DEPARTMENT OF ELECTRONICS& TELECOMMUNICATION ENGINEERING

SHREE L. R. TIWARI COLLEGE OF ENGINEERING,

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Project Report on

"SMART VACUUM CLEANER ROBOT "

SUBMITTED BY

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UNDER GUIDANCE OF

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CERTFICATE

This is to certify that the project entitled "**SMART VACUUM CLEANER ROBOT** " Is a bonafide work of

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Examiner /Reviewer-1 Examiner/Reviewer-2

Guide Head Of Department Principal

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Special thanks to our Guide **MRS. SNEHAL SHAH** for assisting us to complete our project report on **SMART VACUUM CLEANER ROBOT.** She is our faculty for Mini Project whose expertise and talent in STM32 microcontroller USE helped us effectively to complete this project.

We would also like to thank our **HOD MRS. ABOLI MOHRAIL** for providing us facility and labs, which helped us constantly in increasing our technical knowledge, and to write this project report.

ABSTRACT

This project presents the design and implementation of an autonomous car that integrates an ultrasonic sensor for obstacle detection, a vacuum motor for debris collection, and STM32 microcontroller-based control. The car is powered by four DC motors connected to an L298N motor driver for movement and a separate DC motor for vacuum functionality. An ultrasonic sensor detects nearby objects, prompting the vacuum motor to engage when obstacles are detected within a predefined range. The project aims to demonstrate a simple yet effective robotic system capable of environmental navigation and surface cleaning using a low-cost embedded system platform. The hardware and software integration is achieved through the STM32F103C8T6 microcontroller, making this solution adaptable for various autonomous vehicle applications.

INTRODUCTION

Autonomous robotic systems have gained significant attention in recent years due to their potential applications in industrial automation, smart homes, and environmental services. These systems can perform tasks without human intervention, reducing labor and improving efficiency. This project focuses on the development of an autonomous car equipped with a vacuum system for cleaning small surfaces while navigating its environment using an ultrasonic sensor.

The STM32F103C8T6 microcontroller is chosen as the central control unit due to its powerful processing capabilities, extensive peripheral support, and cost-effectiveness. The car is driven by four DC motors through an L298N motor driver, and an additional DC motor controls the vacuum mechanism. An ultrasonic sensor (HC-SR04) detects obstacles, allowing the car to adjust its movement or activate the vacuum motor. This system can be applied to small-scale cleaning tasks, such as collecting debris on floors, in hard-to-reach places, or in areas that require frequent cleaning.

The objective of this project is to create a simple and effective autonomous vehicle capable of navigating autonomously while integrating basic environmental interaction, such as debris collection. This report discusses the hardware components, system design, and programming required to implement the system, as well as the challenges encountered and their solutions.

LITERATURE REVIEW

- In 2022, K. Nguyen, T. Bui, and P. Vo developed an STM32-based robotic vacuum with real-time obstacle avoidance, as published in the *International Journal of Automation and Smart Systems*. The study aimed to enhance the vacuum's autonomy by integrating sensors and algorithms for efficient navigation and obstacle detection, contributing to advancements in smart home automation.

- In 2021, Y. Wang, J. Li, and M. Zhang authored a paper titled "STM32-Based Smart Vacuum Cleaner Robot with Obstacle Detection and Avoidance" in the Journal of Robotics and Embedded Systems. The paper presents the design and implementation of an autonomous vacuum cleaner robot using the STM32F103C8T6 microcontroller, featuring ultrasonic sensors for obstacle detection and motor drivers for movement and vacuum control. While it thoroughly explains the hardware design and control algorithms, it lacks detailed experimental validation and real-world testing, limiting its practical application and scalability in complex environments

- In 2020, A. Patel, S. Kumar, and V. Shah authored a paper titled "Autonomous Cleaning Robot Using STM32 Microcontroller" in the International Journal of Robotics and Automation Technologies. The paper designs a cost-effective autonomous cleaning robot using the STM32F407 microcontroller, integrating ultrasonic sensors for navigation and DC motors for movement and vacuum functionality. While the system architecture and control logic are well detailed, the lack of long-term testing and real-world scenario analysis, along with the absence of a power consumption evaluation, limits its applicability and overall efficiency in dynamic environments.

