

Design & Implementation of Vertical Surface Climbing Cleaner Robot

Abstract- This paper presents a vertical surface climbing robot for cleaning of dust from high rise building. Usually, people clean their wall of outer surface of building by human. Often it becomes risky and costly also. A portable robot having the ability to climb on vertical surface has been expected for a long time. To protect human's life we designed a prototype of vertical surface climbing robot for cleaning and other multipurpose operation. Some combination of technology has been shown such as smart wireless control with all direction moving capability. Four Dc motors are used to move the robot and one Dc motor is used to rotate the cleaning brush. There is one Electric Ducted fan (EDF) which helps the robot to stick to the surface against gravitational force. An Arduino uno is used as a controller for different There is a Bluetooth modular which has been used to connect with smart phone and take command from user. Four motor helps it to move in up, down, right and left direction by the according commands given by smart phone. The full robot is power by using DC battery and AC to DC converted adapter combined. To observe the outcome of the project, we analyzed the performance of the robot by climbing in different surfaces with different nature. The climbing and stick to the surface differ because of grip. Gripping is an important issue for this robot. Most of the surface except glass its performance satisfied us.

Key Words—Electric Ducted Fan (EDF), Bluetooth modular, Arduino Uno, DC Motors

I. INTRODUCTION

Nowadays, constructional developments are increasing as a result high rise buildings are increasing day by day. Moreover, our world's environments has become so polluted with the industrial development. This causes too much dust to the outer surface of building. That is why it is needed to clean the building from outside to keep it clean and beautiful. Sometimes, it is also necessary to make color or to keep surveillance of the surface of building. All these needs make people bound to climb the outer surface of building by taking life risk. It may causes lots of accident which creates lots of fatal condition of patients. In last 15 years, accident of window cleaners were observed by Occupational Safety and Health Administration (OSHA) which states that 62 cases resulted in fatalities out of 88 window washing accidents [1]. It means 59% of accidents creates fatalities which is remarkable [2].

Vertical surface electrical equipment. After many of modifications, this robot can serve many of purpose like cleaning, coloring, surveillance, monitoring etc. The number of high rise buildings are increasing rapidly which contains mega shopping malls, hospitals, hotels, educational institutions, residential building etc. As it is necessary to keep beautiful and attractive those buildings from the outside, it becomes mandatory to clean the outer surface of building. Vertical surface climbing robot can climb over the outer surface of building and it can clean the surface with the help of moving brush which is operated by DC motor.

Vertical surface climbing cleaner robot can play a remarkable role both socially and economically. As it is visible that there

were a large number of accidents occurred, this vertical surface climbing cleaner robot can reduce the number of accident near to zero. Moreover, the cost of cleaning is expensive due to the number of workers. This kind of climbing robot can deduct the cleaning and coloring cost of building. Sometimes, it is difficult to complete the cleaning task within the given time duration due to many problems like rain, thunderstorm etc. For getting the balance against the gravitational force, the robot will have EDF which will create a high amount of rotational energy so that the whole robot will be capable to get stability. The rotating brush can rotate with its 360 degree angle which makes the robot easy to clean.

The development of vertical surface climbing cleaner robot is expected for a long time. This kind of robot can be used as rescue or inspection and others operations with its modification and developments. Initially, we have to choose the way how we implement the system and what types of components we are going to use. Before starting the implementation, there are two objectives for the final representation of the robot. Firstly, to make such a device this can move in vertical direction on wall. Secondly, to provide a cleaning mechanism with the robot so that it can clean the surface. For the implementation of Wall climbing cleaner robot needs three steps like mechanical modeling, electrical design and different types of coding. The very first challenge is how to stick the whole robot with the surface. Electrical Ducted Fan (EDF) is a wonderful and smart solution for the suction of air from surface. EDF is made of brushless motor with bladed fan. This is a 70mm 12-bladed ducted fan. The EDF is made with a 2300KV-6S brushless motor [3]. This EDF has high torque due to its brushless motor. In this manner it can overcome the gravitational force.

A servo tester has been also used to run the EDF. It has been connected with ESC. It has three mode for run manual, neutral and automatic [4]. Here it has been used in automatic mode to control the speed of EDF. This is a 3 channel ESC servo tester [5].

