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Development and fabrication of semi-automatic glass pane cleaning robotic device using Arduino Uno microcontroller

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ABSTRACT

The rate at which our country is developing is increasing day by day. The number of buildings rising towards the sky everyday is astonishing. Gone are those days where buildings were just bricks laid out vertically towards the sky. Now creativity is what designs the building. Glass buildings are those, which are covered by glass panes on the complete outer structure. They have the ability to convert boring buildings to look magnificent. Glass buildings indeed look magnificent but they have a small problem. The glass panes get dirty over time and cleaning them is difficult and time consuming job. The problem of cleaning the window has a great importance as it is now where the man was responsible for manual cleaning regardless what he uses facing tiredness and danger for the man until the man invented a machine to lift him to high building or the places which man cannot reach it. This innovativeness has a great progress and a big factor and helpful for the man until the invention of robot where the man found in this invention the comfort that is because robot is a group of mechanical systems carry out the man's orders. The window cleaning process take many stages represented in the following; manual stage, manual stage with the help of machine and machine stage only. This paper

explains the purpose to replace or minimize human involvement in cleaning the window by replacing it with a small cleaning robot for office window with several capabilities. The abilities are; portable, small size, lightweight, automatic operation and can clean all the corner of the office window.

Keywords: Buildings, Cleaning, Machine, Windows, Robot and Capabilities.

1. INTRODUCTION

Robots have been created to assist or replace humans in various dangerous and difficult tasks. They have been used in construction, manufacturing, security and etc. This is because they are able to adapt to different environments and situations. They have conquered nearly all environments that humans have put them through. Cleanliness is one of the important aspects in human life. Because of the importance, many kind of cleaning mechanisms are invented to ease the human daily chores such as vacuum cleaners, window cleaners which are to clean glass windows. Nowadays, with the large increase in development of tall and smart buildings in urban areas, the window cleaning robot becomes a necessity. The problem of cleaning the window has a great importance as it is now where the man was responsible for manual cleaning regardless what he uses facing tiredness and danger for the man until the man invented a machine to lift him to high building or the places which man cannot reach it. This invention has a great progress and a big factor and helpful for the man until the invention of robot where the man found in this invention the comfort that is because robot is a group of mechanical systems carry out the man's orders. The window cleaning process take many stages represented in the following; manual stage, manual stage with the help of machine and machine stage only.

The industrial robot is considered to be a mechanical device which can carry out the human jobs in dangerous and hazard areas. This is to stop danger on the human's life. Moreover, robots can repeat the job task more frequently with precision and shorter time. The window cleaning robot is operated by itself which will not require an operator. In this millennium, technology has been developing rapidly and every day, new invention appeared in order to make human life easier. The window cleaning robot itself is in evolution to make it intelligent and move by itself without man to operate it. Some of those robots had been already produced. They are intelligent and autonomous cleaner with different features. To make the robot move by itself, we have to fix a system which could drive the robot to move. By integrating the wiping mechanism with mobile robot, we will have our own automatic cleaning robot which can move by itself intelligently while we are reading our daily newspaper. Besides having our smart cleaner moving by it, we also want our cleaner to be smart enough to differentiate the capacity of the dirt so that it can use lower energy for not-so-dirty surfaces and more energy for heavy dirt.

2. RESEARCH MOTIVATION

The emergence of a robotic application will be the next hot field in this current era (Gates, 2007). It shows by the development of many robotics products with autonomous concept for example autonomous vacuum robot (Ulrich et. al., 1997), museum tours guide robot (Burgard et. al., 1998) and etc. When dealing with hazardous job, it is better to replace human with robot that can perform a task without continuous human guidance or autonomous robot (Bekey, 2005) to overcome human risks. Office window cleaning is a hazardous job and it involves high cost. Cases reported to Health and Safety Executive had shown that there had been between two to seven window cleaners were killed each year in Great Britain and 20-30 suffer major injuries while doing cleaning jobs (HSE, 2003). By using conventional method, human involvements are needed to the do all the task. This shows the need for small, lightweight and portable window cleaning robot for office window to replace human involvement in high risk activities.

