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A Simple Window Glass Cleaning device for High Rise Buildings Using Delta PLC

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Abstract:

Cleanliness is one of the most important requirements of maintenance of high-rise buildings with glass facades. The window's architectural glass will befree from dust and dirt using the window cleaning method. The proposed method is an unmanned device that deals with the design and fabrication of a glass cleaning device which would be controlled by using a Delta PLC. This method would be safer compared to the traditional cleaning method which risks human life and eliminate hazards. This device consists of rectangular frames, suction cups, a cleaning mechanism, proximity sensor. The rectangular frames were constructed using aluminum sections which are riveted together to form a rectangular frame. Suction cups are used to attach the frame to the glass. The frame consists of an automated cleaner which is programmed with Delta PLC. The proximity sensor is used to find the obstacle. Once theobstacle is found the motors will stop working. The motion of the device is fully controlled by Delta PLC. A prototype unit was built and tested. This device uses a suction cup as the gripper to enable movement in both directions.

Keywords: PID controller, Delta PLC, Sensors, DC motors

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I . INTRODUCTION

With the increasing number of glass-windowed, high-rise buildings there exists an increasing demand for maintenance. Maintenance involves glass surface cleaning. This process involves glass surface cleaning. This process is being done manually to date as shown in Figure 1. The manual method is risky, time-consuming, and costly. To overcome this limitation robots have been created to assist or replace humans in dangerous and difficult tasks.Robots have been used in manufacturing, construction, security, safety, etc. This is because they can adapt to different situations and environments. The manual way of cleaning office windows cannot be applied to high-rise windows with huge sections of glass. The reason is that windows from outside require special tools in going up and it's unsafe [1]. The main objective of this paper is to design and fabricate a simple window glass cleaning device for glass-covered high-rise buildings and to increase safety and clean the glass. This will ensure the prevention of accidents due to the human workforce used in high-rise buildings [4].

Figure 1: Manual cleaning method[12]

II.Overview of the work

A block diagram of the glass cleaning device is shown in Figure.1.The control method is the PID controller.The controller's feedback signal comes from the proximity sensor used in the setup.The main sources are placed on the surface of the table as shown in Figure2. This is done to reduce the weight of the main device and to improve its cleaning efficiency and its mobility.

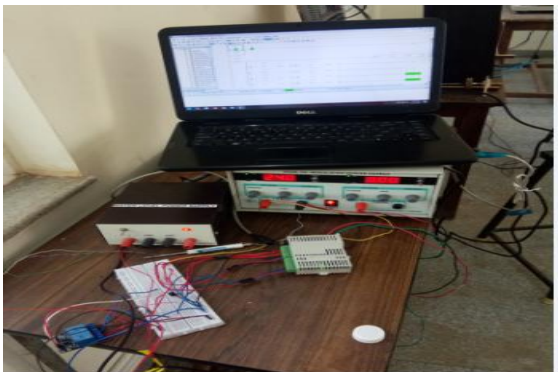

Figure 2: Main sources used for the project

Delta PLC, Relay, and power supply are placed on the table beside the glass. Lines are passed from these components to the main devicefor it to function. The device isfully controlled by Delta PLC. DC motors and sensors are placed on the frame. One motor is for horizontal movement, the second motor is for vertical movement and the third motor is for cleaning. Once the Delta PLC is on, the cleaning motor the vertical motor will be on, which pulls the cleaning mechanism upward. The cleaning willtake place with thehelp of a woolen brush attached to thecleaning mechanism. The movementofthedevice will be fromtopto bottom and bottom to top and hence the cleaning will be done two times for efficient cleaning. Once the cleaning is done on the overall surface it will reach the end. The proximity sensor will detect the obstacle and all the other motors stops working.

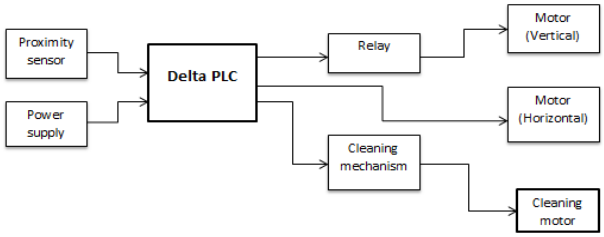

Figure 3: Block diagram of the proposed method

III.Design of hardware controller

The frame is the main part that will take all the load of the components. The frame is made of aluminum because it is less reactive, lightweight, and strong [2]. Suction cups make contact with the glass surface. A Relay board module is used to control the higher current loads. This board has 2 onboard relays. This is a 12V 2-channel relayinterface board that can be directly controlled by the control. Proximity sensors are used to detect whether the object is within the predetermined range or not.The device processes the information received from sensors and reacts in a determined manner according to the design of the control system. A medium-speed, medium torque is used to run the rotary brush for cleaning purposes [3].