II. METHODOLOGY AND ARCHITECTURE OF THE SYSTEM

The initial development plan is shown in Figure 1 by a simple block diagram. The block diagram is divided in two parts as its main duty is in two portions. Microcontroller, ducted fan, dc motors, motor drivers are operated for moving towards vertical direction. Cleaning mechanism is operated to clean the surface or color the wall. For operating two pairs of dc motor, there are two motor driver which is enough for all the dc motors. As a power supply a 12 volt DC battery is used which can supply a continuous electricity. This power supplied can be supplied by 220 volt line voltage by an Ac to DC converter. As it is a prototype of robot, a DC battery is used here for power supply.

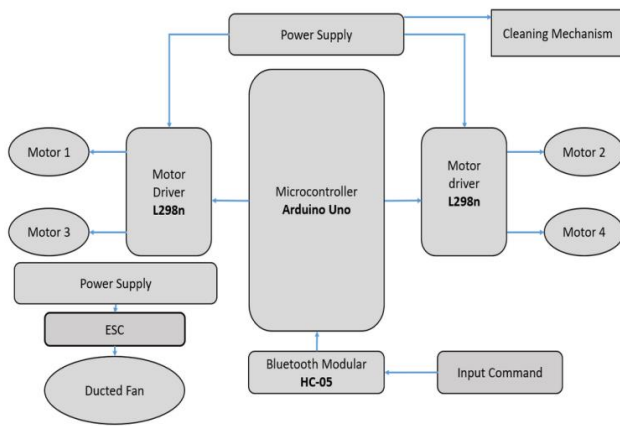


Figure 1: Block Diagram

EDF is connected with the ESC for controlling the speed of motor. Mainly this ESC controls the speed of motors. Two L298 motor drivers are used for operating DC motors. Each motor driver operates two individual motors. As a controller Arduino Uno is used for multiples operation like operating motor driver, modular etc. Besides all these, we have also used a servo tester for running EDF. Throughout the whole hardware implementation, EDF plays a key role. As it is early mentioned that EDF is made of brushless motor with bladed fan, that's why an ESC is used for regulation purposes.

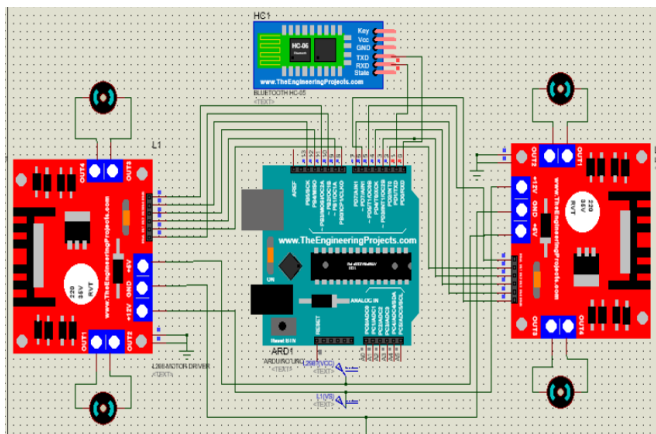


Figure 2: The base of the Vertical Surface Climbing Cleaner Robot

Before moving towards the physical implementation, robot's movement is observed by the software simulation. Figure 2 represents the whole operations procedure. The simulation is done by proteus 8 professional. From the Figure 2, it is visible that an Arduino uno is used as controller and two motor drivers are connected with that controller. Each motor driver is connected with two DC motors. A Bluetooth modular is also connected with the Arduino. This Bluetooth modular is used for operating this robot without any kinds of wired medium. An application of play store named as Bluetooth RC controller is used for operating this robot. The interface of this application is shown in Figure 3. By this application, the robot can be operated

in XY plane. Firstly, the controller is powered on by the source and then it starts to operate. The connecting motor drivers get command from the controller Arduino Uno. When the motor drivers get command from the controller, those motor drivers start to operate the two DC motors individually. As the DC motors are started to run, the whole robot will move towards vertically.

