Automatic Mop and Vacuum Robot

A Major Project Report
Submitted in partial fulfillment of the requirements for the
B. Voc. Robotics and Automation
Batch 2022-2025

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Certificate

This is to certify that project report entitled **"Automatic Mop and Vacuum Robot"** submitted by **Bhumika, Mohit, Sagar Singh, Vrinda** in partial fulfillment of the requirement for the award of the degree of **B. Voc. Robotics and Automation (2022-2025)** of Skill Faculty of Engineering and Technology in Shri Vishwakarma Skill University, Palwal, Haryana is a record of student's own work carried out under our supervision and guidance.

To the best of our knowledge, this project report has not been submitted in part or full elsewhere in any other University or Institution for the award of any degree or diploma. It is further understood that by this certificate the undersigned do not endorse or approve any statement made, opinion expressed, or conclusion drawn therein but approve the project report only for the purpose for which it is submitted.

Signature	**Signature**
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Declaration

We **Bhumika, Mohit, Sagar Singh, Vrinda** the students of **B. Voc. Robotics and Automation (2022-2025)** of Skill Faculty of Engineering and Technology, Shri Vishwakarma Skill University, hereby declare that we own full responsibility for the information, results, conclusions, etc., provided in project report titled **"Automatic Mop and Vacuum Robot"** submitted to Shri Vishwakarma Skill University, Palwal, Haryana for the award of **B. Voc. Robotics and Automation (2022-2025)** degree.

This project work has been carried by us the under the supervision of **Prof. Kulwant Singh** and **Mr. Sansh Bir Dagar** has not been submitted anywhere to any other University or Institutions.

We have completely taken care in acknowledging the contribution of others in this academic work. We further declare that in case of any violation of intellectual property rights or copyrights found at any stage, we, as the candidate will be solely responsible for the same.

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Thank you.

Abstract

The physical strain and time consumption involved in manual home cleaning tasks such as mopping and vacuuming are common issues faced in daily life. This project focuses on developing an **automatic mop** and **vacuum robot** that can operate in both **manual** and **automatic** modes, using a combination of **sensors** and **actuators**. **Robotics** and **automation** are leveraged to create a smart **cleaning** solution that improves **convenience**, accessibility, and hygiene in residential spaces.

The research problem centers on simplifying household cleaning for individuals with limited time, mobility issues, or physical constraints. The proposed solution involves designing, assembling, and testing a robotic **cleaning** system that integrates **ultrasonic sensors** for **obstacle avoidance**, **IR sensors** for **edge detection**, and **Bluetooth** for **manual control** via a custom **mobile application**. The robot includes components such as a **vacuum** motor, water pump, and rotating **mop** mechanism, all controlled through an **Arduino Mega** and motor drivers.

The expected outcomes of this project include an effective and intelligent **cleaning** system capable of navigating various floor surfaces, avoiding falls or collisions, and operating efficiently in **hybrid** (**manual** and **automatic**) **modes**. This **robot** aims to transform household **cleaning** by providing a user-friendly, automated solution that enhances cleanliness, reduces effort, and improves daily living conditions. The project's objective is to demonstrate the feasibility and effectiveness of a low-cost, sensor-driven cleaning robot built with readily available components.

Keywords: *robotics, automation, cleaning, vacuum, mop, Arduino Mega, IR sensors, ultrasonic sensor, Bluetooth, control, obstacle avoidance, edge detection, hybrid mode, mobile application, convenience, automatic, robot.*

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1 Introduction

In recent years, home automation and robotics have witnessed significant growth, driven by the increasing need for convenience, time efficiency, and cleanliness. With this in mind, our project titled **"Automatic Mop and Vacuum Robot"** aims to provide a smart, cost-effective, and hybrid-mode cleaning solution that automates the task of floor cleaning. The robot integrates vacuuming and mopping capabilities within a compact and modular design, making it ideal for domestic environments, especially in urban homes with hard flooring surfaces. This project is particularly relevant in the context of modern lifestyles, where individuals often lack the time for regular household cleaning. Our goal is to create a robotic system that not only performs cleaning efficiently but also allows users to control and monitor it manually through a **Bluetooth-enabled mobile application**, ensuring flexibility and ease of use.

The robot operates in two modes:

- Automatic Mode: Uses sensor-based navigation to detect obstacles and edges, allowing it to operate independently.
- Manual Mode: Enables the user to control the robot remotely via a smartphone app using **Bluetooth communication** (HC-05 module).

At the core of the robot lies the **Arduino Mega**, which controls the overall functioning of the system. For navigation and safety, the robot uses an **ultrasonic sensor** (mounted 15 cm above ground) to detect obstacles and **three IR sensors** for edge detection – one placed at the front, and the other two at the left and right corners.

The cleaning system consists of:

- A **vacuum motor** for dry dust collection
- A **rotating mop motor** for effective scrubbing
- A **5V water pump** for dispensing water during mopping

These are controlled using a combination of **relay modules** (2-channel and 1-channel) to handle power delivery and switching.

Motion is achieved using **two DC gear motors** for the wheels, driven by an **L298N motor driver**, and supported by a **caster wheel** for balance. The robot is powered by a **12V lithium-ion battery**, offering both portability and sufficient operational time.

The primary objective of this project is to design and implement a **low-cost, efficient, and dual-function cleaning robot** that is suitable for Indian households. It combines embedded systems, mechanical design, sensor integration, and mobile interfacing to deliver a functional prototype. This project also serves as a platform to explore real-world applications of robotics, control systems, and automation technologies.

2 Literature Survey

2.1 Introduction

The demand for smart and autonomous home appliances has surged with the increasing pace of modern life. Among these, robotic vacuum and mop systems have emerged as essential tools that assist in routine household maintenance. These devices combine mechanical engineering, embedded systems, and automation to offer hands-free cleaning. The purpose of this literature survey is to explore the evolution of these systems, understand their components and functionalities, analyze their relevance, and study market trends. This also lays the foundation for our project: a cost-effective, Arduino-based automatic mop and vacuum robot tailored for household applications.

2.2 History of Vacuum Cleaning Technology

Vacuum cleaning traces back to the 1860s with manually operated devices using bellows. By the early 1900s, motorized vacuums such as the Hoover revolutionized cleaning. The 20th century saw vast improvements in suction power, portability, and filter systems. Bagless vacuums and HEPA filters enhanced performance. Despite these advances, vacuuming remained a manual task until the emergence of autonomous cleaning robots.

