INTERNATIONAL JOURNAL OF ADVANCED INNOVATIVE TECHNOLOGY IN ENGINEERING

Published by Global Advanced Research Publication House Journal

Home page: www.ijaite.co.in

Floor Cleaning Robot Using Bluetooth

[1]Mahesh N. Raut, [2]Arya Y. Vaidya, [3]Shruti S. Nandanwar, [4]Vikram S. Bhagat, [5]Jatin S. Manne, [6]Monika D. Bhonde

[1,2,3,4,5,6]Agnihotri School of Technology, Wardha, Maharashtra, India

[1]maheshraut6@gamail.com, [2]aryavaidya275@gmail.com, [3]khushinandanwar587@gmail.com, [4]bhagatvikram48@gmail.com, [5]mannejatin6@gmail.com, [6]monubhonde121@gmail.com

Article History

Received on: 10 Feb. 2025
Revised on: 28 Feb. 2025
Accepted on: 30 March 2025

Keywords: Floor Cleaning Robot, Cleaning Industry, Eco-Friendly, Portable Cleanbot

e-ISSN: 2455-6491

DOI: 10.5281/zenodo.15430463

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ABSTRACT

Cleanbot is a smartphone-controlled floor cleaning robot designed to automate the cleaning process with minimal manual intervention. It features two cleaning modes Mopping and Wiping which enhance its versatility for various applications in the cleaning industry. The robot communicates via Bluetooth using an HC-05 module, which transmits commands to an Arduino NANO microcontroller. A 12V lead-acid battery powers the system, supplying the required voltage for all motors. The robot's movement is driven by 100 RPM motors, while 60 RPM plastic-geared motors operate the mopping mechanism. Designed for compactness and ease of use, Cleanbot is portable and user-friendly Additionally, its mops and wipers are repurposed from waste materials, incorporating an eco-friendly aspect into the project. By integrating automation and sustainability, Cleanbot offers an innovative solution for efficient and effortless floor cleaning.

1. INTRODUCTION

Maintaining clean floors is essential for ensuring health and hygiene in both residential and industrial settings. Floor cleaning can generally be categorized into two types: dry cleaning and wet cleaning. Dry cleaning primarily involves the removal of dust, dirt, and particulate matter, often achieved through sweeping, vacuuming, or other mechanical methods. In contrast, wet cleaning, or mopping, requires the use of water and floor disinfectants to eliminate liquid waste, stains, and harmful bacteria, providing a more thorough cleaning process. Despite the importance of clean floors, recent studies have revealed a significant increase in slip-and-fall accidents caused by unclean or improperly cleaned surfaces. Such incidents pose a serious threat to public safety, especially in high-traffic areas like offices, malls, hospitals, and industrial workplaces. Statistics indicate that slip-and-fall accidents contribute to nearly 15% of all accidental deaths annually, while 1 in 6 workplace injuries occurs due to ineffective floor cleaning. These alarming figures highlight the critical need for more effective and reliable cleaning solutions. One of the major challenges in floor cleaning is its labor-intensive and time-consuming nature.

It is often perceived as a repetitive and physically demanding task, leading to negligence and improper execution. Over time, technological advancements have significantly improved dry cleaning methods, particularly with the widespread adoption of vacuum cleaners, which simplify dust and dirt removal in homes and industries. However, wet cleaning and mopping have not seen comparable innovations, making them less appealing and more difficult to execute efficiently. Given the growing concerns over safety, efficiency, and laborious cleaning methods, there is an urgent need for a technological revolution in mopping and wet cleaning. The development of automated and smart cleaning devices could offer a more effective, user-friendly, and time-efficient alternative, reducing human effort while enhancing cleanliness and safety. Such advancements would not only improve hygiene standards but also help prevent accidents, creating a safer environment in both residential and commercial spaces.

2. History And Evolution Of Mopping

A. Evolution of Mopping

Mopping has been a fundamental part of maintaining cleanliness in households and industries, evolving over time to enhance efficiency and convenience. Its invention significantly influenced hygiene practices, making floor cleaning more effective. The modern mop was introduced by Thomas W. Steward, an African-American inventor. His deck mop, made of yarn, gained widespread popularity due to its practicality and ease of use in households, factories, and industrial settings. Steward also introduced a squeezing mechanism, which simplified the wringing process and improved maintenance. Further advancements in mop design emerged in 1950, when Peter Vosbikian developed a sponge mop featuring a built-in lever mechanism. This design incorporated a flat metal strip that pressed against the mop head, allowing users to remove excess water without the need for manual wringing. This innovation significantly reduced the physical effort required for mopping and gradually replaced traditional models, setting the foundation for modern cleaning tools.

