Fully Automatic Vacuum Cleaner

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ABSTRACT:

Main functions of the Smart Vacuum Cleaner combine its intelligent operation with dust cleaning efficiency. The vacuum cleaner runs through automatic operation and manual (Bluetooth) operation. Users can start and operate the vacuum cleaner in automatic mode by pressing a single button while the device autonomously moves based on an ultrasonic sensor. The sensor used for detection transfers information to control the servo motor which allows it to alter its direction to achieve complete cleaning results. Users access control functions through an HC-05 Bluetooth module together with a mobile application during the manual mode. Through Bluetooth mode users have the ability to control the vacuum cleaner with commands for forward movement backward movement and directional changes to the left and right. The interface features an on/off switch which users can activate or deactivate the vacuum cleaner operation as required. The vacuum cleaner includes a mechanical switch which users can operate for manual power control. The smart vacuum cleaner increases cleaning convenience because it includes automatic systems and manual functions which make it an adaptable efficient solution for contemporary homes.

Keywords: Automatic Mode, Manual (Bluetooth) Mode, Maintenance and Cleaning, HC-05 Bluetooth Module, BO Gear Motors, L298N Motor Driver, ArduinoUno microcontroller, HC-SR04 Ultrasonic Sensor , Servo Motor, Lithium-Ion Batteries, ARDUINO IDE

INTRODUCTION:

Automatic smart vacuum cleaners function as self-operating floor-cleaning robots which require minimal human involvement for their operation. These devices integrate technologies like artificial intelligence , Internet of Things , and advanced sensors to navigate, detect obstacles, and optimize cleaning patterns.The evolution of smart vacuum cleaners addresses the modern demand for convenience,time-saving, and effective cleaning solutions for households and commercial spaces Equipped with features such as real-time mapping, obstacle avoidance, and multi-surface adaptability, these devices can clean different floor types, tiles, and carpets. Smart vacuum cleaners often include wireless connectivity, enabling users to control them via mobile .As lifestyles become increasingly fast-paced, the demand for such devices has surged, driven by their ability to maintain cleanliness while reducing manual effort.Continuous advancements in machine learning and robotics promise to enhance the efficiency, and functionality of smart vacuum cleaners, making an integral part of modern smart homes.They can work on different types of floors, such as wood, tiles, or carpets. Users now achieve simple control of smart vacuum cleaners because these devices enable connection to mobile apps. The increase in live pace has encouraged people to use these devices since they automate the cleaning process and minimize labor and effort to achieve home cleanliness. Modern technology advances enable smart vacuum cleaners to become more efficient and affordable thus establishing themselves as necessary household items.

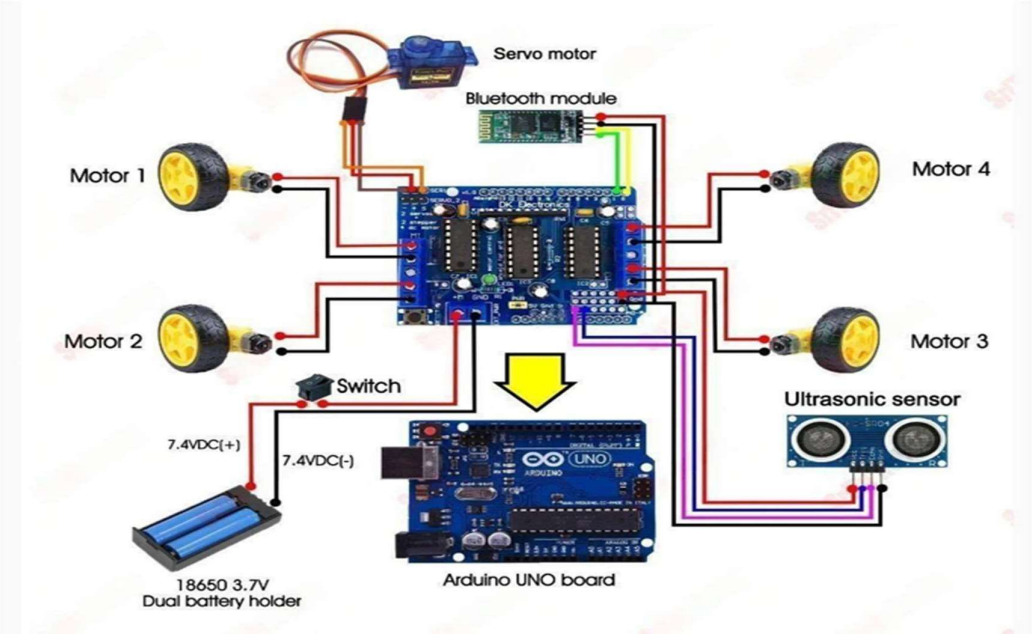
LITERATURE SURVEY:

