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Arduino Based Smart Vacuum Cleaner Robot

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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. The main objective of this project is to design and implement a vacuum robot prototype by using Aurdino uno, Motor shield, Ultrasonic sensor and motor with wheels to achieve the goal of this project. The ultrasonic sensor is used to measure the distance between robot and obstacle. The whole circuit is connected with 12v battery. Vacuum robot will have several criterial that are user-friendly.***
Keywords: Aurdino uno, Ultrasonic sensor, Vacuum cleaner, Motor shield, 12v Battery.

I. INTRODUCTION

An Arduino-based vacuum cleaner is a cleaning device that is powered and controlled by an Arduino microcontroller. The Arduino board is programmed to control the motors, sensors, and other components that make up the vacuum cleaner. This allows for a high degree of customization and control over the cleaning process, making it possible to program the vacuum cleaner to clean specific areas, adjust the suction power, and even navigate around obstacles. Additionally, an Arduino-based vacuum cleaner can be connected to other devices and systems, such as a smartphone or a home automation system, to provide remote control and monitoring capabilities. This makes the vacuum cleaner not only a practical cleaning tool, but also a fun and educational project for makers and hobbyists interested in robotics and home automation.

A. Vacuum Cleaner

A vacuum cleaner, commonly referred to as a vacuum or a hoover, is a machine that creates suction to take dirt off of surfaces like floors, couches, draperies, and other objects. Typically, electricity is used to power it. Either a dust bag or a cyclone collects the dirt for subsequent disposal. Small battery-powered hand-held vacuum cleaners, wheeled canister models for home use, domestic central vacuum cleaners, enormous stationary industrial machines that can hold hundreds of liters of dirt before being emptied, and self-propelled vacuum trucks for cleanup of significant spills or removal of contaminated soil are all different sizes and models of vacuum cleaners that are used in both homes and industry. Both solid objects and liquids can be sucked up using specialized shop vacuums. The performance of a vacuum cleaner can be measured by several parameters:

1) Airflow, in liters per second [l/s] or cubic feet per minute (CFM or ft^3/min)
2) Air speed, in metres per second [m/s] or miles per hour [mph]
3) Suction, vacuum, or water lift, in pascals [Pa] or inches of water.

B. Obstacle Avoiding Robot

An obstacle avoidance robot is an autonomous robot that can move through its environment and avoid obstacles in its route without any human involvement. It is outfitted with sensors that identify obstacles in its path and algorithms that allow it to decide how to avoid them. The robot can be built to work in a range of conditions, from straightforward inside settings to challenging outdoor terrains. As they can travel through unfamiliar environments and avoid potential dangers, these robots are frequently utilised in applications including surveillance, exploration, and transportation.

II. LITERATURE REVIEW

M. Manasa et.al., [1] In this project Smart Vacuum Cleaner has been implemented. It operated using pre-written code that was placed into an Arduino UNO. When an impediment is encountered, an RC car will turn to the side. When there is more space between the car and the obstruction.

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This invention uses a battery-powered vacuum cleaner and a CPU fan to collect dust without the need for human interaction, lowering the risks to human health. This cleaner is easy to use and reasonably priced. However, since cleaning the dust becomes easier, utilising a detachable bag can be preferable.

Pawan kumar Ramkisoon et.al., [2] In this journal, the design and implementation of a smart, autonomous cleaning and mopping robot is presented. The system is powered by a rechargeable dc Lithium Polymer battery of 12 V. The Arduino Mega board is used in this project due to its large number of GPIO pins and a better flash memory storage of256 kB, compared to other Arduino based microcontrollers. The range of the wireless control is 10 meters. It is observed that the system performs the desired task successfully and works both on an autonomous mode or application-controlled mode.

Yuda Irawan et.al., [3] In this study the Ultrasonic Sensor, Motor Shield L298, Arduino Uno microcontroller, Servo, and Dc Motor are the main components of the full floor cleaning robot. The motor shield L298 drives the DC motor after the Arduino Uno microcontroller processes the ultrasonic sensor as a distance detector and a DC motor as a robot driver. The robot will automatically search for a direction that is not blocking its path if an ultrasonic sensor detects an obstacle in front of it. When the distance read by the ultrasonic sensor is less than 15 cm, the distance value on the sensor has been established. In a distance of> 15 cm, the condition of the prototype cleaning robot for the road floor cleaning is obtained.