- In 2019, L. Ahmed, R. Prakash, and N. Singh published "Design of a Smart Vacuum Cleaner Robot Using STM32 and LIDAR Sensors" in the Journal of Embedded and Intelligent Systems. The paper examines the integration of the STM32F103 microcontroller with LIDAR sensors to enhance obstacle detection and navigation in an autonomous vacuum cleaner, aiming for better accuracy than ultrasonic-based systems. However, it lacks a detailed comparison with ultrasonic setups regarding cost, energy efficiency, and processing overhead. The absence of real-world deployment data further limits its practicality in typical home environments, where reflective surfaces could affect LIDAR performance.

PROBLEM STATEMENT

There is a need for an affordable, compact, and efficient vacuum robot that can help people clean their homes without taking up much space or requiring a significant financial investment.

Problem Definition:

- Many people have busy schedules and do not have enough time to clean their homes.
- Technological advancements continue to emerge, offering opportunities to make human tasks easier.
- Most people use hand-controlled vacuums for cleaning, which can be time-consuming and labor-intensive.
- Additionally, many vacuum robots available in the market are expensive and can be large in size, making them less accessible for the average consumer.

SOFTWARE AND COMPONENT REQUIRED

HARDWARE

- STM32F103C8T6
- Motor Driver (L298N)
- Ultrasonic Sensor (SR-04)
- Servo Motor
- 4-Wheel DC Motor
- 1-DC Motor
- 1-Small Fan
- 1-Std Connection Wires
- Jumper Wires (F-F)
- 2-Lithium battery (3.7 V)
- 1-Battery Holder
- Bottle
- T & L shape vacuum

SOFTWARE

- Arduino IDE
- Stm32 Cube

BLOCK DIAGRAM

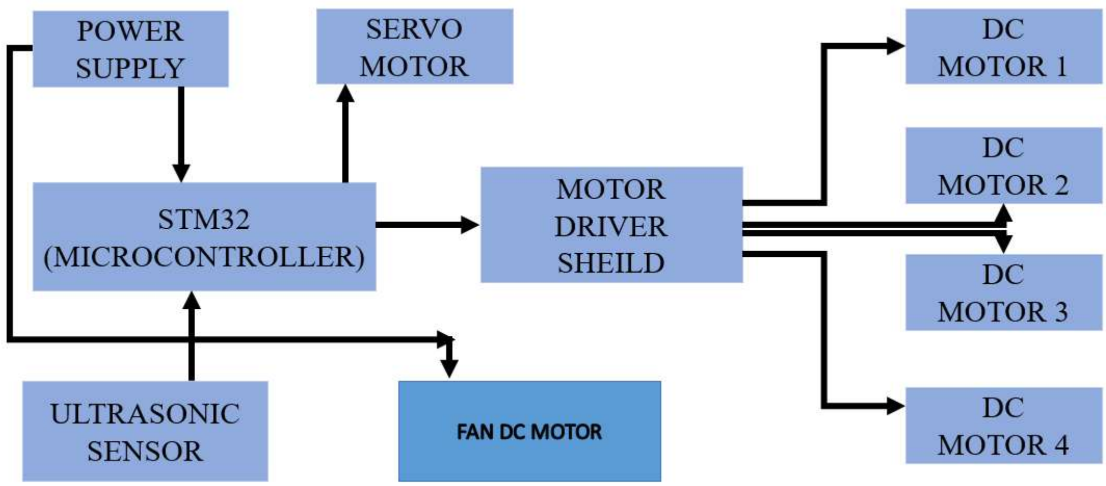

Figure 1

Explanation:

This block diagram provides a high-level overview of a robotic system. The STM32 microcontroller is at the center, controlling all the components. It receives power from an external power supply and interfaces with an ultrasonic sensor. The ultrasonic sensor provides distance data to the microcontroller. The microcontroller controls the motor driver shield, which manages four DC motors. The four DC motors are likely used for movement, such as in a wheeled robot. The system also includes a fan DC motor, which might be for cooling or another function. A servo motor is connected, indicating a part of the system with precise angular movement. The power flow and signal directions are clearly indicated between components. This system can be used for tasks like obstacle detection and motorized movement.

