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Low Cost Pneumatic Glass Climbing Robot

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ABSTRACT
The main motive of glass climbing robot is to climb on vertical glass surface. To achieve this purpose efficient attachment and detachment is an important aspect. This type of robots can take place of humans to carry out hazardous work such as cleaning of glass surfaces, fire rescue, inspection of high rise buildings, etc. this robot can also be used for security purpose and also to calculate the height of building. This project is aimed at developing robot which can move on vertical glass surface . One of the most challenging task is to make the robot's weight as light as possible along with proper adhesion and locomotion system with low cost.
Keywords-Robot, climbing, adhesion, suction cup, microcontroller.

INTRODUCTION

Climbing robot system has been developed rapidly in recent years for verity of applications such as cleaning, maintenance of buildings, inspections, fire rescue, etc. they are mainly designed for the safety of human beings. These systems are basically used where direct access by human operator is not possible. Many climbing devices have already being developed and many of them are under development.

A glass climbing device should be light in weight so that it can stick on the glass surface. Moreover it must also have large payload so that it can carry equipments. The design of this robot is based on three basic principles: - 1. Adhesion principle 2. Locomotion principle 3. Pneumatic principle [2].

We can take an example of lizards for getting the idea that how the robot will stick and move on the glass surface. Lizards which move on the vertical surface, on closer examination we can see that it possess suction cup, in the form of its limbs because of which it can stick and easily move on the vertical surface.

Literature

The following requirements should be observed to design climbing robots.

1. Lightness of weight: This is followed by low energy suction pump, to increase the autonomy and payload of equipment.

2. High mobility: This enables the climbing robots to move over various environments with different geometries and materials such as glass.

3. A reliable grasping mechanism for climbing on various surfaces . [10,6]

Development of a Wall Climbing Robot by Surachai Panich Srinakharinwirot University, 114, Sukhumvit 23, Bangkok 10110, Thailand Journal of Computer Science 6 (10): 1156-1159, 2010 ISSN 1549-3636 © 2010 Science Publications 1156[5]

This paper is useful to obtain the information about adhesion i.e. how the robot can stick to the wall for climbing purpose.

A novel wall climbing robot based on Bernoulli effect " by XiaoQI Chen, Senior Member, IEEE Matthias Wager, Mostafa Nayyerloo, Wenhui Wang, Member, IEEE, And J. Geoffrey Chase "[6]

This paper is useful to obtain information about locomotion. With respect to the locomotive mechanism; climbing robots are of six categories: legged type, wheel-driven type, tracked type, translation type, cable driven type, and combined type. We are using wheel-driven type[7].

Various robots have been designed for climbing applications, cleaning, surveillance and maintenance in the recent past. Currently there are some different kinds of kinematics for motion on smooth vertical surfaces: multiple legs, sliding frame, wheeled and chain track vehicle.

There are also four different principles of adhesion used by climbing robots: like vacuum suckers, negative pressure, propellers and grasping grippers.

The robots with the wheeled and chain-track vehicle are usually portable. The adhesion used by this kind of robot is always negative pressure of propellers, so robots can move continuously. One kind of robot has a pair of wheels actuated by electrical motors in its negative pressure chamber, so that it can move on the walls flexibly. But it can only deal with plane walls without any obstacles. A kind of pneumatic cleaning robot was developed for cleaning the embassy of Canada by a company in Japan, but it cannot walk sideways. Some modifications can be done to that such that it walks in all four directions.

By referring all this information in the paper we aimed to make a robot with 2 wheels (for movement) and suction cup (to stick to the surface).

Basic function provided by climbing robot

The basic function of any climbing robot is as follow[4,8]

1. motion control function
2. Safe and reliable attachment to the surface
3. Movement spreading over all the working areas
4. The ability of crossing obstacles
5. Effective cleaning/surveillance/sensing/glass cutting/ Painting etc.
6. Enough intelligence for the avoidance of obstacle situation.

The first difference between a climbing robot & an ordinary walking robot on the ground is the climbing robot should be sucked to the surface on which it can climb safely. The main function of robot is that a robot should have to move both the up-down direction as well as right-left direction to reach to every point on the glass. When the task signal is given by the user then the robot should keep itself attached to &move on the surface while accomplishing the task of may be cleaning, surveillance, sensing etc. To fulfill the requirement of all kinds of functions, precise motion control is needed. As soon as the signal is received the position control of the movement will begin automatically.

Methedology

Normally for cleaning glasses of high towers or IT buildings people are there which is risky. Also sometimes building catches fire and it would be impossible to go inside from stairs to check the condition there might be requirement to measure height of the tower or alignment for all above needs we planned to make glass climbing robot.

There were two main tasks for our robot

1. Grip
2. Motion

We are using Vacuum pump with suction cap for creating grip on glass and there will be motors which will handle the robot motion. By applying both we are making a robot which will take a grip on glass and also move in any direction. In future this robot can be made wireless so that it can be used in so many tasks like security, details of an object, etc.