The advantage of conventional method by human is the job can be accomplished for many complex office or building structure. The disadvantages of conventional methods by human can be described in four major points. First point is manual labour. Manual labours for conventional method undeniably gamble with high risk and longtime consumption. The second point is limited efficiency. The process could be very slow as it depends on human expertise to finish the job. The third disadvantage is budget constraint. Using conventional method by human or by customized machine involves high cost for its equipment and suppliers, labor cost, insurance (Giamberardino, 2001), and by the machine itself. The last point is limiting factors. There are certain limiting factors with job done by human. If the job is done by human, it depends on weather and daylight factor. This project is hoped to overcome the limitation of conventional methods. This research based project is focusing on the development of a small cleaning robot for preferably office window.

Window cleaning is also one aspect of office maintenance activity. The clean windows will irrefutably provide a comfortable environment to the office inhabitants. The two main points that are emphasized in this work are overcome the hazard (HSE, 2008) of human involvement in cleaning office window activity and reduce high cost by the conventional method of cleaning window. It becomes necessary to overcome the limitation. This project intends to replace or minimize human involvement in cleaning the window by replacing it with a small cleaning robot for office window with several capabilities. The abilities are; portable, small size, lightweight, automatic operation and can clean all the corner of the office window [1, 2].

3. CONSTRUCTION USING ELECTRONIC MODULE

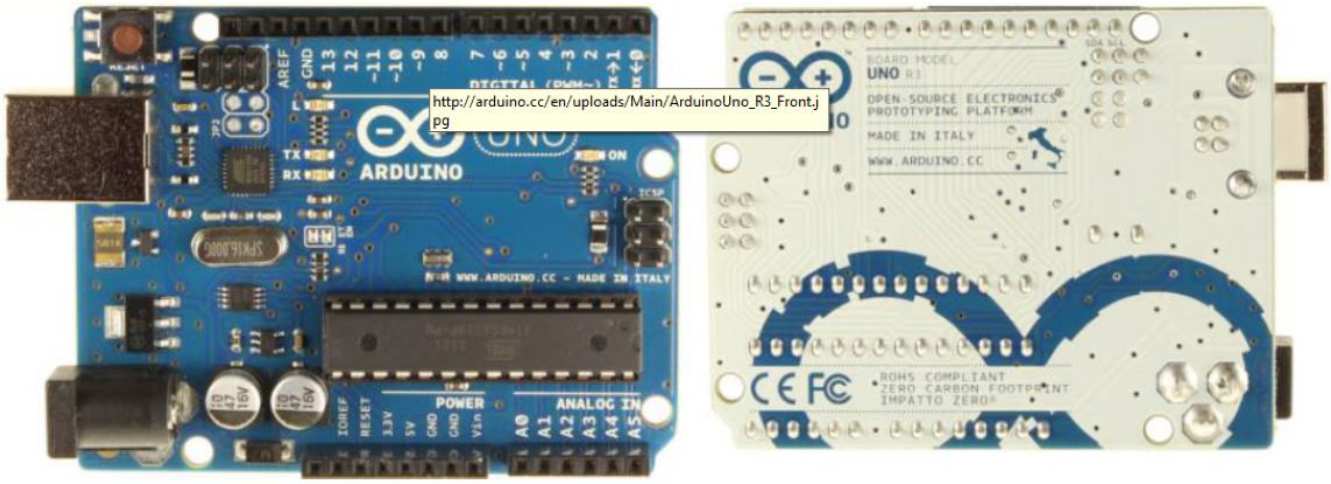

Figure 1 Arduino Uno Microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atx`mega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward.

The Arduino Uno has been powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication.

4. PROGRAMMING

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). The bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available.