B. Types and Components of Mops

The fundamental structure of a mop consists of a cleaning material attached to a handle. Over time, various modifications have been introduced, such as integrating buckets with drying mechanisms (see Fig. 1) to improve usability. The following are the most common types of mops and their components:

Dry/Dust Mop: Dry mops are designed to collect loose particles such as dust and dirt from surfaces. Typically made from yarn or soft fabric, they serve as the initial step in the cleaning process before wet mopping.

Wet/Moist Mop: Wet mops are used as a secondary step to dissolve and absorb liquid waste from floors. These mops are usually composed of microfiber sheets or looped yarn fabric, providing enhanced deep cleaning and sanitization.

Other Variants: Several specialized mops cater to different cleaning needs, including:

Hot Mop: Utilizes heated water to loosen and dissolve contaminants, similar to a steam iron.

Microfiber Mop: Composed of split microfiber strands, which enhance dirt and liquid absorption for more efficient cleaning.

Despite the widespread use of traditional mops, manual mopping remains labor-intensive and often inefficient. While innovations such as spin mops and self-wringing mechanisms have improved convenience, fully automated mopping solutions have yet to become a standard part of daily household cleaning.

The next section will examine advancements in automated mopping technologies, particularly those implemented in large-scale environments such as airports, malls, and offices. Additionally, it will explore the potential for adapting these solutions to household settings, thereby bridging the gap between manual labor and technological convenience in floor cleaning.

during summer and winter seasons but inefficient in rainy conditions, when floors accumulate moisture and water. This limitation presents a significant challenge in maintaining clean and dry surfaces in wet environments. To address this issue, the development of a multi-functional floor cleaning machine capable of operating efficiently in both dry and wet conditions is proposed. Known as a dry and wet floor cleaner, this machine will not only remove

C. The Global Industrial Auto Floor Scrubber

The Global Industrial Floor Cleaner is an integrated floor cleaning device. It is one of the most durable devices and is very easy to use. It has three major components- Machine, Mop Assembly and Pad Driver.

Rotationally molded polyethylene tanks are corrosion and impact resistant. 20" cleaning pad provides a wide 20" cleaning path for greater coverage in less time. Pad Assist feature helps in pulling the machine forward by friction of the scrub deck pad against the floor, the operator simply needs to tilt the scrubber forward to enable the spinning pad to contact the floor. Let us look at the specifications of the machine.

Industrial automatic electric floor scrubbers, such as Global Industrial Automatic Floor Scrubbers, are capable of cleaning up to 19,000 square feet per hour, making them highly effective for heavy-duty industrial cleaning (see Fig. 2). While various types of automatic floor scrubbing machines are available in the market, several factors prevent their adaptation for household use.

Table 1: Technical Specifications of the Global Industrial Electric Auto Floor Scrubber

Clean Width	20”
Squeegee Width	30”
Work Capacity	1800 sq.ft/hr
Pad Pressure	84lbs
Brush RPM	180
Brush Motor	120V/750W/6.25A/60Hz
Suction Motor	120V/1200W/10A/60Hz
Solution Tank	12 gallon
Recovery Tank	15 gallon
Machine Dimensions	46”x 22”x 38”
Cord	12 AWG Cord,82 ft
Machine weight	209lb

Figure 1: Global Industrial Auto Floor Scrubber

SIZE CONSTRAINTS

Industrial floor scrubbers are designed with large solution tanks, making them bulky and difficult to maneuver. Their size and structure are optimized for large commercial spaces, which makes them unsuitable for smaller household environments.

High Cost: The price of these machines can reach up to $5000, making them financially impractical for residential use. Even if scaled down, the cost remains significantly high compared to traditional mopping solutions, reducing their feasibility for everyday household cleaning.

Manual Operation Requirement: Despite being automated, most floor scrubbing machines are walk-behind or ride-on types, requiring constant manual operation. Additionally, these machines demand frequent maintenance, further increasing their long-term costs and making them a less favorable alternative to conventional cleaning methods.