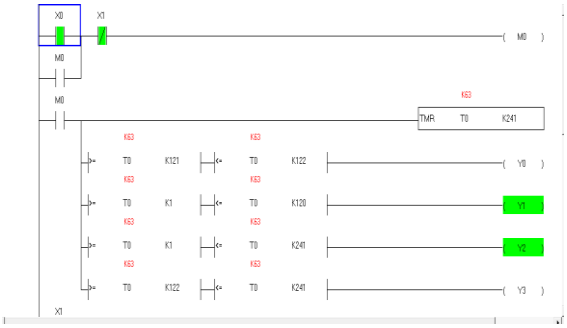

Figure 4: Ladder program for the project.

Figure 5: Hardware Setup of the project

IV. Design of control method

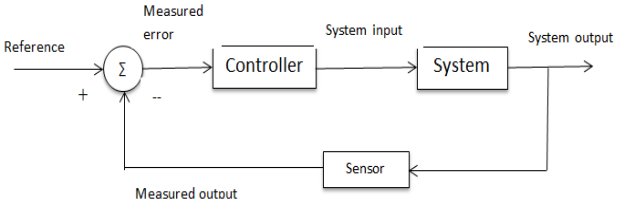

Figure6: General block diagram of PID

The basic structure of a system with PID control implemented is shown in the figure The systemoutput with a sensor and compared to the reading to the reference value Reference and the measured output are compared and the result is an error value which is used in calculating proportional, integral, and derivative responses. In this project, a PID controller is applied to the proximity sensor value. This is a closed-loop system with proximity sensor feedback. The equation for PID is given as

$$u(t)=Kp\ e(t)+ Ki \int e(t)dt + Kp\ de/dt \qquad (1)$$

Where U (t) = PID control variable

Ki=integral gain

Dt=change in time

Kp= proportional gain

de=change in the error value

e (t) = error value

V.Motion of the device

The device will be stuck to the glass surface with the help of suction cups. The cleaning mechanism is the movable part of this design [6]. This device can be stuck to the surface of the glass façade. The cleaning mechanism moves from the top to the bottom in the direction shown in Figure 7. DC motors will be fixed to the frame. One is for horizontal movement and the other is for vertical movement Suction cups are required to grip the device to the glass [11]. The proximity sensor will detect the obstacle or the edge of the frame. Once the device reaches the end of the frame the sensor will be high and then the Delta PLC turns off all the other motors.

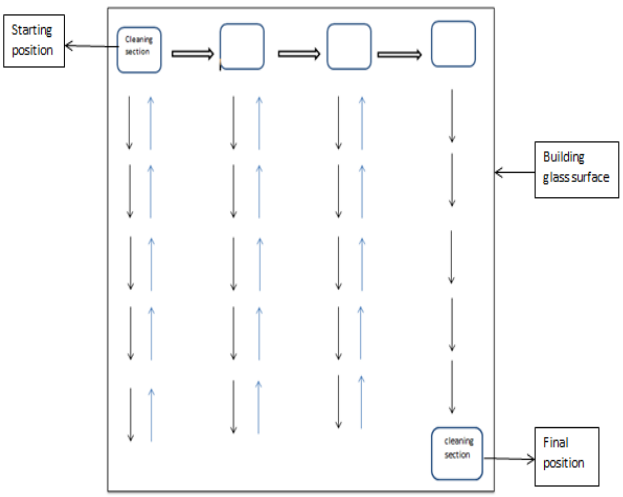

Figure 7: Motion of the device

VI.RESULT AND DISCUSSION

Theprototype of the glass cleaning device was successfully designed and fabricated using Delta PLC. The system has been tested on the glass surface. This machine can work well for buildings having completely glass exteriors [8]. It can perform cleaning of glass surfaces. The motion of the cleaning mechanism [13] is controlled by DC motors. The suction cup attachment system ensures good contact with the support surface and it is simple and reliable. The prototype is shown in Figure 8.