2.3 History of Mopping Technology

Mops were used as early as the 1400s in Europe, with significant developments in the 1900s like the invention of the sponge mop. Modern designs introduced microfiber mops, spray systems, and rotating wringer mops. In recent decades, steam mops and mopping robots have provided deeper cleaning solutions, integrating water dispensing and motorized cleaning.

2.4 Evolution of Vacuum cleaners

The evolution of vacuum cleaners over the past century highlights a continuous drive toward greater efficiency, portability, and automation in home cleaning technology.

2.4.1 Early Innovations (1900s–1950s)

• 1900s: Hoover Model O

The Hoover Model O marked the beginning of commercial vacuum cleaners, introducing a basic but effective method for mechanized dust removal.

• 1910s: The Royal Standard

This era saw improvements in portability and usability, with designs becoming more compact and accessible for household use.

• 1920s: Hoover 700

The Hoover 700 featured enhanced suction and maneuverability, setting a standard for upright vacuum cleaners.

• 1930s: Hoover Model 150

Further refinements in design and efficiency were made, with the Model 150 offering better dust collection and ease of use.

• 1940s: Electrolux Z36

The Electrolux Z36 introduced a sleeker, more modern appearance and improved filtration, reflecting the influence of industrial design trends.

• 1950s: The Hamilton Beach Model 14

This model continued the trend of making vacuums lighter and more convenient for everyday use.

2.4.2 Technological Advancements (1960s–1990s)

• 1960s: The Hoover Constellation

The Hoover Constellation was notable for its unique spherical design and floating capability, enhancing mobility across various floor types.

• **1970s: Interstate Engineering Corporation's Model C-8**

This period focused on improved motor efficiency and ergonomic design, making vacuums more user-friendly.

• **1980s: Cyclone**

The introduction of cyclone technology revolutionized vacuum cleaners by eliminating the need for bags and maintaining strong suction over time.

• **1990s: Dyson DC01 Bagless 'Hoover'**

Dyson's DC01 further advanced cyclone technology, emphasizing bagless operation and transparent dust containers, which allowed users to see when the vacuum needed emptying.

2.4.3 Automation and Smart Technology (2000s–2010s)

• **2000s: Roomba**

The Roomba marked a significant leap toward automation, introducing the first widely adopted robotic vacuum cleaner capable of autonomous cleaning and navigation.

• **2010s: Dyson 360 Eye**

The Dyson 360 Eye incorporated advanced sensors and mapping technology, offering improved navigation, cleaning efficiency, and integration with smart home systems.

Fig 2.1 Evolution of Vacuum Cleaners

2.4.4 Key Innovations (2010–2025):

• **Artificial Intelligence & Smart Navigation:**

Modern vacuum cleaners now feature AI-driven navigation systems, using technologies such as LiDAR, 3D cameras, and advanced sensors. These allow robots to map rooms, avoid obstacles, and optimize cleaning routes with high precision.

• **Integrated Mopping and Vacuuming:**

The latest robot cleaners combine vacuuming with advanced mopping systems. Features include mop pad lifting, hot water mop washing, and auto-drying, enabling seamless transition between hard floors and carpets without manual intervention.

• **Self-Maintenance Docks:**

High-end models now come with multifunctional docking stations that can automatically empty dustbins, wash and dry mop pads, refill water tanks, and even add cleaning solutions. This reduces user maintenance to a minimum.

• **Automatic Dirt Detection:**

Many vacuums use sensors to detect dirt levels and adjust suction power accordingly, ensuring thorough cleaning and efficient battery use.

• **Enhanced Filtration:**

Advanced HEPA filtration and fully sealed systems are now standard, capturing fine dust and allergens to improve indoor air quality-especially important for allergy sufferers and pet owners.

• **Smart Home Integration:**

New models support voice assistants (Alexa, Google Assistant, Siri) and app-based controls, allowing users to schedule, monitor, and control cleaning remotely.

• **Pet-Friendly and Specialized Features:**

Features like anti-tangle brushes, pet hair removal tools, and video monitoring for pets are increasingly common, reflecting the needs of modern households.

2.5 How Robotic Vacuum and Mop Robots Work

A robotic cleaning system typically integrates the following components:

- **Mobility system**: DC motors and motor drivers (like L298N) enable movement and directional control.
- **Sensing system**: IR sensors detect edges; ultrasonic sensors detect obstacles; encoders track distance.
- **Cleaning mechanism**: A vacuum motor generates suction, while a mop motor and water pump handle mopping.
- **Control system**: An Arduino Mega manages signals from sensors and controls actuators.
- **Power source**: Rechargeable lithium-ion batteries supply power.
- **Manual override**: A Bluetooth module allows manual control via a mobile app.

The robot operates in two modes—automatic (sensor-based) and manual (Bluetooth-controlled)—offering flexibility and user control.

2.6 Key Points

- Vacuum and mop robot systems have evolved from simple mechanical tools to AI-based smart devices.
- Our project focuses on a low-cost, Arduino-controlled robot with both automatic and manual cleaning modes.
- It uses edge detection, obstacle avoidance, and component switching through relays.
- It fits into the home cleaning ecosystem with a DIY, customizable, and safety-first design.
- Ideal for student learning, small households, and prototype testing in the Indian environment.

3. Methodology

We divided our project in different phases of development. The process is explained below:

3.1 Conceptualization

As part of our final year project our team had to create a useful and new solution leveraging our knowledge of Robotics and automation. The idea for the Automatic Mop and Vacuum Robot was inspired by the increasing demand for smart home solutions that reduce manual labor in everyday cleaning needs.

Talking to my team, we realized our robotic skills could make this easier. We decided to build an automatic mop and vacuum robot for smart and effective cleaning, reduce human efforts. It's a smart and creative solution for smart and effective cleaning.

3.2 Discussion on Localization Techniques

As a team, we discuss and searched on internet a lot about how to make an automatic mop and vacuum robot for smart and effective cleaning and figure out a best way to do this. We wanted to find a way that worked well, wasn't too expensive, and fit with what we could actually do for the project.

3.2.1 Exploring Localization Techniques:

Here are the **main localization techniques** used in mobile robotics.

1. Ultrasonic Sensor-Based Localization

How it works: High-frequency sound waves are emitted by ultrasonic sensors and the time taken for the echo to travel back after reflecting off objects in the vicinity.

Application in localization:

Delivers distance readings to walls or obstacles.

Can be employed with multiple sensors to localize the robot against landmarks using triangulation.