CIRCUIT DIAGRAM

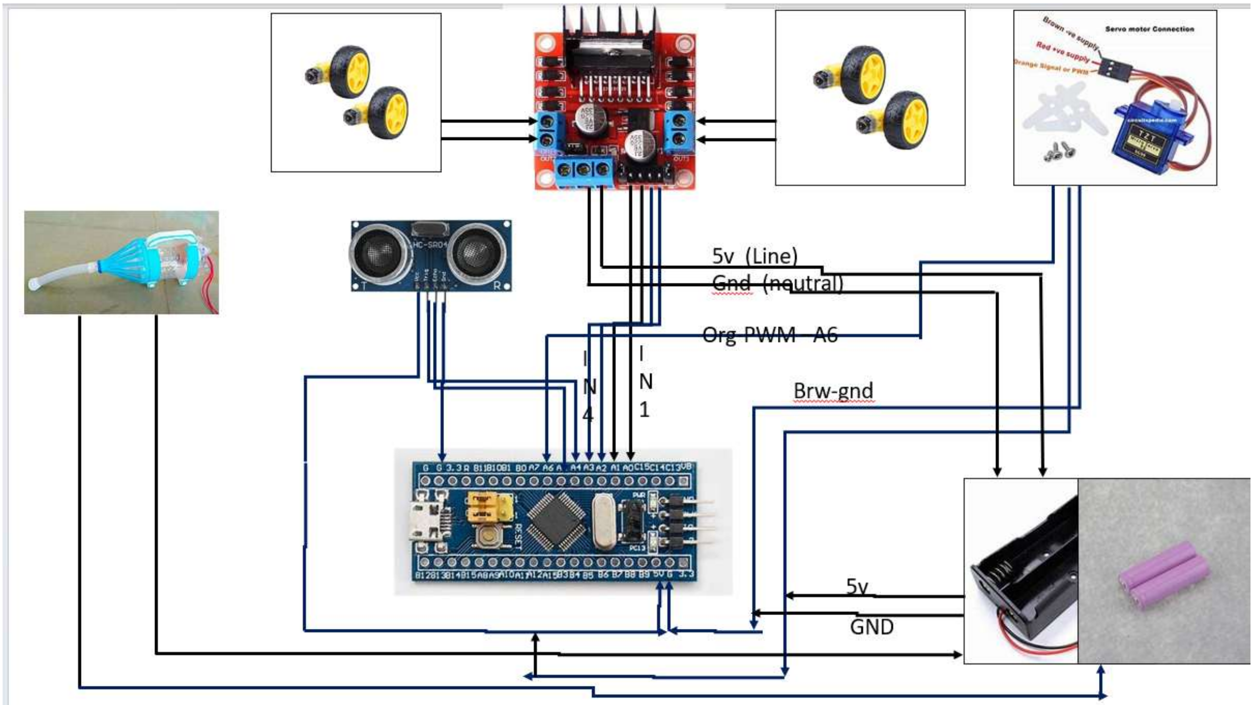

Figure 2

Explanation:

This wiring diagram shows a system that includes a microcontroller (STM32) controlling multiple components. The components include an ultrasonic sensor, a servo motor, a motor driver shield, and DC motors. The microcontroller connects to the ultrasonic sensor for distance measurement. The motor driver shield is used to control the four DC motors. The servo motor is likely for angular movement, controlled by the microcontroller. Power is supplied to the system using a battery (5V and GND connections).The ultrasonic sensor is connected to specific pins for transmitting and receiving signals. The DC motors are connected in pairs to the motor driver shield. The connections are organized with labeled wires for clear signal flow. It appears to be a robotic or automated vehicle system controlled by the STM32 microcontrolle

