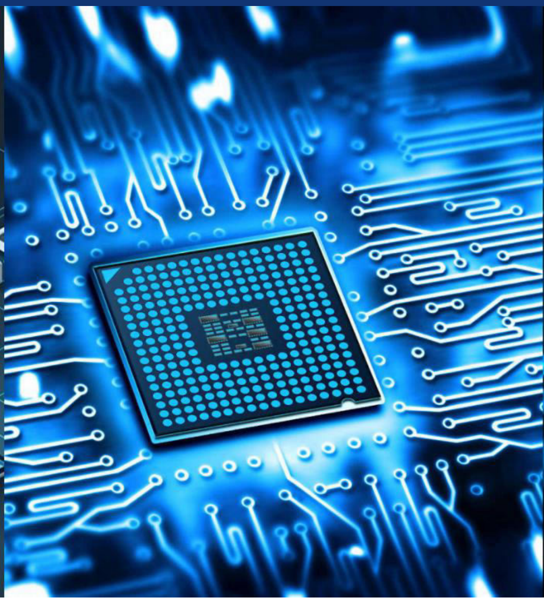
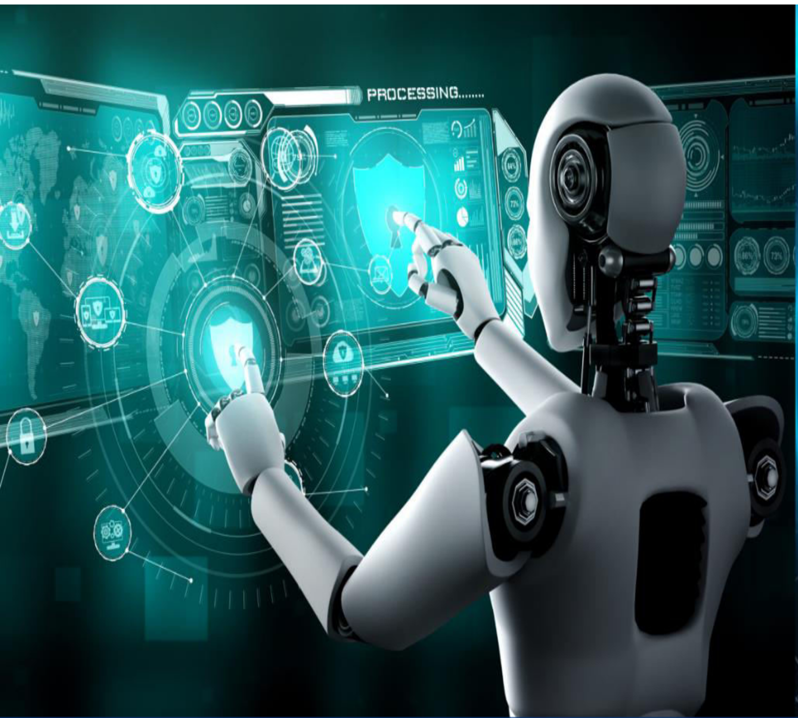
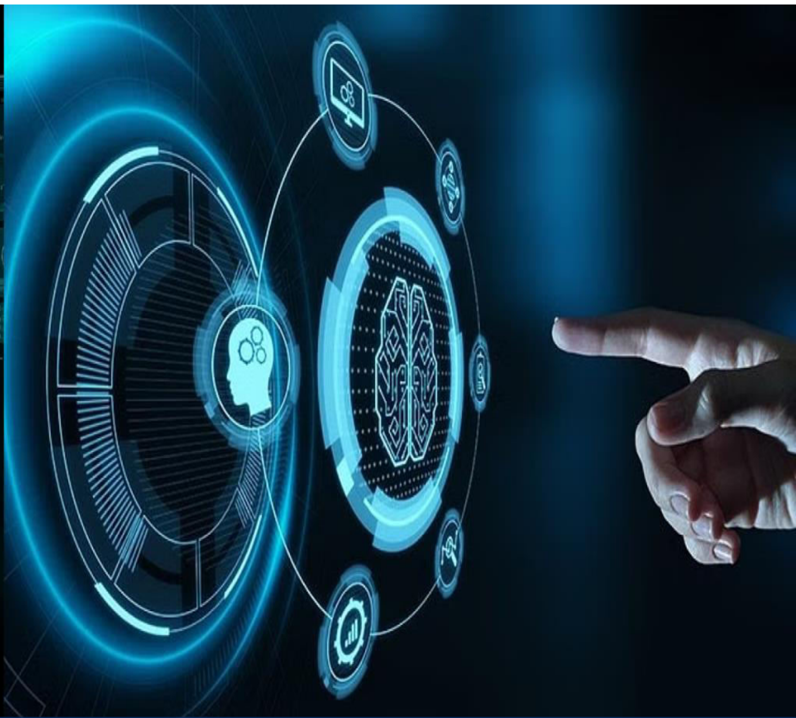
ISSN(O): 2320-9801
ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





Impact Factor: 8.771

Volume 14, Issue 4, April 2026

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Dust Detection and Cleaning Robot Using Arduino

Akash A Magar, Shreyash P Vaidya, Vaibhav M Magar, Shreya A Patil, Dipika R Gamladu, Kalyani D Nawale

Assistant Professor, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

UG Student, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

UG Student, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

UG Student, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

UG Student, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

UG Student, Dept. of EXTC, ACET, Sant Gadge Baba University, Amravati, Maharashtra, India

ABSTRACT: Automation has become an important aspect of modern life, improving efficiency and reducing human effort in various tasks. This project presents the design and implementation of a Dust Detection and Cleaning Robot using Arduino, which aims to automate the cleaning process intelligently. The system uses a dust sensor to detect the presence of dust in the environment and activates the cleaning mechanism only when required.

The Arduino microcontroller acts as the central processing unit, receiving input from the dust sensor and controlling the movement and cleaning operations of the robot. The robot is equipped with DC motors for movement, a motor driver for control, and a cleaning mechanism such as a brush or vacuum system.

