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Smart Floor Cleaning Robot for Domestic and Industrial Use

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Abstract: *Automatic floor-cleaning robots are widely available, but most are expensive for their functionality. This project presents a low-cost Automatic Home Cleaning Robot capable of detecting and avoiding obstacles while cleaning the floor. The robot is smartphone-controlled via Bluetooth using an HC-05 module and an Arduino UNO microcontroller. It features rotating mops, a movable foam roller, a water pump with a reservoir for wet cleaning, and adjustable motor speed control. Powered by a 12V lead-acid battery, the robot uses homemade cleaning mops made from recycled materials, making it cost-effective and efficient for small household areas. Future improvements may include fully autonomous operation and advanced cleaning features.*

Keywords: Robot, Arduino UNO microcontroller, DIY, UI, PWM

I. INTRODUCTION

Automatic floor-cleaning robots are widely available; however, most of them are costly compared to the services they provide. This article introduces an affordable Automatic Home Cleaning Robot designed to perform floor cleaning at a significantly lower cost than commercially available alternatives. The robot is capable of detecting and avoiding obstacles while moving continuously to clean the entire room. A small cleaning brush is attached to enhance floor-cleaning efficiency [1].

The CleanSweep robot is a smartphone-controlled cleaning system designed for household floor maintenance. It uses rotating front mops and a movable foam roller at the rear to ensure effective cleaning. Additionally, the robot includes a water pump and reservoir that can be activated to spray water, keeping the mops moist for better performance. Speed control for the drive motors has also been incorporated for improved operation.

The system operates through Bluetooth communication using an HC-05 module, which transmits commands to an Arduino UNO microcontroller[3]. The robot is powered by a 12V lead-acid battery suitable for all motors used in the system. It employs 100 RPM motors for movement and 75 RPM plastic motors for the rotating mops.

One of the key advantages of this project is its low-cost cleaning mechanism, as the mops are homemade using recycled materials such as old CDs and cloth rags. Although this compact version is more suitable for small spaces, the design can be further enhanced with advanced features, such as fully autonomous operation and intelligent navigation, in future developments [3].

II. LITERATURE REVIEW

The development of automatic floor-cleaning robots has gained considerable attention due to the increasing demand for smart home automation and efficient cleaning systems. Traditional cleaning methods require significant human effort and time, leading researchers to design intelligent robotic systems capable of performing cleaning tasks autonomously or semi-autonomously [4].

Early robotic floor cleaners focused mainly on autonomous navigation and obstacle avoidance. One of the pioneering studies in robotic cleaning systems highlighted the importance of autonomous mobility and intelligent path planning for domestic applications. Robots equipped with sensors such as ultrasonic sensors and infrared sensors were able to detect obstacles and navigate efficiently within indoor environments [5].

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The integration of microcontrollers such as the Arduino platform has made floor-cleaning robots more affordable and easier to implement. Researchers have developed low-cost robotic cleaning systems using Arduino-based control units combined with Bluetooth communication modules, enabling users to remotely control robots through smartphones. Such systems reduce implementation costs while maintaining acceptable cleaning efficiency for household applications [6].

Recent studies have emphasized multifunctional cleaning mechanisms, including dry sweeping, wet mopping, and water spraying features. Rotating brushes, microfiber mops, and water dispensers have improved cleaning effectiveness on different floor surfaces. Many modern robotic cleaners also integrate motor speed control and adaptive movement techniques to enhance cleaning coverage and reduce power consumption [7-8].

Obstacle detection and avoidance remain critical research areas in robotic floor-cleaning systems. Ultrasonic sensors and intelligent algorithms allow robots to detect furniture, walls, and moving objects while preventing collisions. Researchers have proposed autonomous path-planning algorithms to ensure maximum floor coverage with minimal energy consumption. These approaches significantly improve cleaning efficiency compared to manually operated systems [9].

Despite technological advancements, commercial robotic floor cleaners are often expensive, limiting their accessibility for many households. Consequently, recent research has focused on designing cost-effective robotic cleaners using recycled materials, simple electronic components, and energy-efficient motors. These low-cost solutions provide practical alternatives while maintaining satisfactory cleaning performance for small domestic spaces [10].

III. PROBLEM STATEMENT

Maintaining cleanliness in homes and indoor environments is essential for hygiene and healthy living; however, conventional floor cleaning methods require considerable human effort, time, and physical involvement. Although automatic floor-cleaning robots are available in the market, most commercial systems are expensive and often unaffordable for middle-income households. In addition, many low-cost cleaning solutions lack effective obstacle detection, wet cleaning functionality, and user-friendly control mechanisms.

Therefore, there is a need to develop a cost-effective, efficient, and user-friendly automatic floor-cleaning robot capable of cleaning floors with minimal human intervention. The proposed system should be able to detect and avoid obstacles, support dry and wet cleaning operations, and provide smartphone-based control through Bluetooth communication. The solution aims to reduce cleaning effort, save time, and improve accessibility to smart cleaning technology for domestic users.