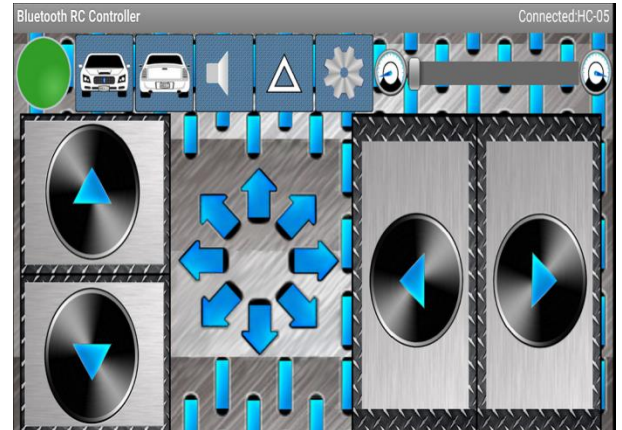


Figure 3: Interface of Bluetooth RC controller

It is visible from Figure 4 that EDF is situated at the center of whole robot.

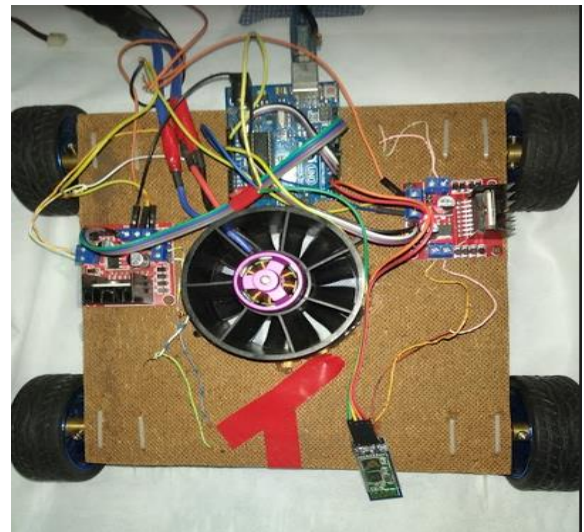


Figure 4: Top View of Hardware Side

The EDF is as heavy in weight as the center of gravity worked properly due to its middle position. Generally, EDF is used for vertical take-off and landing (VTOL) purposes while EDF provides a high amount of rotating energy [6]. Due to its high speed it can deduce the air of the surface where it stands as a result it is possible to get the stability against the gravitational force.

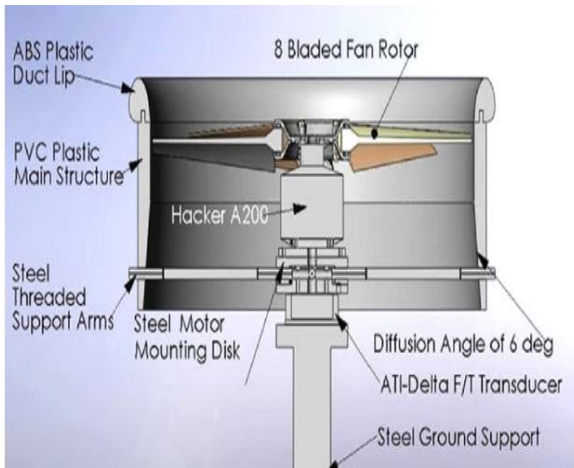


Figure 5: Internal structure of Electrical Ducted Fan (EDF) [6]

From the internal structure of EDF it is visible that Hacker A200 is the central axis of EDF which holds the eight blades fan rotor [6].

As it is a prototype of vertical surface climbing cleaner robot, the whole structure is designed upon a hardboard. Each DC motor is connected with a wheel which helps the robot to move forward.

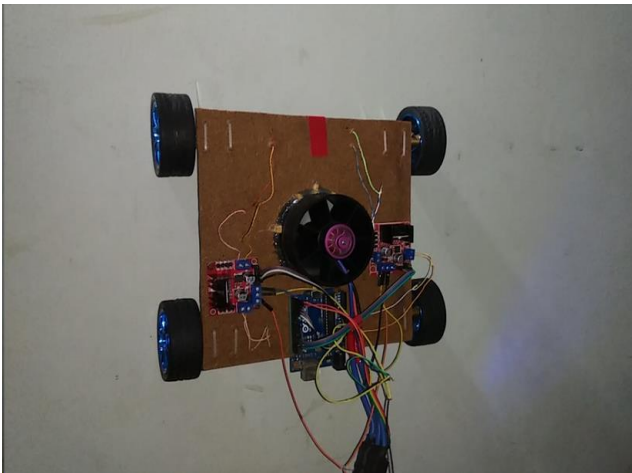


Figure 6: Movement through Vertical Surface

III. RESULT ANALYSIS

Vertical surface climbing cleaner robot will climb above the wall and clean the surface with the help of a moving brush. The initial challenge is overcome by the electrical ducted fan, and it can move through vertical direction with the help of DC motors. In Figure 7, it is shown that the robot is climbing and its moving brush is cleaning the surface.