FLOWCHART

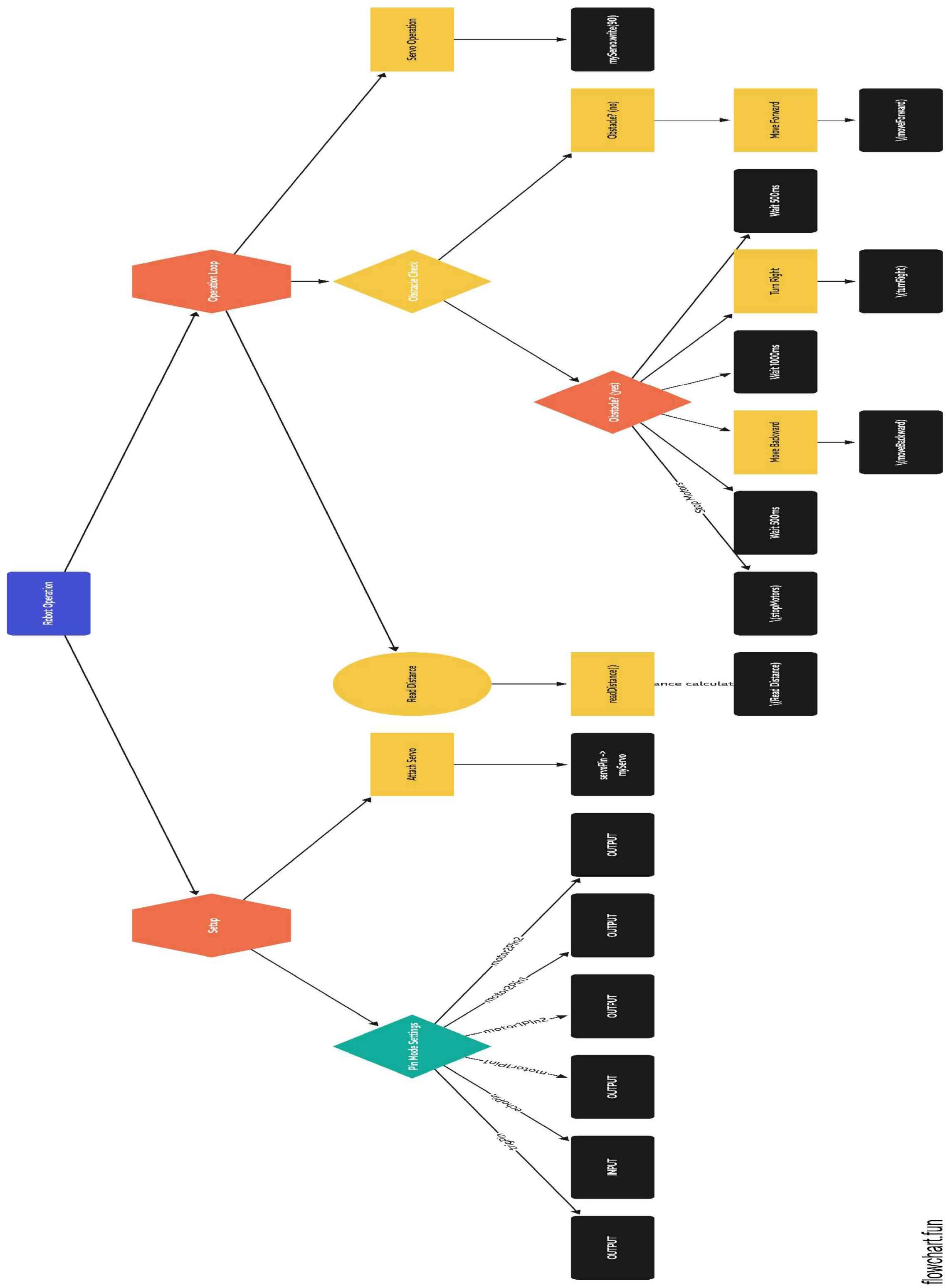

Figure 3

COMPONENT DETAIL

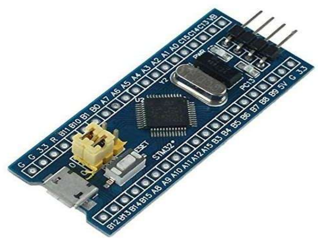

Figure 4

STM32F103C8T6 Microcontroller

Function: Acts as the brain of the system, controlling all the components. It processes sensor inputs, controls motor drivers, and manages overall operation.

Why: Chosen for its low cost, sufficient GPIO pins, and ability to handle real-time tasks efficiently.

Figure 5

Ultrasonic Sensor (HC-SR04)

Function: Measures the distance between the robot and obstacles. It sends out sound waves and measures the time taken for the echo to return.

Why: Simple and low-cost solution for obstacle detection, allowing the robot to avoid collisions.

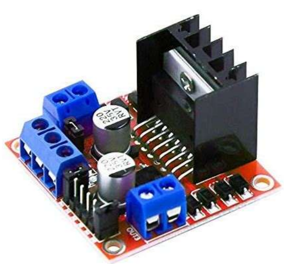

Figure 6

L298N Motor Driver

Function: Controls the speed and direction of the DC motors for the wheels and vacuum motor. It takes signals from the STM32 to drive the motors with the necessary voltage and current.

Why: Provides easy control of multiple motors with sufficient current capability for the DC motors used in the project.

Figure 7

DC Motors (for Wheels and Vacuum)

Function: The four wheel motors drive the robot's movement, while a separate DC motor powers the vacuum mechanism.

Why: Basic DC motors provide affordable, reliable motion control for driving and vacuuming.

Figure 8

Servo Motor

Function: Used for precise movement control, often for steering or other mechanical tasks in the robot.

Why: Provides precise angular control, useful for adjusting parts like a robotic arm or cleaning mechanism.

Figure 9

Power Supply (Lithium-Ion Batteries)

Function: Provides power to all components, including the motors, sensors, and the STM32.

Why: Lithium-ion batteries are lightweight, rechargeable, and provide sufficient voltage and current for the system.

Figure 10

Vacuum System

Function: Creates suction to collect small debris or dust as the robot moves.

Why: It allows the robot to perform cleaning tasks, turning it into a functional vacuum cleaner.

