Smartphone-Controlled Robotic Vacuum Cleaner Using Arduino Embedded Platform

Report submitted by

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19CCE384 – Design and Innovation Lab

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1. **Motivation:** The project was chosen due to the need for a low-cost solution to simplify and automate the cleaning process in households. With hectic schedules and limited time for residential cleaning, professional cleaner robots on the market might be prohibitively pricey.

   As a result, the project's goal is to use Arduino to create a basic and inexpensive floor cleaner robot. When compared to commercial options, the Arduino cleaner will be tiny, practical, and substantially less expensive. By offering a low-cost solution, the initiative hopes to make automated cleaning more available to a larger audience, improving convenience and saving time for those who lead busy lives.

2. **Problem Statement**: The goal of this project is to create an autonomous robot that can clean floors both dry and wet while dodging objects and collisions. In addition, the cleaner must include a status display, automated system functions, and smartphone app control and monitoring capabilities. The project's design requirements are as follows:

   i. Including the Arduino platform to operate the motors, sensors, and wireless communication module, among other parts of the cleaner.

   ii. Use a smartphone app to remotely operate and monitor, offering real-time updates on the cleaning process.

   iii. Create algorithms that direct the vacuum cleaner's motion, guaranteeing effective path planning and obstacle avoidance.

   iv. Create a wireless communication protocol that allows the cleaner and smartphone app to communicate with one another without interruption.

   v. Thoroughly test and evaluate the smartphone-controlled robotic cleaner to determine its dependability and cleaning effectiveness.

   These design specifications will serve as the basis for evaluating the success of the project in achieving its objectives.

3. Design Procedure:

i. Construction of Remote Control (RC) Car:

- Prepare cardboard sheets for motor attachment by drilling specified holes in them.
- Connect the motor cables and fasten the DC motors to the sheets.

- Build the wheels, insert the ball bearings, and fasten them to the motors.
- To regulate the motors' speed and direction, connect the motors to the motor driver.
- To identify impediments, attach the ultrasonic sensor to the servo motor.
- Create the Arduino code and upload it to let the RC vehicle drive continually while avoiding obstacles.
- Put the batteries for the power supply in order on the cardboard sheets.

ii. **Construction of Vacuum Cleaner:**

- Cut a 1.25-litre water bottle horizontally.
- From the bottle's top section, remove the conical framework.
- To provide ventilation, attach a pipe to the bottle cap area.
- For better vacuum, tape the bottle's cylindrical and conical halves together with gauze bandages.
- Connect a fan to the cylindrical structure's other end and provide it with a 12V supply.
- To turn on and off, attach a switch to the motor driver.

iii. **Construction of Mopping System:**

- Use a tiny water bottle that has been cut in half as a reservoir for water on the remote-controlled vehicle.
- Install a 12-volt water pump to draw water out of the container for storage.
- To rotate the sponge and clean the water that has dripped, attach a motor to it.
- To transport water throughout the system, use vinyl tubes.

