GLASS CLIMBING ROBOT FOR GLASS WALL CLEANING

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ABSTRACT

This project is about the cleaning of glass walls using glass climbing robot. The robot is used in cleaning of glass walls of high rise buildings. The design of the project includes four legs and a raspberry pi controller and suction modules. Each leg is consisting of suction cup and a servo motor. Due to the vacuum creation inside the suction cup, robot sticks with the glass surface. Robot leg movements controlled by servo motor and raspberry pi controller. Thus the robot is light weighted and high weight carrying capacity. A wiper is attached with the robot body for cleaning the glass surface.

Keywords: Glass Climbing Robot, Raspberrypi Controller, Suction Modules, Vacuum Creation, Suction Cup, Light Weight Wiper.

I. INTRODUCTION

Glass climbing mechanisms is one of effective applications of the building maintenance. These robots are helpful systems for the various applications in the High-rise Buildings. At present there are a large number of high-rise buildings with Glass curtain walls in modern cities. Glass cleaning robot is designed to clean the surface of glass wall. Maintenance including inspections and cleaning are important for keeping the condition of building and for increasing its lifetime. For efficient automatic cleaning system on outside surfaces of buildings such as curtain walls, windows, walls and stone facades have been increased dramatically along with development of modern architecture.

One of the useful types of robots is the climbing one, which could be adopted in variety of tasks such as exploring in a hazardous environment, non-destructive evaluation, fixing and welding in construction and cleaning and maintaining of high rise buildings. The robot could work beyond the environmental and geographical limitation which could stop a human from work. This study aims to develop high efficiency and high reliable glass cleaning robot. The robot is simple in construction and serve for glass and floor cleaning. The first wall climbing robot can be dated back to 60s last century, developed by Nishi [1]. This wall climbing robot has a large volume and is very heavy, using single vacuum sucking cup. Gregory Wile and Dean M. Aslam, [2] designed, fabricated and tested a miniature wall climbing robot using two smart robotic feets (SRF) in June 2007.

This wall climbing robot has a large volume and is very heavy, using single vacuum sucking cup. Gregory Wile and Dean M. Aslam, [2] designed, fabricated and tested a miniature wall climbing robot using two smart robotic feets (SRF) in June 2007. The design works automatically by PIC16F876 microcontroller and an on-board 6V power supply. It is designed to transition on floors and walls, and it can walk only on surfaces from horizontal (0 Degree) to up to 70 Degrees. Hwang Kim [3] described a concept of using a series chain of two caterpillar wheels equipped with 24 suction pads for attachment mechanism in 2006. The suction pads on caterpillar wheels activated in sequence based on mechanical valves openings due to forward or backward motion of the robot. Cleaning is one of fields which is expected to have a strong benefit by service robots in Europe, it represents a market of more or less 100 billion of Euro per year[4]. Motion planning [5] of the service robot plays an important role to enable the robot to arrive in the target position and avoid or cross obstacles in the trajectory path. There are considerable approaches in the literature to address the motion planning problem of carlike or walking robots, such as Lamiraux and Laumond (2001), Boissonnat etc. (2000), Hasegawa etc. (2000), Chen et al. (1999), Hert and Lumelsky (1999), Egerstedt and Hu (2002), Mosemann and Wahl (2001), to name a few. There are many related works on climbing robots that have been conducted in the past. Houxiang Zhang.[6] have designed and manufactured Sky cleaner 3 for cleaning the curved glass façade of Shanghai Science and Technology Museum in 2006. The design is lightweight and dexterous due to using pneumatic actuators and in order to overcome of high speed movement and precise positioning.

II. HARDWARE REQUIREMENTS

The following components are the hardware required for this robot.

A) RASPBERRY PI PROCESSOR

This proposal involves the on board control of several motors by the use of the processor named as Raspberry pi model B version. The Raspberry Pi is a single-board, pocket sized computer developed in the UK by the Raspberry Pi Foundation. The Raspberry Pi can be plugged into a TV and a keyboard. The design is based around a Broadcom BCM2835 SoC, which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and 512 Megabytes of RAM. The design does not include a built-in hard disk or solid-state drive, instead relying on an SD card for booting and long-term storage. This board is intended to run Linux kernel based operating systems.

Figure.1 Raspberry pi processor

B) SUCTION CUP

These are the feet of the legs which help to stick to wall rigidly. These are made up of rubber or plastic. They stick to almost any surface which is even and non-porous when pressure is applied against the upper part of it or the air inside it is sucked out. There will be eight cups in this robot four of them are under the Central box at each corner of it and two are attached to the each leg at the end. We are using a bit smaller cup in size and more cups so as to compensate the balance and also avoid slipping if any of them failed to stick to wall as the rest of them will stick to wall.