Unlike traditional cleaning robots that operate continuously, this system improves efficiency by working only when dust is detected. This reduces energy consumption and increases the overall effectiveness of the system. The design is simple, cost-effective, and suitable for use in homes, offices, and small commercial environments.

The project demonstrates the practical application of embedded systems and robotics in solving real-world problems and provides a foundation for future enhancements such as IoT integration and smart navigation systems.

KEYWORDS: Arduino, Dust Detection, Cleaning Robot, Automation, Embedded Systems, Motor Driver, Sensor

I. INTRODUCTION

In recent years, technological advancements have significantly transformed the way tasks are performed in everyday life. Automation has emerged as one of the most influential developments, enabling machines to perform repetitive and time-consuming activities with minimal human intervention. From industrial automation to smart home systems, the integration of embedded systems and robotics has improved efficiency, accuracy, and convenience. One of the important areas where automation can bring significant benefits is in cleaning systems, which are essential for maintaining hygiene and a healthy environment.

Cleaning plays a vital role in maintaining cleanliness and preventing the accumulation of dust, dirt, and harmful particles in living and working environments. Dust particles, although often invisible, can cause serious health issues such as allergies, respiratory problems, and infections. Traditional cleaning methods such as sweeping, mopping, and manual vacuuming require considerable physical effort and time. These methods are not only labour-intensive but also inefficient in removing fine dust particles that accumulate over time. As a result, maintaining cleanliness becomes a challenging and repetitive task, especially in modern lifestyles where people have limited time for household activities.

With the rapid growth of urbanization and technological development, there has been an increasing demand for smart and automated solutions that can simplify daily tasks. Cleaning robots have emerged as an effective solution to address this need. These robots are designed to perform cleaning operations automatically, reducing the need for human intervention. They use a combination of sensors, microcontrollers, and mechanical systems to navigate through the environment and clean surfaces efficiently.

However, despite their advantages, existing cleaning robots have certain limitations. Most of the available systems operate continuously without considering whether cleaning is actually required. This results in unnecessary energy consumption and reduces the overall efficiency of the system. In addition, many commercial cleaning robots are expensive and involve complex technologies, making them less accessible to a large section of the population. Some systems also require manual control or supervision, which limits their level of automation and convenience.

Another major limitation of existing systems is the lack of intelligent decision-making based on environmental conditions. Most robots do not have the ability to detect dust levels in real time, which means they cannot optimize their operation according to actual cleaning requirements. This leads to inefficient usage of power and resources. Therefore, there is a need for a smart and cost-effective solution that can overcome these limitations by introducing intelligence and efficiency into the cleaning process.

The project titled "Dust Detection and Cleaning Robot Using Arduino" aims to address these challenges by developing an intelligent cleaning system that operates based on the detection of dust levels. The system uses a dust sensor to monitor the presence of dust in the environment and activates the cleaning mechanism only when the dust level exceeds a predefined threshold. This approach ensures that cleaning is performed only when necessary, thereby conserving energy and improving efficiency.

The Arduino microcontroller is used as the central processing unit of the system. It receives input from the dust sensor, processes the data, and controls the movement and cleaning operations of the robot. The use of Arduino offers several advantages, including simplicity, flexibility, and cost-effectiveness. It provides an easy platform for programming and integration with various sensors and components, making it suitable for developing embedded systems and robotic applications.

The robot is equipped with DC motors for movement and a motor driver to control the speed and direction of the motors. The cleaning mechanism, which may include a rotating brush or a small vacuum system, is responsible for removing dust from surfaces. The entire system is powered by a rechargeable battery, making it portable and convenient to use. The design of the robot focuses on compactness and stability, ensuring efficient operation in different environments.

One of the key features of this project is the integration of sensing, processing, and actuation components to achieve intelligent operation. The dust sensor continuously monitors the environment and sends signals to the Arduino. The microcontroller processes these signals and compares them with a predefined threshold value. If the dust level is below the threshold, the system remains inactive, conserving energy. When the dust level exceeds the threshold, the cleaning mechanism is activated, and the robot starts moving to clean the surface.

This intelligent approach not only improves the efficiency of the cleaning process but also reduces unnecessary operation, thereby extending the lifespan of the system components. The ability to operate autonomously without human intervention makes the system user-friendly and convenient. It also demonstrates the practical application of embedded systems and robotics in solving real-world problems.

The proposed system is designed to be affordable and accessible, making it suitable for use in homes, offices, hospitals, and small commercial spaces. Its simple design and low cost make it an attractive alternative to expensive commercial cleaning robots. In addition, the system provides a platform for future enhancements such as obstacle detection, path planning, IoT integration, and remote control through mobile applications.

In conclusion, the Dust Detection and Cleaning Robot using Arduino represents a significant step towards intelligent automation in cleaning systems. It addresses the limitations of traditional cleaning methods and existing robotic systems by providing a smart, efficient, and cost-effective solution. The project demonstrates how embedded systems and robotics can be used to develop practical solutions for everyday problems, improving quality of life and promoting technological advancement.

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

II. LITERATURE REVIEW

The development of cleaning robots has gained significant attention in recent years due to the rapid growth of automation and smart technologies. With the increasing demand for convenience, efficiency, and time-saving solutions, researchers and engineers have focused on designing intelligent cleaning systems that can perform tasks with minimal human intervention. Cleaning robots are now widely used in residential, commercial, and industrial environments, offering an effective solution to maintain cleanliness and hygiene.

One of the earliest and most basic types of cleaning robots is the manually controlled robot. These robots are operated by users through remote controls or mobile applications using wireless communication technologies such as Bluetooth or Wi-Fi. The primary advantage of these systems is their simplicity and flexibility, as users can control the movement and cleaning operations according to their requirements. These robots are often built using microcontrollers such as Arduino, NodeMCU, or ESP8266, and they allow users to perform cleaning tasks remotely. However, despite their convenience, these systems still require continuous human involvement, which limits their level of automation.