PROGRAM

```
#include <Arduino.h>
#include <Servo.h>
// Pin definitions
#define trigPin A4      // Trigger pin of ultrasonic sensor
#define echoPin A5      // Echo pin of ultrasonic sensor
#define servoPin A6     // Control pin for servo motor
#define motor1Pin1 A0   // Motor driver control pin 1 (Motor 1)
#define motor1Pin2 A1   // Motor driver control pin 2 (Motor 1)
#define motor2Pin1 A2   // Motor driver control pin 3 (Motor 2)
#define motor2Pin2 A3   // Motor driver control pin 4 (Motor 2)
// Ultrasonic sensor variables
long duration;
int distance;
// Servo object
Servo myServo;
void setup() {
  // Set pin modes for ultrasonic sensor
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  // Set pin modes for motor driver
  pinMode(motor1Pin1, OUTPUT);
  pinMode(motor1Pin2, OUTPUT);
  pinMode(motor2Pin1, OUTPUT);
  pinMode(motor2Pin2, OUTPUT);
  // Attach servo to its pin
  myServo.attach(servoPin);
}
void loop() {
  // Read distance from ultrasonic sensor
  int distance = readDistance();
  // Check if an obstacle is detected within 20 cm
  if (distance < 20) {
    stopMotors();      // Stop motors
    delay(500);        // Wait for a moment
    moveBackward();    // Back up
    delay(1000);       // Move back for 1 second
    turnRight();       // Turn right
    delay(500);        // Turn for half a second
  } else {
    moveForward();     // Move forward
  }
```

```
  // Example of using the servo motor
  myServo.write(90);     // Move servo to 90 degrees (this can be adjusted based on your
application)
}
// Function to read distance from ultrasonic sensor
int readDistance() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  int distance = duration * 0.034 / 2;  // Calculate distance in cm
  return distance;
}
// Function to move forward
void moveForward() {
  digitalWrite(motor1Pin1, HIGH);
  digitalWrite(motor1Pin2, LOW);
  digitalWrite(motor2Pin1, HIGH);
  digitalWrite(motor2Pin2, LOW);
}
// Function to move backward
void moveBackward() {
  digitalWrite(motor1Pin1, LOW);
  digitalWrite(motor1Pin2, HIGH);
  digitalWrite(motor2Pin1, LOW);
  digitalWrite(motor2Pin2, HIGH);
}
// Function to turn right
void turnRight() {
  digitalWrite(motor1Pin1, HIGH);
  digitalWrite(motor1Pin2, LOW);
  digitalWrite(motor2Pin1, LOW);
  digitalWrite(motor2Pin2, LOW);  // Stop right motor
}
// Function to stop motors
void stopMotors() {
  digitalWrite(motor1Pin1, LOW);
  digitalWrite(motor1Pin2, LOW);
  digitalWrite(motor2Pin1, LOW);
  digitalWrite(motor2Pin2, LOW);
}
```

FUNCTION

setup(): Initializes pins and sets up components like the motor driver and ultrasonic sensor.

loop(): Continuously checks the ultrasonic sensor for obstacles and controls the motors accordingly.

readDistance(): Measures and returns the distance to an obstacle using the ultrasonic sensor.

moveForward(): Activates the motors to move the robot forward.

moveBackward(): Reverses the motor direction to move the robot backward.

turnRight(): Stops the right-side motors to turn the robot right.

stopMotors(): Stops all motors, halting the robot.

WORKING PRINCIPLE

The autonomous vacuum cleaner robot operates through a coordinated system of sensors, microcontroller, motor drivers, and power supply. At its core, the STM32F103C8T6 microcontroller processes inputs from the ultrasonic sensors, which detect obstacles in the robot's path by emitting sound waves and measuring the time taken for the echoes to return. When an obstacle is detected, the microcontroller calculates the distance and makes real-time decisions to adjust the robot's movement to avoid collisions.

The L298N motor driver receives signals from the microcontroller to control the direction and speed of the four DC motors that drive the wheels, allowing the robot to navigate efficiently. The vacuum motor, controlled separately, activates to create suction for cleaning as the robot moves. The lithium-ion batteries supply power to all components, ensuring that the robot operates autonomously for an extended period.

The servo motor may be employed for precise movements, such as adjusting the angle of a cleaning arm or steering mechanism, enhancing the robot's operational capabilities. Overall, the robot continually senses its environment, processes data, and adjusts its actions to clean effectively while navigating around obstacles.

OUTPUT/RESULT

1.