Other similar machines face comparable challenges in downsizing for efficient household use. By analyzing the design, specifications, and limitations of industrial floor cleaning machines, a compact and efficient alternative has been developed—Cleanbot, a scaled-down floor cleaning machine designed to be as compact and maneuverable as a remote-controlled car. Cleanbot is a scaled-down floor cleaning machine, designed to be as compact and maneuverable as a remote-controlled car. It integrates essential cleaning functions such as dry and wet mopping, vacuuming, and water absorption, making it suitable for both dry and wet environments. Unlike industrial machines, Cleanbot does not require manual operation, allowing for a fully automated floor-cleaning experience in residential spaces. This approach bridges the gap between industrial cleaning efficiency and household convenience, offering a practical solution for modern home maintenance.

CLEANBOT: Cleanbot is an essentially a compact remote controlled autonomous floor cleaning device which cleans the floor by a set of commands given from a smartphone using Bluetooth signals given through a Bluetooth module.

Essentially Cleanbot has a very discrete design in terms of the compactness and usability as it is very handy and easy to operate. Let us discuss the design and the construction of Cleanbot in detail.

Elements: Cleanbot is a combination of various different elements and the complete integration of these elements make it a working prototype. Let us discuss these elements in detail.

A. Base and Mop mechanism

A strong base needs to be prepared so the parts can be placed on it. For this we need a plywood cut roughly of 12x9 inches. The next step is to drill two holes at the back of the plywood, at both sides for the motor clamps. To create the mops, old compact disks are repurposed by cutting a circular piece of cloth to match the CD’s shape and securely sewing it around the edges. The mops are then mounted onto plastic geared motors, which are fixed to the plywood base, ensuring that the motors are positioned equidistantly from the corners for balanced operation.

B. Water Supply Mechanism

A 3V water pump is used to transfer water from the storage tank and dispense it in front of the mops for cleaning. To ensure stability, the storage tank is securely attached to the base using hot glue. Rubber pipes are connected to the pump’s inlet, allowing water to be drawn from the tank and released onto the floor ahead of the mops. The pump is designed to be operated remotely via a smartphone for convenient control.

C. Sensor Mechanism

The device is integrated with multiple sensors to enhance its adaptability to different floor conditions and ensure efficient navigation. These sensors help detect variations in floor height, allowing the device to adjust accordingly and maintain smooth movement across uneven surfaces. By utilizing real-time data from the sensors, the device can autonomously navigate, improving both its efficiency and safety during operation.

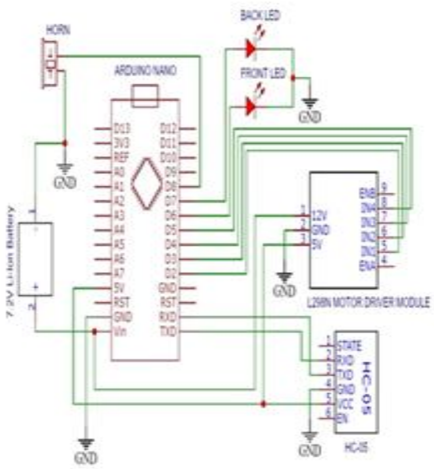

Figure 2: Schematic Circuit Diagram

This Arduino Nano-based project allows for Bluetooth control of a robotic car. The car can move in multiple directions, and additional functionalities include controlling a water pump, a vacuum cleaner, a fan, and a gear motor. Commands are sent via Bluetooth from a smartphone or another device. Pins are assigned to control the motor driver and additional components. The car's movement is controlled using IN1, IN2, IN3, and IN4, while ENA and ENB regulate motor speed via PWM signals. The water pump is connected to pin 6, the vacuum cleaner pump to pin 7, the fan to pin 11, and the gear motor to pin 12. The speed of the motors is set to 180 using a macro definition. In the setup, serial communication is initialized at a baud rate of 9600 to facilitate communication with the Bluetooth module. All control pins are configured as outputs. In the loop, the Arduino continuously checks for incoming Bluetooth commands. When a command is received, it executes the corresponding function. The commands are single-character inputs, such as 'F' for forward, 'B' for backward, 'S' for stop, 'L' for left, 'R' for right, 'G' for forward left, 'I' for forward right, 'H' for backward left, and 'J' for backward right. Additional commands include 'W' and 'w' for turning the water pump on and off, 'U' and 'u' for the vacuum cleaner, 'V' and 'v' for the fan, and 'X' and 'x' for the gear motor.

