Wall Climbing Robots: The Artificial Lizards of Moderns Days

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Abstract- **In this age of 21st century, with the advancement of robotics and its growing application in wide areas, the Wall Climbing Robots (WCR) has acquired a strategic importance because of its capabilities of manoeuvrability it offers. The robot that can have locomotion in vertical surface is advantageous, for various civilian and military purposes. Situated high on a building, the robot thus can be useful for surveillance and thus could give significant military insights [1]. The robot can be used in critical places where there is a risk to human life, and a general robot is incapable of performing its assigned task. For example, to neutralise explosives fixed in critical locations (like vertical walls) in unfriendly territory or beyond enemy lines, to regulate pipes in industrial sites when there are risks of chemical contamination. This article gives an detailed account about the principle of working of WCR's, various locomotion techniques for vertical surfaces, its designing aspects.**

Index Terms **- Wall Climbing Robots, vacuum suction method, magnetic adhesion, vacuum controller, wireless control.**

I. INTRODUCTION

The concept of a Wall Climbing Robots (WCR) is based upon the basic principle of locomotion of lizards in wall. The Lizards possess suction cups along their limbs, which makes them able to move through any vertical surface. This suction cups help them produce a kind of vacuum between the surface (on which it traverses) and its skin which allows them to adhere to the surface. This spark an idea into the mind of innovators, to develop robots which are capable of climbing walls. The adhesion is based on technologies like Vacuum Suction Mechanism or Magnetic Adhesion Mechanism . Nowadays, modern adhesion techniques by using special glues or gripping substances , or by Bernoulli's Technique[2] are also used. Its usability can be improved by using various electronics gadgets in it, as discussed below.

II. BASIC APPLICATION OF CLIMBING ROBOTS

The Wall Climbing Robots are , primarily capable of performing various tasks as mentioned below .This robots usually finds its application, where directly employing human is either too expensive or hazardous, because of the critical work environment. In technical inspection, maintenance and failure or breakdown diagnosis in dangerous environments[3]. It can autonomously, via using surveillance devices can be used for collecting intelligence information. It is used for repairing circuit, instruments, parts in electrical installations, placed on difficult locations. Similarly, it is used for repairing microelectronic circuits in radars, surveillance instruments. It finds uses in cleaning surfaces or objects at placed on walls, for painting, glass cutting etc. The WCR's finds its application also to neutralise explosives placed in critical locations (like high end vertical walls) in unfriendly territory or beyond enemy lines. This helps safeguard the life of security persons deployed for the duty. This all applications can be achieved by using the climbing robot platform, along with combinations of other devices like surveillance devices, GPS, wireless camera etc. The devices required depends on the type of task to the done.

III. DIFFERENT METHODS TO ADHERE THE ROBOT INTO WALL

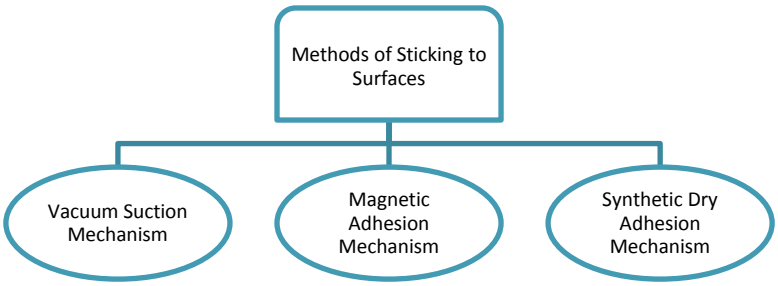

Fig. 1- Classification of the types of methods of adhering to the wall

A. VACUUM SUCTION METHOD

The most commonly used technique for making an robot capable of wall climbing is the Vacuum Suction Method. Its uses the concept of suction pumps to stick to the surface. The advantages is that by regulating the suction pressure as a function of weight, it can be used for carrying loads of various weights in vertical surfaces. Thus, increasing its range of operation. The no. of suction cups required for the robots depends upon the type of task to be performed. Suppose, for an WCR which is designed only to lift heavy loads, then it is required for the robot to have more suction cups (as per the load) is necessary and also in order "to prevent loss of pressure (and adhesion force) due to surface irregularities"[3],[4].The thing that is to be noted here is that the concept of pressure regulation of the suction cups, is limited after a certain extent. So, we must have to go for increase number of suction cups. For WCR developed specially for any purpose other than weight lifting in critical domains, we can generally go for less number of Suction Pumps per locomotors. With more research, a better WCR can be designed which will have the capacity to perform wide range of tasks assigned to it.