2. IR (Infrared) Sensor-Based Localization

How it works: IR sensors emit infrared light and measure reflected light intensity from nearby objects.

Application in localization:

Primarily applied for short-range distance measurement and edge detection.

usually used in conjunction with odometry or other sensors to estimate position.

3. SLAM (Simultaneous Localization and Mapping)

What it is: A computational method by which the robot constructs a map of a previously unseen environment while localizing itself on that map at the same time.

How it works: Integrates sensor information (LiDAR, cameras, ultrasonic, odometry) with probabilistic methods (EKF, Particle Filter, Graph SLAM).

Application in Localization:

Autonomous robots in unfamiliar or dynamic environments.

Indoor/outdoor navigation.

4. LiDAR-Based Localization

How it works: LiDAR emits laser pulses and takes a measure of the time to come back with light reflected from surfaces, building high-resolution 3D or 2D point clouds.

Application in localization:

Creates in-depth environmental scans.

Allows for accurate localization by comparing real-time LiDAR scans to a map (through methods such as scan matching).

Emphasized in SLAM algorithms.

3.2.2 Decision to use:

- **Edge Detection Using IR Sensors:**

One IR sensors are placed at the front for edge detection and left, right corners of the robot to sense obstacles like stairs or table.

Working Principle: IR sensors send out infrared light and sense its reflection from the surface below. If the surface is suddenly lost (e.g., at an edge or a drop), the reflected IR light dramatically decreases, signaling a possible fall.

Purpose in Localization:

Aids the robot to sense and avoid edges or cliffs by reversing or halting.

Gives direct binary feedback (edge or no edge)

which assists in keeping safe borders while moving around.

Benefits:

Lightweight and inexpensive.

Rapid response time.

Drawbacks:

Effective for short-range sensing only.

Can provide false output on dark or shiny surfaces.

- **Ultrasonic Sensor-Based Obstacle Detection:**

An ultrasonic sensor is placed at the front of the robot at a height of 15 cm above the ground. It is utilized to sense obstacles in the robot's path.

Working Principle: The ultrasonic sensor sends out high-frequency sound waves and calculates the time for the echo to come back after reflecting off an object. This time delay is translated into a distance value.

Purpose in Localization:

Detects things in the robot's way and initiates the right actions like halting, turning, or reversing.

Increases real-time awareness of the environment to enable basic obstacle avoidance.

Benefits:

Operates in a range of light levels.

Medium-range distance measurement (usually 2 cm to 400 cm).

Drawbacks:

May have difficulty dealing with soft, absorbent, or sloping surfaces.

Not ideal for accurate localization only. Fabrication: PVC chassis for housing.

3.3 Component selections

We finalize the design Plan (Blueprint) for our project and finalize the components to build it. Here's what we used:

Sr. No.	Component Name	Nos.
1.	Arduino Mega	1
2.	L298N Motor Driver	1
3.	DC geared motor	2
4.	Caster wheel	1
5.	Rubber wheel	2
6.	BLDC Motor for Vacuum	1
7.	ESC	1
8.	Hand Made Fan	1
9.	1-Channel relay Module	2
10.	Pump for mop	1
11.	Dc geared motor for mop	1
12.	Water container	1
13.	Dust container	1
14.	Mop Attachments	1
15.	Vacuum Nozzle	1
16.	Wooden Chassis	1
17.	Ultrasonic sensor	1
18.	Infrared sensor	3
19.	12v Lithium ion battery	1
20.	Lm2596 Buck converter	1
21.	HC-05 Bluetooth Module	1
22.	Jumper Wires	As per Need
23.	Frame	1

Table 3.1 Components List

1. **Arduino Mega**
   A powerful microcontroller board with 54 digital I/O pins, used as the brain of the robot to control sensors, motors, and relays efficiently.

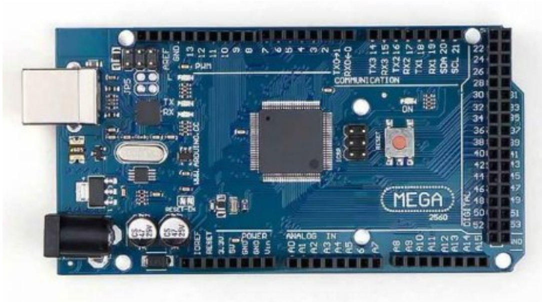

Fig 3.1: Arduino Mega

2. **L298N Motor Driver**

   A dual H-bridge motor driver module used to control the direction and speed of two DC geared motors using signals from the Arduino.

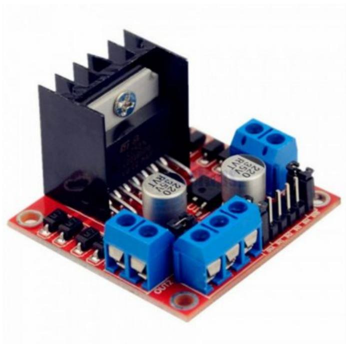

Fig 3.2: L298N Motor Driver

3. **DC Geared Motor (×2)**

   Low-speed, high-torque motors used for driving the robot's wheels, providing movement and load-carrying capacity for the chassis.

Fig 3.3: DC Geared Motor

4. **Caster Wheel**

   A free-rotating wheel that provides balance and directional support at the front of the chassis without motorized control.

Fig 3.4: Caster Wheel

5. **Rubber Wheel (×2)**

   Attached to the DC geared motors, these provide traction and smooth movement on various floor surfaces.

Fig 3.5: Rubber Wheel

6. **BLDC Motor for Vacuum**

   A brushless motor used to generate strong suction power for vacuuming dust and debris into the dust container.

Fig 3.6: BLDC motor

7. **ESC (Electronic Speed Controller)**

   Controls the speed and power of the BLDC motor using PWM signals from the Arduino for efficient vacuum motor operation.

Fig 3.7: ESC

8. **Hand Made Fan**

   Manually crafted fan blade used with the BLDC motor to generate airflow for vacuum functionality.

Fig 3.8: Fan

9. **1-Channel Relay Module**

   Allows the Arduino to switch two high-power devices (like the pump or mop motor) on and off using digital signals.

Fig 3.9: 1 Channel Relay Module

10. **Pump for Mop**

    A small water pump powered by 5V that sprays water onto the floor, enabling the wet mopping mechanism.

Fig 3.10: Pump

11. **DC Geared Motor for Mop**

    This motor rotates the mop attachment for scrubbing the floor surface effectively during cleaning operation.

