Tri-Star Wheel Assembly

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Abstract- *This paper explains the mechanical design and development of tri-star wheel system for firefighting mobile robot. The robot will be used to enter potential dangerous and hazardous disaster site in search of human survivor and to collect some related information forrescue team take quick action on situation.*

Surveillance mobile robot need to be able to overcome natural and virtual obstacles such as stairs and any bumpy terrain which are the most known obstacles in the collapse buildings or somewhere on off roads in forest .Also take in Surveillance on other planets. Movement act is predicted through manual and software simulation by usingAutodesk Inventor Professional 2012. Base on the result of the simulation study, the design were then improved and the prototype were developed. The studied showed that the tri-star wheel system performs successfully. The climbing task to the standard stair was smoothly provided without any serious problem.

Keywords- chain drive instead of gear drive system,Surveillance robot, climbing, tri-star wheel system, firefighting mechanism, off roader ,moon or mars rover.

I. INTRODUCTION

This project targeted to design a stairs climbing robot and cross country run by using tri-star wheel driving system work on chain drive. By using the Autodesk Inventor Professional 2012Education Version software, all the design part been dimensioned using the theoretical formula. This project deals with the development of a robot with Tri-star wheels. The main technical topics have been discuss in this project are; mathematical modeling, mechanical design and fabrication of the robot. The robot uses Tri-star wheels, which are driven both at the peripheral drive wheels and the centerTri-star, therefore enabling the robot to run on any type of road and it can be cross any obstacles by rotating the Tri-star assembly and to move using the powered peripheral wheels.

II. LITERATURE REVIEW

Md. A. Hossain. Nafis studied a new horizon for the transportation of the loads over the stair. Most of the buildings of the country are structurally congested and unavailing of elevator facility so it is difficult and laborious to lift up heavy loads. The system, which can move upper level through strain, or run in very rough and rocky surfaces, is called stair climbing system.

Mr. Ravi R. Mishra modified In the first design, the power transmission to the single or double wheel is useless to climb the stairs due to height factor of stairs creates huge obstacle on the way of vehicle. Also the design of the straight wheel frame became more complicated and was needed modified with its curve- spherical shape to give proper drive, which create more frictional force. For these reason, three wheel set on each side of vehicle attached with frame was introduced to provide smooth power transmission in order to climb stairs without obstacles. Frame arrangement is suitable to transmit exact velocity ratio also. It provided higher efficiency and compact layout with reliable service.

Lauren M. Smith described Driving Mode, two of the three individual wheels in each mechanism are in contact with the ground and roll across smooth surfaces efficiently and quickly just as a wheeled robot would. The Tri-Wheel's orientation is not locked in place relative to the robot body, allowing the wheels to passively pivot about the main drive shaft located at the centroid of each mechanism. This facilitates effective adaptation to grades and slopes. If the Tri-Wheel is lifted completely off the ground in this mode of operation and all reaction forces from the environment are removed, the frictional forces in the gears effectively lock up the gear set) and cause the entire assembly to rotate in the direction of motor output with no individual wheels spinning.

Actually this system completely based on gear drive mechanism, but complicated design and manufacturing us use chain drive system instead of gear drive mechanism. It also helps to reduce the cost and weight of system. For these reason, three wheel set on each side of vehicle attached with frame was introduced to provide smooth power transmission in order to climb stairs without obstacles.

III. DESIGN CONSIDERATION

There are many types of robot designed which are used to cross the obstacles. This project focused on the tri-star

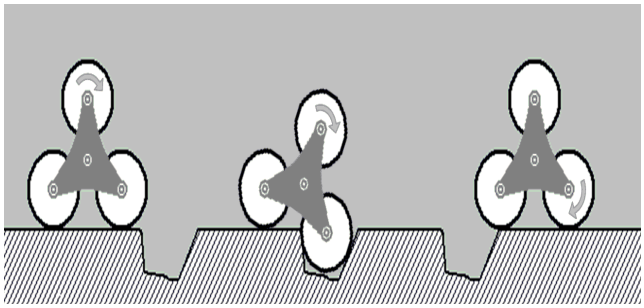
wheel designby using chain drive. The focuses are more on the tri-star wheel design and the chain drive system. The project was designed and research on the force, sprocket and chain and some applications (we are not included programming and electronics section,just focused on chain drive tri-starassembly)

There are two section of designing first is design of tri-star wheel assembly, second the main body of robot

During a design for the tri-star wheel in the first phase of the project, the features of the holder were necessary. This is the most key part because the tri-star holder determines whether the robot is able to cross the obstacles. The type of driving system used to drive the robot was also necessary in this stage. The main body was designed by seeing its determination as a carrier.