The motor control functions define how the car moves based on the received commands. Forward motion is achieved by setting the left and right motors to rotate in the forward direction, while backward motion is achieved by reversing them. Turning left or right is accomplished by stopping one motor while running the other. The advanced movements such as forward-left, forward-right, backward-left, and backward-right are achieved by varying the speed of the motors accordingly.

Additional functions control the water pump, vacuum cleaner, fan, and gear motor. Each function turns the respective component on or off by setting its designated pin high or low. The program also sends confirmation messages to the serial monitor whenever a command is executed.

This enables wireless Bluetooth control of the car, allowing it to navigate in different directions while also managing extra functionalities like pumping water, vacuuming, and operating a fan or a gear motor.

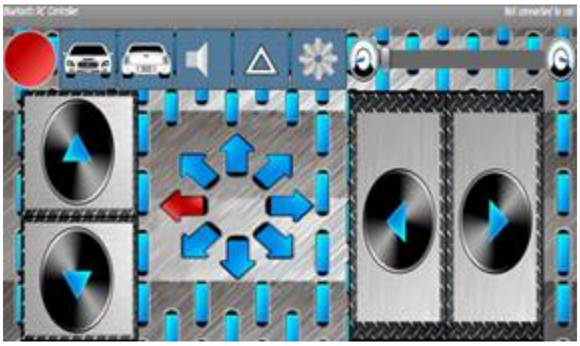

Figure 3: Mobile App Interface (Bluetooth RC Controller)

such as cars, robots, drones, and home automation systems using Bluetooth communication. This app acts as a virtual remote, allowing users to send commands from their smartphone or tablet to a connected microcontroller, such as an Arduino, ESP32, or Raspberry Pi, through a Bluetooth module like HC-05, HC-06, or BLE-enabled devices. The app provides an intuitive user interface, which typically includes buttons, joysticks, sliders, or even voice commands to control the movement and functionality of the RC device. It establishes a Bluetooth connection between the mobile device and the hardware, sending control signals in the form of serial data. The range of operation is usually between 10 to 30 meters, depending on the Bluetooth module and environmental conditions.

A Bluetooth RC Controller App is a powerful tool for controlling RC cars, robots, and other smart devices wirelessly. Its flexibility, ease of use, and multiple control options make it an essential component in modern robotics and IoT applications. Whether using an existing app or developing a custom solution, this technology offers an efficient and interactive way to operate remote-controlled devices.

D. Description Of Important Components & Results

Some of the most essential components used in the device are:

Arduino NANO: The Arduino Nano is a compact, breadboard-friendly microcontroller board based on the ATmega328P microcontroller. It is a smaller version of the Arduino Uno, designed for projects that require minimal space without compromising on functionality. The board operates at a voltage of 5V and can be powered through a Mini-USB cable, regulated 5V input, or an external voltage source of 6-12V through the VIN pin. It features 14 digital input/output pins, of which 6 support PWM output, along with 8 analog input pins. The Nano runs at a clock speed of 16 MHz and includes a built-in bootloader, allowing easy programming via the Arduino IDE without requiring an external programmer.

Figure 4: Arduino NANO

The Arduino Nano supports various communication protocols, including UART (TX/RX), I2C (SDA/SCL), and SPI, making it compatible with a wide range of sensors, modules, and displays. It also has a built-in voltage regulator that enables safe operation when powered externally. Unlike the Arduino Uno, the Nano lacks a dedicated DC power jack but compensates for this with its small form factor, making it an ideal choice for embedded and portable applications.

HC 05 (Bluetooth Module): The HC05 is a class two slave Bluetooth device designed especially to transmit data through wireless serial communication. The HC-05 Bluetooth module is a widely used wireless communication module that enables devices to exchange data over short distances using Bluetooth technology. It operates on Bluetooth 2.0+EDR (Enhanced Data Rate) and supports both Master and Slave modes, making it suitable for a variety of applications such as wireless data transfer, remote control systems, and IoT projects. The module communicates with microcontrollers like Arduino, ESP32, and Raspberry Pi through a UART (Universal Asynchronous Receiver-Transmitter) serial interface, allowing for easy integration into embedded systems.

