

---

## ***Smart Clean: A DIY Autonomous Vacuum Cleaning Robot***

***Mohit Ahuja,***

*Assistant Professor, Department of Electronics and Communication Engineering,*

*Aryabhata Institute of Technology, Delhi*

*mohit.ahuja@aitdelhi.ac.in*

### ***Abstract***

*This paper presents the design and implementation of a DIY autonomous vacuum cleaning robot, aimed at domestic applications. With the rising demand for home automation and smart cleaning technologies, building a low-cost robotic vacuum solution using off-the-shelf components offers an educational and practical project. The proposed robot integrates ultrasonic sensors for obstacle detection, an Arduino-based control system, and a vacuum module capable of surface cleaning. The design emphasizes modularity, efficiency, and autonomy, addressing basic path planning, battery efficiency, and object avoidance. The implementation was tested across multiple flooring types and under varied obstacle scenarios, yielding satisfactory results for typical household use. This paper also discusses challenges encountered during development, provides system schematics, and concludes with potential enhancements including IoT integration, AI-based mapping, and solar-powered energy solutions.*

***Keywords:*** *DIY vacuum robot, home automation, Arduino, obstacle detection, robotic cleaner, ultrasonic sensors.*

### **INTRODUCTION**

In recent years, the adoption of smart technologies in household applications has grown significantly. Among these innovations, robotic vacuum cleaners have gained considerable popularity due to their ability to autonomously clean environments without direct human control. Although commercially available robots such as iRobot Roomba or Xiaomi Mi Vacuum offer comprehensive cleaning solutions, they come at a high cost and limited user customization. As an alternative, DIY (Do-It-Yourself) robotics offers engineering enthusiasts and students an opportunity to build custom low-cost cleaning robots while learning

embedded systems, sensor integration, and path planning. The motivation behind developing a DIY vacuum cleaner stems from the desire to combine affordability, functionality, and educational value. This project utilizes accessible electronic components like Arduino UNO, motor drivers, vacuum fans, ultrasonic sensors, and chassis kits to create a robot capable of navigating a room and performing dry vacuum cleaning tasks.

The robot's main functionalities include object detection, forward navigation, basic edge detection, and circular motion to ensure floor coverage. Obstacle avoidance is implemented through real-time distance readings using ultrasonic sensors, while a low-power vacuum fan attached at the base serves the cleaning purpose. The logic and control flow are coded using Arduino IDE, enabling custom algorithms and flexible upgrades.

This paper is organized as follows: Section II presents a review of related work and the state of vacuum robotics. Section III discusses the methodology and design of the robot. Section IV describes the performance and limitations, followed by future scope in Section V. Finally, the paper concludes with key findings and improvement areas.

## **LITERATURE REVIEW**

Robotic vacuum cleaners have evolved significantly over the past two decades. In 2002, the introduction of the iRobot Roomba marked a pivotal shift in autonomous domestic cleaning. Various research studies have since explored methods for enhancing efficiency in robotic vacuums, focusing on sensor fusion, mapping technologies, and object avoidance mechanisms. In recent work by Park et al. (2020), ultrasonic and infrared sensors were evaluated for collision avoidance, concluding that a multi-sensor approach improves adaptability in dynamic environments.

DIY robotic vacuum solutions have also emerged, especially in educational contexts. Arduino-based systems dominate due to their ease of use, extensive community support, and open-source libraries. Studies by Kumari and Raj (2019) demonstrate that integrating ultrasonic sensors with motorized platforms yields efficient cleaning patterns even without SLAM (Simultaneous Localization and Mapping). The primary limitation observed in low-budget systems is their lack of adaptive mapping and battery optimization. Nevertheless, these DIY systems provide a learning platform for students in embedded systems and robotics.