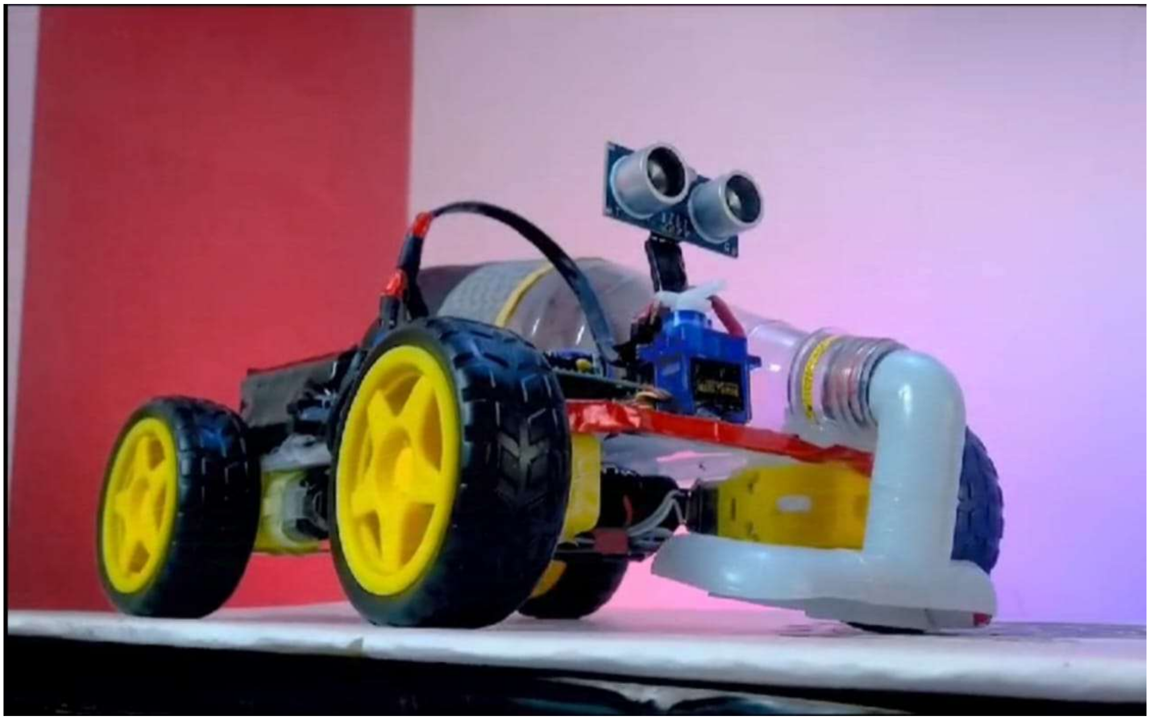

Figure 11

2.