Saman Mohammdi et.al., [4] In this article, the authors make a cordless vacuum into a smart vacuum. The cell phone serves as a control panel in the remote-control mode. Due to the suction motor not having to run all the time the energy consumption will be reduced which reduces the cost and increases the life span of the vacuum cleaner. They also included the automatic system which indicates the charging percentage and turns off the robot if the charging is low to prevent the damage of the robot.

Akanksha Vyas et.al., [5] In this journal an efficient and economical floor cleaner is implemented. The cleaner can perform both wet cleaning and dry cleaning. In the process of cleaning the cleaner can sanitize the floor using UV Lamp, by which it can kill more than 90% of the Germicides. By this the usage of this cleaner will be increased in industries.

Li Hung Goon et.al., [6] A simple automatic floor polisher was built through this project. It consists of several important components which are Bluetooth module, ultrasonic sensor, motor driver, DC motors and PC fans. The Bluetooth module was implemented to insert the remotely turn ON and OFF function. The ultrasonic sensor is used to detect the obstacles and avoid them. The robot weight heavier than expected, thus draw more power from power supply to DC motors to run the robot. The PC fan required high voltage supply but it operates at low rpm, and torque, it is not an efficient vacuum system for the robot.

Adeel Saleem et.al., [7] In this paper the algorithm bases its movement on the identification of impediments and accomplishes this with the aid of an infrared sensor. The robot model that has been put into practise produces excellent results in a real-world setting and saves a lot of time while cleaning a space. This version was tested in a real-world setting and is solely intended for use in cleaning rooms. For usage in shopping malls and other applications where the environment is uneven, the intelligent dust cleaner should also be somewhat updated and expanded in size. Having thoroughly studied other waste and obstacle detection.

P. B. Jarande et.al., [8] In this journal they have designed a simple automatic cleaner which can operate from a far distance with the help of wifi. The user can start the vacuum cleaner by having a direct click at www.adafruit.io account id connected to the vacuum cleaner. When message is received from server robot and vacuum cleaner will start. When obstacle is detected then robot will move left then if obstacle is again detected then robot will move right and then vacuum cleaner will start.

Nwe Ni Tun et.al., [9] The axial fan employed in the vacuum cleaner has been researched for this project. Axial fans are created for 0.9 W vacuum cleaners in this project. Utilizing the slip steam hypothesis, the pressure differential across the fan is determined. The calculations reveal a 6.56 pressure differential across the fan. The machine has a 42% efficiency.

Iwan R. Ulrich et.al., [10] In this project an automatic vacuum cleaner is designed which can operate at contour environment with the robots shape tentacle sensor and the algorithm used in this. The robot can detect the obstacles in front of them and avoid them without any damage to the robot.

S Yatmono et.al., [11] The hardware for a floor cleaning robot is made up of several mechanical and robot control parts, and Android application software serves as the robot motion controller. The hardware for controlling the robot is divided into two master and slave subsystems, each of which has an Arduino control module, input sensors, and motor drivers. The master block controls the motor wheel, and the slave block controls the cleaning and polishing motor. The performance of Android as a manual robot controller can work in accordance with the buttons.

The ultrasonic sensor robot can avoid obstacles with an object distance of less than 15 cm when operating in automatic mode. Floor cleaning performance for various types of dusty dirt, fine sand, pieces of paper and fur carpet shows that the remaining less than 20% of the dirt on the floor.

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Pranal Mahajan et.al., [12] This work facilitates that floor cleaning can be done in easier way and more efficiently using home clean machine. A newly created smart machine minimises the expense and time needed for house cleaning, leading to simple and rapid cleaning operations. The machine created as a single device can carry out all cleaning activities, including vacuuming, mopping, drying, and water spraying, with basic hardware and programming. UV germicidal lamps can be used to sanitise surfaces effectively and without contact.