C) DC SERVO MOTOR

This high torque standard servo can rotate approximately 180 degrees (90 in each direction).It utilizes Servo system utilizing positive input control. Here accuracy of rigging revolution is greatly required which could be made accessible just by utilizing servo engines. The order is given to it by controller which gives sign for particular turn plot. For giving summons for forward and retrogressive turn, encoders are introduced on the focal body. This current engine's pole is associated with both pinions and makes them pivot and henceforth the legs make headway. A movement in converse heading and settling the legs to the divider makes the Central box to advance. Two engines will turn two pinions in same way. Position “0” (1.5ms pulse) is middle, “90” (~2ms pulse) is all the way to the right, “~90” (~1ms pulse) is all the way to the left.

D) SOLENOID VALVE:

A solenoid valve is an electromechanical valve for use with liquid or gas. The valve is controlled by an electric current through a solenoid coil. Solenoid valves may have two or more ports: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between.

E) AIR COMPRESSOR/VACUUM PUMP

Air Compressor/Vacuum Pump is used to create a very low pressure end to suck the air inside the suction cups with the help of reservoir. It operates on 230 volt AC supply.

Figure.2: Vacuum pump

F) RELAYS

A relay is an electrically operated Switch. Many relays use an electromagnet to operate a switching mechanism. Relays find applications where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. In the project we are using 5V relays.

Figure 3: Relay

G) CLEANING SYSTEM:

The cleaning mechanism takes place by 4 wipers that are attached at the bottom. Among them, 3 wipers are flat and the other one is roller. The flat wipers are symmetrically placed at the bottom of the platform. They are placed in a ‘V’ shape so as to ensure that the dirt water falls down along the wiper when it moves along the walls in every particular direction. The roller wiper is placed at the end of the platform using proper links this is driven by motor at a higher rate in the opposite direction to the direction of vehicle propagation. The wipers in the middle are connected by means of a screw which can be adjusted and removed whenever needed. The cleaning is made efficient using wet wiping system. This system employs a small water storage tank and a 12V DC submergible pump creates the water flow through the pipes straight to the front sponge wiper, where it percolates down through a perforated pipe chamber on to the floor. The overflow of water is corrected by proper knobs. A tube runs from the small tank to the entire length of the perforated wiper at the front. This wets the surface. The remaining wipers take away the dirt from the floor and the final roller wiper collects the dirt water from the surface and dry similar to a moping action.

III. DESIGN

The design consists of four active type suction modules, four servo motors, a cleaning mechanism, and a programmable on-board microcontroller Each of the suction modules includes a vacuum generator and a chamber mounted on the supporting frame for adhering to the surface. The servo motors are for transition motions. The vacuum generator is a rotary impeller with a driving D.C servo motor.

WORKING MECHANISM:

ROBOT MECHANISM:

The mechanism of the robot includes the following,

1. The robot consists of 4 servo motors and 4 legs, in which the functions of 2 motors are to generate rotary motion of 2 legs only (leg contains suction cup 1 & 4).These 2 legs motion will operate synchronized. The remaining 2 legs are to support a body of robot during a movement. To make the body of robot move forward and backward. The slider-crank mechanism consists of the links. For the link 1 it joint with the servo motor and link 2, while for the link 2 which include with suction cup joint with the link 3, lastly the link 3 is joint with slider. A joint is a non-fixed connection between two or more links allows certain relative motion between these links. Each of the 4 cranks is connected with the slider part and sucking cup. Only the motion of the slider-crank mechanism of legs consist suction cup 1 & 4 will cause the robot to move. The remaining of legs consist suction cup 2 & 3 will l be fixed at a certain position. All of these position (1,2,3 & 4) will occur during rotational motion of 2 legs only. The 2 movement legs will move synchronized. These positions depend on a movement of robot whether it move forward or backward.

For the forward movement: Two rotation legs will touch the first switch at position 2 then it will stop. At this state all 4 suction cups will stick on the surface of wall. After a few seconds, the suction cups of 2 non-rotational legs will release it contact to the surface of wall. 2 rotation legs will rotate until it touching to the second switch at position 4 then it will stop. At this state the suction cups of 2 rotation legs will stick on the surface of wall. At this state all 4 suction cups will stick on the surface of wall. After a few seconds, the suction cups of 2 non-rotational legs will stick to the surface of wall while the 2 legs will rotate continuously until it touching the first switch without any contact of suction cup to the surface. This process will repeat continuously to generate movement of robot.

