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Voice Integrated Multi-surface Floor Cleaning Robot

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Abstract

The Voice-Controlled Multi-Surface Floor Cleaning Robot is a smart autonomous system developed to clean floors efficiently using voice commands through the HC-05 Bluetooth module. It uses two Arduino Uno boards to handle multiple tasks at once- such as managing four 100 RPM motors for movement and controlling RS775/DC motors for both vacuuming and mopping through L293 and BTS7960 motor drivers. The robot avoids obstacles using ultrasonic sensors mounted on SG90 servo motors, while a TCS34725 color sensor helps it detect different types of floor surfaces. It is powered by a 12V 8.6A supply, with LM2596 buck converters used to regulate voltage. To ensure safety and stable operation, components like noise-reducing capacitors, TVS diodes for surge protection, and Schottky diodes for motor safety are used. Mopping is handled by a water pump operated through a relay, and dust is removed using a centrifugal vacuum propeller, making the robot a reliable solution for automatic floor cleaning.

Introduction

With the rise of automation in both homes and industries, robotic cleaning systems have become increasingly popular for saving time and reducing physical effort. Thanks to improvements in embedded systems and sensor technology, these robots are now more efficient, smarter, and easier to use. This project introduces a Voice-Controlled Multi- Surface Floor Cleaning Robot, capable of cleaning various floor types on its own while being easily operated through simple voice commands offering convenience and adaptability for users.

The system is built around two Arduino Uno boards: one handles movement and cleaning tasks, while the other manages sensors and communication. The robot uses four 100 RPM DC motors for movement, which are controlled by two L293D motor drivers for stability and smooth operation. A high-powered 775 DC motor, managed by a BTS7960 driver, takes care of the vacuum cleaning, while a separate 12V DC motor powers the mopping unit. For navigation and obstacle detection, two ultrasonic sensors are mounted on SG90 servo motors to scan the surroundings and help the robot steer clear of obstacles. To identify different types of flooring, the robot uses a TCS34725 color sensor, allowing it to adjust its cleaning method accordingly.

Voice commands are transmitted via the HC-05 Bluetooth module, enabling wireless control through an Android smartphone.

This project brings together voice command functionality, autonomous navigation, surface-sensitive cleaning, and smart power handling—all within a compact robotic system designed to clean floors efficiently. It demonstrates how embedded systems and robotics can be used to simplify everyday chores in a smart and practical way.

The report is structured into several key sections. The Introduction highlights the purpose and goals of developing the voice-enabled multi-surface cleaning robot. The Literature Survey reviews existing technologies and systems related to cleaning automation, which inspired and influenced the development of this project. These studies helped shape the project's direction by adapting useful ideas and concepts. The Methodology section dives into the system design, explaining the architecture with supporting visuals like block diagrams and flowcharts, and detailing the components and work completed. The report concludes with a Conclusion, which summarizes the overall achievements and proposes possible improvements for the future.

Literature survey

In recent years, there has been growing interest in developing smart and self-operating robotic systems, particularly for household and industrial use. Among these, cleaning robots have significantly advanced—from basic manually operated machines to more intelligent systems capable of navigating on their own and interacting with users. This literature review focuses on prior work related to voice-controlled robots, systems that clean various types of surfaces, obstacle detection methods, and microcontroller-based control architectures. By studying the strengths and limitations of existing technologies, this review helps identify the essential components and design strategies needed to create a more capable and user-friendly voice-controlled multi-surface cleaning robot.

Researchers have highlighted that using Bluetooth modules like the HC-05, in combination with Android-based voice command apps, provides an easy and efficient method for controlling robots through speech, making these systems especially practical for home environments.[1]

Some studies have shown that using multiple microcontrollers, such as two ATmega328P units, helps divide tasks effectively allowing one to handle movement and the other to process sensor data or communication. This division improves the robot's overall functionality and makes the system easier to manage and expand.[2]

Mounting ultrasonic sensors on servo motors is a proven method used in smart robots to scan surroundings with a wider field of view. This setup allows the robot to react more accurately to obstacles, enhancing its ability to navigate dynamic environments safely and efficiently.[3]

Many earlier robotic cleaners rely on either vacuuming or mopping but combining both methods such as using an RS775 vacuum motor along with a mopping system—has been shown to significantly improve cleaning results. This project takes it a step further by running both systems at the same time for better surface coverage.[4]