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

5. WORKING AND PHYSICAL CHARACTERISTICS

The salient components in semi-automatic glass pane cleaning robotic device are DC geared motor, stepper motor, gear unit, bearing pillow block, linear shaft, rack & pinion, joystick module and bracket. The joystick module controls the movement of the complete system. The cleaning mechanism follows the path directed by the operator. On pushing the joystick upwards, the mechanism moves up. So is the case with all the different directions. Cleaning is done by the sponge scrubbers aided by water which is sent at high pressure by a pump. The movement of the cleaning mechanism is done by motors, dc geared motor for vertical movement and a stepper motor for the horizontal movement. Both the motors are controlled by their respective drivers. A rack and pinion arrangement sets the vertical path whereas the horizontal movement is provided by a belt drive. The calibration of the joystick is done by programming the Arduno chip which is integrated into the circuit used for this project.

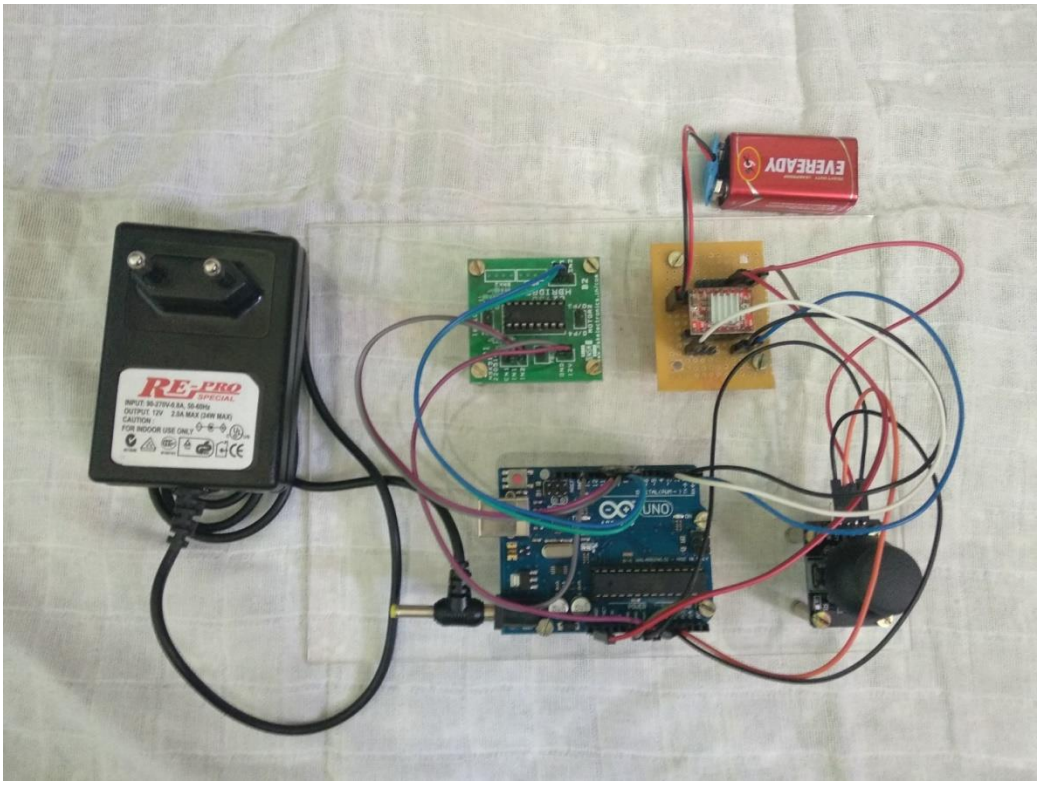

Figure 2 Comprehensive Electronic Module

The power is supplied to the system by a 12V adapter. This power is supplied to all the component except the stepper motor driver, which has it's an external power supply source, an 9V external battery. This battery is provided since the stepper motor requires additional current for its operation and the primary power supply doesn't meet the current demand. The joystick, stepper motor driver is connected to the Arduino board using a 5V and ground connection where the connection for the dc geared motor is a binary one. Looking at the joystick, the connections are made to the Arduino board, for the control of the cleaning mechanism and the stepper motor driver, for the power supply.