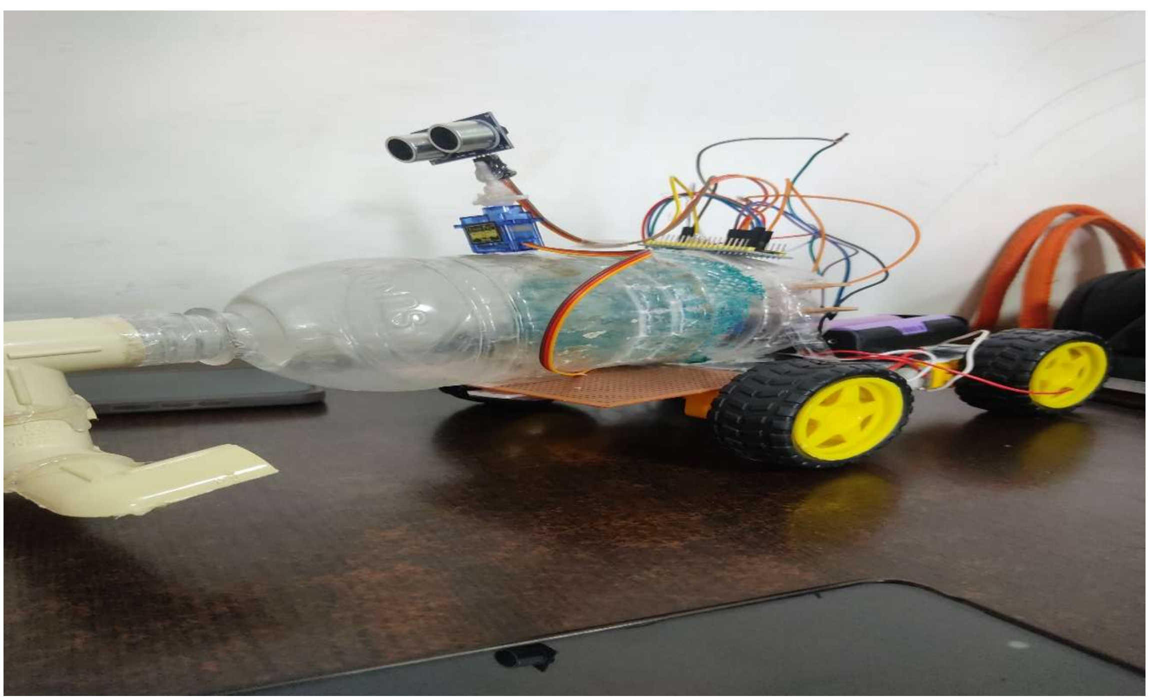

Figure 12

ADVANTAGES & DISADVANTAGES

Advantages:

1. **Autonomous Operation:** The robot can navigate and clean surfaces without manual intervention, using sensors for obstacle detection.
2. **Efficient Cleaning:** Integrated vacuum functionality allows for simultaneous movement and debris collection, reducing cleaning time.
3. **Low Power Consumption:** The STM32 microcontroller and efficient motor drivers enable low power usage, prolonging battery life.
4. **Compact and Cost-Effective:** The use of inexpensive components like the STM32F103 and ultrasonic sensors keeps the overall cost low.
5. **Versatility:** Capable of functioning on different surfaces and can be adapted to various cleaning environments with minimal changes.

Disadvantages:

1. **Limited Obstacle Detection:** Relying solely on ultrasonic sensors might result in blind spots, especially for smaller or complex obstacles.
2. **Battery Life Constraints:** Lithium-ion batteries may limit the robot’s operational time before requiring a recharge.
3. **Lack of Real-Time Feedback:** The system doesn't always provide immediate user feedback or error detection during operation.
4. **Simple Navigation Algorithms:** Path planning might be inefficient in highly cluttered environments, limiting its usability.
5. **Maintenance:** Regular cleaning and maintenance of motors and sensors are necessary for continued optimal performance

APPICATION

1. **Household Cleaning**: The robot can autonomously clean floors in homes, particularly under furniture or in hard-to-reach places.

2. **Office Spaces**: Useful for cleaning large office areas, where manual cleaning is time-consuming.

3. **Hospitals and Clinics**: Can be used to keep hospital floors free from dust and small debris, ensuring cleanliness in sensitive environments.

4. **Workshops**: Suitable for removing dust and small debris in manufacturing or mechanical workshops.

5. **Retail Spaces**: Automated cleaning in retail environments, maintaining cleanliness without disrupting customers

CONCLUSION

The STM32-based vacuum cleaner robot provides an affordable, autonomous cleaning solution by integrating obstacle detection and real-time motor control. Although its ultrasonic sensor-based navigation system works well in simple environments, it has limitations in complex, dynamic spaces. The efficient use of power and low-cost components make it practical for residential and small commercial applications, but improvements in navigation algorithms and obstacle detection could enhance its performance.

FUTURE WORK

Future iterations of this robot could incorporate **advanced sensors** like LIDAR or infrared for better obstacle detection and path planning. Additionally, integrating **machine learning algorithms** could allow the robot to learn and optimize its routes over time. Further improvements in **battery technology** could extend its operational time, and adding **real-time feedback systems** could enhance user interaction and maintenance predictability.

REFERENCE

1. K. Nguyen, T. Bui, and P. Vo authored "Development of STM32-Based Robotic Vacuum with Real-Time Obstacle Avoidance" In 2022, in the International Journal of Automation and Smart Systems

2. Y. Wang, J. Li, and M. Zhang authored a paper titled "STM32-Based Smart Vacuum Cleaner Robot with Obstacle Detection and Avoidance" In 2021, in the Journal of Robotics and Embedded Systems

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