Fig 3.11: DC geared Motor

12. **Water Container**

    Holds water for the mop mechanism. It supplies water to the pump, enabling wet cleaning functionality.

Fig 3.12: Water Container

13. **Dust Container**

    Collects dust and debris sucked in by the vacuum motor. It can be cleaned and emptied after use.

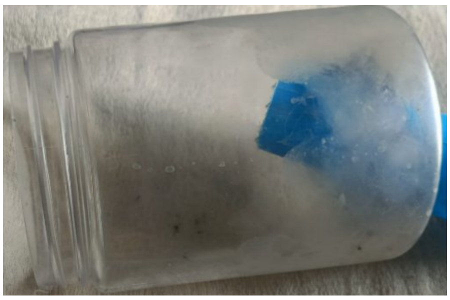

Fig 3.13: Dust Container

14. **Mop Attachments**

Includes rotating or stationary mop pads used to scrub or clean the floor surface, working with the pump motor.

Fig 3.14: Mop Attachments

15. **Vacuum Nozzle**

Fitted at the suction inlet to concentrate airflow and maximize the vacuum motor's efficiency in collecting dust.

Fig 3.15: Vacuum Nozzle

16. **Wooden Chassis**

A custom-made wooden base that houses all components. It supports motors, sensors, and electronics, giving the robot structure.

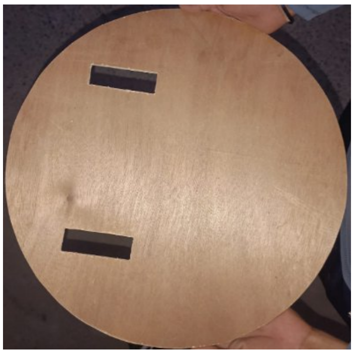

Fig 3.16: Wooden Chassis

17. **Ultrasonic Sensor**

    Used for obstacle detection and avoidance. It measures distance by emitting ultrasonic waves and calculating their reflection time.

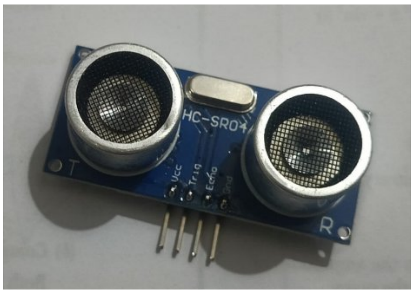

Fig 3.17: Ultrasonic Sensor

18. **Infrared Sensors (×3)**

    Used for edge detection, obstacle detection these sensors detect variations in surface reflectivity to prevent the robot from falling off edges.

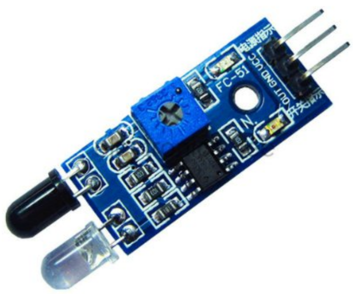

Fig 3.18: IR Sensor

19. **12V Lithium-ion Battery**

Primary power source for the entire robot, providing a stable voltage to motors, sensors, and other electronics.

Fig 3.19: Lithium-ion Battery

20. **LM2596 Buck Converter**

Steps down 12V from the battery to 5V for powering the Arduino and low-voltage sensors or modules safely.

Fig 3.20: LM2596 Buck Converter

21. **HC-05 Bluetooth Module**

Enables wireless communication between the robot and a smartphone, allowing manual control via a mobile app.

Fig 3.21: HC-05 Bluetooth Module

22. **Jumper Wires**

Used to connect components to the Arduino and other modules for signal and power transfer across the circuit.

Fig 3.22: Jumper wires

23. **Frame**

A custom wooden frame which cover the robot components from above.

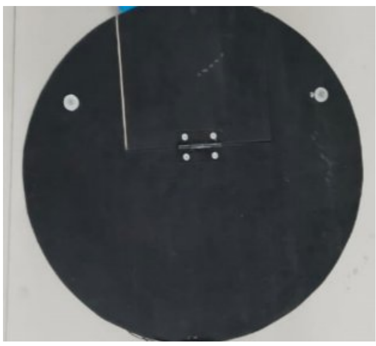

Fig 3.23: Frame

3.4 Market Survey

To build our Automatic mop and vacuum robot we needed to find the right parts that were reliable, efficient, and affordable. We visited local electronics store to compare prices, checking availability, and see the quality of the part. Our first approach was to find a microcontroller. We compared various microcontroller including Arduino uno, Arduino mega, ESP32, and Raspberry pi. We preferred to use the Arduino mega its number of I/O pins and compatibility with a wide range of sensors and module. Pricing from different suppliers showed that the Arduino mega was affordable and fit to our project.

Secondly, we had to look for motors and motor drivers to drive wheels, run vacuum and mop mechanism. After evaluating Various geared Dc motors with different specifications regarding voltage, torque and RPM. we selected geared DC motor for wheels, BLdc motor for Vacuum, a DC gear motor for mop mechanism, and a 5v pump. Then we buy an ESC for Bldc motor, 2 channel relay module for Mop mechanism for both motor and pump, and a L298N motor driver for our wheels and a caster wheel.

Next, we needed a battery sufficient for our project. We examine various types of batteries including li-ion, Lipo, and NiMH from local store. The focus was on finding a balanced between capacity(mAh), Weight, and cost. We selected a 12v Li-ion rechargeable battery with a charger

Next, we buy a Bluetooth module to run our project through our app i.e. HC-05 bluetooth module.

Next, we buy sensors i.e. IR sensors and ultrasonic sensors for localization of our project.

Next, we ordered vacuum nozzle and mop cloth from amazon.

Next, we buy two containers as vacuum dust container and water holding container for mop.

Next, we buy Rocker switch and jumper wires.

Next, we create a chasis of 40 cm for wooden ply for our robot base.