Varieties of material are one of the important things that need to be careful in this project. The autonomous, mechanical design and structure of the robot are directly limited for the matter to decrease cost, weight, and advance ergonomics.

The tri-star is a novel wheel design firstly by Lockheedin 1967 in which three wheels are arranged in an upright triangle with two on the earth and one overhead them, as shown in Figure 1. If either of the wheels in contact with the ground gets jammed, the complete system revolves over the obstacle. A Tri-Star wheel consists of a three leaf, with 3 leaf wheels on the end of the each leaf, all powered. This means, at rest, each Tri-Star wheel is likely to have two leaf wheels in contact with the ground. On the flat ground, the leaf wheels will simply turn, and give simple and relatively well-organized grip.

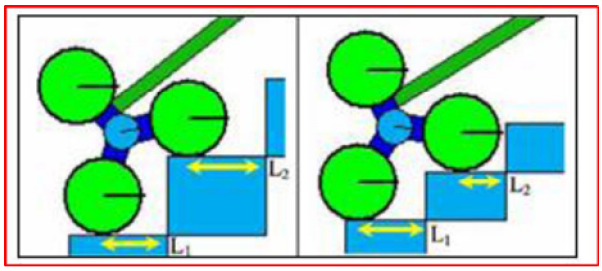


Tri-Star Wheel Design

Deriving the Tri-Star wheel parameters depends on the position of Tri-Star wheel on stairs. It depends on two parameters, the distance between the edge of wheel on lower stair and the face of the next stair(L1), and the distance between the edge of wheel on topper stair and the face of next stair (L2),

By comparing these parameters, three states may occur., as follow:

1. L1 < L2
2. L1 >L2
3. L1 = L2



According to the project requirements, the value of (a) and (b) are determined as

a= 20 cm, b= 25 cm, r = 5cm, (minimum value)
a=25cm , b=30, r=10. (maximum values)

$$R=\sqrt{\frac{a^2+b^2}{3}} \quad \text{.....(1)}$$

$$R=\sqrt{\frac{20^2+25^2)}{3}}=17.569\text{cm}=18.484\text{cm}$$ (for minimum values)

$R=\sqrt{\frac{25^2+30^2}{3}}$ =22.54 (for maximum values)

Take 18 cm as standard radius for spider

- The minimum value of the radius of regular wheel (r_{min}) to prevent the collision of the holders to the stairs is derived as follows
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$$r_{\min}=\frac{6Rt+a(3b-\sqrt{3}a)}{(3-\sqrt{3})a+(3+\sqrt{3})b} \text{ where } t=1 \quad \text{.....(2)}$$

$$r_{\min}=\frac{6(18.484)(1)+20(3*25-\sqrt{3*20})}{(3-\sqrt{3})*20+(3+\sqrt{3})*25}=10.135cm$$

$r_{max}=\frac{6(18)(1)+25(3*30-\sqrt{3*25})}{(3-\sqrt{3})*25+(3+\sqrt{3})*30}$ =12.33cm

The maximum value of the thickness of holders (t_{1max}) to avoid the collision between the holders and stairs is derived by

$$t_{1\max} = \frac{ar(3-\sqrt{3}) + br(3+\sqrt{3}) + a(\sqrt{3}a - \sqrt{3}b)}{6R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$t_{1\max} = \frac{20*5*(3-\sqrt{3}) + 25*5*(3+\sqrt{3}) + 20*(\sqrt{3}*20 - \sqrt{3}*25)}{6*18.484} = 4.915cm$$

Motor Requirement

Power=force*velocity=m*g*v
Power=60*9.8*0.25
P=147.15N
Taking motor of 0.37 KW=370W

Torque=force*arm moment=m*g*r
60*9081*0.12=70.63N

IV. CONCLUSION

- This project open many future aspects like highly automation ,also it can be run on wireless technology
- It was found that the vehicle was moving well over the stair. It can move on flat surface uniformly at 20 rpm without any fluctuation and there was no variation of speed over steps. It was observed that there was moderate noise and low vibration over flat surface or stair. It was observed that the vehicle was disturbed when it faced the stair of different step sizes. This was because of the shape and size of the wheel frame. Therefore for a range of stairs size can be considered for this vehicle.
- This pioneer project, with a little further development, was hoped to be succeed to meet up the demand of carrying loads over the stair, off roads ,rocky terrene and other difficult areas where normal vehicle cannot run easily
- With the arrangement of four sets of tri-star wheels, it can perform six modes of movements: forward driving, backward driving, climbing up, climbing down, turning right and turning left. This proposed robot can be used in real world applications such as climbing over the uneven terrain for rescue, military operation, security monitoring, exploration of dangerous environments, de-mining and other works.

V. ACKNOWLEDGMENT

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