

Design and Development of Wall Climbing Swarm Robot

Rahul Ranjan, Humsheer Sandhu , A.Suvarnamma

Abstract: With the advent of construction technologies, there has been a rise in the number of tall buildings. At such heights, it is dangerous and difficult for human life to reach. So, the design and control of the movement of a wall climbing swarm robot which uses adhesion force which enables it to climb multiple robots at same time on vertical surface with the swarm intelligence in order to reach high place. The design and control of robot is such that it can be operated for any place like vertical and horizontal. A wireless communication link is used with swarm technology that perform the numbers of multiple robots which works together to complete task With simultaneous communication between two robots, it tends to ease the work load and improves the time used in rescue or surveillance operations. The three major advantages of Robotic approach are that it is scalable, flexible and robust.

Keywords: Robot, climber, (glass/wall), locomotion, adhesion force, communication link, swarming

I. INTRODUCTION

Wall climbing swarm robot (WCSR) are exceptionally versatile robot that can be utilized as part of assortment of use like review and support of surfaces for distinguishing splits painting of ocean vessel surfaces, oil tanks, glass sections of heightened buildings etc. To build the operational productivity and ensuring human well-being and security in dangerous task make this robot a valuable gadget. These frameworks are basically embraced in such conditions where human administration is extremely costly and hazardous because of the risky and unsafe environment. This robot has light weight and large payload so that reduce adhesion force to carry components at the time of navigation and surveillance. This autonomous robot can be used to accomplish all needs of military, police and personal security. For mechanical stability a centrifugal impeller with position above the robot produces and maintains low pressure area in isolation for adhesion force to stick on the vertical wall.

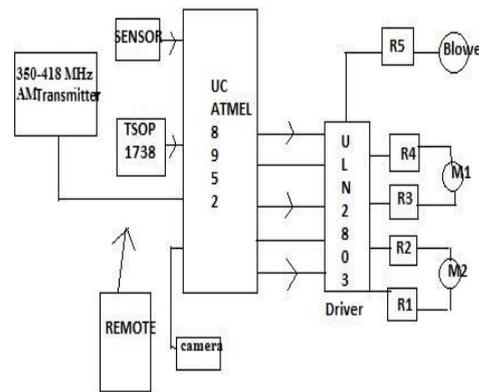
The idea of swarming is based on the view that sometimes it is impossible or quite difficult to complete a task by a single person. In such cases, there is a need of a

team or group of members that can collaboratively work and make the work of that person comparatively easy.

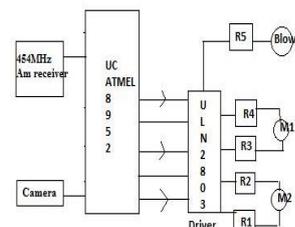
Swarm Robotics has varied applications in all fields like communication, military services, civil engineering, building construction etc.

II. BLOCK DIAGRAM

Master Fig 1



Slave Fig 2



III. DESIGN AND ANALYSIS OF WALL CLIMBING SWARM ROBOT

A. CAD Modeling

Motor Specification:

- 60 RPM Compact DC Gear Motor of Side shaft 37 mm diameter is suitable for small robots.
- Voltage range of 4 -12V
- Stall torque: 3.3Kg-cm at stall current of 1.3Amp.
- Diameter of shaft: 6mm
- RPM of motor: 60 at 12V voltage
- Material of brush : Carbon
- Motor weight: 100gm

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Table1: Parameter Calculation of the motor

Operating Speed	RP M	Torque	Power
0.15sec/60 degree	60	1.52Nmat 4.8V	0.84kw

Design robot using centrifugal impellers is done in solid works software

The Cad models for Wall climbing robot

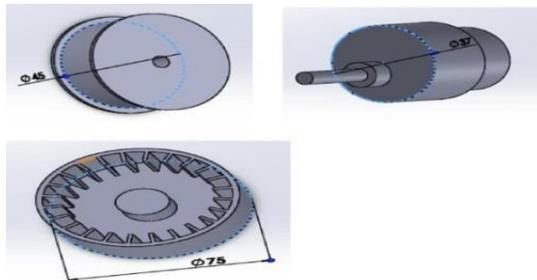


Figure2: Cad design of robot

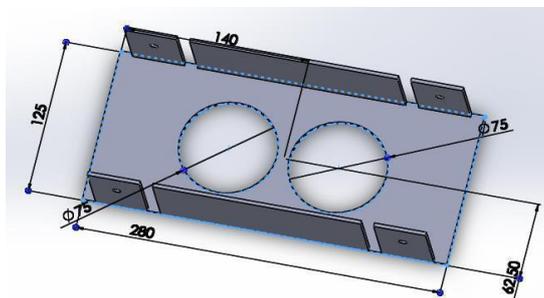


Figure 3: Belt with dimensions

IV. FORCE ANALYSIS

The required suction constrain is dissected from diagram as shown below From it, we can examine all driving forces falling on the wall and slant of the wall shifts from 0 so, that implies parallel with the ground to 90 degree which is vertical with the ground.

