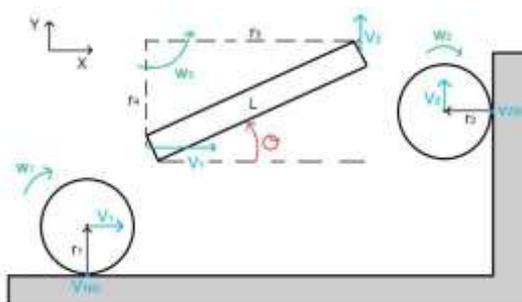
3.1 System Model :-

Fig.4 Kinematic Scheme of Robot While Climbing Stairs

w1, w2, w3 – Angular velocities of each body (rad/sec)
r1, r2, r3, r4 – distance as marked (m)
L – Length of connecting arm (m)
V1, V2 – linear velocities of the wheels centres (m/sec)
Θ – Arm angle with horizontal surface (degree)
V1(0), V2(0) – velocity at the wheels contact point (m/sec)

Kinematic analysis shows that the required relation between the front and the rear wheels' angular speeds that would allow no slip is w1 = w2 x tanΘ. The kinematic model describes the relation between the rotation speed of the front and the rear wheels as a function of the climbing angle. Fig. 2 describes the kinematic model of the connected robots.
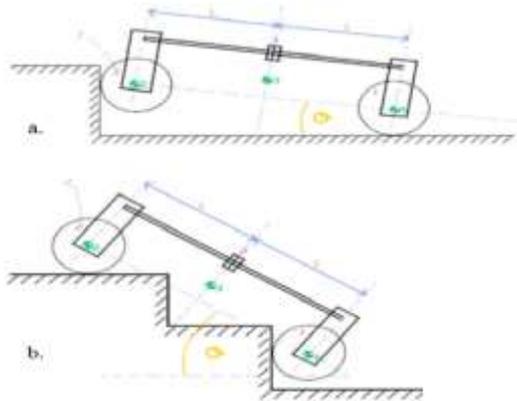

L – Length of each robot arm (m)

r – wheels radius (m)

Θ – arm angle with horizontal surface (degree)

1,2,3 – index of analysed bodies

Fig.5 Schematic Description of the Two Stairs Climbing Cases

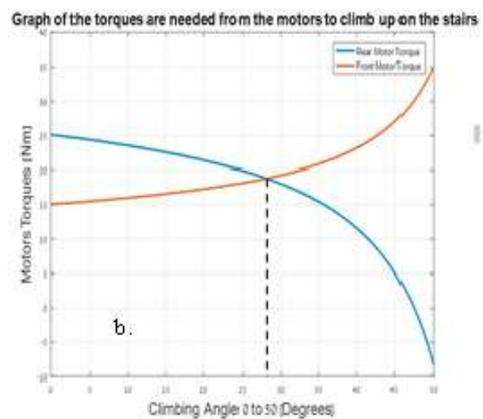a. the front wheels climb and the rear support, b. the rear wheels climb and the front support.

After obtaining the kinematic model, the kinetics of the system determine the torque required for each wheel in order to climb the stair.
Two general climbing states were described: -
In the stage a) When Front wheel is climbing, torque required by rear wheel is greater than the front wheel. In the stage b) When Rear wheel is climbing, torque required by the front wheel is higher than the rear wheel.
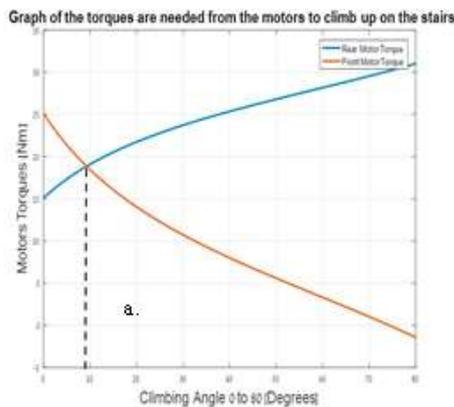
a.   In case the front wheel is climbing.   b.   In case the rear wheel is climbing
Fig No. 6 Graph Torque vs Climbing Angle

In fig. 4, the results of evaluating the required torques for the front and the rear wheels in the two different cases as function of the angle of the arm with the level surface are represented. Fig. 4a shows that when the front wheels are climbing, smaller climbing angles will lead to lower power requirements from motors. However, above a climbing angle of about 9.50, the rear supporting wheels require higher torques. Fig. 4b shows that when the rear wheels are climbing, using less power means the robot can operate for longer time because they will use less power from batteries. The fact that occurs is that when the front wheel is climbing the climbing angle increases during the climb whereas when the rear wheel is climbing the climbing angle is decreasing during the climb.

