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# Smart vacuum cleaner

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ABSTRACT

In the current hectic schedule, cleaning houses and surrounding environment is more arduous. At present, there are vacuum cleaners which require humans to handle it. Thus, there is a dire need to implement vacuum cleaner which works without human intervention. An efficient method to clean the desired area has been implemented through this project. By using this vacuum cleaner, hazardous places can be cleaned which thereby reduce risks to mankind. This is achieved by implementing an autonomous system. Here, RC car which is embedded with a vacuum cleaner is used. This system has an ultrasonic sensor attached to it, that helps in avoiding large obstacles such as tables, chairs, walls etc. By measuring the distance via this sensor, the car takes the direction where the distance between obstacle and car is more, hence avoiding the collision with the obstacles. The vacuum cleaner is designed with a CPU fan and a pipe is attached to the mouth of the bottle. The entire system is run by batteries.

## 1. Introduction

Cleaning the environment around us is one of the important duties of each and every individual. Bigger the area to be cleaned, greater number of people will be needed. Some places will be so dirty that cleaning such areas causes huge impact on health. Due to dust present in the surroundings, people are prone to allergies, watery eyes, cold, cough, rashes etc. [1]. Vacuum cleaner can be used for domestic purposes such as to clean the floor, car, carpets etc. It can be used efficiently in colleges as the space is also large [2]. In the current COVID situation since social distancing has to be maintained, a greater number of people cannot clean together. In this era where digital technology is rising rapidly, mankind is becoming more and more dependent on the same [3]. Since majority belong to the working population, there is always a shortage of time [4]. Since, the Arduino can be coded to cover specific areas, moving the vacuum cleaner in the desired direction and the time taken for the same can be saved as it is possible through the car carrying it. Swachh Bharat Mission is an initiative taken by Government of India in the year 2014 to keep the surroundings clean. The main aim of this mission was to make every individual prioritize cleaning as it has huge impact on every living organism's health. This has been implemented in both rural and urban areas. At present, hand held vacuum cleaners are available in the market. Automation is still budding and smart vacuum cleaners will be a huge break-through in the industry.

In this project, an automated vacuum cleaner is designed. It consists of a RC car to which a vacuum cleaner is attached. Ultrasonic sensor is attached to the front of the car which is used to measure the distance if any obstacle is detected. If suppose there is an obstacle, the car changes its course as per the code. Vacuum cleaner consists of CPU Fan which runs by a battery. At the front of cleaner, a pipe is attached to suck the dust from the floor. The cleaner has space to collect the dust. Once it gets filled, it should be removed and cleaned manually. Vacuum cleaner will be carried on the RC car and the direction of the wheels depend on the code uploaded to the Arduino.

## 2. Literature survey

Mohd. Shahbaz Khan et al "Bluetooth control cleaning robot using Arduino". They have designed a robot and the robot is controlled using Bluetooth which is present at both transmitter and receiver end [1]. Vijayalakshmi M et al proposed "Smart Vacuum Robot" with progressive technology. S-curve planning is used for efficient working along with sensors to avoid obstacles [2]. Gaurav Dhariwal et al have proposed "Development of Driverless RC Car". In this paper, an automatic car is built using concept of neural networks. This detects the obstacles present using sensors. Arduino and Raspberry Pi is used in this model [3]. S Yatamono et al proposed a paper on "Development of Intelligent floor cleaning Robot". They have developed a smart floor cleaning Robot that can clean the place by navigating, sucking the dust and polishing the floor. The robot consists of an omni wheel which is equipped with a vacuum cleaner and floor polishing motor. It is coded in Arduino IDE by using Arduino microcontroller and it is equipped with Bluetooth so that it can work from smart phone connected via Bluetooth [4]. Sabir Hossain et al proposed "Deep Reinforcement Learning-based ROS-Controlled RC Car for Autonomous Path Exploration in the Unknown Environment".

