IDEA-2016-IC-02-Low Cost Window Cleaning Robot

Idea Lab Project

Submitted By

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Under the mentorship of

Asst. Prof. Vishal Vaidya

DEPARTMENT NAME

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Declaration

We do hereby declare that the technical project report submitted is original, and is the outcome of the independent investigations/research carried out by us and contains no plagiarism. The research is leading to the discovery of new facts/techniques/correlation of scientific facts already known. This work has not been submitted to or supported by any other University or funding agency.

We do hereby further declare that the text, diagrams or any other material taken from other sources (including but not limited to books, journals and web) have been acknowledged, referred and cited to the best of our knowledge and understanding.

Date:

Place: AHMEDABAD

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NIRMA UNIVERSITY

INSTITUTE OF TECHNOLOGY

IDEA LAB

Annual/Final Report of the work done on the Idea Lab Project.

1. Idea Lab Project ID: IDEA-2016-IC-02

2. Project Title: Low Cost Window Cleaning Robot

3. Period of Project: to 5th June 2016 to 5th April 2017

4. (a) Name of Student (Roll No.): Aneesha Gujral (13bic005

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   (b) Name of Student (Roll No.): Saloni Sharma (13bic053)

   Department: Instrumentation and Control

   Name of Mentor:Asst. Prof. Vishal Vaidya

5. Project Start Date: Project Start Date
   5th June 2016

6. (a) Total Amount Approved: Rs. 15000/- (b) Total Expenditure: Rs. 14900/-

   (c) Report of the work done:

   i. Brief objective of the project: The objective of the project was to construct a prototype of mobile wheeled robot which could climb the windows and autonomously clean the surfaces of the window.

   ii. Work done:

   Work done iii. Results achieved from the work :A prototype which can be further developed to make a final product for market.

Results achieved : Two major objectives were successfully accomplished but two other objectives remain.

Reasons:

The time duration was a constraint.

Technical Difficulties : The failure of the first design and less time for testing the second design completely.

Summary of findings of the study
The prototype can be further improved by buying better quality components. It has a good scope of getting converted into marketable product in future.

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1.1 Introduction

The exteriors of many buildings are being constructed with Huge glass Panes which give an immense aesthetic beauty, but cleaning the outer part of the building is a tough job. Generally, human labor clean the outer pane by clinging themselves to the high storied building which involves high life risk factor.

So, the motive of building this project was quite simple, it ensures safety of human labor, and also cuts the maintenance budget of commercial buildings. But it can be used effectively for domestic purposes as well.

The project intends to design a prototype of a two wheeled mobile robot which could climb the glass windows and autonomously cleans the surface.

In the coming sections of the report we shall be elucidating the research we indulged in before designing our prototype.

We have approached the problem with two distinct approaches on the basis of design and components used.

The epitome of our work is the technical problems we faced in our first design and the troubleshooting we did before designing the second prototype.

We shall also mention the objectives we proposed and achieved after the successful completion of the project in the given time duration.

1.2 Literature Survey

Before the proposal of the project we went through different kinds of window cleaning solutions available in market. We went through a robot which is available outside India with the name 'Windoro'. It is a remote controlled robot, with two wheels. It uses the principle of magnetism to climb the window. There are two magnets, one is inside the robot and the other is placed at the opposite surface of the window.

The robot's weight is balanced by the magnetic forces of magnets. The dispenser is placed in the middle of the body and brushes at four corners. The dispenser dispenses washing liquid and the brushes roll over it to rub the glass.

We got inspired by this model and thought of designing the model using a novel concept rather than magnetism. The magnets of such high magnetism power are difficult to acquire in local markets.

We observed balls which are used to throw on walls. They stick to the surface of wall and gradually leave it. They had suction cups, which are quite frequently using in day to day lives.

These suction cups are cheap and available in abundance. They can be manufactured as required.

We proposed this particular idea during the selection. We were planning to fabricate these suction cups on the wheels. They would provide the necessary suction for the wheels to stick on the surface.

But due to technical difficulties and with further literature surface we observed another prototype of wall climbing. It used high speed brushless dc motors with large amount of torque.

We observed the working of brushless dc motors in quadcopters, where it produces thrust enough to lift the body in the air.

We did some digging and came to consensus that the same motor can be used to produce vacuum and force equivalent to force applied downwards.