To overcome the limitations of manually controlled systems, autonomous cleaning robots have been developed. These robots are designed to operate independently without human intervention by using various sensors and intelligent algorithms. Sensors such as ultrasonic sensors, infrared sensors, and proximity sensors are commonly used to detect obstacles and navigate the environment. Autonomous robots are capable of moving around objects, avoiding collisions, and covering a larger area for cleaning. Some advanced systems also include mapping and path-planning algorithms that enable efficient navigation.

In recent years, the integration of Internet of Things (IoT) technology has further enhanced the capabilities of cleaning robots. IoT-based cleaning systems allow users to monitor and control the robot remotely through cloud platforms and mobile applications. These systems offer advanced features such as real-time monitoring, scheduling of cleaning tasks, performance tracking, and remote diagnostics. However, the inclusion of IoT technology increases the complexity of the system and requires additional hardware and software components. It also raises concerns related to data security and reliability.

Another important area of research in cleaning robots is the improvement of cleaning mechanisms and efficiency. Many systems use vacuum cleaning techniques combined with rotating brushes to remove dust and debris effectively. Some robots are also equipped with water spraying and mopping mechanisms for wet cleaning. Despite these improvements, many systems still operate continuously without considering whether cleaning is actually required. This leads to unnecessary energy consumption and reduces the overall efficiency of the system.

A major limitation observed in most existing cleaning robots is the lack of real-time dust detection capability. These systems do not have the ability to sense the level of dust present in the environment and therefore cannot make intelligent decisions based on actual cleaning requirements. As a result, they may continue to operate even when the surface is already clean, leading to wastage of energy and reduced battery life.

The proposed system addresses these limitations by introducing a dust detection mechanism using a dust sensor. The sensor continuously monitors the environment and provides real-time data on dust concentration. This data is processed by the Arduino microcontroller, which determines whether cleaning is required based on a predefined threshold value. The cleaning mechanism is activated only when the dust level exceeds the threshold, ensuring efficient operation and energy conservation.

In addition to improving efficiency, the proposed system focuses on simplicity and cost-effectiveness. By using readily available components such as Arduino, dust sensors, and DC motors, the system can be implemented at a lower cost compared to advanced commercial robots. This makes it accessible to a wider range of users and suitable for practical applications in homes, offices, and small commercial spaces.

In conclusion, the literature review highlights the evolution of cleaning robots from manually controlled systems to advanced autonomous and IoT-based solutions. While significant progress has been made in improving automation and functionality, existing systems still face challenges related to cost, complexity, and inefficiency. The proposed project

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

addresses these issues by introducing a simple, intelligent, and cost-effective cleaning robot that operates based on real-time dust detection.

III. PROBLEM STATEMENT

Maintaining cleanliness in indoor environments is essential for ensuring good health, comfort, and overall well-being. Dust accumulation is a common problem in homes, offices, and other working spaces, and it can lead to various health issues such as allergies, respiratory problems, and skin irritation. Despite the importance of cleanliness, traditional cleaning methods such as sweeping, mopping, and manual vacuuming are time-consuming and require significant physical effort.

In modern society, where people lead busy and fast-paced lifestyles, spending time on routine cleaning tasks becomes difficult. This has created a demand for automated solutions that can perform cleaning tasks efficiently without requiring constant human involvement. Cleaning robots have emerged as a potential solution to this problem by offering automated cleaning capabilities. However, despite their advantages, existing cleaning robots face several limitations that reduce their effectiveness and usability.

One of the major issues with current cleaning robots is their high cost. Many advanced robots available in the market use complex technologies such as artificial intelligence, mapping systems, and advanced sensors, which significantly increase their price. As a result, these systems are not affordable for a large section of the population, limiting their widespread adoption.

Another significant limitation of existing systems is their inefficient operation. Most cleaning robots operate continuously without considering whether cleaning is actually required. They follow pre-programmed paths or operate for a fixed duration, regardless of the presence of dust or dirt in the environment. This leads to unnecessary energy consumption and reduces the overall efficiency of the system. Continuous operation also results in faster battery depletion and increased wear and tear of components.

In addition to inefficiency, some cleaning robots require manual control or supervision. These systems depend on user input through remote controls or mobile applications, which reduces the level of automation. The need for human intervention defeats the purpose of having an automated system and limits its convenience. A truly efficient cleaning system should be capable of operating independently without requiring constant user involvement.

A critical limitation observed in most existing cleaning robots is the lack of an intelligent dust detection mechanism. These systems do not have the ability to sense the level of dust present in the environment. Without real-time information about dust concentration, the robot cannot make decisions based on actual cleaning requirements. This results in either excessive cleaning or insufficient cleaning, both of which are undesirable.

Considering these challenges, there is a clear need for an intelligent cleaning system that can overcome the limitations of traditional methods and existing robotic solutions. The project titled "Dust Detection and Cleaning Robot Using Arduino" aims to address these issues by developing a smart and efficient cleaning system. The proposed system uses a dust sensor to detect the presence of dust in the environment and activates the cleaning mechanism only when the dust level exceeds a predefined threshold. This approach ensures that the robot operates only when required, thereby improving efficiency and conserving energy.

IV. OBJECTIVES

The primary objective of this project is to design and develop a dust detection and cleaning robot using Arduino that can automate the cleaning process efficiently and effectively. The system is intended to reduce the dependency on manual cleaning methods, which are often time-consuming and require significant physical effort.

Another important objective of this project is to integrate a dust detection mechanism using a dust sensor. The sensor continuously monitors the surrounding environment and detects the presence and concentration of dust particles. Based on the data received from the sensor, the Arduino microcontroller processes the information and determines whether

© 2026 IJIRCCE | Volume 14, Issue 4, April 2026 DOI: 10.15680/IJIRCCE.2026.1404033

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

cleaning is required. The system is designed to activate the cleaning mechanism only when the dust level exceeds a predefined threshold value.

The project also focuses on developing a compact, lightweight, and portable robotic system that can operate in different environments such as homes, offices, and small commercial spaces. The design of the robot emphasizes ease of movement, allowing it to navigate across various surfaces while performing cleaning tasks. Special attention is given to the structural design to ensure stability, durability, and effective operation of the system.