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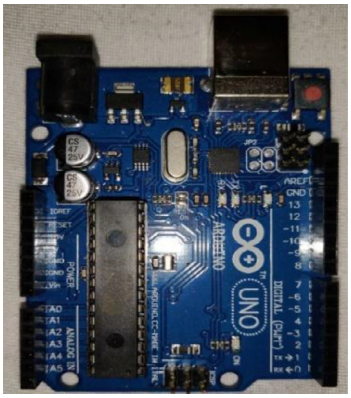

**Fig 1.** Arduino UNO.

In this paper, LiDAR equipped car using the concept of deep learning is discussed. The software used here is ROS and Arduino [5]. R J Ong and K N F Ku Azir proposed "Low-Cost Autonomous Robot Cleaner using Mapping Algorithm based on Internet of Things (IoT)". Here, sensors are used to detect any obstacle and Arduino is used to control the robot. Mapping is applied so that the robot can clean without any huma intervention once it is switched on [6]. Anbumani V et al proposed a paper "Development of Ingenious Floor Cleaner using ARDUINO". Here, different modes of cleaning available such as mopping, sweeping or both mopping and sweeping is discussed. For controlling the robot, Bluetooth module is used and other functions are coded in Arduino. This can even clean corners of the floor [7]. Adeel Saleem et al proposed "Design and Implementation of an Intelligent dust cleaner robot for uneven and non-structural environment". In this paper, a robot has been designed which stores the plan of the room and makes the working feasible. This can be used for various environments as well. It is a cost-effective system [8]. Md. Farhanul Islam et al have proposed "Designing and Optimization of An Autonomous Vacuum Floor Cleaning Robot". Here, an economic prototype is designed using Arduino Mega and Raspberry Pi. GPS module is also present which helps the bot to move in the right direction [9]. Anshu Prakash Murdan et al proposed "A smart autonomous floor cleaner with an Android-based controller". Here, a bot is designed which can be controlled through Android. By using the application, the bot can be turned in the desired direction [10]. Amir Talebi Sheikh Sarmast et al have proposed "Designing a Smart Vacuum Cleaner in Two Modes of Remote and Automatic". In this paper, vacuum cleaner is implemented which operates automatically or through android application. If the battery percentage is less, a message is sent to the registered mobile number regarding the same [11]. Md. Rawshan Habib et al proposed "Automatic Solar Panel Cleaning System Based on Arduino for Dust Removal". In this paper, a bot is designed to clean the solar panels using DC Motor which powers the wiper. Water is not used to clean the panels. This system's efficiency is about 87 to 96 percent [12].

## 3. Requirements

### 3.1. Hardware

#### 3.1.1. Arduino UNO

The key hardware of the prototype, Arduino Uno is shown in Fig. 1. This is a microcontroller which is used for interfacing hardware and software [13]. To do the same, USB cable is required. Once the board is embedded with the code, it can be operated by a battery supply without using any PC or laptop.

#### 3.1.2. Batteries

Fig. 2 shows the heart of the prototype, 9V batteries. These are rectangular in shape and have positive and negative terminals at the top which supplies 9V so as to make the prototype run.


**Fig 2.** Batteries.

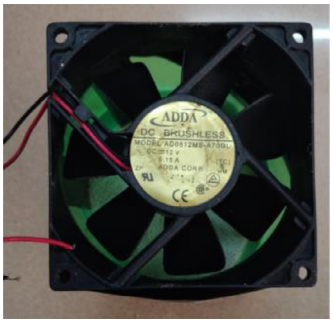


**Fig 3.** CPU fan.

**Fig 4.** DC Motor.

#### 3.1.3. CPU fan

Fig. 3 shows the CPU fan used in the prototype. This is used in the vacuum cleaner which has a rating of 12 volts. It rotates at maximum of 200 rpm. As the voltage increases, rpm increases until the value reached up to 200.

#### 3.1.4. DC motor

Fig. 4 shows one of the DC Motors used in the prototype. These motors essentially are the key components in this prototype. To make the machine move, these are required. As the voltage increases, rpm also increases. The least rpm will be at 6V and maximum at 12V.

#### 3.1.5. Motor driver shield

Fig. 5 shows the Motor Driver Shield. This is used to run different types of motors. L293D IC is the main IC present in this shield [14–16]. The direction and speed of motors depends on the motor shield, as the shield is embedded on Arduino UNO board and the speed and direction can be controlled by coding in Arduino IDE.

