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# Manufacturing of Autonomous Vacuum Cleaning Robot with Optimum Cost

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**Abstract**

Robots are widely used in modern industrial manufacturing, in households, in entertainment, and in the security sector. To facilitate targeted functions, interactivity in conjunction with high quality sensors play essential roles.Cleanliness is one of the needs of the modern world. We require clean environments to work in. people spend tons of money hiring staffs for cleanliness in homes and offices all around the world. Various tools like brooms, mops etc. are used in the cleaning process. With the advent of machines, the cleaning process has also been mechanized. The next step in the evolution of cleaning equipment is automation in such a way that human supervision is no longer needed. In this paper, the autonomous vacuum cleaning robot design is proposed. Basically, this vacuum cleaning robot is designed to make cleaning process easier compare to manually used vacuum cleaner. The cleaning robot has various sensors for detecting obstacle and that data use for operating robot movement. Furthermore, this autonomous vacuum cleaning robot is remotely operated and worked automatically in entire cleaning process. According to human safety, the autonomous vacuum cleaning robot is design with proper selection of motors, sensors, microcontroller, etc.

**Keywords:** Autonomous vacuum cleaning robot; optimization; microcontroller; Gear design;

## 1. Introduction

Robots have been used all over the world. A role for a new generation of robots is eagerly awaited. In order to improve society in general, new types of robots are being introduced. As new trends in the modern world evolve, robots begin to make their presence felt. Robotic vacuum cleaners, ladder-climbing robots and robots for the blind have already been created [1-4]. Currently, various robotic vacuum cleaners have been presented; however, they have focused on ground cleaning and lack interactivity between the robot 10 and the user. One such robot, roomba, created by iRobot for ground cleaning, cleans by expanding the vacuuming area with a screw path, recodes the path coordinates, and then sweeps the non-cleaned area [5-9]. Soon, though, the robots path is blocked and a new vacuuming area is required, hence an interactive user becomes crucial. In order to improve interactivity between robot and user, an intelligent robot has been developed. The main aim of the project is to

create an artificially intelligent vacuum cleaner that would i) require negligible human guidance reducing human time utilized on cleaning purpose, ii) efficiently sweep and clean dust particles from the surface, iii) understanding weather conditions and chose an optimized work path and return to its initial position for charging, and iv) it have small size to clean underneath furniture [10- 15].

The main plan is to organize and assemble all the parts that are easily available in the market and to design an autonomous vacuum cleaner. The main limitation is that height of the robot should be too high so that it can also work under tables and other furniture. Also, the price of the robot should not be too high.

## 2. Materials/tools required in autonomous vacuum cleaning robot

The selection of material Materials and tools required in the productions are as follows:

- Steel plate for the chassis.
- Wires and connecting pins for connecting various sensors to microcontroller.
- Microcontroller programming guides.
- Welding and cutting equipment for preparing the chassis.
- Various electronic and mechanical components like motors, gears, etc.

The product uses a blower fan to create a pressure difference which blows in the air which carries the dust particles. Heavier dust particles not carried by the air easily are swept in to motion by the movement of brushes which are then vacuumed in the similar fashion. The microcontroller senses the environment and notes the obstacles which help to avoid the obstacles. It also looks out for stairs and platforms such that the tumbling of the product is prevented.

### 2.1. Advantages

- Increase in cleanliness of the area due to periodic cleaning at regular intervals.
- Independence from the tantrums of cleaning staffs and maid unions.
- Negligible human supervision needed.
- Reduced health concerns as it does not sweep and distend the dust particles in the air.
- No security concerns as the robot is not programmed to steal and valuable items accidently vacuumed can be easily recovered.
- Suitable for use in any closed enclosures.
- Available for work 24/7.

## 3. Modelling: Analysis, Modelling Step and Implementation Strategy

The first part was to enlist the number of components. After that, the components which were readily available in the market were procured. The main task is the programming of the microcontroller to behave in the desired manner as it the brain of the project.

### 3.1. Experimental Model Construction

For the implementation of the robot, we will use an array of limit switches and infrared sensors to drive the robot and avoid hitting the obstacles and to prevent toppling of the robot from stairs. Also, we will use brushes on 3 sides of the robot to sweep up the dust particles so

that bigger size dust particles can also be vacuumed. This will increase the efficiency of the robot. The robot is at the first stage of development and it is tested and found to efficiently vacuum dust particles and paper bits usually found on an office floor. The speed of the vacuum cleaner is kept low so that it can efficiently vacuum larger dust particles. The isometric view of vacuum cleaner body is shown in figure 1.