S. S. Saravana Kumar et.al., [13] In this paper the the author discusses about the automatic floor cleaning process using obstacle avoidance principle with the help of ultrasonic sensor and Arduino UNO. Three sensors are employed to detect impediments, and the controller drives the motors and cleaning units. This also applies to vacuum cleaning, which can help improve human lifestyle. Based on the design and testing of the floor cleaning robot system, it was determined that the robot automatically cleans the floor using cleaning solution and a brush while it is moving under the control of an ultrasonic sensor and motor driver.

Ajitha Sukumaran et.al., [14]

The system is effectively implemented in terms of connecting the ultrasonic with Arduino to control the movement of the object, tracking the light source to recharge the system, and notifying the user when the job is finished. Given that it uses a Bluetooth module with a low bandwidth, the functions could be improved in a variety of ways. WIFI and IOT technology may work better and provide complete control of the gadget, and the microcontroller Arduino can be replaced by the Raspberry Pi, which can handle cameras and image-possessing devices.

The main disadvantage of this research is that the Ultrasonic sensor is very sensitive to variation in the temperature so when the temperature is high the performance of the sensor will reduce, and some difficulties in reading different reflections from curved, soft, and thin materials.

D. C. Patel et.al., [15] In this paper the Indigenous vacuum tunnel made with 18,000 rpm DC motor is sufficient to vacuum small objects for commercial cleaning purpose. The indigenous wiper system made with Teflon bevel gears is strong enough to wipe the floor. The indigenous Arduino logic programme for working of limit switch, infrared sensor and drive motors is sufficient to turn smart vacuum cleaner in commercial floor by developing arbitrary path and cover all the floor area. The developed AI vacuum cleaner is highly cost effective compared to commercially available smart vacuum cleaners.

R. Radha et.al., [16] They have created a cleaning programme that uses a hand gesturecontrolled robot and obstacle avoidance to carry out all cleaning tasks in both manual and autonomous modes. The user controls the robot using hand motions, and it works wonderfully. We are introducing features like dust bag full and battery status indication for autonomous mode. It detects the wall's edges, corners, and adequate cleaning. This robotic application is employed in settings like homes, workplaces, and businesses. Time is saved, and the human condition is improved.

T. B. Asafa et.al., [17] The journal describes about A robot vacuum cleaner has been designed, fabricated, and put through testing. It is shaped like a disc and collects dirt using a retractable trash can with a cooling fan installed on top. The suction fan contributes to the vacuum created, which draws dirt to the trash can. A front caster wheel, two rear wheels, and ultrasonic sensors are used by the robot to navigate. When the inbuilt battery is fully charged, it can run continuously for two hours on a 28.8 V DC battery.

M. Vijayalakshmi et.al., [18] The vacuum cleaner robot designed in this journal is run more effectively to remove dry dust particles that are present on the floor. Since the robot is wireless, therefore they can navigate a vast region. Additionally, less human interaction means less human work. The robot can be upgraded with additional features to improve cleaning, including self-charging, self-dust disposal, the ability to sense and identify dust, as well as the ability to travel in the direction of dust.

E.S. Rahayu et.al., [19] In this journal the Vacuum cleaner is designed wich can run automatically and manually. In automatic mode the robot will move randomly in a room by avoiding the obstacles and cleans the room. Whereas in manual mode the robot moves on the command of the person with the help of a controller and cleans the room. The only problem is that the robot can’t clean the narrow places due to its design.

Charnia Iradat Rapa et.al., [20] In this research about Design of Micro controller Arduino Mega 2560, we need four Ultrasonic sensors to detect the obstacles in 25 cm distance. The driver will move in accordance with the state of the obstacles and activate the vacuum cleaner to sweep and clear the dust after a dust censor that can detect dust with a size less than about 0.30 mg/mm3 causes the LCD to display logic "1.