Cost-effectiveness is another key objective of this project. Many existing cleaning robots are expensive due to the use of advanced technologies and complex designs. This project aims to provide an affordable alternative by using the Arduino microcontroller and basic electronic components. The goal is to develop a system that is accessible to a wider range of users without compromising on functionality and performance.

In addition to achieving immediate functionality, the project is designed to serve as a platform for future enhancements and improvements. The system can be further upgraded by incorporating features such as obstacle detection using ultrasonic sensors, path planning for efficient navigation, and integration with Internet of Things (IoT) technology for remote monitoring and control.

Overall, the objective of this project is to develop an intelligent, efficient, and cost-effective cleaning robot that demonstrates the practical application of embedded systems and robotics in solving real-world problems. The system aims to improve convenience, reduce human effort, and promote the use of automation in everyday life.

V. METHODOLOGY

The methodology of the proposed dust detection and cleaning robot is based on the systematic integration of sensing, processing, and actuation components to achieve efficient and intelligent cleaning. The design of the system follows a structured approach in which each component plays a specific role in the overall operation.

The first stage of the methodology involves sensing, which is carried out using a dust sensor. The dust sensor is responsible for detecting the presence and concentration of dust particles in the environment. It continuously monitors the surrounding air and generates an analog signal that corresponds to the dust level. The sensitivity of the sensor allows it to detect even fine dust particles that are not easily visible.

The second stage involves processing, which is performed by the Arduino microcontroller. The Arduino acts as the central control unit of the system and is responsible for interpreting the data received from the dust sensor. The analog signal generated by the sensor is read by the Arduino through its input pins and converted into digital values using an analog-to-digital conversion process. The microcontroller then compares the received values with a predefined threshold value stored in the program.

The comparison process plays a critical role in the decision-making capability of the system. If the detected dust level is below the threshold value, the Arduino determines that cleaning is not required and keeps the system in an idle state. On the other hand, if the dust level exceeds the threshold value, the Arduino activates the cleaning mechanism and initiates the movement of the robot.

The third stage of the methodology involves actuation, which includes the movement of the robot and the operation of the cleaning mechanism. The movement of the robot is controlled using DC motors, which are connected to the Arduino through a motor driver module. The motor driver acts as an interface between the microcontroller and the motors, allowing the Arduino to control the speed and direction of the robot.

The cleaning mechanism, which may consist of a rotating brush or a small vacuum system, is also controlled by the Arduino. When the cleaning process is activated, the mechanism starts operating to remove dust from the surface. The combined action of movement and cleaning ensures that the robot covers the area effectively and performs efficient cleaning.

The methodology also emphasizes simplicity and reliability in system design. By using readily available components such as Arduino, dust sensors, and DC motors, the system is easy to implement and maintain. Energy efficiency is another key focus of the methodology. By activating the cleaning mechanism only when the dust level exceeds the threshold, the system avoids unnecessary operation, reduces power consumption, and extends battery life.

VI. SYSTEM DESIGN

The system design of the dust detection and cleaning robot is based on a structured and modular approach that integrates three main sections: input, processing, and output. Each section performs a specific function and works in coordination with the others to ensure efficient and reliable operation of the system.

The input section of the system primarily consists of the dust sensor, which plays a crucial role in detecting the presence and concentration of dust particles in the environment. The dust sensor continuously monitors the surrounding air and generates an electrical signal that corresponds to the dust level. The sensor is strategically positioned on the robot to ensure accurate and consistent detection during movement.

The processing section of the system is centered around the Arduino microcontroller, which acts as the brain of the robot. The Arduino receives input signals from the dust sensor through its analog input pins. These signals are then converted into digital values using the built-in analog-to-digital converter of the microcontroller. Once the data is processed, the Arduino compares the detected dust level with a predefined threshold value stored in its program.

The output section of the system includes the motor driver module, DC motors, and the cleaning mechanism. The motor driver acts as an interface between the Arduino and the motors, allowing the microcontroller to control the speed and direction of the motors. Based on the signals from the Arduino, the motor driver operates the DC motors to move the robot in different directions such as forward, backward, left, or right.

The cleaning mechanism is another important component of the output section. It is responsible for removing dust from the surface and may consist of a rotating brush, suction device, or a combination of both. The design of the cleaning mechanism is kept simple to maintain cost-effectiveness while still providing adequate performance.

In addition to the main components, the system also includes a power supply unit, which is typically a rechargeable battery. The battery provides the necessary power to all components of the system, including the Arduino, sensors, motor driver, and motors. The overall system is designed in a compact and integrated manner, with all components mounted on a single chassis.

The design also focuses on energy efficiency by ensuring that the system operates only when necessary. By incorporating a dust detection mechanism, the robot avoids continuous operation and activates the cleaning process only when the dust level exceeds the threshold. The modular structure of the design allows for easy addition of new components and features in the future.

VI. HARDWARE COMPONENTS AND THEIR FUNCTIONS

7.1 BO Motor (Dual Shaft / 60 RPM)

The BO motor (Battery Operated motor), especially the dual shaft 60 RPM variant, is widely used in small robotic applications due to its simplicity, affordability, and ease of integration. This motor consists of a DC motor coupled with a plastic gearbox that reduces speed while increasing torque, making it ideal for driving robot wheels. The dual shaft design allows wheels to be attached on both sides, providing better balance and flexibility in robot design. Operating at around 60 revolutions per minute, it provides controlled and stable movement.

7.2 XL6009 DC-DC Step-Up Module

The XL6009 DC-DC step-up module is a high-efficiency boost converter used to increase the input voltage to a higher output voltage as required by different components in a robotic system. It is particularly useful when the available battery voltage is lower than the required operating voltage of certain modules or motors. This module uses switching regulator technology, which ensures minimal power loss and high efficiency compared to linear regulators. It includes an adjustable potentiometer that allows users to fine-tune the output voltage according to system requirements.