Figure 5: HC05 Bluetooth Module

The HC-05 module operates at a voltage of 3.3V for logic levels, but its power supply can range between 3.6V to 6V, making it compatible with 5V systems when properly interfaced. It features two modes of operation: Command Mode, which allows configuration of the module using AT commands, and Data Mode, where it transmits and receives data wirelessly. The module has a default baud rate of 9600 and can be reconfigured through AT commands to adjust parameters such as device name, pairing password, and baud rate.

Motor Drive: The L298N motor driver is a dual H-Bridge motor driver module used to control the speed and direction of DC motors and stepper motors. It is based on the L298N integrated circuit, which is capable of handling two motors independently and operating at voltages between 5V to 35V with a maximum continuous current of 2A per channel. This makes it an ideal choice for robotic applications, automation systems, and other motor-driven projects. The L298N module consists of a high-current dual H-

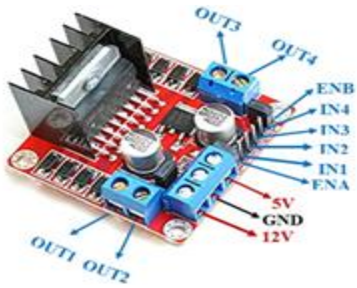

Figure 6: L298N Motor Driver

Bridge circuit that allows motors to rotate in both forward and reverse directions by controlling the polarity of the voltage applied to the motor terminals. The module has a built-in voltage regulator (5V output), allowing it to power low-power circuits such as microcontrollers. It features two motor output terminals (OUT1, OUT2 for Motor A and OUT3, OUT4 for Motor B) and can be controlled using four input pins (IN1, IN2, IN3, IN4), which determine the rotation direction of the motors.

DC geared motor: A 60 RPM gear motor is a type of DC motor with a gearbox that reduces its speed while increasing its torque. It is commonly used in applications requiring controlled movement, such as robotics, automation systems, conveyor belts, and mechanical actuators. This motor consists of a DC motor and a gear reduction system (gearbox). The gearbox lowers the motor's high speed to a more manageable 60 rotations per minute (RPM) while significantly increasing torque. The torque output of a 60 RPM gear motor depends on the motor voltage (typically 6V, 12V, or 24V) and the gear ratio, which determines how much the speed is reduced. The higher the gear ratio, the higher the torque but the lower the speed.

Figure 7: Gear Motor (60 RPM)

Vacuum cleaner: The motor inside a vacuum cleaner creates a channel of suction caused by the differences in pressure of the air inside the vacuum cleaner and the air outside. This creates a circulatory motion of air, forcing the air outside to push inside the vacuum cleaner therefore taking the dust and dirt particles inside the vacuum cleaner.

Figure 8: Vacuum Cleaner

Fig.9 Prototype Model

Conclusion

This paper has presented a comprehensive study on the Remote-Controlled Autonomous Floor Cleaning Robot, highlighting its design, implementation, and functionality. The project represents an interdisciplinary approach, integrating various technological principles to create a practical and efficient solution for household cleaning. By leveraging automation, we aimed to scale down advanced robotic technology to meet every day domestic needs. Throughout the development process, we carefully analyzed and defined the architectural and operational requirements necessary to achieve an effective cleaning system. The robot was designed to incorporate both vacuuming and mopping functionalities within a single device, optimizing cleaning efficiency while reducing human effort. The integration of these two essential cleaning mechanisms ensures that the robot can perform thorough floor maintenance autonomously, making it a valuable tool for modern households. The experimental results confirmed that the proposed design and strategy were effective in achieving the desired cleaning objectives. The robot successfully demonstrated its ability to navigate and clean different surfaces, validating the effectiveness of our approach. These findings suggest that autonomous cleaning robots not only enhance convenience but also represent a step toward intelligent home automation systems.

This robot operates independently; its functionality can be further improved when used in cooperation with human supervision. The system's design allows for enhancements, including the ability to avoid rugged surfaces, walls, and obstacles with greater precision. Future advancements could involve integrating AI-driven navigation, advanced sensors, and improved battery efficiency to enhance the robot's autonomy and adaptability. Ultimately, this study contributes to the growing field of autonomous service robots, demonstrating their potential to revolutionize household cleaning. As technology continues to evolve, the scope for innovation in this domain remains limitless, paving the way for smarter, more efficient cleaning solutions.

Conflict Of Interest

The authors declare that they have no conflict of interest.

Funding Support

The author declare that they have no funding support for this study.

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