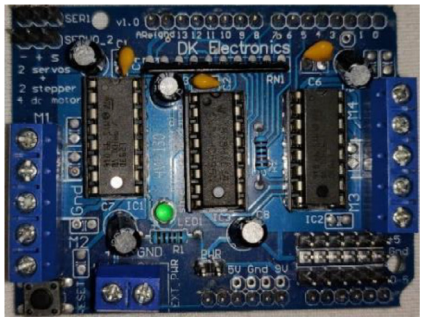


**Fig 5.** Motor driver shield.


**Fig 6.** Ultrasonic sensor.

**Fig 7.** Wheels.


**Fig 8.** Arduino IDE.

**Fig 9.** RC Car.

#### 3.1.6. Ultrasonic sensor

Fig. 6 shows the Ultrasonic sensor used in the prototype. This HC-SR04 sensor is used for measuring distance. It uses sound waves to calculate the same. There are 4 pins – Echo, Ground, Trigger and VCC [17-19]. External controller is triggered by Trigger pin that sends ultrasonic waves whereas echo pin sends ultrasonic waves and duration it takes to travel decides the distance between the car and obstacle. VCC will take up to 5V and gives the voltage so that the sensor can run.

#### 3.1.7. Wheels

Fig. 7 shows the wheels which are responsible for the movement of RC car. These are used to move in any specified direction. Wheels are run by a DC Motor with a pre-defined RPM. Wheels rotate in the same direction as DC Motor.

### 3.2. Software

Fig. 8 shows the software used in this project, Arduino IDE. This is an application written in C and C++. Programs can be written and uploaded to Arduino boards. The version used in here is 1.8.9.

## 4. Methodology

### 4.1. Design

#### 4.1.1. RC car

The RC car designed is shown in Fig. 9. The construction of RC is as car is as follows. Acrylic sheets have holes in specific areas. To these places, using nuts and bolts, the motor is fitted, motors are attached with wheels. Motors are soldered with wires – positive and negative. RC car is built by using 4 DC motors they run with the speed provided in Arduino IDE code, it uses motor shield to work in desired speed and direction [20]. Ultrasonic sensor attached to RC car detects the distance at which obstacle is present in front of it. So, whenever it encounters any obstacles such as walls, tables, chair or any big things that cannot be considered as garbage or dust, RC car which carries vacuum cleaner changes its direction so that it won't crash and destroy itself. The code fed to the Arduino runs continuously and the cycle repeats in regular intervals whenever the obstacle is detected. The batteries are placed on the acrylic sheets [21].

#### 4.1.2. Vacuum cleaner

Vacuum cleaner is made up of 1.25L water bottle, CPU fan, pipe, tape, gauze bandage, batteries and switch.

**Fig 10.** Vacuum cleaner.

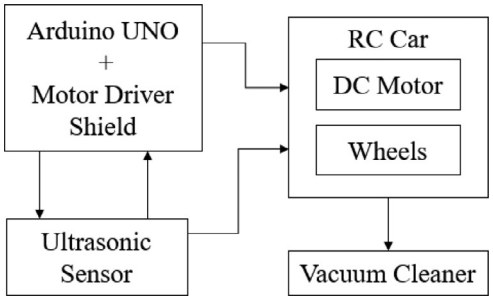


**Fig 11.** Block diagram.

The vacuum cleaner is shown in Fig 10. The steps to design the same is described below.

Steps to create the vacuum cleaner:

1.25L water bottle is cut into half horizontally

Top portion has conical and cylindrical structure, the conical structure is cut

The bottle cap area is attached with a pipe as shown in the image. The length of the pipe used is 45 cm and its diameter is 1.5 cm.

The other end of conical structure is covered with a gauze bandage to improve the vacuum.

Now, the cylindrical part which was separated in step ii is taped with the conical part which has the gauze bandage.

The other end of cylindrical structure is attached with a CPU fan

It is given with a 18V supply so as to develop the required vacuum. Switch is also attached to the side.

### *4.2. Block diagram*

Fig. 11 shows the block diagram of the proposed model. Here, Motor Driver Shield is placed on top of Arduino Uno. In the front of the prototype, Ultrasonic sensor is attached which measures the distance. Towards the back of the car, vacuum cleaner is placed. The vacuum cleaner holds the CPU Fan. The wheels, DC Motor and batteries placement is as shown in Fig. 9.

### *4.3. Flow chart*

Fig. 12 shows the flowchart of the proposed model. Here, once the car is started, the distance is measured and moves forward. If distance is less than 20cm, it turns left and right respectively to measure distance and the prototype moves where the distance is greater. The same process repeats.