Using sensors like the TCS34725 to recognize different floor types (such as tile, wood, or carpet) enables a robot to adjust its cleaning strategy accordingly. This smart adaptation not only boosts cleaning performance but also helps save power by avoiding unnecessary actions.[5]

To handle different types of motors in the robot—like those for motion, mopping, and vacuuming—this project uses a mix of L293D drivers (for smaller motors) and BTS7960 drivers (for high-power DC motors). This ensures efficient and stable control of all mechanical tasks.[6]

LM2596 buck converters are commonly used in robotic systems to step down a 12V battery to suitable voltage levels—like 5V for sensors or 7V for microcontrollers. This ensures that every component gets a stable and safe power supply, preventing damage from voltage mismatch.[7]

In many cleaning and irrigation systems, relay modules are used to manage water pumps. This technique is also used in this robot to control the mopping fluid pump, ensuring precise and on-demand dispensing of water during cleaning.[8]

Studies emphasize that installing ceramic and electrolytic capacitors on power lines and near motor terminals helps suppress electrical noise and smooth out voltage fluctuations. This is especially important in robots with multiple motors, as it maintains system stability during operation.[9]

Research into robotic vacuum systems has shown that using centrifugal propellers with well-designed blade angles can generate strong airflow, which significantly improves dust collection—even in smaller, compact cleaning robots. On the control side, integrating voice commands through Android applications, either by using Google's Speech API or dedicated voice recognition modules—has proven to be a cost-effective and user-friendly way to operate robots. When connected via Bluetooth to an Arduino, this setup allows for smooth and intuitive control, making the system more accessible and practical for everyday users.[10]

This review outlines how autonomous cleaning robots have developed over time, along with the key technologies that power them. The current project builds upon these established methods—like ultrasonic sensors for navigation, Bluetooth for wireless communication, and microcontrollers for system control. What sets this project apart is the way it combines all these elements into a single, voice-operated robot that can clean multiple types of surfaces. By using two microcontrollers to manage different tasks, the system becomes more flexible, user-friendly, and efficient than many traditional robots that focus on just one feature or function.

Methodology: Proposed System

A. Introduction

The system introduced in this project is a smart, voice-activated floor-cleaning robot capable of working on different types of surfaces. It uses two Arduino Uno microcontrollers to manage various tasks efficiently, one handling movement and cleaning operations, and the other processing voice commands received through the HC-05 Bluetooth module. For obstacle avoidance, the robot uses ultrasonic sensors mounted on servo motors to scan its surroundings. It includes a powerful centrifugal vacuum driven by an RS775 motor and a sponge- based mopping system supported by a water pump. To recognize surface types and adjust cleaning methods, a TCS34725 color sensor is used. Reliable power distribution is maintained using LM2596 buck converters, while components like capacitors, TVS diodes, and Schottky diodes ensure voltage stability and protect the electronics from surges and electrical noise.

B. System Overview

1. Dual Microcontroller Architecture - Two Arduino Uno boards are used, one manages motor controls for movement, vacuum, and mopping; the other handles sensors and voice command communication.
2. Voice-Controlled Operation: An HC-05 Bluetooth module receives voice commands from a smartphone, enabling hands-free control of the robot's actions.
3. Autonomous Navigation & Obstacle Avoidance - Ultrasonic sensors mounted on SG90 servo motors scan the surroundings and detect obstacles, allowing safe and efficient movement.
4. Multi surface Cleaning Mechanism - The robot uses an RS775 motor for vacuum suction, a DC motor-driven sponge mopper, and a TCS34725 color sensor to detect floor types and adjust cleaning behavior accordingly.

Input Devices:

1. Colour Sensor: Detects surface type to adjust cleaning behavior.
2. Ultrasonic Sensor: Provides obstacle detection for navigation.
3. Smartphone & HC-05 Module: Enables voice control via Bluetooth commands.

Control Unit:

- The Arduino Microcontroller receives all inputs and processes them to control the outputs accordingly.