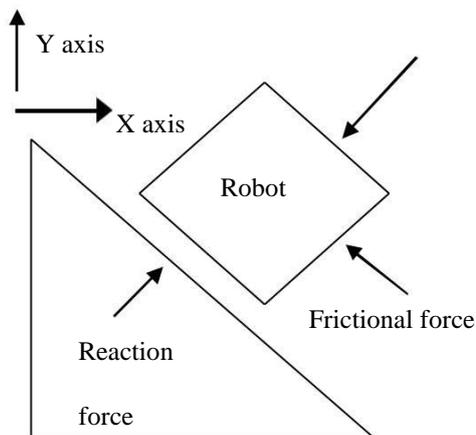


Fig 4: Diagram of all forces act on slanted wall

That figure 4 comprises of total force that are vacuum, reaction, robot weight and frictional. The force of robot

weight are depends upon mass (M) and acceleration due to gravity (g=9.81m/sec) which has downward path.

[2] The two equilibrium equations as per the

Newton's law

$$\sum F_x=0; \quad (1)$$

$$\sum F_y=0; \quad (2)$$

From (1) and (2), we know that sum of the X axis and the sum of the Y axis with given forces are zero at balance.

The force of vacuum required to catch the robot can be calculated using the following equations.

$$P_{vacuum} = P_{atmosphere} - P_{absolute} \quad (3)$$

Where

P_v - vacuum pressure

$P_{atmosphere}$ - pressure of atmosphere

$P_{absolute}$ - absolute pressure

As we know,

$$Force = Pressure \times Area$$

therefore

$$F_{vacuum} = P_{atmosphere} A_o - P_{absolute} A_i \quad (4)$$

As,

F_{vacuum} - force of vacuum need to catch the robot.

A_o - outer circle part of impeller A_i - inner

circle part of impeller.

$$\text{The frictional force is given by } u (V_{vacuum} + Mg \cos \theta) = Mg \sin \theta \quad (5)$$

Where

'u'- is the coefficient of friction and

'g' - acceleration due to gravity.

From equation (5), we will get the friction force

fig 5, says the equilibrium of forces on the horizontal surface is

$$Force_z = P A - m_{robot} g = 0 \quad (1)$$

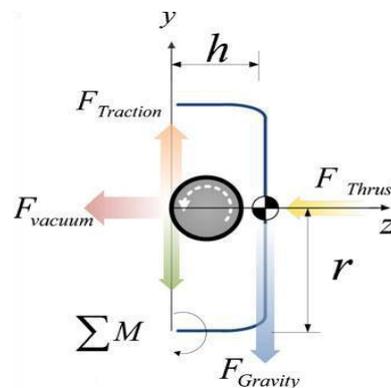


Fig5: Static force analysis in horizontal Plane

X

$$(F_z = F_{vacuum} + F_{thrust} = N) \quad (3)$$

X

$$(F_y = F_{Traction} - F_{Friction} - F_{Gravity} = 0) \quad (4)$$

$$M = -hF_{Gravity} + r(F_{Thrust} + F_{Vacuum}) = 0 \quad (5)$$

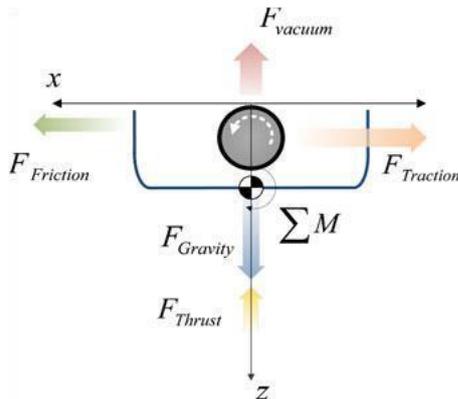


Fig6: Static analysis in vertical plane

$F_{Traction} = F_{Friction} + F_{Gravity}$ (7) Assuming the robots are going up and gravitational force is acting through y direction.

A. Mechanism for Adhesion

It has a power of generator that comprises a first motor along with a rotor and the cover to take the air out.

B. Tracked belt mechanism

A continuous movement arrangement is made of the track belt of the robot. These are not only positive transfer but also can track relative movement.

Working circuit of wall climbing swarming locomotion

In the project, a server-client concept was used to perform the given task. Therefore, for creating a 'Swarm' of robots the size of the client device was decided to be as small as possible to include robustness, scalability and flexibility to the project. It should also be well equipped with abilities such as sensing, computing and communicating with the external environment to smartly perform the task assigned by the server.