4. ADVANTAGES

The main advantage of this work is to develop a wheeled robot with the capability of climbing stairs with a short variation of height. Such a design enables mobility over a considerable variation in terrains, including hills, rocks and sand. The long term advantage of this research is to add a vigorous outdoor platform which is suitable to be incorporated in disaster fighting missions and in security and observation missions.

The robots can be upgradeable with utilization sensors, e.g. cameras, thermal vision, or chemical sensors. To be used in any search or security application, the robot can be operating without any power source for less than two hours. Also the robot is wireless control which will steer the robot in target area from remote using Arduino Mega 1280/2560. In industries for doing a reprogrammable work, reduce human mistakes and replace human being from hazardous work this kind of stair climbing robots can be used.

5. CONCLUSION

Step climbing is very difficult task in urban areas. Also if we want to transport some load from one floor to another, it is very crucial for robots. In this paper, all processes like step rise climbing, rise crossing and edge climbing are explained in detailed. Since there are no standard dimensions for steps & there is wide range for it. Hence, it is difficult to set fix distance between front wheels and rear wheels.

Also while climbing the steps, one of the set perform the climb while the other pair support them by either pushing or pulling. In this work, it is concluding that, if the step climbing angle is lower, the power required for climbing is lower. The distance between the front and rear wheels is also important. To reduce power consumption, front and rear wheel should be as far as possible during step climbing.

6. REFERENCES

[1] Optimizing step climbing by two connect wheeled inverted pendulum robots. Avi Weiss, Eli Fadida, Uri Ben Hanan. Procedia Manufacturing 21 (2018) 236-242

[2] Analysis of Stairs-Climbing Ability for a Tracked Reconfigurable Modular Robot. Jinguo Liu, Yuechao Wang, Shugen Ma, Land Bin Li. International Workshop on Safety, Security and Recue Robotics. Kobe, Japan, June 2005

[3] Development of a small survey robot with a step-climbing ability. Kohei Takeda, Tomoki Sakaue ,Koju Nishizawa & Shin Yoshino.International Research Journal of Engineering and Technology. Volume: 04 Issue: 07

[4] Implementation Of Stair Climbing Robot using Microcontroller. Mrs. A. H. Tirmare1, Ms. P. S. Mali & Ms. S. M. Bhoi. International Journal of recent trends in engineering & research. ISSN (Online) :- 2455- 1475. Impact Factor : 4.101

[5] A Kinect-sensor-based Tracked Robot for Exploring and Climbing Stairs. I-HsumLi , Wei-Yen Wang and Chien–Kai Tseng. International Journal of Advanced Robotics System.

[6] Design of Low Cost Stair Climbing Robot Using Arduino. Jeyabalaji, Vimalkhanna, Avinashilingam, Mohamed Zeeshan M and Harish Kumar.Int. Journal of Engineering Research and Applications.ISSN : 2248-9622, Vol. 4, Issue 10 (Part -3), October 2014, pp.15-18

[7] High-grip Stair Climberwith Powder-filled Belts. KanYoneda Yusuke Ota and KanYoneda Yusuke Ota.The International Journal of Robotics Research. January 2009. pp. 676–687

[8] A study on a wheel-based stair-climbing robot with a hopping mechanism. Koki Kikuchi , Keisuke Sakaguchi, Takayuki Sudo, Naoki Bushida, Yasuhiro Chiba &Yuji Asai. Mechanical systems and Signal processing. 22 (2018) 1316-1326

[9] An autonomous air-climbing wheel chair. Michael Hinderer, Petra Friedrich & Bernhard Wolf. Robotics and Autonomous Systems. S0921-8890(16)30332-3

[10] Climbing of Stairs of AnAutonomous, Bipedal Robot. Amos Albert. Making feasible walking motion of humanoid robots from human motion capture data. IEEE International Conference on Robotics and Automation, ICRA 2, 1044 - 49.

[11] Report on Design, Analysis and Fabrication of a reconfigurable stair climbing robot. Ashish Singh.