For the backward movement: Two rotation legs will touch the first switch at position 4 then it will stop. At this state all 4 suction cups will stick on the surface of wall. After a few seconds, the suction cups of 2 non-rotational legs will release it contact to the surface of wall. Two rotation legs will rotate until it touching to the second switch at position 2 then it will stop. At this state the suction cups of 2 rotation legs will stick on the surface of wall. At this state all 4 suction cups will stick on the surface of wall. After a few seconds, the suction cups of 2 non-rotational legs will stick to the surface of wall while the 2 legs will rotate continuously until it touching the first switch without any contact of suction cup to the surface. This process will repeat continuously to generate movement of robot.

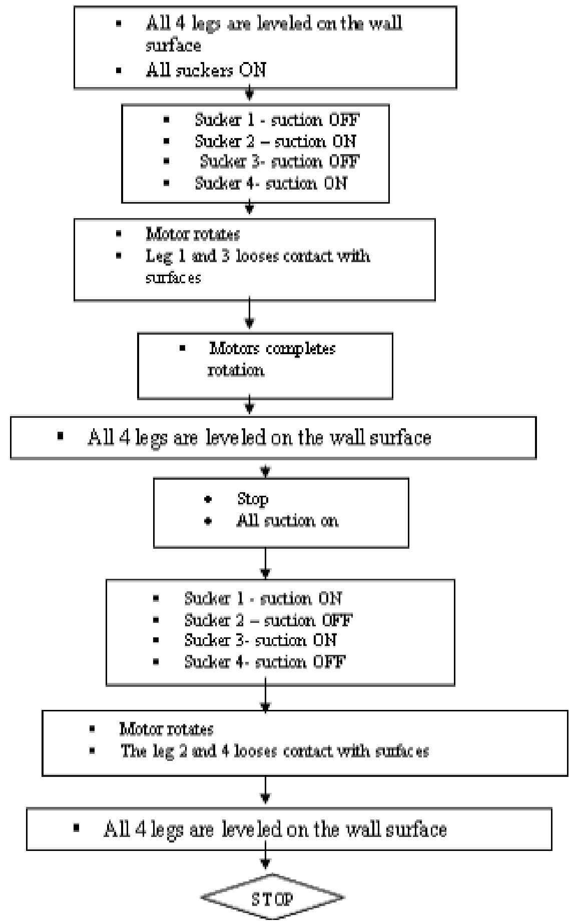

Figure 4: Flow chart for climbing Mechanism.

IV. EXPERIMENTAL RESULTS

The servo motors and the wheels added and the experimental results for adhering mechanism obtained. The mathematical relationship of suction force and transition motion to impeller RPM is shown in Figure 4. With reference to Figure 4, the required RPM for operation is ranging from 8000 to 13,000. Less than the lower limit will not provide enough adhering force for the robot to attach to the surface and more than the upper limit will make it difficult for agile locomotion, and easy manoeuvrability. As the rotation of the impeller increases the suction force is increasing, but the scanning speed is decreasing simultaneously. Therefore the challenging part is finding the optimum value of adhering force to meet the requirement of both safety operation and easy locomotion.

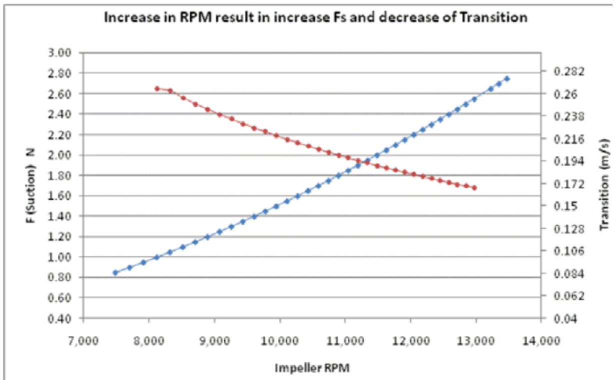

Figure 5: Relation of suction force and transition Motion to impeller RPM**.**

V. CONCLUSION

This paper proposes a simple wall cleaning robot that uses a portable rigging for the motion there by reducing the cost of climbing mechanism. It saves 70-80% labour and cleans buildings with offsets and window frames. The robot is light in weight and mobile, easy to transport and operates safely from top of the building. The components required are simple enough to do the cleaning task. Finally, this robot should be further developed so that it can be assigned to do tasks that would be difficult for humans to do.

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