By considering all the above-mentioned journals, as per our knowledge we observed that In comparison to conventional vacuum cleaners, the arduino-built vacuum cleaners are more cost-effective and efficient. The vacuum cleaners built on an Arduino platform can be operated both manually and automatically thanks to their design. However, the main drawback is that it takes longer than normal cleaners

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III.METHODOLOGY

The methodology for creating an Arduino-based smart Vacuum cleaner entails defining the cleaning requirements, selecting the necessary hardware components, such as motors, sensors, and batteries, writing the software code using the Arduino IDE, assembling the components in accordance with the design, testing and debugging the system to ensure it satisfies the requirements, improving the design to add features, and documenting the design and code for later use. To produce a practical and effective tool that can carry out particular cleaning activities automatically or manually, this requires a mix of hardware and software design and testing.

IV.FABRICATION

A. Components Required

1) Arduino UNO
2) Motor shield
3) Ultrasonic sensor
4) Servo motor
5) Lithium ion batteries
6) Geared motor wheels
7) 6v motor

B. Fabrication of robot

The robot has the following design:

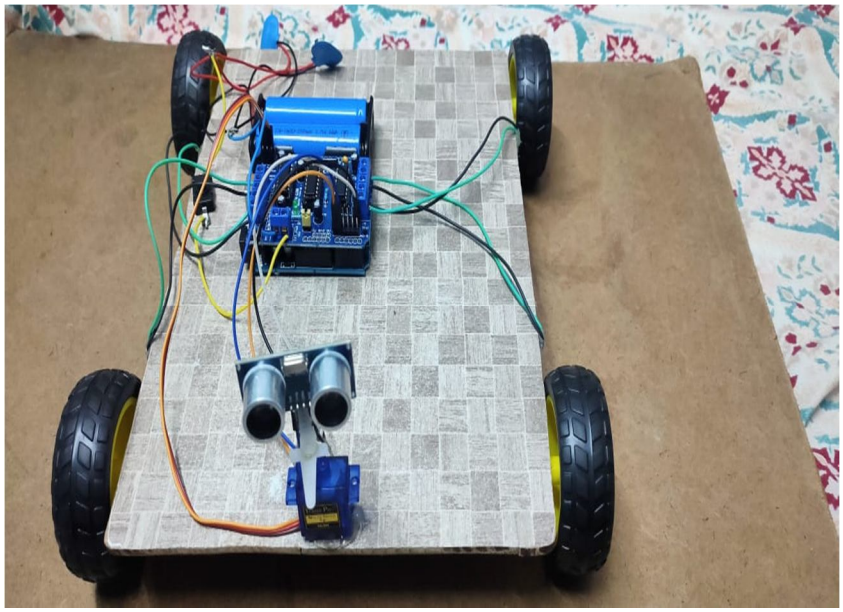


Fig. 1 Obstacle avoiding robot

The robot is supported on a wooden board as shown in figure 1. The required rectangular shape is created by cutting the board. The hardwood board's sides and edges are smoothed off by grinding. At this point, glue is used to secure the geared motor wheels in place at the bottom of the board. As seen in the illustration, the Arduino UNO is mounted on the motor shield. According to the code provided to Uno through the Arduino IDE software, the motor shield controls all the motors and wheels that are wired to it.
Over the servo motor, an ultrasonic sensor is mounted. This sensor identifies any obstructions in the robot's path and allows it to avoid collisions that could harm it. It is the robot's front that the servo motor is mounted on. The motor shield's slots are occupied by the pins of the servo motor and the ultrasonic sensor, respectively.
The lithium ion battery, which is mounted on the robot's back side, powers the entire circuit. The robot can be turned on and off whenever necessary using a switch.

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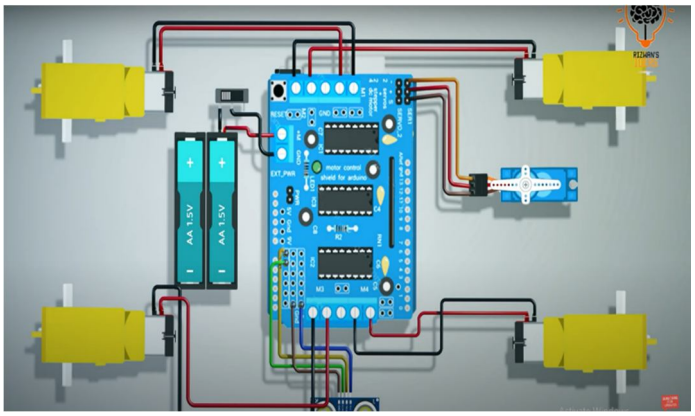


Fig. 2 Circuit diagram

All connections are done in accordance with the circuit schematic above as shown in figure 2.