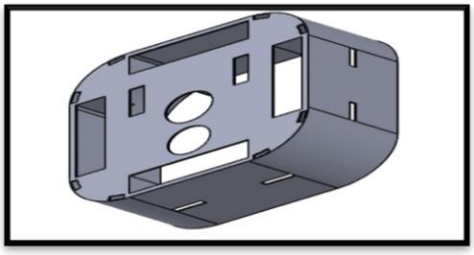


Figure 1: Isometric view of vacuum cleaner body

We have procured the necessary items required in our project which are available in the market and developed the other components depending on our needs using resources from college. The procured items include items which are of standardized dimensions. The list of procured items is as follows:

1) **Microcontroller:** The microcontroller used is Arduino mega 2560. It has 54 digital input/output points and 16 analog inputs.
2) **Infrared sensor:** This sensor is used for detecting sudden change in ground level as in case of stairs to prevent the tumbling of the robot. It outputs a binary signal as the distance increases.
3) **Limit switch:** Limit switch is used to detect collision of robot which helps in detection of obstacles.
4) **DC motor:** DC motor is used for creating vacuum in vacuum tunnel. It has an rpm of 18,000.
5) **Servo motor:** Servo motor is used for turning the robot and steering the robot around the obstacles. Turning angle of servo motor is 0 to 180 degree.

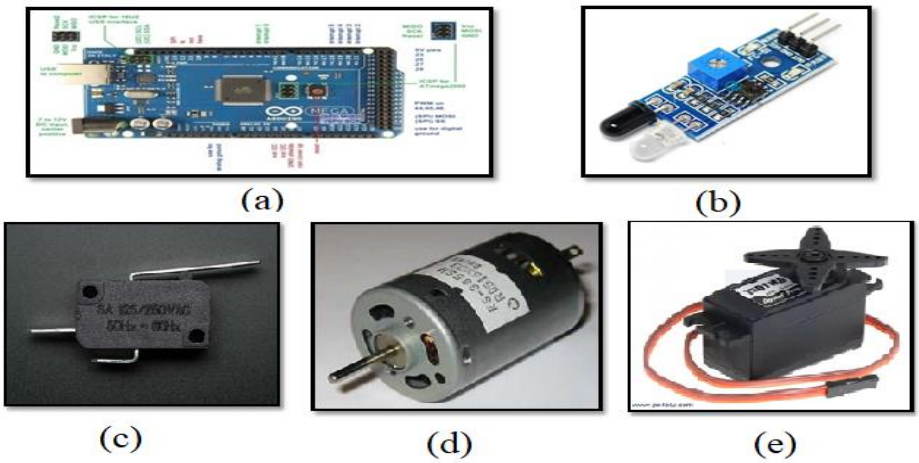



Figure 2: (a) arduino mega 2560 microcontroller, (b) infrared sensor, (c) limit Switch, (d) Dc motor, (e) Servo motor

6) **DC gear motor:** Dc gear motor is used to rotate the wheel and to provide linear motion to the robot. It has 30 rpm.
7) **Blower fan:** Blower fan is used to create pressure difference to vacuum dirt particles.
8) **Bevel gears:** Bevel gears are used to rotate the brush assembly so as to eliminate the need of individual motor for each brush. It has a shaft diameter of 8 mm.
9) **Wheels:** Wheels are used to balance and drive the robot. The wheel has a diameter of 70 mm.
10) **Brushes:** Brushes are used to sweep of dust particles and to provide motion for heavy particles for easy vacuuming action. The brushes are made up of microfiber chenille and have a shaft of 8 mm diameter.