### *4.4. Comparison*

Table 1 shows the comparison between the manual mode of cleaning and automatic mode. In manual cleaning, as the word says, human is required. Whereas, in automatic mode there is no human intervention. Automatic mode is helpful as it doesn't cause any health risks.

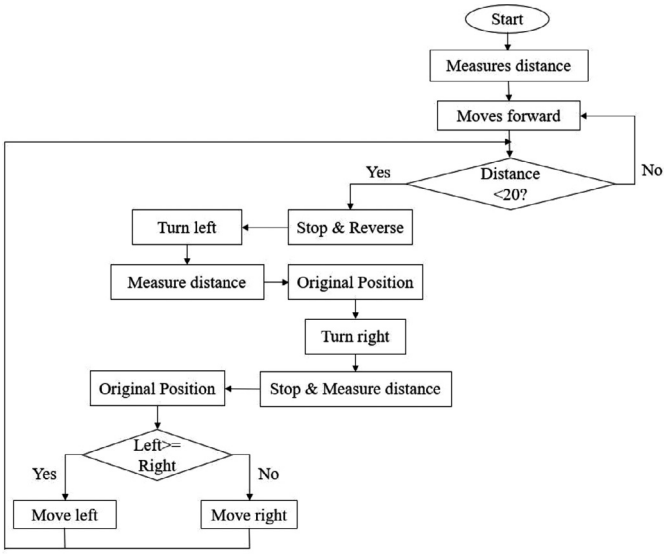


**Fig 12.** Flowchart.

**Table 1**
Comparison between manual and automatic system.

| Features | Manual | Automatic (Designed Prototype) |
|---|---|---|
| Human intervention | Yes | No |
| Economic | No | Yes |

**Table 2**
Comparison between algorithms.

| Features | Existing | Designed Prototype |
|---|---|---|
| Simple | No | Yes |
| Accuracy | 60% | 75% |

## 5. Implementation

9V supply will be given to both RC car and vacuum cleaner separately, once the car is started it measures the distance between obstacle and vehicle by using ultrasonic sensor, further it moves in the forward direction as per the code in Arduino IDE. If the distance is less than 20cm then RC car stops and reverses for a second and then moves towards left side and measures the distance, again it gets back to its original position. After that it turns right and stops for a second, after which it gets back to its original position. After measuring both the distances, whichever distance is greater car starts to move in that direction to avoid the collision with any objects. If there are no obstacle in its path it travels in straight direction without turning until it encounters any obstacle. The process repeats whenever there is an obstacle in the path.

Table 2 shows the comparison between the existing and the designed algorithm. In the existing prototypes, through an application, there will be an interaction between the model and the user. However, in the designed prototype, it is run through batteries and there is no human intervention needed. The algorithm is simpler and is easier to debug as well.

## 6. Result

Fig. 13 shows the obtained distance from the ultrasonic sensor. Arduino IDE contains a serial monitor and this distance is displayed in that. Here, it can be seen that the distance is continuously displayed. Once the obstacle is detected, the distance at right and left is calculated and whichever is greater, the prototype moves in that direction.

Fig. 14 shows the final set-up of the prototype implemented.

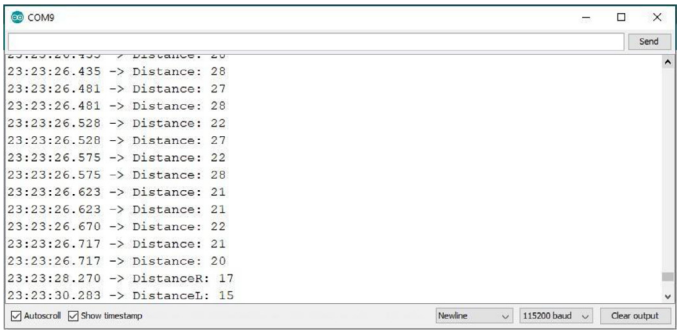


**Fig 13.** Distance measurement.

**Fig 14.** Prototype.

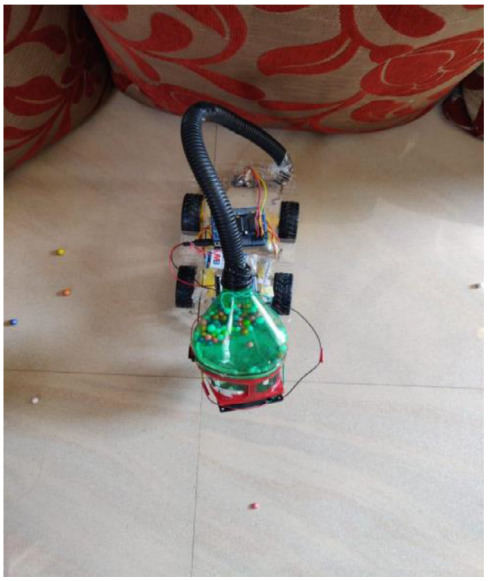

**Fig 15.** Forward movement.

Fig. 15 shows the forward movement of vehicle. In this image, the vehicle is moving forward and stops as it encounters an obstacle present in front of it.