It became our inspiration for the next design we demonstrated in the last review.

1.3 Major Objectives Proposed

The major objectives we proposed for the project were:

1. Design of lightweight chassis
2. Methodology/ Technique which can get the robot to stick to the surface vertically
3. Motion of robot over the surface
4. Cleaning the surface along with the motion

1.4 Objectives Achieved

The objectives we achieved were:

1. Designing of lightweight chassis.
2. Using the high speed brushless motor to create vacuum for the robot to counteract the gravitation force.

1.5 Objectives Not Achieved

The objectives we could not achieve in the given duration of project are:

1. Motion of robot over the surface
2. Cleaning the surface along with motion.

1.6 Experimental Setup, Technical Difficulties and Results

Experimental Setup 1:

The main challenge is to manage the weight of the body, our original idea was to fabricate the wheels of the robot in such a way that it could stick to the window. The wheel used was a pulley wheel with 4 cm width and 6 cm diameter, where we used flat suction cups of 2 cm diameter, which were fitted on the wheel, by drilling holes on the wheel. In this way, we had got around twenty four to thirty suction cups on a single wheel.

The components used to make the robot along with the weight:

1. LiPo 11.1 Volts Battery: For powering up the controller as well as for driving the motors.

2. DC Motor (10 RPM high torque 10 kg-cm)

3. Arduino Mega: Control action

4. Dual DC motor driver 20 Amperes

5. Miscellaneous: Cleaning material.

WEIGHT OF THE ENTIRE ROBOT:

Components of robot	*Weight (grams)*
Wheels (Four)	152 gms
Acrylic Chassis	250 gms
DC Motor (Two)	360 gms
LiPo Battery 11.1V	140 gms
Arduino Mega	40 gms
Cleaning Purpose	40 gms
Total	***980 gms***

We designed a four wheel robot with all wheels fabricated with suction cups. The body is shown in figure. As per our calculations, the suction wheels took the weight of the robot perfectly. The robot got stuck to the window with all the components.