3.5 Circuit Diagram

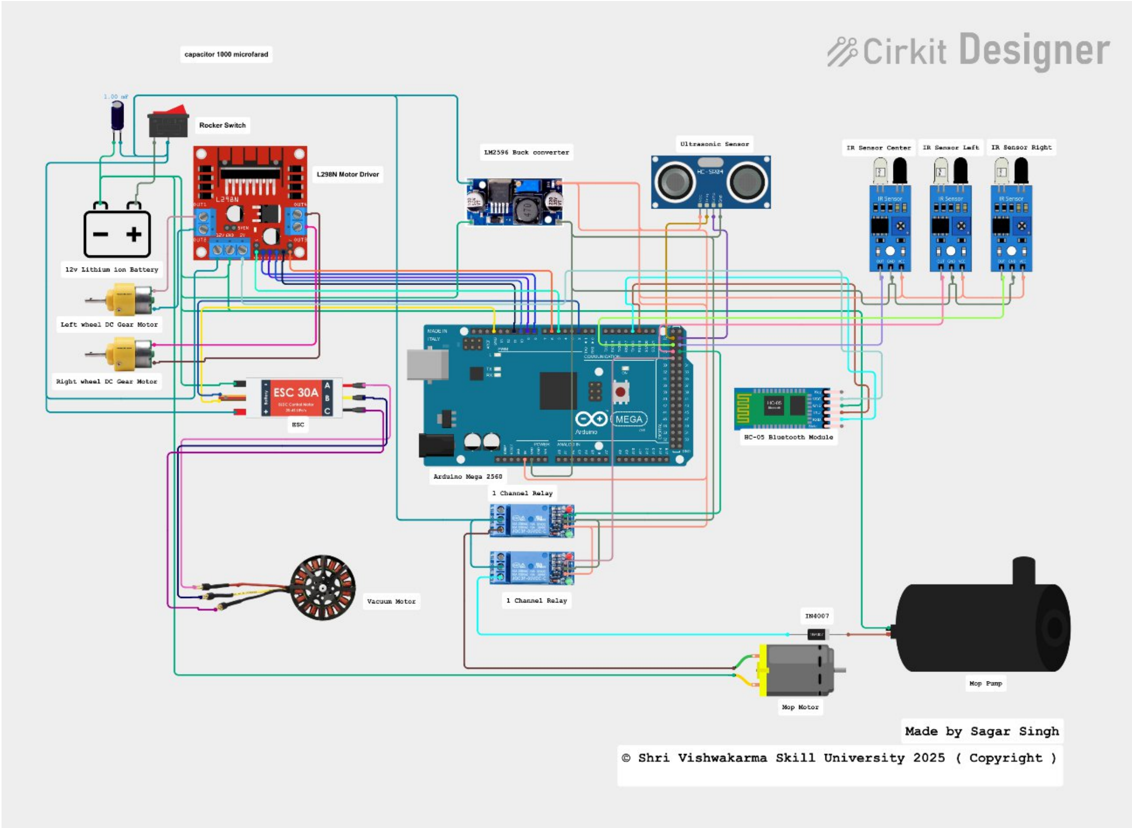

Fig 3.24: Circuit Diagram

3.6 Programming and testing

We programmed and successfully tested our project. Here are the program used in our project.