The complete calibration of the joystick was done by programming the Arduino chip using a laptop. The connection for that is provided in the board itself. An USB port is provided in the board using micro controller to the laptop and program it using the relevant software. Basically the joystick is like a potentiometer. Every change in its position gives out a different value of resistance. This forms the base for the calibration. On pushing the joystick to the right, it produces a certain resistance which, is fed to the micro controller as a direction, a command basically, to direct the motor to go right. That's how the calibration was done for all the four directions. Four directions because this project is based on a X-Y robot, a 2 D configuration planar robot which has only 2 horizontal and 2 vertical movements.

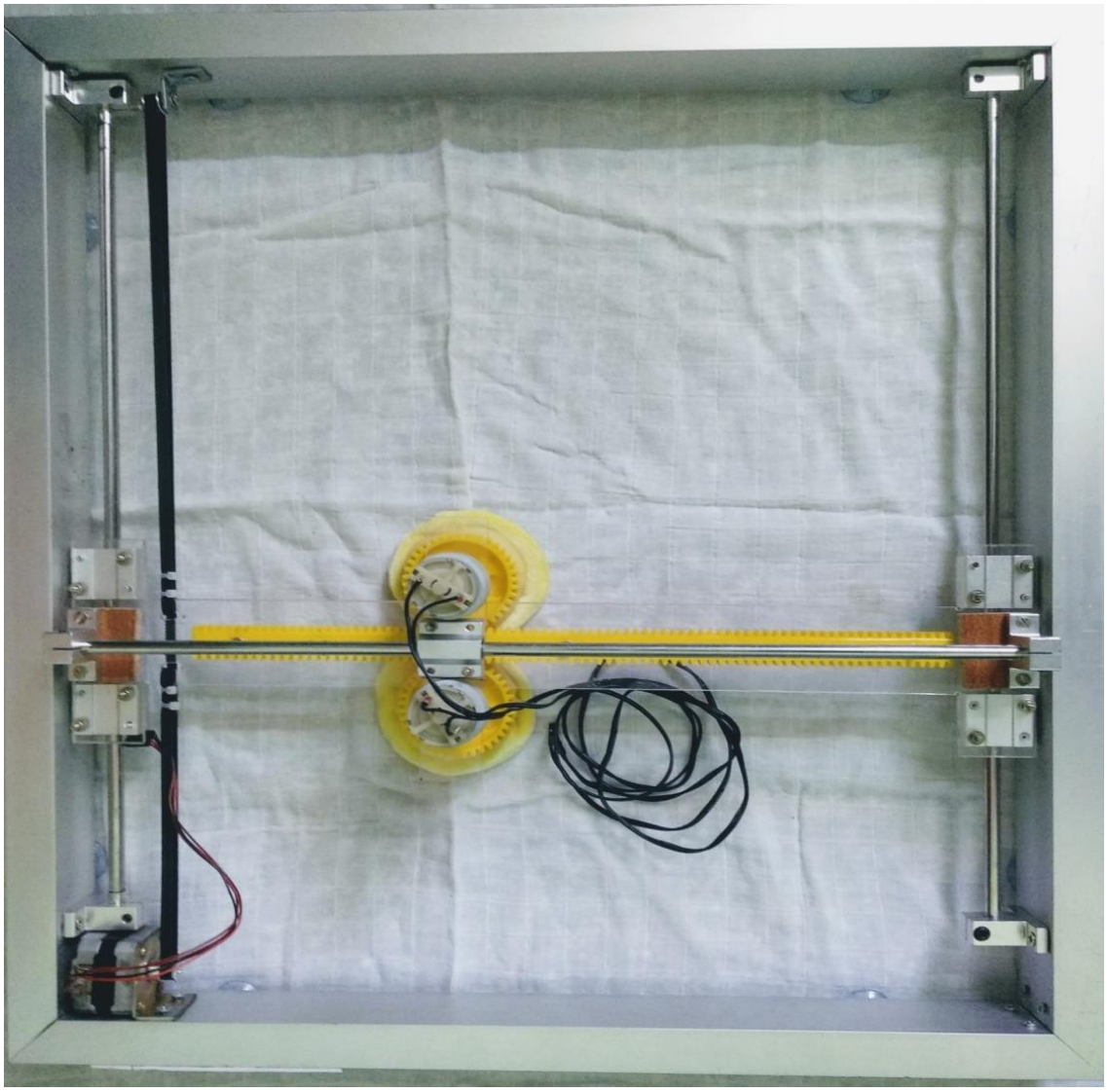

Figure 3 Semi-Automatic Glass Pane Cleaning Device

All the connections of the DC geared motor driver are to the Arduino board and the motor. The supply, 12V and ground is regulated to 5V using a regulator which is an integral part of the board. The Arduino board supplies the power and the directions to the driver board. The motor is then fed with these two inputs for its function. As mentioned earlier, this driver uses an external power source along with the primary source. External source since the stepper motor requires additional current. Connections are to the Arduino board and the stepper motor, along with a supply to the joystick. As before, the Arduino board sends the power and the directions for the functioning of the stepper motor. As seen in fig. 2 and 3, there are basically 4 circuit boards, joystick, 2 driver boards and the Arduino board, all interconnected everything here is installed using spacers for the installment and smooth functioning of the complete system. The information provided above only discusses about the circuit board and its functioning. Now to the main system, the frame and the cleaning mechanism with its corresponding motor. This complete system is connected to the circuit boards using relevant connectors. Dividing the system, 2 major dividends; cleaning mechanism, mechanism for movement.

6. CLEANING MECHANISM

Cleaning action is proved by the sponges aided by water pumped at high pressure onto the glass. The circular sponges are directly connected to the DC geared motor and its rotatory motion is in line with that of the motors. Sponges are used because of their absorbent and light weight nature; pressurized water, to clear away dirt and dust. Water is stored in an external reservoir and pumped using a water pump. The reservoir and the pump are not an integral part of the system, rather placed away at a convenient place. The water is pumped in the most efficient way to reduce excessive usage of water and the sponges chosen for excellent absorption.