A smart IoT vacuum cleaner system developed by Smith and Kumar (2020) utilized mobile apps for real-time cleaning operation tracking while showing variable results before reaching its optimal performance stage. [1] The researchers from Lee and Tan (2021) developed an adaptative robotic vacuum cleaner path planning system that demonstrated efficient space cleaning but needed extensive processing power. [2] The smart vacuum cleaner developed by Zha and Wang (2022) needed significant model training resources to operate their efficient power management system. [3] Chen and Gupta (2023) integrated SLAM technology with real-time feedback in autonomous vacuum cleaners yet this improvement required expensive components due to complexity. [4] The left wheel receives control through pins no 3 and 6 of L293D to operate as first motor. The right wheel connections run from the 11^{th} and 14^{th} pins of L293D while the 16^{th} pin of L293D receives power from the Arduino 5V supply. [5] The robot uses the arduino as its primary processing machine from its available 14 digital input output pins yet only six pins are implemented in this design. [6] In designing the Fully Automatic Vacuum Cleaner, I have drawn inspiration from various research works. The concept of automation and embedded control systems, as discussed in the water- jet PV cleaning robot [1], has been utilized in developing an efficient, automated navigation system. Additionally, insights from power optimization studies [11] have guided energy management strategies in my vacuum cleaner, ensuring improved efficiency and battery life. Furthermore, fabrication techniques explored in antenna design studies [13-17] have influenced the structural development of my device. By integrating these interdisciplinary approaches, this project aims to contribute to the field of smart home automation.

METHODOLOGY:

Working Principle:

The smart vacuum cleaner functions through Automatic Mode and Manual (Bluetooth) Mode exploitation sequences. The device comes with built-in easy maintenance aspects to promote long-lasting operation. The user runs the vacuum cleaner function with direct wires connected to its system. The user's switch action leads to instant server acknowledgement through the system connected.



Circuit diagram

1. Automatic Mode

The automatic mode allows the vacuum cleaner to work independently after one activates the system without manual operator input. The system activation begins after pressing a single button. From the time of power activation the ultrasonic sensor operates by checking for obstacles throughout the area. Enemy objects detected by the microcontroller lead to modified vacuum movements through data processing. The servo motor guides the automatic vacuum device through different motion paths to reach every surface area efficiently while preventing accidents. During this operation the cleaning mechanism operates as a continuous cycle to efficiently gather debris and dust. A hands-free cleaning solution that suits people with particular requirements exists in this mode.

2. Manual (Bluetooth) Mode

Users who want to control the smart vacuum cleaner manually can use the HC-05 Bluetooth module in their mobile application for operation. Through this configuration the user gains access to four movement commands which let them steer the cleaner in all directions. Users of the mobile application interface can begin or interrupt vacuuming through the simple ON/OFF button located on the interface. The system receives benefits from the relay module which serves to increase its operation efficiency. Different users can choose between operating the through an ON/OFF button switch on the device and through their mobile application thanks to the relay module. Through the relay module users obtain a dependable solution to control power states of the vacuum cleaner without disturbing functional capabilities. The vacuum cleaner feature a manual control switch which operates independently from the mobile application interface. The system provides two control methods so users can select either the mobile application interface or the physical device switch according to their personal needs.