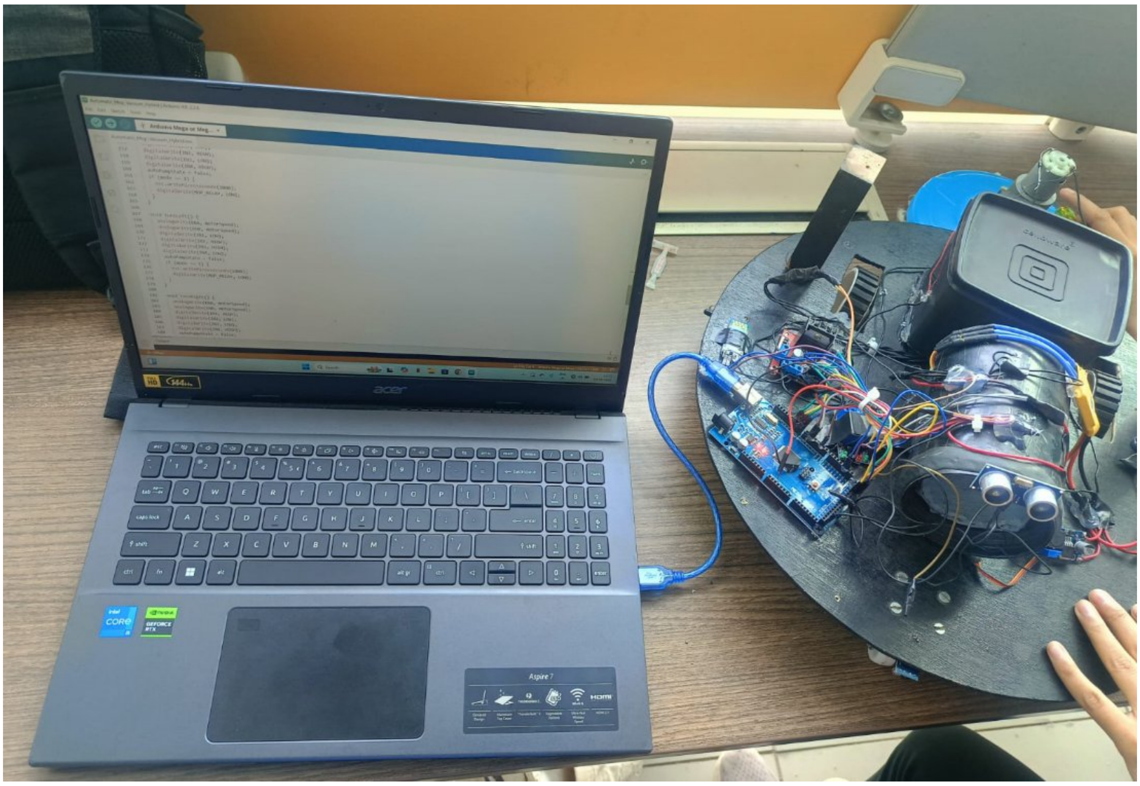

Fig 3.25: Programming

Code used in our project:

```
// Define motor pins
#define ENA 5
#define IN1 8
#define IN2 9
#define ENB 6
#define IN3 10
#define IN4 11

// Relay pins
#define MOP_RELAY 27
#define PUMP_RELAY 28
```

```
// Ultrasonic Sensor Pins
#define TRIG_PIN 22
#define ECHO_PIN 23

// IR Sensors Pins
#define IR_LEFT 26
#define IR_CENTER 25
#define IR_RIGHT 24

// BLDC ESC control
#include <Servo.h>
#define ESC_PIN 2
Servo esc;

// Bluetooth
#define bluetooth Serial1

// Variables
int mode = 0; // 0 = Manual, 1 = Automatic
unsigned long lastCommandTime = 0;
unsigned long commandTimeout = 20000;
bool isBluetoothConnected = true;
int motorSpeed = 150;

bool manualPumpState = false;
bool autoPumpState = false;
unsigned long autoPumpLastToggleTime = 0;
unsigned long autoPumpOnDuration = 3000;
unsigned long autoPumpOffDuration = 10000;

bool mopStateManual = false;
bool vacuumStateManual = false;

void setup() {
```

```
pinMode(ENA, OUTPUT);
pinMode(IN1, OUTPUT);
pinMode(IN2, OUTPUT);
pinMode(ENB, OUTPUT);
pinMode(IN3, OUTPUT);
pinMode(IN4, OUTPUT);

pinMode(MOP_RELAY, OUTPUT);
pinMode(PUMP_RELAY, OUTPUT);

pinMode(TRIG_PIN, OUTPUT);
pinMode(ECHO_PIN, INPUT);

pinMode(IR_LEFT, INPUT);
pinMode(IR_CENTER, INPUT);
pinMode(IR_RIGHT, INPUT);

Serial.begin(9600);
bluetooth.begin(9600);

esc.attach(ESC_PIN);
esc.writeMicroseconds(1000); // Initially off

stopMotors();
digitalWrite(MOP_RELAY, LOW);
digitalWrite(PUMP_RELAY, LOW);

// --- Sensor Calibration Output ---
Serial.println("=== SENSOR CALIBRATION ===");

int leftIR = digitalRead(IR_LEFT);
int centerIR = digitalRead(IR_CENTER);
int rightIR = digitalRead(IR_RIGHT);
```

```
  Serial.print("IR LEFT: ");
  Serial.print(leftIR == LOW ? "EDGE " : "SURFACE ");
  Serial.print(" | IR CENTER: ");
  Serial.print(centerIR == LOW ? "EDGE " : "SURFACE ");
  Serial.print(" | IR RIGHT: ");
  Serial.println(rightIR == LOW ? "EDGE" : "SURFACE");

  int dist = getDistance();
  Serial.print("Ultrasonic Distance: ");
  Serial.print(dist);
  Serial.println(" cm");

  Serial.println("============================");
  delay(2000); // Wait for user to read
}

void loop() {
  while (bluetooth.available()) {
    char data = bluetooth.read();
    lastCommandTime = millis();
    isBluetoothConnected = true;
    processCommand(data);
  }

  if (millis() - lastCommandTime > commandTimeout && isBluetoothConnected) {
    isBluetoothConnected = false;
    mode = 1;
    stopMotors();
  }

  // Pump control
  if (mode == 0) {
    digitalWrite(PUMP_RELAY, manualPumpState ? HIGH : LOW);
  }
```

```
  if (mode == 1) {
    automaticMovement();
    if (autoPumpState) {
      if (millis() - autoPumpLastToggleTime >= (digitalRead(PUMP_RELAY) ==
LOW ? autoPumpOffDuration : autoPumpOnDuration)) {
        digitalWrite(PUMP_RELAY, !digitalRead(PUMP_RELAY));
        autoPumpLastToggleTime = millis();
      }
    } else {
      digitalWrite(PUMP_RELAY, LOW);
    }
  }

  delay(50);
}

void processCommand(char cmd) {
  switch (cmd) {
    case 'F': moveForward(); break;
    case 'B': moveBackward(); break;
    case 'L': turnLeft(); break;
    case 'R': turnRight(); break;
    case 'S': stopMotors(); break;
    case 'V': esc.writeMicroseconds(1300); vacuumStateManual = true; break;
    case 'v': esc.writeMicroseconds(1000); vacuumStateManual = false; break;
    case 'M': digitalWrite(MOP_RELAY, HIGH); mopStateManual = true; break;
    case 'm': digitalWrite(MOP_RELAY, LOW); mopStateManual = false; break;
    case 'P': manualPumpState = true; break;
    case 'p': manualPumpState = false; digitalWrite(PUMP_RELAY, LOW); break;
    case 'A': mode = 1; stopMotors(); break;
    case 'a': mode = 0; stopMotors(); break;
  }
}
```

```
void moveForward() {
 analogWrite(ENA, motorSpeed);
 analogWrite(ENB, motorSpeed);
 digitalWrite(IN1, HIGH);
 digitalWrite(IN2, LOW);
 digitalWrite(IN3, HIGH);
 digitalWrite(IN4, LOW);
 autoPumpState = true;
 if (mode == 1) {
   esc.writeMicroseconds(1300);
   digitalWrite(MOP_RELAY, HIGH);
 }
}

void moveBackward() {
 analogWrite(ENA, motorSpeed);
 analogWrite(ENB, motorSpeed);
 digitalWrite(IN1, LOW);
 digitalWrite(IN2, HIGH);
 digitalWrite(IN3, LOW);
 digitalWrite(IN4, HIGH);
 autoPumpState = false;
 if (mode == 1) {
   esc.writeMicroseconds(1000);
   digitalWrite(MOP_RELAY, LOW);
 }
}

void turnLeft() {
 analogWrite(ENA, motorSpeed);
 analogWrite(ENB, motorSpeed);
 digitalWrite(IN1, LOW);
 digitalWrite(IN2, HIGH);
```

```
  digitalWrite(IN3, HIGH);
  digitalWrite(IN4, LOW);
  autoPumpState = false;
  if (mode == 1) {
    esc.writeMicroseconds(1000);
    digitalWrite(MOP_RELAY, LOW);
  }
}

void turnRight() {
  analogWrite(ENA, motorSpeed);
  analogWrite(ENB, motorSpeed);
  digitalWrite(IN1, HIGH);
  digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW);
  digitalWrite(IN4, HIGH);
  autoPumpState = false;
  if (mode == 1) {
    esc.writeMicroseconds(1000);
    digitalWrite(MOP_RELAY, LOW);
  }
}

void stopMotors() {
  analogWrite(ENA, 0);
  analogWrite(ENB, 0);
  digitalWrite(IN1, LOW);
  digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW);
  digitalWrite(IN4, LOW);
  autoPumpState = false;
  if (mode == 1) {
    esc.writeMicroseconds(1000);
    digitalWrite(MOP_RELAY, LOW);
```

```
  }
}

void automaticMovement() {
  int distance = getDistance();
  int leftIR = digitalRead(IR_LEFT);
  int centerIR = digitalRead(IR_CENTER);
  int rightIR = digitalRead(IR_RIGHT);

  static unsigned long recoveryStartTime = 0;
  static int recoveryState = 0;

  if (leftIR == LOW && rightIR == LOW && centerIR == LOW) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 1;
  } else if (leftIR == LOW && centerIR == LOW) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 3;
  } else if (rightIR == LOW && centerIR == LOW) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 4;
  } else if (leftIR == LOW) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 5;
  } else if (rightIR == LOW) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 6;
  } else if (distance < 15) {
    stopMotors(); recoveryStartTime = millis(); recoveryState = 1;
  }

  if (recoveryState == 1) {
    moveBackward();
    if (millis() - recoveryStartTime > 600) {
      stopMotors(); recoveryStartTime = millis(); recoveryState = 2;
    }
  } else if (recoveryState == 2) {
    turnLeft();
    if (millis() - recoveryStartTime > 700) {
```

```
      stopMotors(); recoveryState = 0;
    }
  } else if (recoveryState == 3) {
    turnRight();
    if (millis() - recoveryStartTime > 700) {
      stopMotors(); recoveryState = 0;
    }
  } else if (recoveryState == 4) {
    turnLeft();
    if (millis() - recoveryStartTime > 700) {
      stopMotors(); recoveryState = 0;
    }
  } else if (recoveryState == 5) {
    turnRight();
    if (millis() - recoveryStartTime > 400) {
      stopMotors(); recoveryState = 0;
    }
  } else if (recoveryState == 6) {
    turnLeft();
    if (millis() - recoveryStartTime > 400) {
      stopMotors(); recoveryState = 0;
    }
  } else {
    moveForward();
  }
}

int getDistance() {
  long sum = 0;
  int samples = 5;
  for (int i = 0; i < samples; i++) {
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
```

```
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    long duration = pulseIn(ECHO_PIN, HIGH, 30000);
    if (duration == 0) duration = 30000;
    sum += (duration * 0.034 / 2);
    delay(5);
  }
  return sum/samples;
}
```