The movements are provided by the motors, X direction by the stepper motor; Y direction by 2 DC geared motors. The stepper motor is mounted at the base and the movement is provided by a belt drive with an idler at the opposite and of the motor. The DC geared motors are attached to a rack and pinion system for the vertical movements. When the signal is for horizontal movement, the stepper motor drives the belt, moving the whole cleaning system, DC motors and the sponges along with it. And when the signal is for vertical movement, the DC geared motors move up and down taking the sponges along with it. This movement also cleans the glass. This is how the cleaning action takes place in this project. The whole system is attached onto a frame on 8mm shafts for movement. Shafts attached to the frame by SK8 brackets. The complete description of the components used is discussed in the Construction page of this report. Overall weight, pump efficiency, speed and practicality are the major aspects considered for this project.

7. ENVIRONMENTAL IMPACT & HUMAN SAFETY

Commercial window cleaning can be a major undertaking. As energy consumption continues to be of concern on the social agenda, it is important for us all to be doing our bit to reduce the impact that we have on the environment. This project does its best to avoid wasted water. Not only does this reduce our environmental impact, but it also helps to keep costs down and reduce disruption to the occupants in a building. By using the latest equipment, it is always offer most efficient water delivery systems and that can be tailored to suit each project. There are many examples within the cleaning industry of accidents involving working at height, for example: whilst working on stepladders, overstretching from ladders whilst window cleaning, standing on benches or chairs to clean high surfaces. To overcome the risk whilst cleaning the windows, automation is preferred to clean the glasses. The automation in this project is to clean the glass to eliminate human risks involved while cleaning the glasses of high rise buildings.

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Conflicts of Interest: The authors declare no conflict of interest.

REFERENCE

1. A Albagul, AAsseni, O Jomah, M Omer and B Farge, "Design and Fabrication of Window Cleaning Robot", *International Journal of Engineering and Research,* Vol. 2, 2013, pp. 1 – 4.
2. I B Iska, Article on Small Cleaning Robot for Office Window, University Malaysia Pahang.