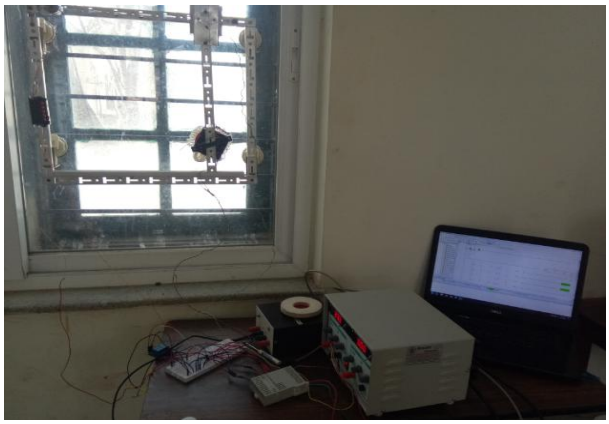

Figure 8: Final working model

Table 1: Experimental readings

Time(sec)	**Working motor**
1-12	Motor 1 is on(forward)
12-24	Motor 1 is on (reverse)
1-50	Motor 2 is on(cleaning)
24-26	Motor 3 is on(vertical)

VII.CONCLUSION AND FUTURE SCOPE

Glass cleaning of high-rise buildings is a risky and difficult task. The prototype of the glass cleaning device is designed in this paper. In this design, the dry cleaning method is used, where the cleaning mechanism consists of a soft woolen brush. The cleaning machine uses portable rigging for the motion thereby reducing the cost of the climbing mechanism. In future work, this device can be extended by the rectangular frame and fix the suction cups where requirecleaning, and also include wet cleaning method for accurate cleaning.With some further modifications, it can also be used for wall painting [10].

REFERENCES

[1]. Tohru Miyake and Hindenoi Ishihara, "Mechanism and Basic properties of window cleaning robot" in Proc. International Conference of Advanced Intelligent Mechatronics, 2003.

[2]. Professor Yoram Koren, "Winrobo Window-washing Robot", ME 450 Section 2 Fall 2007, December 11, 2007

[3]. Tohru Miyake and Hindenoi Ishihara, "Mechanisms and Basic Properties of Window Cleaning Robot, ieeexplore, 2008

[4]. Meng Joo, Lio yewin, Ong Lok Ping, "Design and Development of small glass cleaning robot", IEEE Xplore, 2013.

[5]. Vinod Kumar M V, Prem Kumar Naik, Prasad B G "Design and fabrication of automated glass curtain cleaning Machine" International Journal of Scientific and Technology Research (IJSTR), Volume-3 Issue-9, September 2014.

[6]. Shinichi Yoshida, Ryu shoji, "Development of small sizewindow cleaning robot by wall climbing mechanism", ISARC,2016.

[7]. Ernesto Gambao, Miguel Hernando and Dragoljub Surdilovic, "Development of a Semi-Automated Cost- Effective Facade Cleaning System", Robotics and Automation in Construction, 2017

[8]. NazimMir-Nasiri,Hdyjaya, siswoyoj Md, Hazrat Ali, "Portable Autonomous Window Cleaning Robot", Procedia of computer science,Elseiver, volume133,2018.

[9]. Dong Sun, Jian zhu and Shiu Kit Tso, "Aclimbing robot for cleaning Glass surface with motion planning and visual sensing", Development of Manufacturing Engineering and Engineering City University of HongKong, Volume 13, 2018.

[10]. A. Albagul, A. Asseni, O. Jomah, M. Omer, B. Farge, "Design and Fabrication of an Automatic Window Cleaning Robot", Recent Advances in Signal Processing, Robotics and Automation, 2012

[11]. Noriaki Imaoka, Se-gon Roh, Nishida Yusuke, and Shigeo Hirose,"SkyScraper-I: Tethered Whole Windows Cleaning Robot" The IEEE/RSJ International Conference on Intelligent Robots and Systems October 18-22, 2010.

[12]. Commercial building cleaning pictures, images, and stock photos https://www.istockphoto.com/photos/commercial-building-cleaning.

[13]. Kavya S Gogi, MaheshanCM, H Prasanna Kumar, "Automatic solar tracker with dustwiper using PID controller", International Journal of Trend in Scientific Research and Development, volume-2 2017.