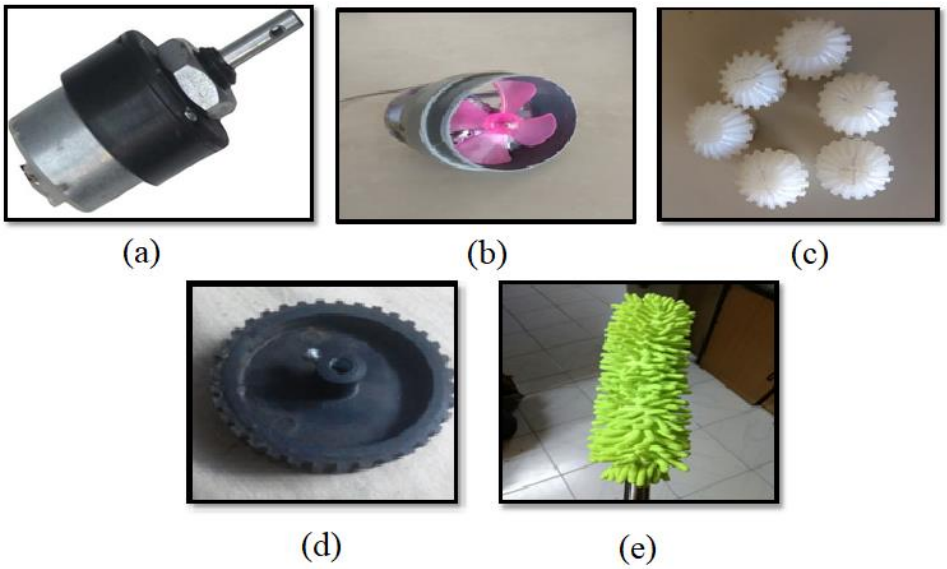



Figure 3: (a) DC gear motor, (b) blower fan, (c) bevel gears, (d) wheels, (e) brush

## 4. Manufacturing of body of autonomous vacuum cleaning robot

The material used in the fabrication of robot body is mild steel. The dimensions of the chassis are decided considering the standard dimensions of individual components. AutoCAD was used for designing the robot. The chassis of the robot was cut on plasma cutting machine.


Figure 4: (a) Plasma cutting of chassis, (b) Final component after plasma cutting

**Gear Design Process**

The gear diameter is very important for arranging multiple gears in single row. Here, the gear diameter calculation is shown with considering module value 1. The gear design is shown in figure 5.

Thus, M=1 mm

No. of teeth, Z =18

So, Module, $M = \frac{d}{Z}$

$$\therefore 1 = \frac{d}{18}$$

$$\therefore d = 18\ mm$$ (As built d = 19 mm)

Where, d is Minor diameter.

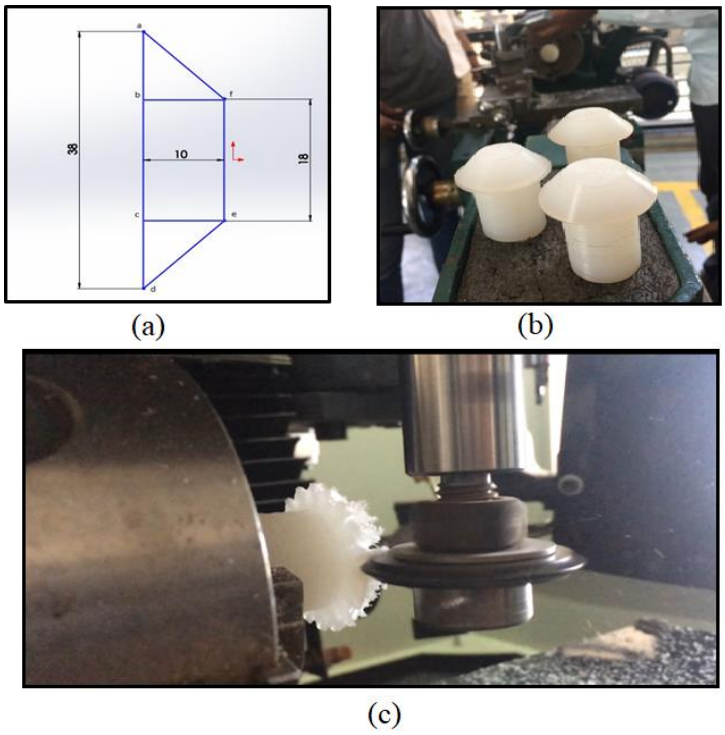
$$\therefore \tan 45 = \frac{ab}{10}$$

$$\therefore ab = 10\ mm$$

So, Major diameter, D = ab + bc + cd

= 10 + 18 + 10

= 38 mm




(a) (b)

(c)

Figure 5: (a) bevel gear dimensions, (b) initial machining of gear, (c) final Assembly of Vacuum Cleaner

## 5. Final Assembly of Vacuum Cleaner

The Final assembly has been done after manufacturing body and gears. All necessary other equipment were procured from local market which reduces the overall cost of product. All equipment were fitted on support body. The large three brushes assembly joined with bevel gears which eliminates individual motor for each brush. Blower fan was fitted on suction pipe which create vacuum pressure for dust particle. The electronic devices and sensor

assembles on body to control the movement of robot. The final assembly of the autonomous vacuum cleaning robot is shown in figure 6.