Block Diagram

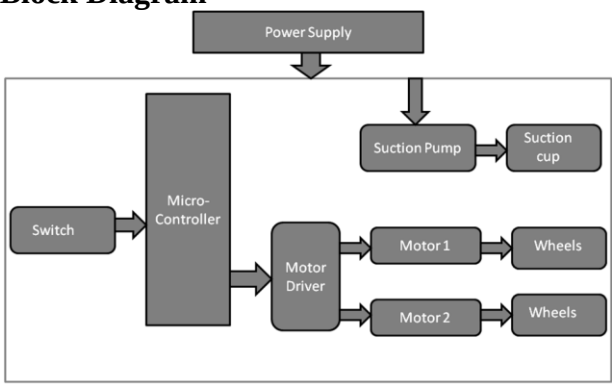

Fig.a. Block diagram of Pneumatic Glass Climbing robot

Software

For the programming of 8051microcontroller we are using 'RIDE' software.

Program in microcontroller for the direction of robot (left, right, up, down) –

```
        mov p0,#00h
        lcall delays

        start:   jnb p1.2,left
        jnb p1.3,up
        jnb p1.4,right
        jnb p1.5,down
        lcall delays
        mov p0,#00h
        sjmp start

        left:       clr p0.1
        clr p0.2
        clr p0.4
        setb p0.3
        ljmp start
        up:      clr p0.2
        clr p0.4
        setb p0.1
        setb p0.3
        ljmp start

        right:       clr p0.2
        clr p0.3
        clr p0.4
        setb p0.1

        ljmp start

        down:  clr p0.1
        clr p0.3
        setb p0.2
        setb p0.4
        ljmp start

        delays:  mov 70h,#04h
        upper:          mov 71h,#0ffh
        lower:  mov 72h,#0ffh
        djnz 72h,$
        djnz 71h,lower
        djnz 70h,upper
        ret
```

Components used

A. **Microcontroller**

80C51 Microcontroller is used to control all the control functions of robot. When direction signals are sent it acts according to the program written in the memory.

B. **Motor**

We are using two motors and they are used to control the movement of wheels. Movement of these motors i.e. directions will control with the help of microcontroller.

C. **Suction Cups**

A suction cup, also sometimes known as a sucker is an object that uses negative fluid pressure of air or water to adhere to nonporous surfaces. They exist both as artificially created devices, and as anatomical traits of some animals such as octopuses and squid. The working face of the suction cup has a curved surface. When the centre of the suction cup is pressed against a flat, non-porous surface, the volume of the space between the suction cup and the flat surface is reduced, which causes the fluid between the cup and the surface to be expelled past the rim of the circular cup. When the user ceases to apply physical pressure to the centre of the outside of the cup, the elastic substance of which the cup is made, tends to resume its original, curved shape.

D. **7805 Regulator IC**

7805 is a regulator IC, We are using 2 regulator Ics in circuit. It is used to obtain constant voltage of 5V.

As the IC is 7805 it gives positive output of 5V at 3rd pin when I/p voltage of 12V is applied at 1st pin with 2nd pin being ground.

E. **Suction Pump**

Suction pump work by pumping air away from an enclosed area, creating a partial vacuum. As the air withdraws from the area, the vacuum forces the liquid to rise into the area where the pump is working, transferring it from one area into another.

F. **Driver IC-L293D**

IC L293D is driver IC.It is used to drive the motor .it is used to provide the sufficient current to motor.Motor driver act as current

amplifier since they take a low current control signal and provide a higher current signal.

Working

As shown in the block diagram, a microcontroller controls all the required actions. When power supply is made on 12V is applied at the 1st pin of regulator IC. Regulator regulates the output to 5V which is required by microcontroller. Pull up resisters are also used to increase the output voltage. Capacitors are used with the regulator IC to remove the ripple. In this circuit four switches are used, when the direction control signals are received by the microcontroller, it acts according to the program written in the memory. Relay is used as a switch.

Input signals are applied to port1 of microcontroller and output is given to motor driver IC through Port 2. According to signal received by the motor driver IC the robot will move in all the required.

Robot design

Fig.b. Working Model of glass climbing robot

Apllications and future scope

With little or no modification, the climbing robot can be used for the following applications and also its advantages are mentioned.

1. It can be a replacement for GONDOLA system for high rise building cleaning
2. Wireless/wired video surveillance possible
3. public safety & military applications (surveillance, search & rescue)

On close observation, the climbing robot can be further enhanced in many ways. They can be listed as follows.

1. Payload can be increased by increasing the pumping capacity.
2. Robot weight can be reduced.
3. Elevation angle of the robot on walls can be enhanced.
5. Robot movement Speed on glass can be increased.

Conclusion

This robot can work well for buildings having completely glass exterior. Also this robot can walk easily on ground surface. For future expansion the design of this robot could be modified to clean glass of buildings having sections.

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