© 2026 IJIRCCE | Volume 14, Issue 4, April 2026 DOI: 10.15680/IJIRCCE.2026.1404033

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

7.3 7805 / 7812 Voltage Regulator IC

The 7805 and 7812 are fixed linear voltage regulator integrated circuits used to provide a stable output voltage of 5V and 12V respectively. These regulators are essential in electronic circuits where consistent voltage is required for proper functioning of sensitive components such as microcontrollers and sensors. The 7805 is commonly used for powering Arduino boards and logic circuits, while the 7812 is used for higher voltage components such as motors or relays. These ICs also help protect components from voltage spikes and fluctuations.

7.4 IR Infrared Sensor Module

The IR infrared sensor module is a commonly used component in robotics for obstacle detection and surface sensing. It operates based on the principle of infrared light reflection. The module consists of an IR LED (transmitter) and a photodiode or phototransistor (receiver). When the IR LED emits infrared light, it reflects off nearby objects and is detected by the receiver. This sensor is widely used in line-following robots, obstacle avoidance systems, and automation projects. Its output is typically digital (HIGH or LOW), which can be easily interfaced with microcontrollers like Arduino.

7.5 Submersible Water Pump (6-9V)

The submersible water pump is a compact DC motor-driven device used to move liquids, typically water, in robotic cleaning systems. Operating within a voltage range of 6-9V, it is designed to function while fully submerged in water. In robotic cleaning applications, this pump can be used to spray water onto surfaces for wet cleaning. The pump works by using an internal motor to rotate an impeller, which creates suction and pushes water through an outlet pipe. Its small size, lightweight design, and low power consumption make it suitable for portable battery-powered systems.

7.6 L298N Motor Driver Module

The L298N motor driver module is a dual H-bridge driver used to control the speed and direction of DC motors. Since microcontrollers like Arduino cannot supply enough current to drive motors directly, the L298N acts as an interface between the microcontroller and the motors. It allows control of two motors simultaneously, enabling forward, backward, left, and right movement of a robot. The module includes onboard voltage regulators, heat sinks, and protection circuits, making it robust and reliable. It operates using logic signals from the Arduino to control motor direction, while PWM (Pulse Width Modulation) signals are used to control speed.

7.7 Jumper Wires (Male to Female)

Jumper wires are essential components used to establish electrical connections between various parts of a circuit. Male-to-female jumper wires are particularly useful when connecting modules with header pins to breadboards or microcontrollers. These wires eliminate the need for soldering and allow quick prototyping and modifications. They come in different lengths and colors, which help in organizing and identifying connections easily. Reliable connections are crucial for proper signal transmission and system stability.

7.8 RGB Colour Sensor Module

The RGB color sensor module, such as the TCS3200, is used to detect colors by analyzing the intensity of red, green, and blue components in light. It consists of an array of photodiodes with color filters and a frequency output that corresponds to the detected color. This sensor can be used in advanced robotic systems for tasks such as sorting objects, detecting floor patterns, or identifying dirt areas. The module communicates with the Arduino by sending frequency signals, which are then processed to determine the color.

7.9 Arduino Uno (ATmega328P)

The Arduino Uno is the central control unit of the robotic system, based on the ATmega328P microcontroller. It acts as the brain of the robot, processing inputs from sensors and generating outputs to control motors, pumps, and other components. The board features digital and analog input/output pins, PWM outputs, USB connectivity, and onboard voltage regulation. It is programmed using the Arduino IDE, which provides a user-friendly environment for writing and uploading code. The Arduino Uno is widely used due to its simplicity, open-source nature, and extensive community support.

7.10 SPDT Switch

The Single Pole Double Throw (SPDT) switch is used to control the power supply of the robotic system. It has three terminals: one common terminal and two output terminals. Depending on the switch position, the common terminal connects to one of the outputs. In most cases, it is used as an ON/OFF switch to control the flow of current from the battery to the circuit. The SPDT switch is reliable, easy to install, and widely used in electronic circuits.

7.11 Hot Glue Gun

The hot glue gun is a mechanical tool used for assembling and securing components on the robot chassis. It works by melting solid glue sticks and dispensing the molten adhesive through a nozzle. Once applied, the glue cools and solidifies quickly, forming a strong bond. It is widely used in robotics for mounting motors, sensors, and circuit boards without the need for screws or complex fixtures. The glue provides insulation and vibration resistance, ensuring that components remain securely in place during operation.

7.12 Relay Module (5V, 2 Channel)

The relay module is an electrically operated switch used to control high-power devices using low-power signals from a microcontroller. A 5V 2-channel relay module allows control of two separate devices, such as a water pump or high-current motor. It uses an electromagnetic coil to open or close contacts, enabling isolation between the control circuit and the load circuit. Relay modules often include optocouplers for additional isolation and LEDs for status indication. They are essential when controlling devices that require more power than the Arduino can handle directly.

7.13 Rechargeable Battery (2000mAh)

The rechargeable battery is the primary power source for the robotic system, ensuring portability and uninterrupted operation. A 2000mAh battery provides a balance between size and capacity, allowing the robot to run for a reasonable duration without frequent recharging. Lithium-ion batteries are commonly used due to their high energy density, low weight, and rechargeability. The battery supplies power to all components, including motors, sensors, and the Arduino.

7.14 16x2 LCD Display

The 16x2 LCD display is a commonly used output device that displays text information in two rows, each containing up to 16 characters. It is based on the HD44780 controller and can be interfaced with Arduino using either parallel communication or an I2C module. This display is used to show important information such as system status, sensor readings, battery level, or operating mode of the robot. It enhances user interaction by providing real-time feedback.

VIII. SOFTWARE FUNCTION AND OUTPUT

The software of the dust detection and cleaning robot is developed using the Arduino platform and is written in Embedded C. It controls the overall functioning of the system by integrating sensing, processing, and actuation operations. The program uses libraries such as Wire.h, Adafruit_TCS34725.h, and LiquidCrystal_I2C.h to interface with the color sensor and LCD display.