C. Programming

The code for an Arduino-based vacuum cleaner is written in the Arduino Integrated Development Environment (IDE) using the C++ programming language.

The Arduino IDE is a software platform that allows you to write, upload, and run code on the Arduino board. To start programming an Arduino Uno, you need to connect it to your computer via USB and open the Arduino IDE as shown in figure 3.

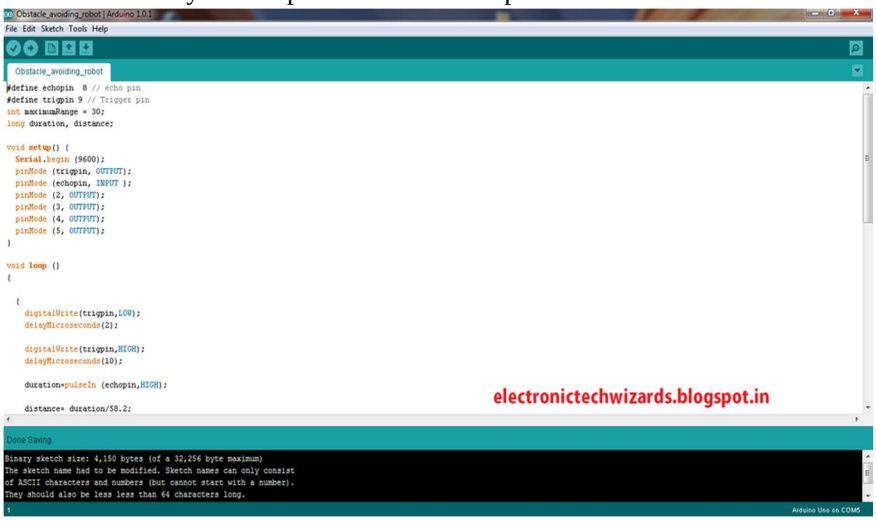


Fig. 3 Coding profile

D. Making of Vacuum Cleaner

A litre water bottle, a 6 volt motor, a fan, a switch, battery, and a thin mesh net are used to create the vacuum cleaner.

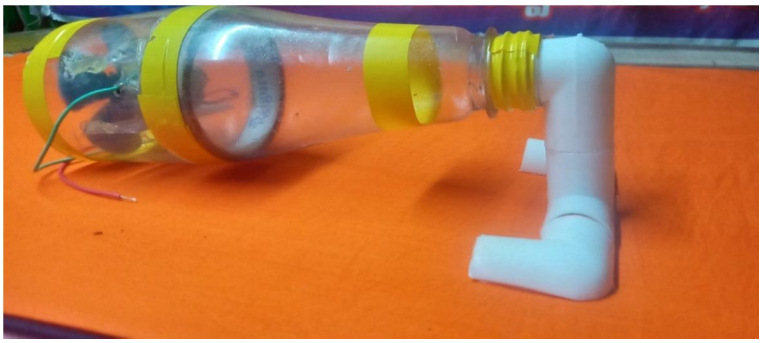


Fig. 4 Vacuum cleaner

The vacuum cleaner is prepared as shown in the figure. The process of the vacuum cleaner is preparation is done as follows:

1) The bottle's bottom is first chopped off with a knife to be removed.
2) The bottle-shaped portion of a fine mesh is cut. Now wrap the net over a cardboard piece that was given a bottle-diameter cut out.
3) Attach both the cardboard piece and the net. In the bottle, place the net arrangement.
4) After putting the filter in place, take the 6V motor and, using the wooden sticks as supports, put it inside the bottle.
5) Fix the fan to the motor.
6) The bottle opening has a T-shaped aperture attached to it to extend the suction area, which allows it to clean a larger area.
7) It is provided with a 12V power in order to create the necessary vacuum. Also linked to the side is a switch. This serves as a controller for turning the vacuum cleaner ON or OFF as shown in figure 4.