3. Maintenance and Cleaning

Maintaining vacuum cleaner performance and reducing maintenance work becomes easier because its front component is detachable. The device's users benefit from its removable front part that enables quick dust and debris clearing inside the machine. The maintenance feature ensures optimal performance through its simple operation which keeps the vacuum cleaner operating in good condition without much work.

HARDWARE REQUIRED

HC-05 Bluetooth Module

The Bluetooth module(HC-05) serves as the critical element for wireless communication between mobile application and vacuum cleaner systems. Through its wireless connection users can control both movement and power functions of the vacuum cleaner. The module uses Serial communication through UART protocol to function between command and data modes. A 10-meter working range of the HC-05 allows it to transmit user commands effectively to the microcontroller which ensures complete manual control over the device.

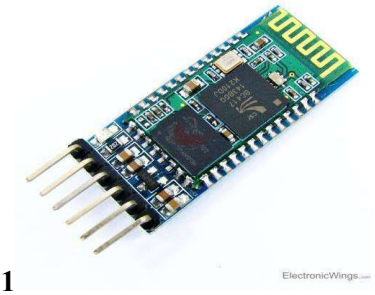


Figure 1

BO Gear Motors

Electric motor units of type BO (Battery Operated) within the vacuum cleaner drive its movement through different directions. The devices run on voltages between 3V to 12V which makes them applicable for tiny robotic systems. The motors produce sufficient torque for effective movement of the vacuum cleaner when cleaning different floor types. The vacuum cleaner depends on these compact motors due to their energy-efficient design to power its movements yet avoid power consumption beyond requirements.

Figure-2

L298N Motor Driver

An motor driver(L298N) controls the movements of the vacuum cleaner. The dual H-bridge driver of the L298N provides two-directional control capabilities for managing two DC motors therefore making it suitable for managing the BO gear motors. Pulse Width Modulation enables the Arduino Uno to send control signals to the L298N that controls the speed and directions of the motors. The driver enables forward, backward, left, and right movements of the vacuum cleaner in response to user input as well as sensor-based commands and protects against electrical overload.

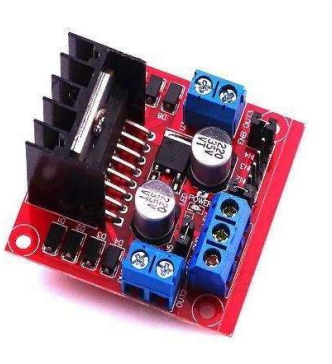


Figure-3

Arduino Uno Microcontroller

The Arduino Uno functions as the main controller of the vacuum cleaner by managing all hardware functions together. Through its ATmega328P microcontroller the Arduino executes sensor data from the ultrasonic sensor and Bluetooth module to send motor driver and servo motor control signals. The Arduino is responsible for:

The Arduino Uno analyzes distance measurements collected by the ultrasonic sensor to enable safe obstacle avoidance function.

The Bluetooth module transmits user instructions to the processing system for manual vacuum cleaner operation.

The L298N motor driver allows the user to control the BO gear motors.

The servo motor can be adjusted by the system to alter its direction according to needs.

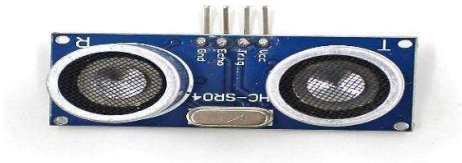
The Arduino Uno utilizes its 14 digital I/O pins together with 6 PWM outputs to offer the needed flexibility during intelligent operation.

Figure-4

Ultrasonic Sensor (HC-SR04)

The automatic navigation system of the vacuum cleaner depends on an HC-SR04 ultrasonic sensor. The sensor operates through ultrasonic waves to get distance measurements which the Arduino Uno uses for real-time data transmission. The sensor functions through sound wave emission at a high frequency while recording the amount of time it requires to detect an echo bisecting an obstacle.