Figure 1 Acrylic Cutting

Figure 2 For Mounting Wheels

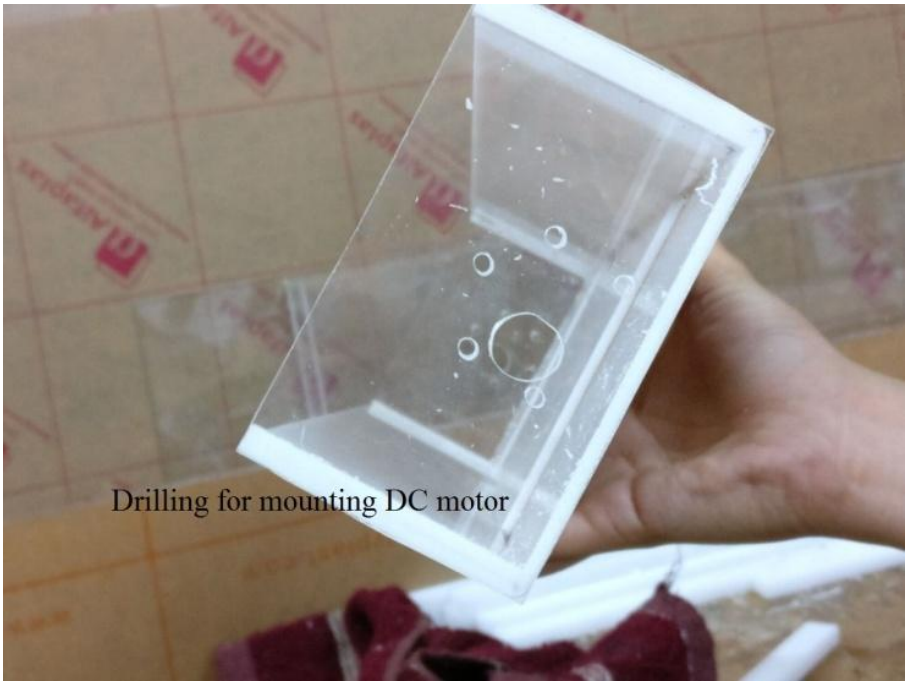

Figure 3 Holes for mounting the dc motors

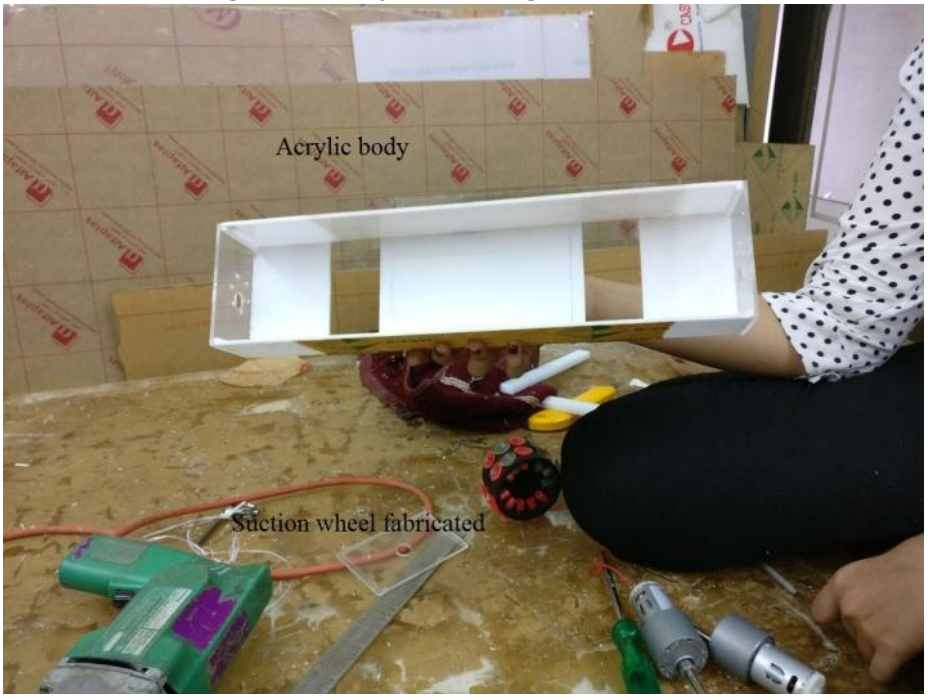

Figure 4 Final Acrylic Chassis

Figure 5 Robot balancing on window

When the robot was moved, our robot slipped on surface. It eventually freed itself from surface and fell down. The suctions cups were capable of counteract the force of gravitation but when the robot was in motion suctions cups were not able to counteract the forces. The weight of the robot was also an issue.

Experimental Setup 2:

When the previous model failed, we did further in depth literature survey. We decided to take a different approach by not using the suction cups rather producing vacuum.
We saw a four wheeled wall climbing robot using high speed brushless dc motor along with ducted fan to generate vacuum.
We first designed the body in such a manner that the centre of gravity lies in the centre of robot. It was done in order to balance the forces which will act on robot while it climbs the window.

We used acrylic sheet and did laser cutting in order to get the perfect shape for the body.
But the acrylic sheet body later became a weight issue. We had to keep the weight of body below 500g.
The greater the weight, greater the gravity will pull robot down. The vacuum produced is used to counteract the gravitational pull.
Now we modeled the acrylic sheet in CAD and got it laser cut using a laser cutting machine.

We used gaskets to decrease the distance of the ducted fan and surface. But initially we improperly placed the gasket over the boundaries of the ducted fan.
We mounted the body with ESC (Electronic Speed Controller) , Arduino Mega 2560 to control the movement of robot on the surface, batteries in which one is used for supplying power to the brushless dc motor and other is used for supplying power to dc motors.
We were successfully able to stick the chassis on the wall, but the motors we had purchased previously were not able to provide right amount of force to push the robot upwards or downwards.
We went back to literature survey and we found that the wall climbing project we were inspired by used mini gear dc motors. They were small sized dc motors which used gears to increase the torque and they were light in weight.
It suited the application we were trying to build. As we had already used our entire budget , we were not able to get those motors.
Apart from that the other problems we faced were that the ESC got heated up in prolong use. We had got the right rated ESC. The ESC are chosen according to the maximum current the motor can draw. If the maximum current drawn in 32 A , then we need to bring a ESC with a rating 25% more than the maximum current which is 40A.
We bought 40A ESC, but with prolong use ESC get highly heated. We troubleshooted the problem and it was the improper quality of ESC which resulted into heating.
The ESC must be bought from trusted proprietors.