Output Devices:

1. DC Motors: Drive the robot for motion.

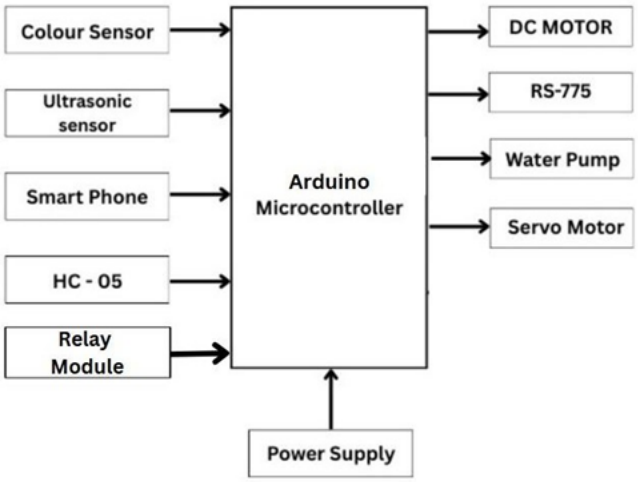

Fig 1. Block Diagram: Voice Integration Multi surface floor Cleaning Robot

2. RS-775 Motor: Powers the vacuum suction system.
3. Water Pump: Dispenses water for mopping.
4. Servo Motor: Rotates ultrasonic sensors for scanning.
5. Relay Module: Switches high-power devices like the pump.

Power Supply:

- Feeds regulated power to all components through buck converters and protection circuits.

The block diagram outlines how the Voice Integrated Multi-Surface Floor Cleaning Robot operates as a complete system. At the core of the setup is the Arduino microcontroller, which acts as the main controller for the entire robot. It receives input from various components, including a color sensor, ultrasonic sensors, a smartphone, and the HC-05 Bluetooth module that enables voice command reception. After processing these inputs, the Arduino sends signals to control key output devices such as DC motors for movement, an RS-775 motor for vacuuming, a water pump for mopping, and servo motors that help ultrasonic sensors scan for obstacles. A relay module manages high-power devices like the pump, while a stable power supply—regulated through buck converters—keeps all parts of the system functioning smoothly. This setup allows the robot to clean floors intelligently, respond to voice commands, and avoid obstacles effectively.

C. Functional Overview

The Voice Integrated Multi-surface Floor Cleaning Robot is built to clean various types of floors on its own, while also giving users the convenience of voice-based control. Using an HC-05 Bluetooth module linked to a smartphone voice app,

users can send commands without needing to touch the robot directly. For smart navigation, it relies on ultrasonic sensors mounted on servo motors, which help it detect and avoid obstacles in real time. Its movement is managed by four

100 RPM DC motors, guided by L293D motor driver modules, allowing the robot to move smoothly and respond quickly to the environment around it.

To handle cleaning tasks effectively, the robot uses a combination of vacuuming and mopping systems. The vacuum function operates through a centrifugal fan driven by an RS775 DC motor, while the mopping unit uses a sponge mechanism powered by a 12V DC motor. A relay-controlled water pump ensures that the right amount of cleaning liquid is dispensed during operation. The TCS34725 color sensor helps the robot recognize different types of floor surfaces, allowing it to adjust its cleaning approach as needed. Two Arduino Uno boards are used to split up the workload—one manages motion and cleaning, while the other handles sensor input and communication. Power delivery is regulated using LM2596 buck converters, and components like capacitors, TVS diodes, and Schottky diodes are added to protect the electronics and maintain stable operation. This thoughtful integration results in a smart, efficient, and user-friendly robotic cleaning solution.

The robot is designed to move and clean on its own across different types of floors. It responds to voice commands for user-friendly control and uses ultrasonic sensors to avoid obstacles in its path. Its movement, vacuum cleaning, and mopping functions are handled by dedicated motors, while the entire system is supported by specific drivers, sensors, and protective circuits that ensure safe and efficient power management throughout the operation.

The system starts by powering up and getting ready for operation. It then waits for a voice command to begin the cleaning process. Once it receives the command, the robot checks its surroundings using sensors to detect any obstacles. If something is in its way, it pauses, figures out a new route, and moves around the obstacle. If the path is clear, it keeps going forward. As it moves, the robot uses a sensor to identify the type of floor and automatically switches to the right cleaning method. This cycle continues until the cleaning task is finished or a stop command is given, at which point the robot shuts down the operation

D. Calculations

Total Current Draw Estimate

- 4 × 100 RPM motors: 4 × 0.3 A = 1.2 A
- 1 × 12V mopping motor: 0.5 A
- Vacuum motor (RS775): 2 A Total current ≈ 5.5 A