Figure 6: final assembly of the autonomous vacuum cleaning robot

## 6. Results and Conclusions

The autonomous vacuum cleaning robot is manufactured with optimum cost. The various parts are assembles in this robots like bevel gears, DC gear motor, microcontroller, etc. are used. The important observations are written below:

- Arduino Mega 2560 is sufficient to control the required inputs and outputs for smart vacuum cleaner.
- Our indigenous vacuum tunnel made with 18,000 rpm DC motor is sufficient to vacuum small objects for commercial cleaning purpose and it work effectively for long time duration.
- Our indigenous wiper system made with Teflon bevel gears made on VMC machine which is strong enough to wipe the floor.
- Our indigenous logic for limit switch and infrared sensor program is sufficient to turn smart vacuum cleaner in commercial floor by developing arbitrary path and cover all the floor area.
- We have developed smart vacuum cleaner at the cost of Rs. 5,410 which is highly competitive with commercially available smart vacuum cleaners which cost Rs 20,000 to Rs. 25,000. Still we need to implement distance sensors, GPS sensors and automatic charging system to compete with commercially available vacuum cleaners which will increase the cost of our vacuum cleaner by Rs 3,000 to Rs 3,500.

## References

1. A. Louchene and N. E. Bouguechal, Indoor mobile robot local path planner with trajectory tracking, Journal of Intelligent and Robotic Systems, Vol. 37 (2003), pp. 163–175.
2. Buck, 'The Best Robot Vacuums of 2015 | Top Ten Reviews', Top Ten REVIEWS, 2014. [Online]. Available: http://robot-vacuumreview.toptenreviews.com/.
3. Dyson.com, 'Latest Dyson Vacuum Cleaner Technology |Dyson.com', 2015. [Online]. Available: http://www.dyson.com/vacuum-cleaners.aspx.

4. Dyson 360 Eyeâ„¢ robot, 'Dyson 360 Eyeâ„¢ robot', 2015. [Online]. Available: https://www.dyson360eye.com/.
5. Hiba Ghannam Hawa' Osama, Robotic vacuum cleaner, An-Najah National University, 2012.
6. H. Mori, S. Kotani and N. Kiyohiro, A robotic travel aid 'HITOMI', Proceedings of the IEEE/RJS/GI, International Conference on Intelligent Robot and Systems, Vol. 13 (1999), pp. 1716–1723.
7. Irobot.com, 'iRobot Corporation: We Are The Robot Company',2015. [Online]. Available: http://www.irobot.com/.
8. J. W. Lee, S. U. Choi, C. H. Lee, Y. J. Lee and K. S. Lee, A study for AGV steering control and identification using vision system, Industrial Electronics, Vol. 3 (2001), pp. 12-16; pp. 1575–1578.
9. Min-Chie Chiu and Long-Jyi Yeh, The design and application of a robotic vacuum cleaner, Chungchou Institute of Technology and Tatung University, April 2008.
10. M. D. Mohsen and M. M. Majid, Stair Climber Smart Mobile Robot (MSRox), Tarbiat Modares, University of Iran, Iran Autonomous Robots, Vol. 20 (2006), pp. 3–14.
11. Noor Hubaida Binti Daud, Design and implementation of vacuum robot, University Teknikal Malaysia Melaka, May 2008.
12. Neato, 'Neato Robotics | Smartest, Most Powerful, Best Robot Vacuum', 2015. [Online]. Available: http://www.neatorobotics.com/.
13. Y. X. Chen, Design and Implementation of Car-Like Mobile Robot with Intelligent Parking Capability, Department of Electrical Engineering, NCKU, ROC, 2002.
14. Y. Ando and S. Yuta, Following a wall by an autonomous mobile robot with a sonar-ring, IEEE International Conference on Robotics and Automation, Vol. 4 (1995), pp. 2599–2606.
15. Yusmarnita Binti Yusop, A Study in industrial robot programming, Kolej Universiti Teknologi Tun Hussein Onn, November 2004.