Fig. 16 shows the prototype turning towards left. In this image as the distance between obstacle and the vehicle is less than 20 cm, it turns left to measure the distance.

Fig. 17 shows the prototype turning towards right. After turning left, it turns right and measures the available distance between vehicle and obstacle.

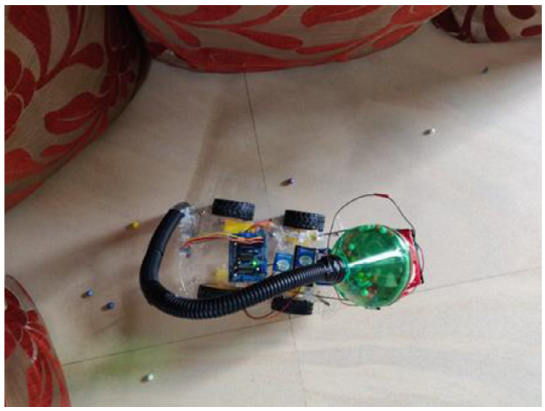

**Fig 16.** Left turn.

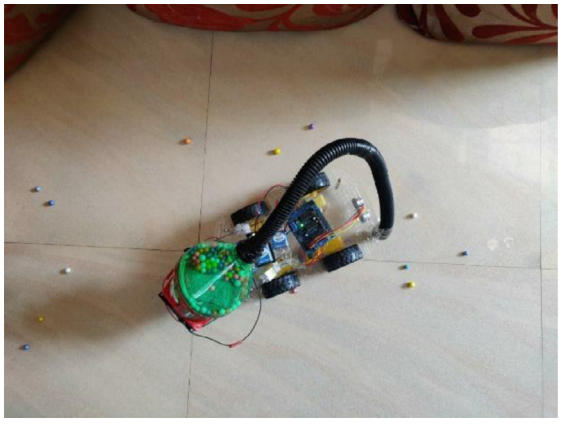

**Fig 17.** Right turn.

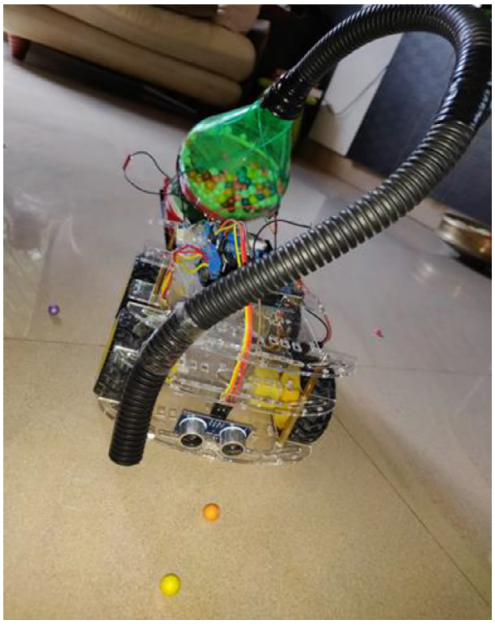

**Fig 18.** Collecting dust.

Fig. 18 shows the amount of dust collected in the bottle through the vacuum cleaner. Dust will be collected throughout the movement of vehicle. Here, thermocol balls collected can be seen inside the bottle.

## 7. Conclusion and future scope

In this project Smart Vacuum Cleaner has been implemented. It was works on a pre-defined code inserted in Arduino UNO. Whenever RC

car encounters any obstacle, it turns to the side where the distance between obstacle and car is more. This project helps collect the dust using a vacuum cleaner made using CPU fan and batteries without human intervention thereby reducing the hazards to human health. This is a simple and cost-effective cleaner. However, using a detachable bag may be better as removing the dust becomes simpler.

## Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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