E. Working principle of the vacuum cleaner

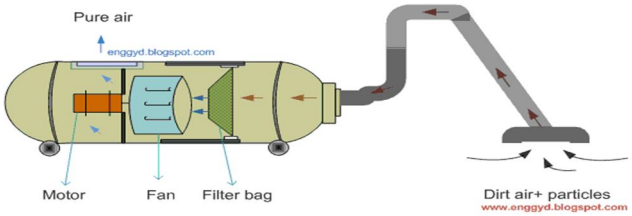


Fig. 5 working of vacuum cleaner

As shown in figure 5, when there is a pressure difference between two places, materials flow from one place to another. The fundamental operating principle of the perfect vacuum cleaner is this phenomena. A centrifugal fan moves the air by introducing external kinetic energy to it while it turns. Negative pressure is created behind the fan as air is drawn in from behind and forced forward with it. This centrifugal fan, which is attached to a motor, is found in the ultimate vacuum cleaner. This device has connections for suction and discharge; on the suction side, a filter bag is installed prior to the hose connection. The discharge is open to the atmosphere and features a second air purifier filter. The motor and centrifugal fan both rotate when electricity is applied. All airborne particles, including cat allergen, mist, dirt, and minute solid particles, are delivered to the suction filter together with the air that is drawn into the device from the suction side. Filtered air is forced out of the discharge aperture while the particles are trapped in the filter.

F. Working of Robot

The following flow chart shows the working of the robot.

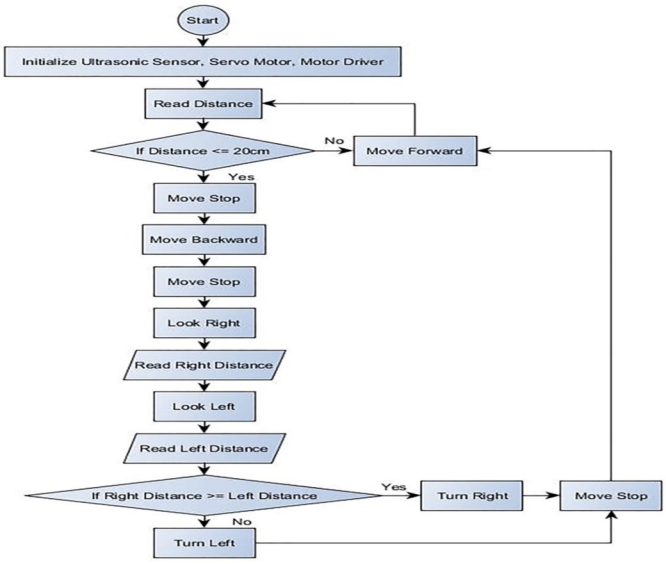


Fig. 6 working of robot

According to the flowchart above, as soon as the robot is turned on, an ultrasonic sensor measures the space in front of it. If the distance is less than 20 cm, the robot stops moving, and it moves backward while the servo motor rotates at an angle to measure the space on the robot's right and left sides. The robot goes in that direction if the distance is larger than 20 cm, and the process is repeated if the robot encounters any impediments. The vacuum cleaner is turned on at the same time as the robot. The vacuum cleaner cleans the area by sucking up all the dust particles, bits of paper, and other undesired things.

Once the system is turned on, the Arduino is powered by a power source, and the vehicle moves using a motor driver and caster wheel until an obstacle is detected. If an obstacle is detected, the robot changes its direction using the motor driver and program that has been loaded into the Arduino. The robot continuously changes its direction as it moves through the area it covers the entire space of the room. During the movement of the robot the vacuum cleaner is also turned on. The vacuum cleaner picks up the dust particles and cleans the area it moved as shown in figure 6.