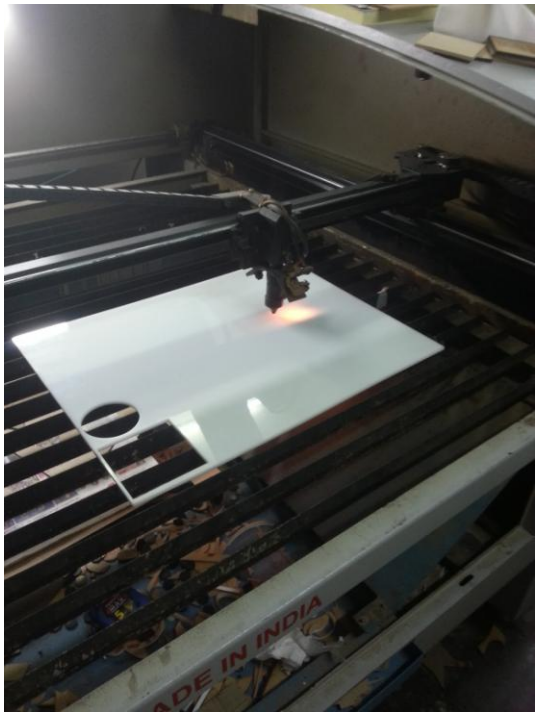

Figure 6 Laser Cutting

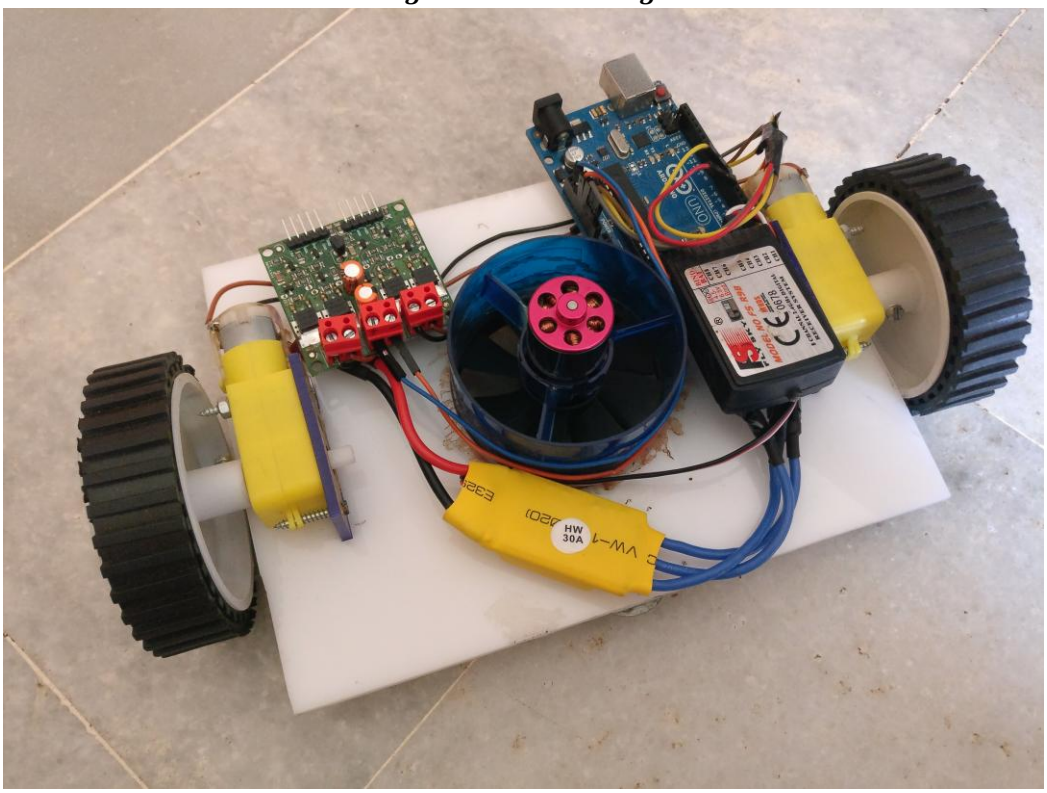

Figure 7 Robot's Top View

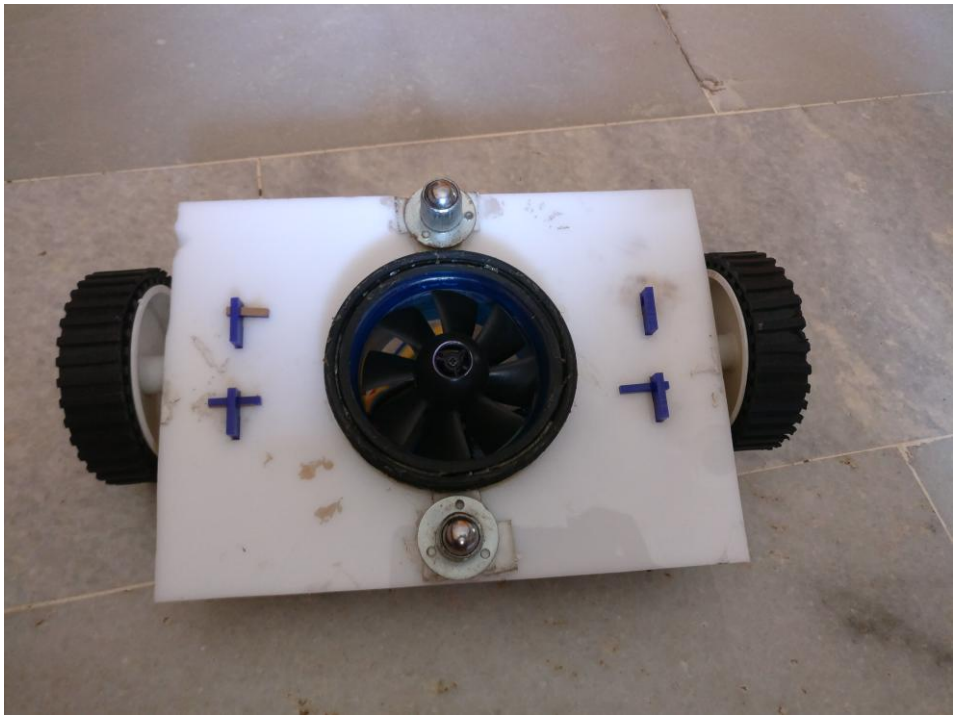

Figure 8 Robot's Bottom View

1.7 Budget Analysis

1. Budget Sanctioned: Rs.15000 /-
2. Budget Utilized: Rs. 14819/-
3. Budget Unutilized: Rs. 181/-

Sr. No.	Name of Item	Qty.	Rate/Item	Total Amount
1	1) Roboduino Mega 2560 R3	1	895	895
	2) Pully for track belt 4cm	4	60	240
	3) Dual DC motor driver 20A	2	700	1400
	4) Dual shaft Bo Motor	4	120	480
			Tax	151
			Total Rs.	**3166**
2	1) Suction Cup	50	3.2	160
	2) Motor fitting and suction cup fabrication work	-	500	500
			Total Rs.	**660**
3	1) High torque DC geared motor 10RPM	2	800	1600
			Tax	80
			Total Rs.	**1680**
4	1) Suction cup fabrication	-	900	900
	2) Suction Cup	5	40	200
			Total Rs.	1100
	3) Body Fabrication(Late Bill submitted-12/11/2016)	-	1050	1050
			Total Rs.	**2150**
5	1) Lithium-Polymer Rechargeable Battery 11.1V 1500mAh (30C)	1	1400	1400
	1) Lithium-Ion Rechargeable Battery Pack 22.2V 2200mAh (2C)	1	1450	1450
			Tax	143
			Total Rs.	**2993**
6	1) Rubber Gasket	1	90	90
	2) Laser cutting fabrication with material	-	1800	1800
	3) Miscellaneos	-	300	300
			Total Rs.	**2190**
7	1) Brushless ESC 40 amperes	1	1500	1500
			Tax	75
			Total Rs.	1575
	2) Miscellaneous	-	405	405
			Final Total	**1980**

1.8 Conclusion and Future Work

The robot's performance can be improved using mini geared dc motors and high quality ESC. The applications for this project is vast. In future cleaning mechanism can be added and it can be made autonomous by using machine leaning algorithms.
It can be made into complete market product, if the above stated problems are solved.