4 Results and Discussion

4.1 Results

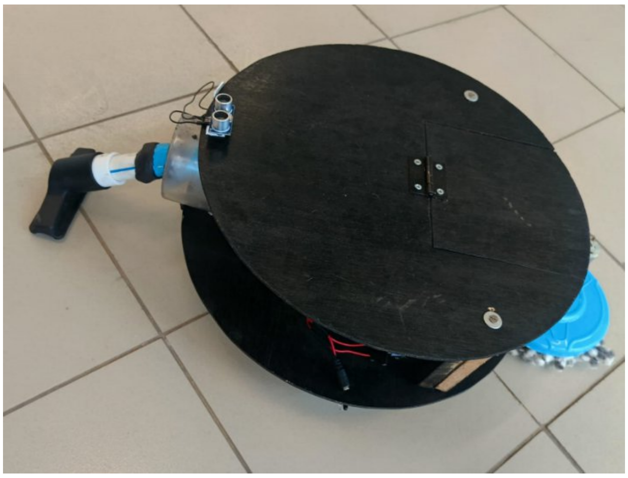

Fig 4.1: Automatic Mop and Vacuum Robot

4.1.1 Performance of the robot:

The automatic mop and vacuum robot, after successful hardware and software integration, was subjected to testing across different indoor spaces like tiled flooring, wooden panels, and marble. The test results are captured below:

Test Criteria	**Observed Performance**
Obstacle Detection	Successfully detected obstacles with the help of ultrasonic sensors
Vacuum Efficiency	Picked up 85–90% of visible dry dust and dirt
Mopping Performance	Successful on light spots and dust; not as good on sticky stains
Navigation Accuracy	Executed zig-zag cleaning with ~90% coverage
Battery Backup	About **30** minutes of uninterrupted usage
Anti-Fall Protection	IR sensors averted falls from table edges

Table 4.1: Performance of the robot

Fig 4.2: Before Cleaning

Fig 4.3: After Cleaning

4.2 Discussion

4.2.1 Selecting the Appropriate Controller

Problem:

We needed a controller that could handle multiple components: motor driver, sensors (IR and ultrasonic), Bluetooth module, relays for vacuum and mop systems, and still have enough I/O pins for future additions.

Discussion:

We debated between Arduino Uno and Arduino Mega. Uno had fewer pins, and expansion would require I/O extenders.

Solution:

We chose the **Arduino Mega** due to its higher number of digital and analog I/O pins, making it suitable for our complex circuit without needing additional modules.

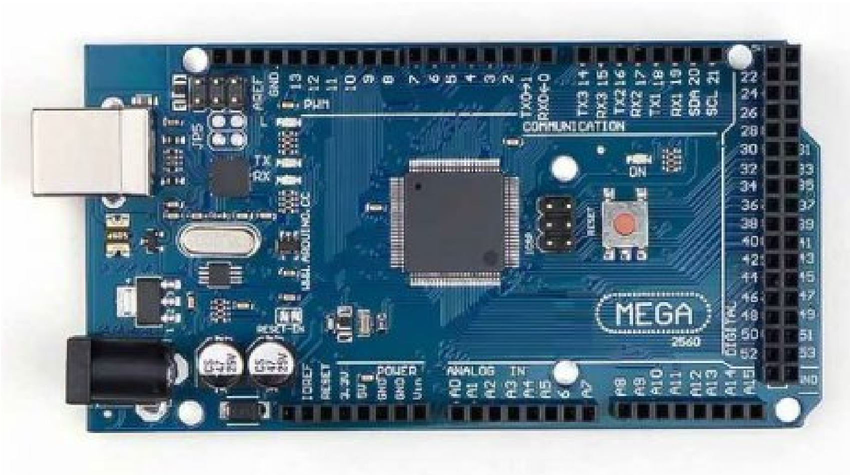

Fig 4.4: Arduino Mega

4.2.2 Designing a Hybrid Operating Mode (Manual + Automatic)

Problem:

The robot needed to operate both manually (via Bluetooth) and automatically (using sensors), but switching between the two modes without interference was tricky.

Discussion:

There was confusion about how to switch modes safely and detect edges and obstacles in automatic mode while maintaining Bluetooth control in manual mode.

Solution:

We implemented a **mode switch in the mobile app** that toggles between manual and automatic operation. The Arduino code was written to prioritize sensor input only when automatic mode is active and ignore sensor readings in manual mode. A flag system in the code was used to manage this transition smoothly.

4.2.3 Edge Detection/ Obstacle Detection Using IR Sensors

Problem:

There was a risk of the robot falling off edges or stairs during autonomous operation.