In the setup function, all pins are initialized, and the relay modules for the water pump and cleaning motor are turned off initially to ensure safety. The LCD display is initialized to show system messages, and the color sensor is also initialized to detect dust levels. If the sensor fails to initialize, the system stops execution to avoid incorrect operation.

The main working of the system is implemented in the loop function, which runs continuously. The color sensor reads values of red, green, blue, and clear light intensity, where the clear value is used to detect dust. This value is compared with a predefined threshold to determine whether dust is present. The result is displayed on the LCD as "Dust: YES" or "Dust: NO," along with the sensor value.

If dust is detected, the cleaning process starts automatically. The robot moves forward using DC motors controlled by the motor driver, and the relay modules activate the cleaning motor and water pump. During this process, the infrared sensors continuously monitor for obstacles. If an obstacle is detected, the robot moves backward to avoid collision and then continues its operation. If no dust is detected, the system remains in an idle state, displaying "Waiting" on the LCD while all motors and relays remain off.

The program also includes separate functions for movement control such as forward, backward, and stop, making the code organized and easy to manage. Overall, the software ensures real-time monitoring, intelligent decision-making, and efficient operation of the robot.

8.1 Source Code

```
#include <Wire.h>
#include "Adafruit_TCS34725.h"
#include <LiquidCrystal_I2C.h>

// ----- Pin Definitions -----
const int pumpRelayPin = 2;
const int cleaningMotorRelayPin = 3;
const int frontIRPin = 4;
const int backIRPin = 5;
const int IN1 = 6;
const int IN2 = 7;
const int IN3 = 8;
const int IN4 = 9;
const int ENA = 10;
const int ENB = 11;

// ----- Sensor & LCD Setup -----
Adafruit_TCS34725 tcs = Adafruit_TCS34725();
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  pinMode(pumpRelayPin, OUTPUT);
  pinMode(cleaningMotorRelayPin, OUTPUT);
  digitalWrite(pumpRelayPin, HIGH);
  digitalWrite(cleaningMotorRelayPin, HIGH);
  pinMode(frontIRPin, INPUT);
  pinMode(backIRPin, INPUT);
  pinMode(IN1, OUTPUT); pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT); pinMode(IN4, OUTPUT);
  pinMode(ENA, OUTPUT); pinMode(ENB, OUTPUT);
  lcd.begin(); lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("System Starting...");
  Serial.begin(9600);
  if (tcs.begin()) {
    lcd.setCursor(0, 1); lcd.print("Sensor OK ");
  } else {
    lcd.setCursor(0, 1); lcd.print("Sensor FAIL ");
    while (1);
  }
  delay(2000); lcd.clear();
}

void loop() {
  uint16_t r, g, b, c;
  tcs.getRawData(&r, &g, &b, &c);
  lcd.setCursor(0, 0);
  lcd.print("Dust: ");
  lcd.print(isDustDetected(c) ? "YES" : "NO ");
  lcd.setCursor(12, 0); lcd.print("C:"); lcd.print(c);
  if (isDustDetected(c)) {
    lcd.setCursor(0, 1); lcd.print("Cleaning... ");
    startCleaningProcess();
  } else {
```

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

```
    lcd.setCursor(0, 1); lcd.print("Waiting... ");
    stopAll();
  }
  delay(1000);
}

bool isDustDetected(uint16_t clearValue) {
  return (clearValue > 13);
}

void startCleaningProcess() {
  moveForward(); delay(200);
  digitalWrite(pumpRelayPin, LOW);
  digitalWrite(cleaningMotorRelayPin, LOW);
  unsigned long startTime = millis();
  const unsigned long timeout = 15000;
  while (millis() - startTime < timeout) {
    if (digitalRead(frontIRPin) == LOW) {
      lcd.setCursor(0, 1); lcd.print("Obstacle Front ");
      digitalWrite(pumpRelayPin, HIGH);
      digitalWrite(cleaningMotorRelayPin, HIGH);
      moveBackward();
    } else if (digitalRead(backIRPin) == LOW) {
      lcd.setCursor(0, 1); lcd.print("Cleaning Done ");
      moveForward(); delay(500); stopMotors(); delay(5000); break;
    }
  }
  stopAll(); delay(500); lcd.clear();
}

void stopAll() {
  stopMotors();
  digitalWrite(pumpRelayPin, HIGH);
  digitalWrite(cleaningMotorRelayPin, HIGH);
}

void stopMotors() {
  digitalWrite(IN1, LOW); digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW); digitalWrite(IN4, LOW);
  analogWrite(ENA, 0); analogWrite(ENB, 0);
}

void moveForward() {
  digitalWrite(IN1, HIGH); digitalWrite(IN2, LOW);
  digitalWrite(IN3, HIGH); digitalWrite(IN4, LOW);
  analogWrite(ENA, 200); analogWrite(ENB, 200);
}

void moveBackward() {
  digitalWrite(IN1, LOW); digitalWrite(IN2, HIGH);
  digitalWrite(IN3, LOW); digitalWrite(IN4, HIGH);
  analogWrite(ENA, 150); analogWrite(ENB, 150);
}
```

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IX. WORKING PRINCIPLE

The working principle of the dust detection and cleaning robot is based on the integration of three fundamental processes: sensing, processing, and actuation. These processes work together in a coordinated manner to achieve intelligent and efficient cleaning. The system is designed to operate automatically by continuously monitoring the environment, analyzing the collected data, and performing actions only when necessary.

The operation of the system begins with the sensing stage, where the dust sensor plays a crucial role in detecting the presence and concentration of dust particles in the surrounding environment. The dust sensor continuously monitors the air and surface conditions and generates an electrical signal proportional to the dust level. The sensor is highly sensitive and capable of detecting even fine dust particles that are not visible to the human eye.

Once the dust sensor detects the dust level, the generated signal is transmitted to the Arduino microcontroller, which serves as the processing unit of the system. The Arduino reads the analog signal through its input pins and converts it into digital data using an internal analog-to-digital converter. The Arduino is programmed with a predefined threshold value that represents the minimum dust level required to initiate the cleaning process.