Battery Runtime Estimate

- Battery capacity: 8.6 Ah at 12 V

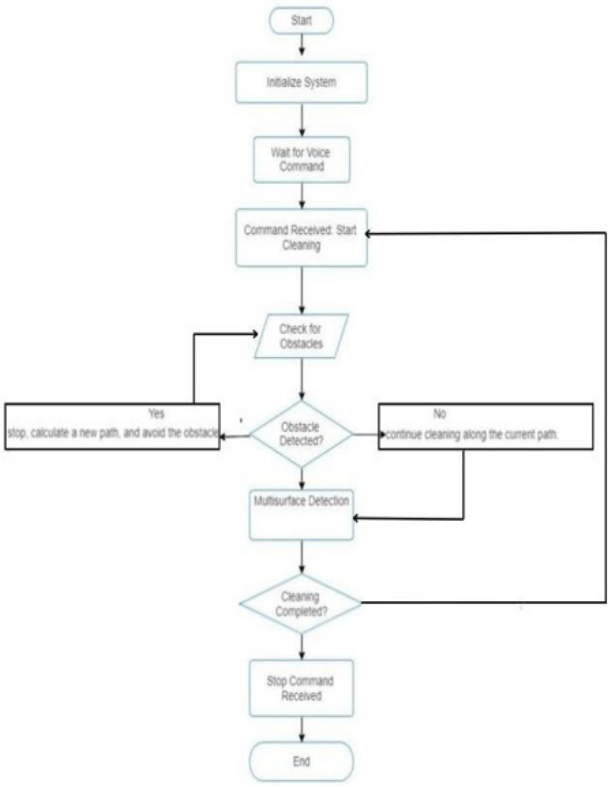

Fig 2. Flowchart: Voice Integration Multisufarce Floor Cleaning Robot

- Estimated current draw: 5.5 A Buck Converter Rating for Servos
- Servos total current: 1.3 A at 5 V
- Choose buck converter rated for at least **2 A** for safety.

Power Supply Check

- Power supply: 12 V, 8.6 A → max power = 12 × 8.6 = 103.2 W
- Estimated consumption: 12 V × 5.5 A = 66

Results and Discussion

The Voice-Controlled Multi-Surface Floor Cleaning Robot was successfully built and tested to carry out vacuuming, mopping, obstacle avoidance, and voice- guided movement. During trials, it responded well to spoken commands through the HC-05 Bluetooth module, allowing the user to operate it easily. The ultrasonic sensors, which were mounted on SG90 servos, helped the robot detect obstacles in its surroundings and move safely around them. The vacuum system, powered by an RS775 motor and a centrifugal fan, effectively picked up small dust particles and debris using a connected pipe. At the same time, the sponge-based mopping unit and a water pump controlled by a relay worked efficiently to clean flat surfaces.

The robot could also recognize different floor types using the TCS34725 color sensor, allowing it to adjust its cleaning method based on the surface.

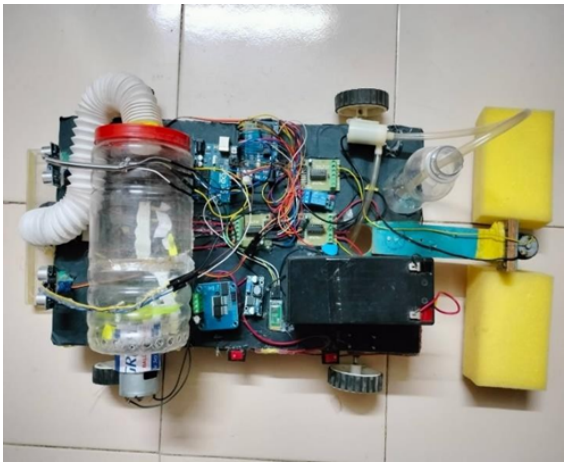

Fig 3. Structure of multi surface floor cleaning robot

The robot is constructed on a rectangular base with four wheels for support and mobility. At the front, it features two ultrasonic sensors attached to servo motors, which help detect and avoid obstacles. The central area houses two Arduino Uno boards along with motor driver modules like the L293D and BTS7960. All wiring and power-related components are neatly arranged on the platform for better organization. The vacuum setup is prominently placed, including a clear container equipped with a centrifugal fan powered by an RS775 motor, and a flexible pipe that draws in dust and debris from the floor. At the back of the robot, there is a mopping system featuring two yellow sponge rollers that rotate, driven by a DC motor. The system also includes a water dispenser that uses a small pump and relay to control the flow of water from a bottle. The entire setup is powered by a 12V battery, which is neatly enclosed in a black casing for protection. Around the main control boards, essential components like buck converters, capacitors, diodes, and an HC-05 Bluetooth module are carefully arranged. This thoughtful and compact design ensures both efficient operation and ease of maintenance.