Figure-5



Servo Motor

The vacuum cleaner system incorporates a servo motor for completing exact directional command functions. The Arduino Uno sends PWM signals to the servo through which it achieves rotational control within its designed angle range. The vacuum cleaner achieves automatic movement adjustments through its rotational ability.

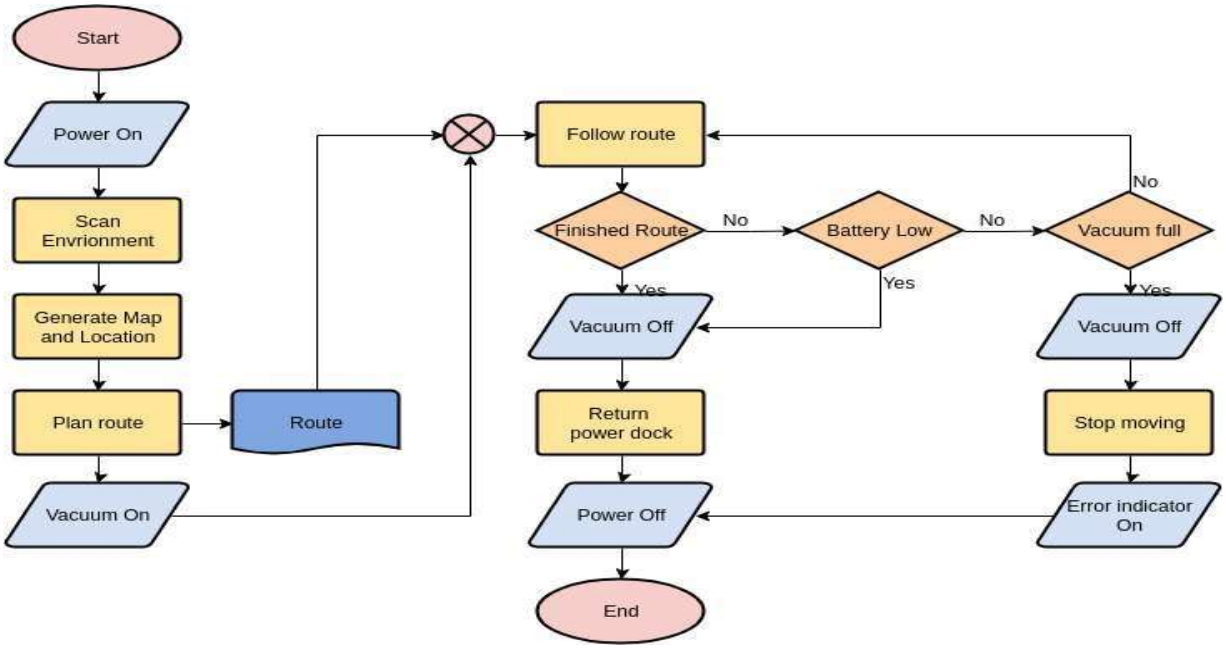
Figure-6

Lithium-Ion Batteries

All the system components receive power from lithium-ion batteries. The Arduino Uno together with BO motors, servo motor, ultrasonic sensor and Bluetooth module receives reliable power from these batteries which deliver prolonged functionality. Lithium-ion batteries exist in two standard configurations at 7.4V and 11.1V but their preferred status results from their energy-dense design and compact dimensions as well as their ability to recharge. The vacuum cleaner functions efficiently throughout long sessions because these batteries prevent constant charging requirements.