The processing stage involves comparing the sensor data with the threshold value. If the detected dust level is below the threshold, the Arduino determines that cleaning is not required and keeps the system in an idle state. When the dust level exceeds the predefined threshold value, the Arduino activates the actuation stage. Control signals are sent to the motor driver module and the cleaning mechanism.

The motor driver acts as an interface between the Arduino and the DC motors, enabling the microcontroller to control the movement of the robot. Simultaneously, the cleaning mechanism is activated to remove dust from the surface. The cleaning mechanism may consist of a rotating brush, a vacuum system, or a combination of both. The rotating brush helps in loosening and collecting dust particles, while the vacuum system can be used to suck the dust into a container.

The system operates in a continuous loop, where the sensing, processing, and actuation stages are repeated continuously. This loop ensures real-time monitoring of dust levels and immediate response to changes in the environment. As the cleaning process continues, the dust level gradually decreases. The sensor detects this reduction and sends updated signals to the Arduino. Once the dust level falls below the threshold value, the Arduino stops the cleaning mechanism and halts the movement of the robot.

X. CIRCUIT DIAGRAM AND EXPLANATION

[Note: Circuit diagram image is referenced from original project report. Please insert circuit diagram here.]
The circuit diagram of the dust detection and cleaning robot represents the complete hardware integration of various components such as the Arduino Uno microcontroller, motor driver module, DC motors, sensors, relay module, water pump, LCD display, and power supply. The design follows a structured approach in which all components are interconnected to perform sensing, processing, and actuation functions efficiently.

The power supply section consists of a rechargeable battery pack that provides the required voltage to the system. The battery is connected to the circuit through a switch, which allows the user to turn the system ON or OFF. At the core of the system is the Arduino Uno microcontroller, which serves as the brain of the robot. All input and output components are connected to the Arduino through its digital and analog pins.

The dust detection functionality is implemented using a color sensor module (TCS34725), which is connected to the Arduino via I2C communication lines (SDA and SCL). This sensor detects the intensity of light reflected from the surface and provides data that is used to determine the presence of dust.

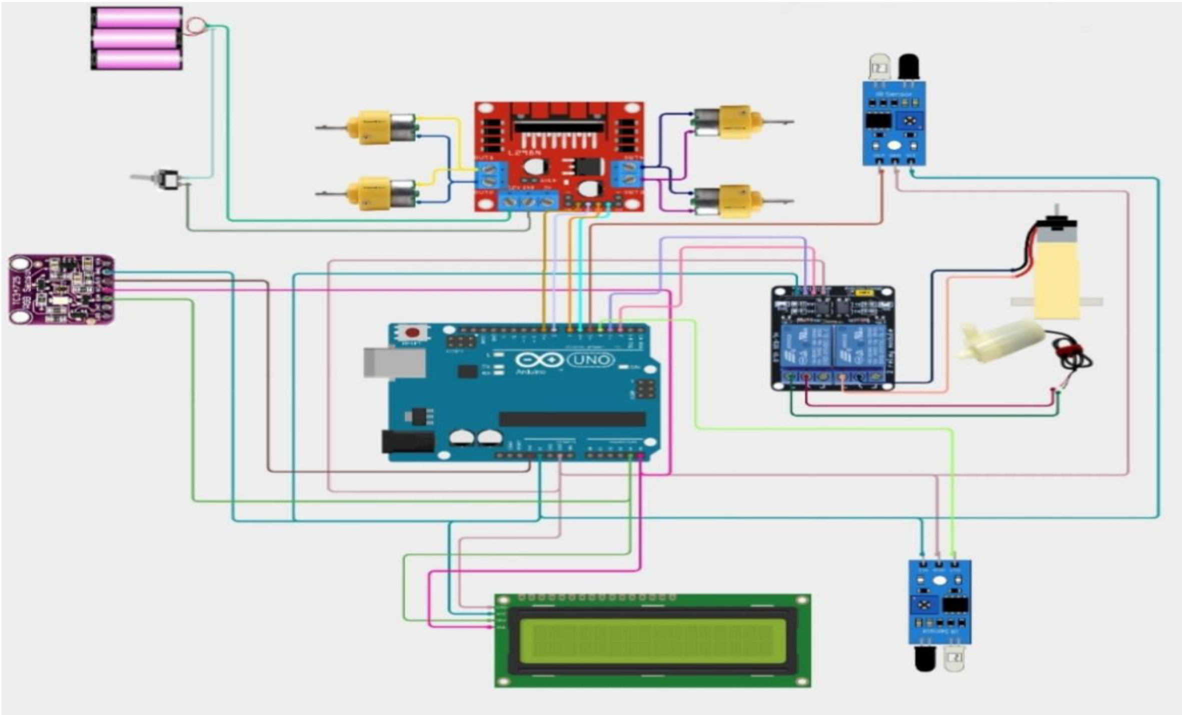
The motor driver module (L298N) is used to control the movement of the robot. The input pins of the motor driver are connected to the digital output pins of the Arduino, while the output pins are connected to the DC motors. Infrared (IR) sensor modules are used for obstacle detection and are connected to the digital input pins of the Arduino.

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

The cleaning mechanism of the robot includes a water pump and a cleaning motor, which are controlled using a relay module. When the Arduino detects dust, it sends a signal to the relay module to turn ON the water pump and cleaning motor. The LCD display (16x2) is connected to the Arduino using I2C communication and is used to display real-time information such as dust detection status and system messages.



XI. ADVANTAGES AND LIMITATIONS

11.1 Advantages

The dust detection and cleaning robot developed in this project offers several advantages that make it an efficient and practical solution for automated cleaning. One of the primary advantages of the system is the significant reduction in human effort. By automating the cleaning process, the robot eliminates the need for manual intervention, allowing users to focus on other important tasks.

Another important advantage of the system is improved efficiency in cleaning operations. The integration of a dust sensor enables the robot to detect the presence of dust in real time and perform cleaning only when necessary. Unlike conventional cleaning robots that operate continuously, this system uses an intelligent approach by activating the cleaning mechanism only when the dust level exceeds a predefined threshold.