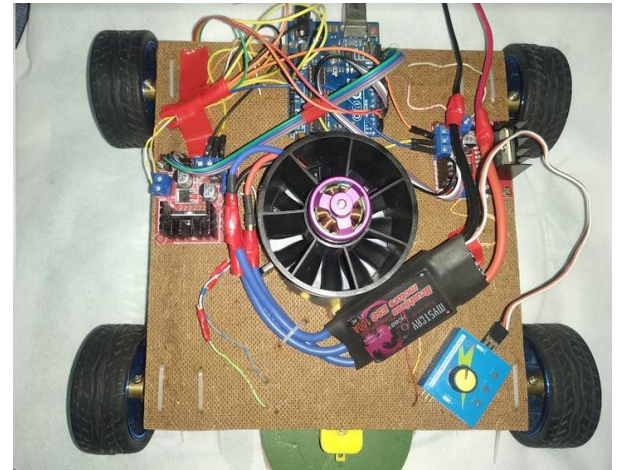


Figure 7: Movement through Vertical Surface

From Figure 7, it is shown that the cleaning mechanism. The brush which is used for cleaning, that is stayed at the front of the robot.

This PVC frame provides stability and shape of the robot. All the equipment are inserted with a zip wire for tiding all the equipment with the PVC board.

Vertical surface climbing robot can move both X and Y axis also. It means the robot can start its journey from horizontal surface very comfortably.

According to a comparison of a ten storied buildings cleaning cost by labor and robot, it is noticeable that the robot is much efficient than labor. From Table 1, it is easily noticeable that for the cost of workers is 150\$-210\$ approximately where the two robots cost will be around 400\$ [6]. It represents that the cost of cleaning robot is twice than labor. But the mentionable thing is these robots can be utilized multiple times without any costing except the power supply. On the other hand, for the cleaning purpose 150\$ will be required for every cleaning time. This comparison shows that vertical surface climbing cleaner robot would be economically efficient and ethically helpful for human being.

Table 1: Comparative cost for cleaning wall [7]

Number	Unit Cost	Working Time	Total cost
Labor Cost(Four Person)	25\$-35\$ per hour	6 hours	600\$-840\$
Two Robots	150\$ each robot	Continuous Power Supply	300\$

IV. CONCLUSION AND SUGGESTION FOR FUTURE WORK

The main purpose of this project is to reduce the life risk of workers from high rise building. We have implemented a small proto type of vertical surface climbing cleaner robot which can go through any wall and clean its surface. An EDF is used for the suction of air to stick it on the wall. For cleaning, a brush is added at the center of the robot so that it can clean its surface. To maintain the sustainability, we need to take care of the cost of our projects so that government grants it for the implementation in countrywide. If we would get the finding and facilities, we can upgrade it as multipurpose tasks like coloring, inspection, rescue etc. We faced some difficulties, while we selected our motors. Initially, we selected the motor with high rpm but those were heavy in weight. After that, we overcome our difficulties by shifting to light weight low rpm motors. While, we supply voltage with DC battery (24 V), it becomes heavier than normal condition. That's why it cannot carry more than 2.2 kg weight. Moreover, it can't clean smartly like with soda and water. Only normal cleaning is possible by this. According to our limitations, we can overcome this by some up gradations. We can add one more EDF for more proper suction of air. In that time the robot's carrying ability will increase from 2.2 kg to 4.8 kg. This project structure can be printed on PCB layout as a result it may reduce the number of wires required. Thus, making the project more reliable and effective.

For the suction of air, EDF is used which can suck the air and stick it to the wall. Microcontroller has been used as the main control part. The desired implementation of hardware was performed with the help of EDF, ESC, servo master and modular. Since EDF start to operate, robot can overcome the gravitational force and four dc motors help it to move the vertical direction. Within the mechanical area of our robust platform, it is developed to climb on relatively smooth surfaces and non-porous surface.

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