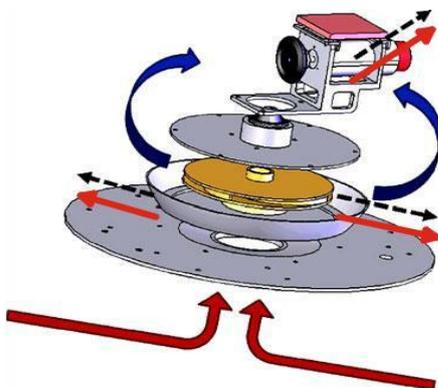


Fig 7: Inhalation Air Flow

V. EXPERIMENTS AND RESULTS

Various experiments were conducted for the evaluation of the working of the wall climbing swarm robot. After making the robot, the working of the adhesion system on vertical and horizontal surfaces was tested are shown in the Fig. The complete robot was on to the wall and with a remote control

for the left, right, forward and backward direction the initiation of the first robot prototype was done. When the motor started to work, adhesion force was generated which made it stick on the wall.



Experiment of surface adhesion



Experiment of horizontal surface driving

VI. CONCLUSIONS

This paper presents wall climbing swarm robot technology, which moves on vertical as well as horizontal surfaces. A dynamic model was used to build, analyze and test the mechanism of robot. Two swarm models, that is swarm I, and swarm II were fabricated and their exhibitions of swarming were approved tentatively in the lab situations and additionally the genuine one.

The applications and advancement of this robot can be used in areas of defense as well as architecture restoration sites. Other applications include bomb disposal squad, mine handling, information provider in hostage places. With more research and proper modification, it can be made cost effective for commercial use

REFERENCES

- 1 Kazunori Sakurama, Shin-ichiro Nishida, "Source seeking by distributed swarm robots with sample variance control", American Control Conference (ACC) 2016, pp. 2484-2487, 2016.
- 2 Vincent Autefage, Serge Chaumette, Damien Magoni, "Comparison of time synchronization techniques in a distributed collaborative swarm system", Networks and Communications (EuCNC) 2015 European Conference on, pp. 455-459, 2015.

- 3 Mahdi Agheli n, LongQu,StephenS. Nestinger “Shero:Scalable hexapod robot for maintenance,repair and operations” in the Science Direct Robotics and Computer-Integrated Manufacturing (2014)478–488.
- 4 Daniel Schmidt ,Karsten Berns “Climbing robots for maintenance and inspection of vertical structures” in Robotics and Autonomous Systems 61 (2013) 1288–1305
- 5 Ganesh Kumar K., Pushparaj Mani Pathak “Dynamic modeling and simulation of a four legged jumping robot with complaint legs” in Science Direct Transactions Robotics and Autonomous Systems 61 (2013) 221–228.
- 6 Bahr, Y. LI’ and M. Najafi’ “ Design and suction cup analysis of a wall Climbing robot” in Science Direct
- 8 TeresaG.Miller,Stephen Roc “control of a climbing robot using Real time convex optimization “in The science Direct Mechatronics 18(2008) 301-313.
- 9 Yi Zhanga,, Akira Nishi “Low pressure air motor for wall climbing robot actuation” in Science Direct Transactions of Mechatronics 13 (2003).
- 10 Avishai Sintov , Tomer Avramovich, Amir Shapiro“Design and motion planning of a autonomous climbing robot with claws” in Science Direct Transactions of Robotics and Autonomous Systems 59 (2011) 1008–1019.
- 11 Amirpasha Peyvandil, Parviz Soroushian1, Jue Lu “A New self loading locomotion mechanism for wall climbing robots employing biomimetic Adhesives” in Science Direct Transactions of Journal of Bionic Engineering 10 (2013) 12–18.
- 12 Mahmoud Tavakoli , Carlos Viegas “Analysis and application of dual row omni directional wheels for climbing robots” in Mechatronics 24 (2014) 436–448
- 13 Giuk Lee a, Geeyun Wua, Jongwon Kimin “High payload climbing and transitioing by complaint locomotion with magnetic adhesion” inScience Direct Transactions of Robotics and Autonomous Systems 60 (2012) 1308–1316.
- 14 Guido La Rosa, Michele Messina, R.sintara “A low cost light weight climbing robot for the inspection of vertical surfaces” presented in Science International Symposium on Mechatronics 12 (2002).
- 15 Nagakubo, A., Hirose, S.: Walking and running of the Quadruped wall-climbing robot. In: Procceding of IEEE International Conference on Robotics and Au-tomation, vol. 2, pp. 1005–1012 (1994)
- 16 Teresa G. Miller, Stephen Rock. “Control of a climbing robot using real time convex optimization” in the Science Direct Mechatronics 18 (2008) 301–313.