IV. PROPOSED ARCHITECTURE

CleanSweep is an ultra-affordable, DIY mobile floor cleaner designed to disrupt the overpriced commercial market. Built on a modular plywood chassis, it utilizes upcycled household materials—like old CDs, rags, and a plastic bottle—to create a functional, dual-action cleaning platform for a fraction of retail cost.

Step 1: Parts and Tools Inventory: Establishing a precise BOM (Bill of Materials) ensures all components match electronically before assembly. Choosing an Arduino UNO balances low cost with vast community support. Opting for a 12V power rail satisfies the high-torque demands of the DC motors and water pump, while using upcycled consumer waste (CDs, plastic bottles, rags) keeps the project's financial footprint to a bare fraction of commercial alternatives.

Step 2: Preparing the Chassis Base: A custom 12 inchplywood deck provides the optimal balance between surface area (for mounting bulky items like a 12V battery and a water reservoir) and structural rigidity. Sealing and painting the wood prevents the raw fibers from warping or rotting when exposed to water from the fluidics loop.

Step 3: Constructing and Mounting the Floor Mops: Placing the scrubbing array at the absolute front of the chassis ensures that the robot tackles floor debris before its own driving wheels pass over the area. Using lower-speed, high-torque 75 RPM motors ensures the mops maintain enough friction against the floor to scrub effectively without burning out or spinning out of control.

Step 4: Installing the Water Supply System: Placing the fluidics reservoir on top of the deck utilizes gravity to assist the pump. Positioned right behind the front mops, the pump uses a simple vinyl line split into drinking straws to spray fluid exactly one inch ahead of the scrubbing pads, ensuring the floor is consistently pre-moistened for optimal stain removal.

Step 5: Building the Lifting Roller Mechanism: A trailing foam roller acts as a dry squeegee to pick up left-over moisture. Because a wet foam roller creates significant friction and drag when dragging backward or turning, a 180 servo linkage is integrated to dynamically lift the mechanism off the ground during dry transit or complex turning maneuvers, saving battery power.

Step 6: Soldering the Control Circuitry:The Arduino's ATmega328P chip can only supply5V at 40 mA per pin—grossly insufficient for a heavy-duty 12V pump or mop array. Building an isolated TIP122 NPN transistor circuit acts as an electronic switch, allowing low-power Arduino logic pins to safely switch high-power 12V lines. Creating external bus rails solves the problem of the Arduino's limited physical 5V and GND pins.

Step 7: Wiring and Electronic Connections: This step establishes the definitive communication and power distribution lines. The L293D H-bridge driver is dedicated to the 100 RPM drive wheels because they require bi-directional control (forward/reverse) and speed modulation (PWM). The Bluetooth module's RX pin is step-down protected with a voltage divider because the HC-05 operates on 3.3V logic, and direct 5V signals from the Arduino would degrade the chip over time. Unified common grounding prevents floating electrical signals and erratic behavior.

Step 8: Final Mechanical Assembly: Cable management is a mechanical necessity; unanchored wires risk wrapping around spinning motor axles or crimping water lines. Calibrating the split-straw nozzles ensures symmetric fluid distribution so one mop doesn't run dry.

Step 9: Uploading the Firmware: Temporarily disconnecting the RX/TX lines is a physical requirement of the hardware architecture. The Arduino UNO uses the same hardware serial channel (`Pins D0 and D1`) for both its USB computer connection and the HC-05 module. Isolating the Bluetooth module avoids data collisions that instantly brick or fail the programming upload.

Step 10: Installing the Battery Pack: Placing the heavy 12V battery pack directly along the central midline optimizes the center of gravity, preventing the robot from tipping and ensuring uniform traction across both drive wheels. Routing the 12V battery directly to the Arduino's `VIN` pin utilizes the board's onboard linear regulator to power the system logic safely without requiring a separate step-down buck converter.

Step 11: Configuring the Smartphone Control Application: Utilizing an off-the-shelf serial terminal app eliminates the need to develop a custom Android/iOS application from scratch, drastically saving software development time. Mapping discrete characters to specific app buttons creates a reliable, lightweight User Interface (UI) that instantly matches the `Serial.read()` logic embedded in the firmware.

Step 12: Future Upgrades & Possibilities: By keeping the entire system architecture open-source and modular, the design is deliberately future-proofed. The digital and analog pins left open on the Arduino UNO allow future makers to easily transition this manual prototype into a fully autonomous system simply by mounting plug-and-play sensors.