The image illustrates how the robot communicates with a mobile device through the HC-05 Bluetooth module, using a Bluetooth terminal application. The robot continuously sends live updates about its obstacle detection and movement choices, allowing real-time monitoring of its actions. The robot uses ultrasonic sensors to scan its surroundings and determine the safest path to follow, for example, deciding to decision, it sends status updates such as ”Moving Forward” or ”Turning Left.” When it encounters an obstacle, it alerts the user with messages like ”Obstacle detected! Initiating avoidance... Stopping Motors,” showing that it can respond

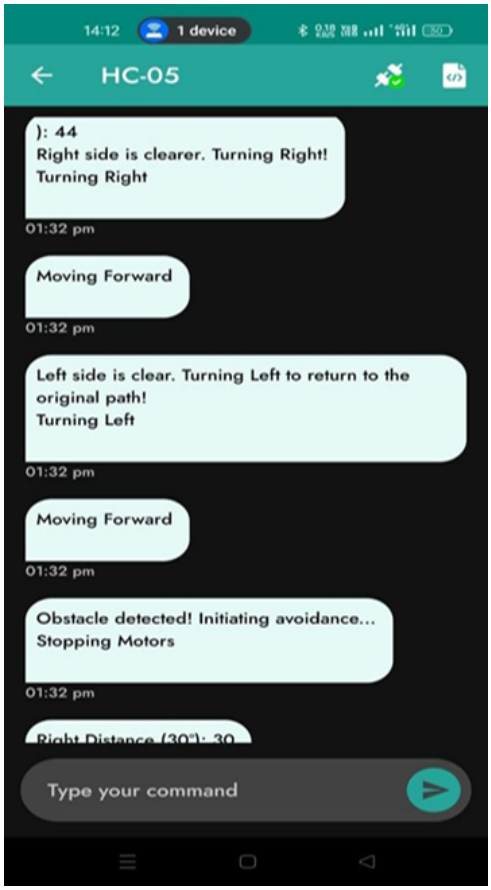

Fig 4. Bluetooth Terminal

safely and autonomously. Additionally, the user can control the robot by sending voice commands from their phone, which are converted to text and transmitted via Bluetooth.

Conclusion

In this research, a comprehensive design and implementation of a Voice Integrated Multi-surface Floor Cleaning Robot with Obstacle Avoidance has been successfully carried out. The project demonstrates effective integration of mechanical, electronic, and software systems to achieve autonomous and voice-controlled cleaning operations. By utilizing dual Arduino Uno microcontrollers, the robot efficiently coordinates the simultaneous tasks of vacuuming, mopping, and obstacle detection while adapting to various floor surfaces using the TCS34725 color sensor. The integration of voice commands through the HC-05 Bluetooth module provides an interactive and user-friendly interface, enhancing accessibility for users of all age groups, including elderly and physically challenged individuals.

The cleaning system utilizes a centrifugal vacuum mechanism powered by an RS775 motor and a sponge-based mop-

ping unit supported by a water dispensing system, allowing for simultaneous dry and wet cleaning. The ultrasonic sensor assembly, mounted on servo motors, ensures dynamic obstacle detection and real-time path correction, significantly improving the robot's adaptability in cluttered environments.

In addition to its practical cleaning capability, the system emphasizes protection and stability through the incorporation of capacitors, TVS diodes for surge protection, and Schottky diodes for back-EMF suppression. This results in a robust system capable of sustained operation under varying load conditions.

Overall, the proposed robot offers a promising solution for intelligent home automation and floor cleaning applications, combining autonomy, voice integration, and multi-surface adaptability. The modular design also opens pathways for future enhancements such as IoT integration, smartphone app control, advanced mapping algorithms (SLAM), and AI-based voice assistance, making this prototype a scalable platform for future smart cleaning systems.

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