## METHODOLOGY

The DIY vacuum cleaning robot was designed to achieve autonomy using cost-effective components. The core components include an Arduino UNO, dual motor driver (L298N), two ultrasonic sensors (for obstacle and edge detection), DC motors for wheel movement, a 12V mini vacuum fan, a rechargeable lithium-ion battery, and a two-wheel chassis. The implementation was broken down into the following subsystems:

1. Control Unit: The Arduino UNO acts as the brain of the robot. It receives input from the sensors and makes movement decisions.
2. Obstacle Detection: Two ultrasonic sensors are positioned at the front and side angles of the robot to detect nearby objects. When an object is detected within a 15cm range, the robot adjusts direction to avoid collisions.
3. Motor Control: The L298N motor driver manages motor direction and speed based on signals from the Arduino.
4. Vacuum Mechanism: A mini vacuum fan is attached at the center bottom to suck dust particles into a dust chamber.
5. Power Supply: A 12V lithium-ion battery powers the system. Voltage regulators ensure that individual components receive optimal current.

The control logic is programmed using Arduino IDE. The loop function continually checks sensor distances, updates motor direction, and powers the vacuum unit. Path planning is implemented via a simple wall-following and spiral motion algorithm to cover maximum area.

***Table 1: Key components used in the robot assembly. Each part plays a critical role in ensuring smooth functionality and autonomy of the vacuum robot.***

Component	Specification	Function
Arduino UNO	ATmega328P Microcontroller	Control Unit
Ultrasonic Sensor	HC-SR04	Obstacle Detection
Motor Driver	L298N	Controls DC Motor
Vacuum Fan	12V Mini Fan	Dust Collection
Battery	12V Li-ion	Power Supply
Chassis	2-Wheel Drive	Structural Frame

## FUTURE SCOPE

While the prototype robot demonstrates reliable functionality for small rooms, it has scope for enhancement in terms of intelligence, battery management, and user interaction. Future improvements may include:

1. Integration of IoT: Enabling smartphone control and Wi-Fi-based monitoring for real-time feedback and operation scheduling.
  2. Mapping and Navigation: Adding infrared sensors or LiDAR to develop SLAM algorithms and memory-based room mapping.
  3. Solar Charging: Incorporating solar panels to reduce dependency on plug-in charging, enhancing energy sustainability.
  4. Voice Assistant Integration: Interfacing with Alexa or Google Assistant for voice-based cleaning control.
  5. Improved Suction: Upgrading the vacuum fan and dust storage unit for deeper cleaning.
- These upgrades can transition the robot from a basic vacuum cleaner to a semi-intelligent autonomous unit suitable for larger homes.

## CONCLUSION

This paper details the development and performance of a DIY vacuum cleaning robot that offers cost-effective and autonomous floor cleaning. Utilizing Arduino-based logic, ultrasonic sensors, and basic motion control, the robot effectively navigates home environments and removes surface dust. The modular nature of the robot allows for component replacement and functional upgrades. It serves as an excellent academic and practical project for students interested in robotics, automation, and embedded systems. While basic in function, its future potential in integration and performance enhancement makes it a viable platform for continued research and home utility.

## REFERENCES

1. iRobot Corporation. 'Roomba Vacuum Cleaning Robot.' 2021.
2. Kumari, A., & Raj, M. 'Low-Cost Arduino Based Smart Vacuum Cleaner.' International Journal of Innovative Research in Technology, vol. 6, no. 4, 2019.

3. Park, H., et al. 'Multi-Sensor Fusion for Obstacle Avoidance in Indoor Mobile Robots.' *Robotics and Autonomous Systems*, vol. 125, 2020.
4. Ghosh, A. 'Smart Autonomous Robots for Indoor Cleaning.' *Journal of Robotics*, vol. 9, no. 2, 2021.
5. Yadav, N. 'Arduino-based Robotics Projects.' *Embedded World*, 2018.
6. Patel, J., & Mehta, K. 'Autonomous Home Cleaners: Opportunities and Challenges.' *Home Automation Digest*, vol. 5, 2020.
7. Choudhury, P. 'Intelligent Robots for Domestic Use.' *International Conference on Mechatronics and Robotics*, 2019.
8. Bose, R. 'Applications of Robotics in Smart Homes.' *TechEra Journal*, 2022.