The limitation in this methods are :-
1). The first limitation is with Suction Adhesion Mechanism. If there is any hole in the suction seal, the robot may loosen its grip. Hence, the technique is applicable only for smooth and non-porous surfaces[3].
2). Usually, more than one vacuum cup is used in each feet in order to prevent loss of pressure (and adhesion force) due to surface irregularities[3]. This adds a limitation to the speed of the robot. Here, as we climb upwards, the effect of gravity on the robot will increase. This effect has to be taken care of simultaneously. So, the vacuum pressure has to be adjusted accordingly, for each step forward in order to generate sufficient adhesion force required. This effects the speed of locomotion of the robot.

Fig.2 - Robotic Arm sticking to the wall using Vacuum Suction Method

Fig.3 - Vacuum Suction Pad used in WCR's

B. MAGNETIC ADHESION METHOD

Magnetic Adhesion Method is based on the principle of adhering of ferromagnetic materials into magnets. If the surface on which the robot is required to have locomotion is made up of ferromagnetic materials, then we can use magnetic arms of the robot for movement. It is more reliable in the sense, that the gripping is very strong in comparison to the Vacuum Suction Adhesion Method. But the use of magnetic materials makes the robot bulky. It is very surface specific, thus limiting the use of this technique.

C. OTHER ADHESION PRINCIPLES

These days modern climbing robots, climb using gripping techniques that uses special glue for sticking to the surface. This glues are added in the climbing limbs, which makes them adhere to the surfaces. The main limitation of this method is the adhering capacity of the limbs decreases gradually, making loose sticking with the wall. This glues are produced either from natural products or synthetically prepared. It is similar to that of lizards. With the use of Bernoulli's Principle, the robot can also stick to the wall [2]. Also, research in this field suggests new adhesion using biological findings.[5],[6]

IV. DESIGNING OF THE ROBOT

In this portion, we will have a brief discussion about the designing of the robot. Different macro aspects in the design are being considered and discussed, that might affect the working efficiency of the robot. The robot will have a main base body, from which its arms (generally four) will spread out. The robot will have its vacuum pad attached to its arms. We can also use the vacuum pads on the main body, but this depends on the need. For example if the robot is tasked for any weight lifting purpose, then it will be preferable to use the suction pads in the main body. The reason is, it will give more strength to the robot in sticking itself to the wall. Thus, making sure that it does its task without failure i.e. without detaching from the surface due to heavy weight of the load. The vacuum controller can be placed either on on-board or on the external[3]. Placing the controller on the main body of the robot will make it more independent, and thus can be operated wirelessly. This will also increase the effectiveness of performing work by the robot, while placing it external will add a limitation to the manoeuvrability of the robot.

Fig.4 - A Wall Climbing Robot

We can make modifications as per our requirement, to make the robot capable of performing the various task assigned to it. For example, in order to lift weights, we can add a robotic arm of particular specifications. Robotic arm of different specification, can similarly be used for repairs in electrical or electronic installations. Adding an camera to the climbing robot will help us in surveillance and intelligence purpose.

Here, A list of various manufacturing components required to design a normal climbing robot based on Vacuum Suction Method are given -

Table 1- Basic components of the climbing robot

Serial no.	Name of components	Remarks
1.	Vacuum Pad	The quantity depends upon the task. But a minimum number equal to the no. of arms used, is required
2.	Robotic arm	Either 3 or 4. Increasing no. of arms makes the robot bulky, and also makes the movement slow.
3.	Vacuum controller	The quantity depends upon

		both the no. of arm and vacuum pads used. A high powered vacuum controller is preferred.
4.	Wireless remote	A remote having greater range of connectivity is used
5.	Receiver	It is used to receive the signals from the wireless remote
6.	Microcontroller	It is required for carrying out automated commands

CONCLUSION

The recent past has seen an phenomenal growth in the development of climbing robots. With technological advancements, the applicability has also increases. This paper discusses about the basic idea behind the climbing robots, applicability, techniques used for adhesion to the vertical surface, macro aspects of its designing and latest development in the fields. As research are going on in this field, we can expect to see a lot more development in this fields.

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