Figure-7

FLOW CHART:



Flow Chart

IMPLEMENTATION:

Modern floor cleaners have undergone technological advancement through smart vacuum technology. The fundamental components of robotic vacuum cleaners contain sensors that help them identify situations in order to prevent accidental contacts. A robust microcontroller functions as the main processing unit that analyzes sensor information to direct the vacuum cleaner through its efficient route. The smart system gives the device the ability to create space maps while executing cleaning operations in an optimized way to reach every area completely. Through a dedicated smartphone application users can access Wi-Fi connectivity which provides them remote access to vacuum control. Users can benefit from scheduling cleaning times by monitoring session progress while ensuring customized cleaning mode selection through this feature which delivers exceptional control of floor cleaning automation.

RESULTS AND DISCUSSION:

An intelligent robot utilizes an open-source electronics platform called Arduino that connects with vacuum cleaner cleaning functions. An independent system constructed through integrated sensors and motors and programming code enables programmed flooring cleaning tasks.

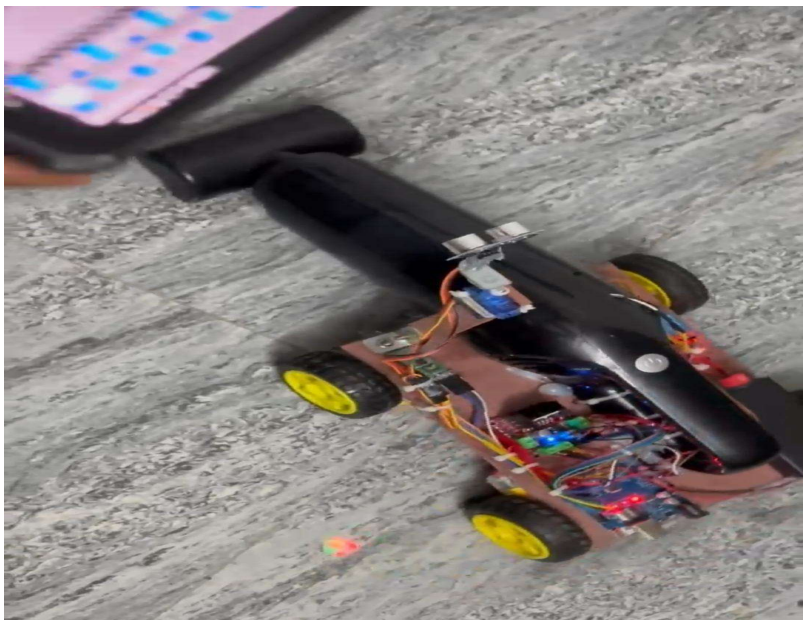


Fig-8

ADVANTAGES:

- Saves time and effort with automated cleaning.
- Ensures through cleaning with advanced sensors and suction technology.
- Reduces allergens with HEPA filtration.
- Multi-surface compatibility for versatile usage.
- App-based and voice-controlled operations for user convenience.
- Self-charging capability ensures uninterrupted cleaning.

LIMITATIONS:

- **Energy Output** – Limited by walking speed, pressure applied, and material efficiency.
- **Battery Efficiency** – Requires optimization for prolonged energy storage.
- **Durability** – The integration of sensors must be robust to withstand repeated mechanical stress.

CONCLUSION:

The Smart Vacuum Cleaner integrates automated and manual control mechanisms with its dust removal system for efficient operation. This device uses an ultrasonic sensor that enables self-navigating and obstacle-detection functions to perform hands-free operations. The HC-05 Bluetooth module gives vacuum cleaner users the ability to operate the equipment through their mobile devices which provides manual control options with additional comfort and freedom of use.

Both BO gear motors and L298N motor driver and servo motor function together with Arduino Uno to provide smooth accurate performance and execute system functions effectively. A lithium-ion battery pack gives the needed power supply to sustain running operations while the device remains both power-saving and mobile.

Users can benefit from the intelligent cleaning experience provided by this vacuum system thanks to its features for relay power control and easy part replacement as well as dual-mode capabilities. An automatic clean function lets the system perform independently while remote control in manual mode enables users to operate the system themselves which results in a smart and reliable solution for surface maintenance in modern establishments and households.

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