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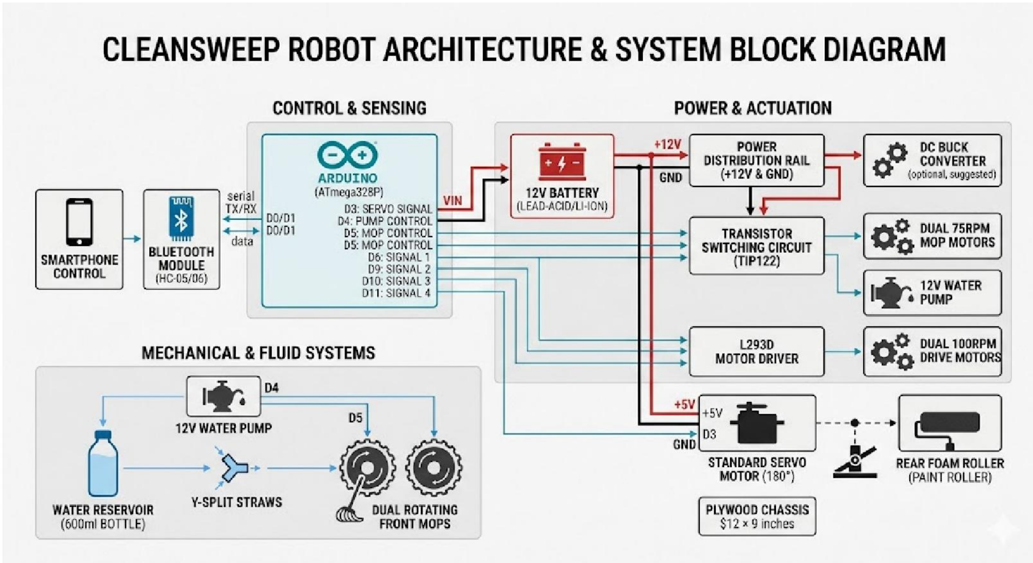

The above architecture diagram visually maps out how CleanSweep operates by dividing the robot into four distinct, functional subsystems: Control & Sensing, Power & Actuation, Mechanical & Fluid Systems, and User Interface.

1. Control & Sensing Subsystem (The Brain)

a) Arduino UNO (ATmega328P): Serves as the central microcontroller. It reads incoming serial data from the Bluetooth module and outputs low-power 5V control signals to the motor drivers and transistors. It is the cost-effective "brain" that coordinates all actions.

b) HC-05/06 Bluetooth Module: Handles the wireless communication link. It acts as a bridge, converting the smartphone's radio signals into hardware-level Serial Data (`TX/RX`) that the Arduino can parse.

2. Power & Actuation Subsystem (The Muscle)

a) 12V Lead-Acid/Li-ion Battery: Provides the high-current, 12V main power rail required to run the heavy-duty components (drive motors, mops, and pump). It also feeds power into the Arduino's `VIN` pin, where the board's internal regulator steps it down to 5V for the logic circuits.

b) L293D Motor Driver: This H-bridge integrated circuit acts as an intermediary for the two 100RPM Drive Motors. Because the Arduino cannot handle the high current demands of driving wheels, the L293D takes the low-power commands (`D6`, `D9`, `D10`, `D11`) and safely routes the raw 12V battery power to spin the motors forward, backward, or adjust their speed.

c) Transistor Switching Circuit (TIP122): Used to control the Dual 75RPM Mop Motors and the 12VWater Pump. Since these components only need simple "On/Off" functionality (rather than directional shifting), using cost-effective NPN power transistors instead of a second full motor driver shield saves money while easily managing the 12V load via Arduino pins `D4` and `D5`.

d) Standard Servo Motor 180: Runs directly on the 5V logic power rail. It receives a Pulse Width Modulation (PWM) signal from pin `D3` to precisely control its physical angle, mechanical arm, and height position.

V. MECHANICAL & FLUID SYSTEMS (THE CLEANER)

a) Water Reservoir & Pump: Shows the physical flow of the cleaning fluid. The 12V pump draws water out of the recycled plastic bottle reservoir and pushes it down a main line, which splits via a Y-joint straw assembly to evenly spray liquid right in front of the mops.

b) Dual Rotating Front Mops: Positioned at the very front of the physical Plywood Chassis, these spin in opposite directions to scrub the floor, absorbing the moisture distributed by the pump straws.

c) Rear Foam Roller: Positioned at the back of the 12X9 inch chassis. It is mechanically linked to the servo motor so that it can be dynamically dropped to dry/squeegee the floor, or lifted completely out of the way when the robot is traveling over surfaces that shouldn't be wiped.

VI. CONCLUSION

The CleanSweep prototype successfully achieves its primary design objective: delivering a functional, dual-action floor-cleaning robot for a small fraction of the cost of commercial alternatives. By combining off-the-shelf electronics with everyday household items—such as a plastic bottle for a reservoir, a paint roller for dust collection, and old CDs wrapped in rags for scrubbing pads—the project demonstrates that automated home maintenance doesn't require expensive, proprietary hardware.

In testing, the robot effectively executes real-time directional movements and speed adjustments via smartphone commands. The dynamic fluid distribution system delivers targeted moisture right before the counter-rotating mops scrub the floor, while the servo-controlled rear roller successfully transitions between active drying and lifted idle modes.

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