Energy conservation is another key benefit of the system. Since the robot operates only when required, it avoids unnecessary power consumption, which not only extends the battery life but also reduces the overall energy usage. Cost-effectiveness is also a significant advantage. By using simple and readily available components such as Arduino, dust sensors, and DC motors, the overall cost of the system is greatly reduced.

11.2 Limitations

Despite its advantages, the system has certain limitations that need to be considered. One of the major limitations is its limited cleaning capability compared to advanced commercial cleaning robots. The cleaning mechanism used in this project is relatively simple and may not be as powerful as industrial-grade vacuum systems.

Another limitation of the system is the lack of advanced navigation and obstacle detection features. The robot does not include sophisticated sensors or algorithms for mapping and path planning. This means that it may not be able to navigate complex environments efficiently. The system is also limited in terms of coverage area and may not be suitable for cleaning large areas or multi-room environments.

XII. APPLICATIONS

The dust detection and cleaning robot has a wide range of applications in various environments. One of the primary applications of this system is in residential areas, where it can be used for regular cleaning of floors and surfaces. In modern households, where people have busy schedules, this robot provides a convenient solution by automating the cleaning process.

The system can also be effectively used in office environments, where cleanliness is important for maintaining a professional and comfortable workspace. Dust accumulation in offices can affect the health and productivity of employees. Another important application of the system is in hospitals and healthcare facilities, where maintaining a high level of hygiene is critical.

The robot can also be used in educational institutions such as schools and colleges, and in small commercial spaces such as shops, showrooms, and workshops. The project also has applications in research and educational purposes, where it can be used as a learning tool for students studying embedded systems, robotics, and automation. Furthermore, the system can be adapted for use in smart home environments as part of home automation systems.

XIII. RESULTS AND DISCUSSION

The developed dust detection and cleaning robot was tested under various environmental conditions to evaluate its overall performance, efficiency, and reliability. The testing was conducted in different indoor environments such as tiled floors, wooden surfaces, and slightly uneven surfaces.

During the initial phase of testing, the dust sensor was calibrated to ensure accurate detection of dust particles. It was found that the dust sensor responded effectively to variations in dust concentration and provided stable analog outputs. When the environment was clean, the sensor output remained below the threshold value, and the robot stayed in an idle state. When dust particles were introduced into the environment, the sensor output increased significantly.

The robot successfully activated its cleaning mechanism when the detected dust level exceeded the predefined threshold. This demonstrated the effectiveness of the system in performing intelligent cleaning operations. The cleaning mechanism was able to remove dust particles from the surface efficiently, and the DC motors enabled the robot to move across the surface.

The efficiency of the robot was also evaluated by comparing its performance with traditional cleaning methods. It was observed that the robot was able to clean small areas effectively without requiring human intervention. Additionally, since the system activates only when dust is detected, it avoids unnecessary operation, thereby conserving energy.

However, certain limitations were observed during the testing phase. One of the primary limitations is the limited coverage area. The robot moves in a simple pattern, which may result in incomplete coverage of larger areas. Additionally, the robot may face difficulty in navigating around obstacles. Despite these limitations, the overall performance of the system was satisfactory for its intended purpose.

XIV. CONCLUSION

The project titled "Dust Detection and Cleaning Robot Using Arduino" successfully demonstrates the design, development, and implementation of an intelligent and automated cleaning system. The primary objective of reducing human effort in cleaning tasks while improving efficiency through automation has been effectively achieved by integrating a dust detection mechanism with a robotic cleaning system.

One of the most significant achievements of this project is the successful implementation of dust-based activation of the cleaning mechanism. Unlike conventional cleaning robots that operate continuously, this system introduces an intelligent approach where cleaning is performed only when necessary. This not only improves efficiency but also reduces unnecessary energy consumption, making the system more sustainable.

The integration of various hardware components such as the Arduino microcontroller, dust sensor, motor driver, DC motors, and cleaning mechanism has been carried out effectively. The software implementation of the project also plays a vital role in ensuring proper functionality. The Arduino program is designed to continuously monitor sensor inputs and control the system accordingly.

From a practical perspective, the developed system proves to be highly useful for small-scale applications such as homes, offices, and laboratories. The compact design, portability, and cost-effective nature of the system make it accessible to a wider range of users. The project successfully demonstrates the potential of embedded systems and robotics in developing intelligent and efficient solutions for everyday problems, paving the way for further research and development.

REFERENCES

1. Arduino Official Documentation, "Arduino Programming and Hardware Interface," available at: https://www.arduino.cc
2. Adafruit Industries, "TCS34725 Colour Sensor Documentation," available at: https://learn.adafruit.com
3. Datasheet of L298N Motor Driver Module, STMicroelectronics, available online.
4. Infrared Sensor Module Documentation and Working Principle, available at various electronics learning platforms.
5. K. Ogata, "Modern Control Engineering," Prentice Hall Publications.
6. Raj Kamal, "Embedded Systems: Architecture, Programming and Design," McGraw Hill Education.
7. Research papers on cleaning robots and automation systems from IEEE Xplore Digital Library.
8. Tutorials and technical resources from electronics websites such as https://www.electronicshub.org and https://www.circuitdigest.com
9. Liquid Crystal Display (LCD) interfacing with Arduino, available in Arduino official tutorials.
10. Various online resources and project references related to robotics and automation systems.
11. V. Sharma, A. Sharma, H. Sharma, and A. Bhinchar, "A Design Study on Arduino Based Autonomous Cleaning Robot," Pratibodh - A Journal for Engineering, Jaipur Engineering College and Research Centre, Jaipur, India, 2025.
12. S. Tiwari, S. Kotecha, G. Rasal, P. Shukla, and A. Mandavkar, "Arduino Based Cleaner Robot," International Journal of Engineering Research & Technology (IJERT), ICIATE Conference Proceedings, vol. 5, no. 1, 2017.