Discussion:

We discussed using multiple IR sensors and their placement for effective edge detection. Initially, only a front IR sensor was considered.

Solution:

We decided to use **1 IR sensors** — one at the front for edge detection, and two at the left and right corners for obstacle detection. This triangular arrangement allowed better edge detection, obstacle detection and quick response, avoiding falls even during turns.

4.2.4 Obstacle Avoidance using Ultrasonic Sensor

Problem:

The robot needed to detect and avoid obstacles during autonomous cleaning.

Discussion:

We considered various sensor options: ultrasonic, bump sensors, and IR. We needed reliable long-distance detection.

Solution:

We mounted an **ultrasonic sensor** , which effectively detected obstacles in front of the robot. The sensor was programmed to stop or change direction when an obstacle was within a predefined threshold (e.g., 20–30 cm).

4.2.5 Integration of the Rotating Mop Mechanism

Problem:

We wanted to improve mopping efficiency using a **rotating mop**, but wiring and controlling it along with other components required careful planning.

Discussion:

We evaluated if a single relay could control both vacuum and mop or if dedicated relays were needed. Speed control of the mop was also discussed.

Solution:

A **separate relay channel was assigned to the mop motor**. The motor operates at full speed when turned on. All relays were managed via digital pins on Arduino Mega. We used one relay each for mop, and water pump.

Fig 4.5: Mop Mechanism

4.2.6 Managing the Power Supply

Problem:

Powering multiple motors, relays, sensors, and the controller from a single power source caused voltage drops and erratic behavior.

Discussion:

We discussed whether to use separate power supplies for motors and logic components or a common regulated battery.

Solution:

We chose a **12V lithium-ion battery** with proper voltage regulation. Motors and relays were powered directly from 12V through relays and driver boards, while the Arduino was powered via its onboard voltage regulator or a buck converter. This avoided overload on the Arduino’s 5V output.

4.2.7 Wiring Complexity and Circuit Management

Problem:
With multiple sensors, relays, and modules, wiring became messy and difficult to debug.

Discussion:
We considered PCB design but had time constraints. Color-coded jumper wires and modular circuit testing were suggested.

Solution:
We used **color-coded wires** for each system (motors, sensors, relays), labeled connections, and broke the project into smaller testable modules before full integration. A **detailed pin-to-pin circuit diagram** was created and regularly updated.

4.2.8 Mobile App Interface

Problem:
Controlling the robot manually required a Bluetooth-based mobile app interface.

Discussion:
We discussed using MIT App Inventor or any custom app. Button layout and functions needed to be clear for forward, reverse, left, right, and toggling mop, pump, vacuum.

Solution:
We designed a custom mobile app using MIT App Inventor, which had buttons for directional control, vacuum ON/OFF, mop ON/OFF, water spray, and a mode toggle switch. Bluetooth commands were predefined and decoded in the Arduino code accordingly.

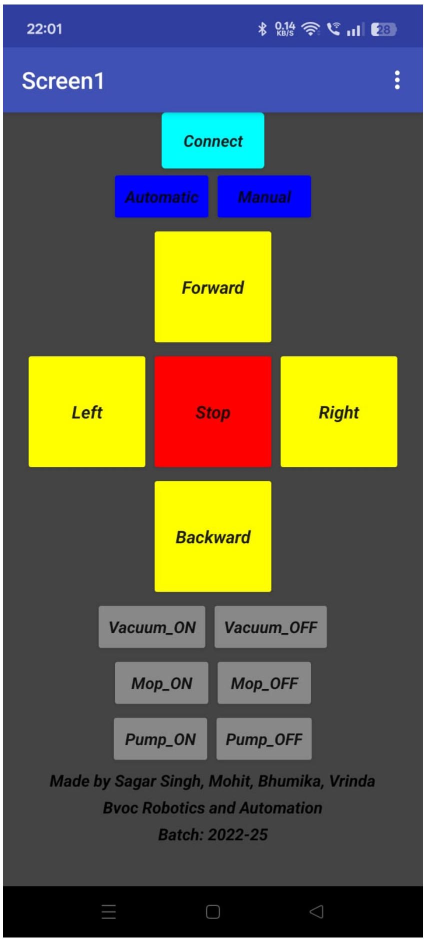

Fig 4.6: Mobile App Interface

5 Conclusion and Future Work

5.1 Conclusion

The development of the Automatic Mop and Vacuum Robot successfully demonstrates the integration of robotic systems for efficient floor cleaning. By combining vacuuming and mopping functions into a single autonomous platform, the robot minimizes human effort while maintaining cleanliness in both residential and commercial environments. The system utilizes a microcontroller-based design with sensor inputs for navigation, obstacle detection, and floor-type recognition. Testing shows that the robot is capable of adapting to different surfaces and cleaning scenarios, making it a reliable solution for routine cleaning tasks. This project validates the potential of automation in daily life and contributes to the growing field of domestic robotics.

5.2 Future Work

1. **Advanced Navigation**: Incorporate SLAM (Simultaneous Localization and Mapping) and computer vision to improve navigation accuracy and path planning in complex environments.
2. **Voice Assistant Compatibility**: Enable integration with smart home assistants like Alexa or Google Assistant for hands-free control.
3. **Auto Dirt Disposal**: Implement an automatic dirt disposal system where the robot can empty its dustbin into a docking station.
4. **Water Tank Automation**: Add features like automatic water refilling and used water draining to make the mopping process more autonomous.
5. **Battery Optimization**: Use advanced battery management systems and auto-charging capabilities to extend operational time and reduce downtime.
6. **AI-based Dirt Detection**: Implement machine learning algorithms to detect high-dirt areas and increase cleaning effort accordingly.

Reference

Research Articles / Papers

1. Adithya, P. S., Tejas, R., Varun, V. S., & Prashanth, B. N. (2019, November). Design and development of automatic cleaning and mopping robot. In *IOP Conference Series: Materials Science and Engineering* (Vol. 577, No. 1, p. 012126). IOP Publishing.
2. Kukde, M., Nagpurkar, S., Dhakulkar, A., & Amdare, A. (2018). Automatic & manual vacuum cleaning robot. *International Research Journal of Engineering and Technology (IRJET)*, *5*(02), 2196-2198.

YouTube

3. https://www.youtube.com/watch?v=wYbFEKLWjEc&t=495s
4. https://www.youtube.com/shorts/b-CqcBanhbI