V. RESULTS AND DISCUSSIONS

A. *Formulae*

- The torque,
$$T = \frac{60P}{2\pi N}$$
- The flow rate of air across the fan;
$$Q = AV$$
- The storage capacity of storage tank collecting the dust;
$$C = (1/3) * \pi * h * (r^2 + r * R + R^2)$$
- The area of the axial fan is as follows;
$$A = \frac{\pi}{4} D^2$$
- The mass flow rate across the fan is;
$$m = \rho AC$$
- Input power of the fan;
$$P_i = VI$$
- Output power of the fan;
$$P_o = Q(p_2 - p_1)$$
- The efficiency of the fan;
$$\eta = \frac{Out\ put\ Power}{Input\ Power}$$

Where,

- T: Torque of shaft (N-m)
- P: Motor power (Watt)
- N: Motor speed (rpm)
- P1: Pressure at the Inlet of Fan (N/m2)
- P2: Pressure at the Outlet of Fan (N/m2)
- Pi: Input Power of Fan (W)
- Po: Output Power of Fan (W)
- Q: Volumetric Flow Rate of Air (m^3/s)
- A: Area of axle fan (m^2)
- V: Velocity of Air (m/s)
- C: Storage Capacity (m^3)
- h: Storage Length (m)
- r: radius of the top surface(m)
- R: radius of the bottom surface(m)
- D: Diameter of the Fan (m)
- m: Mass Flow Rate (kg/s)
- ρ: Density of Air (kg/m^3)
- η : Efficiency of the Fan (%)

B. Calculation

- Torque = $\frac{60*15.6}{2*\pi*1000}$
  = 15.6 N-m
- Storage capacity = (1/3)*π*0.135*0.0115^2+(0.0115*0.0365)+0.0365^2
  = 0.00177 m^3
- Area of axial fan = $\frac{\pi}{4} * 0.06\text{^}2$
  = 0.002827 m^2
- The mass flow rate across the fan = 1.22*0.002827*0.00177
  = 6.1046*10^-6 kg/s
- Input power of the fan = 12*0.3
  = 3.6 W
- The flow rate of air across the fan = 0.002827*13.16
  = 0.03720 m^3/s
- Output power of the fan = 0.03720*(28.79)
  = 1.0709 W
- Efficiency of the Fan = 1.0709/3.6
  =0.2974
  = 29.74 %

C. Results

The result of using arduino based vacuum cleaner is that it is less cost compared to the regular automatic vacuum cleaners, and it can do the cleaning of the surroundings effectively. The following are some benfits of arduino based smart vacuum cleaner.

Cost-effective: Arduino-based smart vacuum cleaners are relatively inexpensive compared to commercially available vacuum cleaners, making it a cost-effective option for those on a budget.

Customizable: Arduino provides a platform for developers to customize their smart vacuum cleaner, allowing them to add features that meet their specific needs.

User-friendly: Arduino's programming environment is user-friendly, making it easier for non-programmers to create their own smart vacuum cleaner.

Scalability: The modular design of Arduino boards allows users to easily upgrade or add new features to their smart vacuum cleaner as needed.

Flexibility: With an Arduino-based smart vacuum cleaner, users can choose to use different sensors, motors, and other components, allowing for greater flexibility in terms of design and functionality.

Remote Control: The smart vacuum cleaner can be remotely controlled through a smartphone or tablet, allowing users to operate it from anywhere in their home.

Real-time monitoring: The smart vacuum cleaner can be equipped with sensors to monitor its environment in real-time, providing data on the level of dirt and dust in the environment.

Efficient cleaning: An Arduino-based smart vacuum cleaner can be programmed to optimize its cleaning patterns, making it more efficient in terms of cleaning time and energy consumption.

VI. CONCLUSION

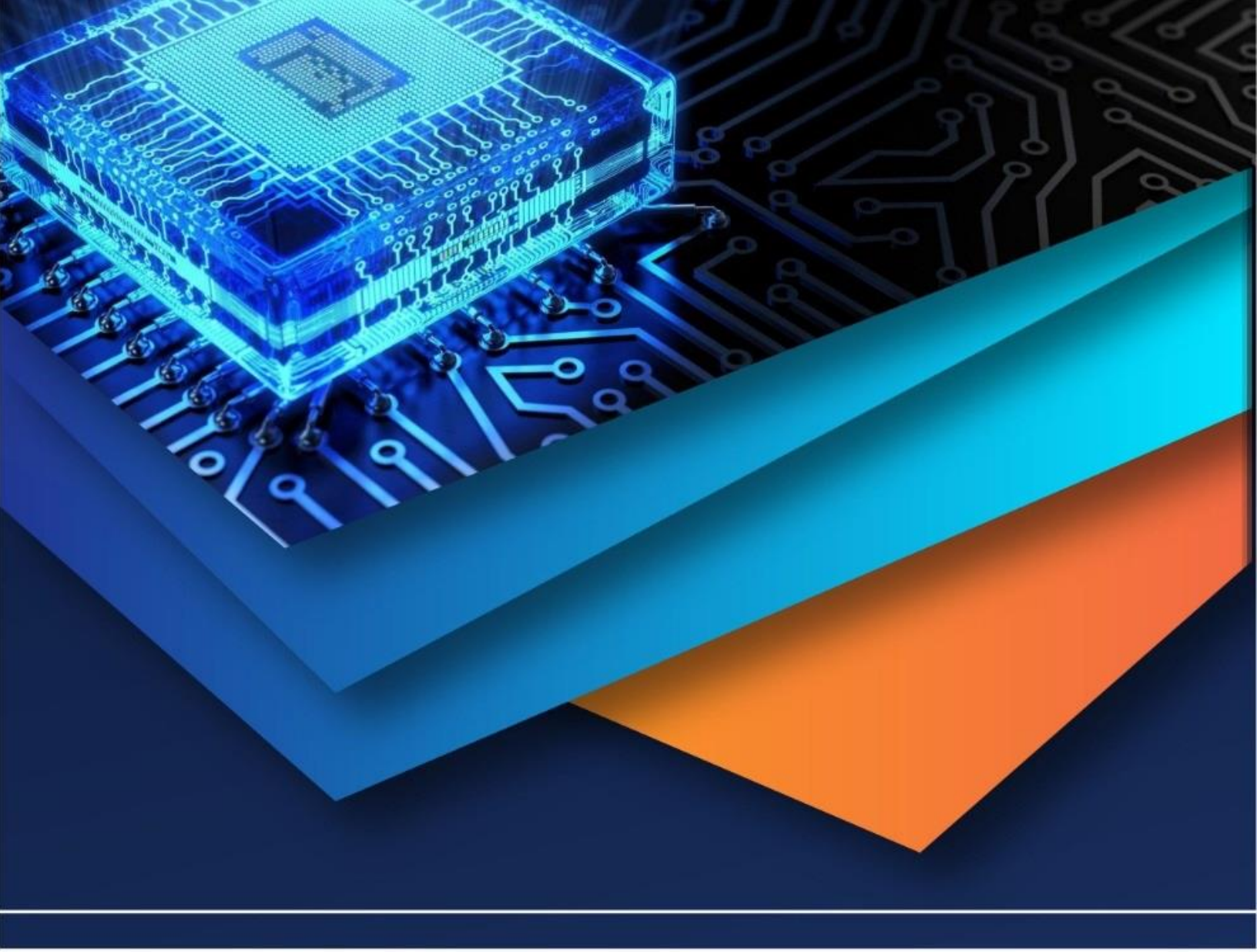
The use of a smart vacuum cleaner has been implemented in this project. It operated using pre-written code that was placed into an Arduino UNO. When an impediment is encountered, a Vehicle will turn to the side. When there is more space between the car and the obstruction. This invention uses a battery-powered vacuum cleaner and a axial fan connected to the 6v motor to collect dust without the need for human interaction, lowering the risks to human health. This cleaner is easy to use and reasonably priced. However, since cleaning the dust becomes easier, utilising a detachable bag can be preferable.

A lithium battery with an input power of 3.6 watts powers the vacuum cleaner that was created for this project. An anemometer measures the air velocity passing through the vacuum cleaner, while a pressure gauge measures the pressure inside the vacuum cleaner. The vacuum cleaner's effectiveness is 29.79%.

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