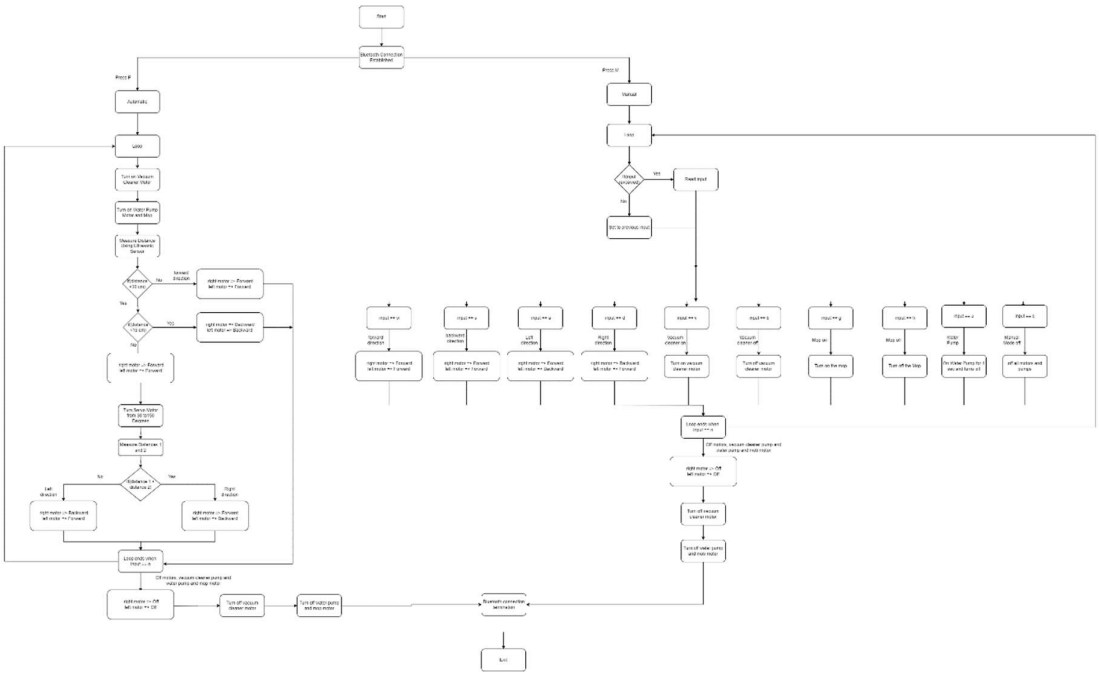

Fig. 1 Flow Chart for Code Work

4. Budget:

Serial Number	Component Name	Purpose	Quantity	Cost (in Rupees)
1	12V Rechargeable Lead-Acid Battery	Power Source	1	480
2	9V Battery with Connector Clips		4	17 X 4 = 68
3	Arduino Uno with USB Cable	Embedded Control Board	1	880
4	HC-05 Bluetooth Transceiver Module with TTL Outputs and Base	Communication Protocol	1	270
5	HC-SR04 Ultrasonic Module Distance Measuring Transducer Sensor	Sensor Data Obtained From	1	75
6	7805 5V Fixed Linear Voltage Regulator IC	Actuator in Vacuum Cleaner and Remote Control (RC) Car	1	8
7	RS775 High RPM Torque 12V Brushed DC Motor		1	270
8	Battery Operated (BO) 10 RPM Gear DC Motor for Robot		2	200 X 2 = 400
9	SG90 Micro Servo		1	125

	Motor – 180 Degree Rotation			
10	L298N Motor Driver Module		2	130 X 2 = 260
11	65 mm BO Motor Wheel for Smart Car Arduino Robotics	Construction Material in Remote Control (RC) Car	2	25 X 2 = 50
12	Metal Caster Bearing Wheel		2	30 X 2 = 60
13	Mini Aquarium Water Pump R385	Actuator in Mopping System	1	170
14	PVC Pipe	Construction Material in Mopping/Vacuum System	1 Meter	30
15	Single Pole Double Throw (SPDT) Switch	Turn ON/OFF RC Car and Mop/Vacuum System	2	8 X 2 = 16
16	Pre-Fabricated Printed Circuit Board (PCB)	Build Electronic Circuits	1	40
17	Jumper Wires Set (MM, FF, MF)		As Per Requirement	50
			Total	3,252

5. Circuit Diagram:

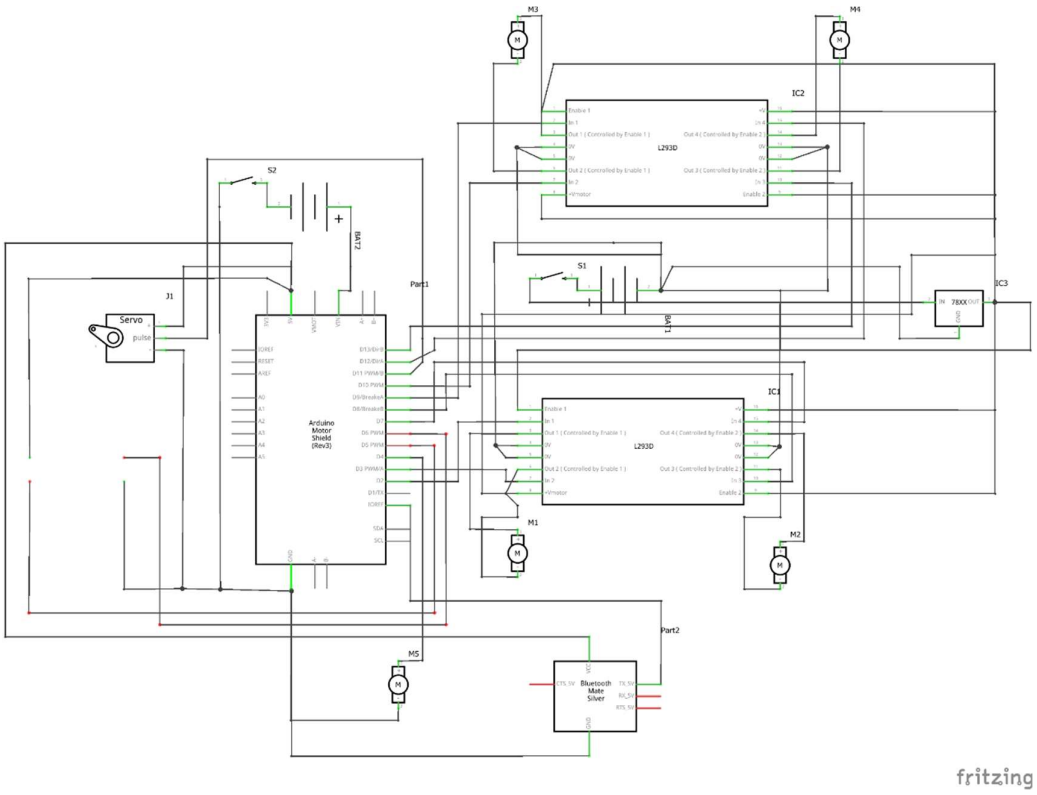

Fig. 2 Circuit Diagram

On an integrated Arduino platform, the circuit diagram for a smartphone-controlled robotic cleaner normally comprises several parts that are linked to create a working system. Here is a broad breakdown of the key elements and how they relate:

i. Arduino Board: The robotic cleaner's general functionality is controlled by the Arduino board, which acts as the system's brain. Through a wireless connection module (like Bluetooth), it gets instructions from the smartphone and manages the motor drivers accordingly.

ii. Motor Drivers: The motor drivers are used to manage the robotic cleaner's motors, which power its movement. The cleaner/mop often has two sets of motor drivers, one for directing movement in the X-direction (horizontal) and the other for directing movement in the Y-direction (vertical). After receiving instructions from the Arduino board, the motor drivers regulate the motors appropriately.

iii. Motors: The robotic cleaner's motors are what drive it around by powering its wheels or other mechanical parts. The motor drivers are attached to the motors, which are typically DC motors.

iv. Sensors: Sensors are utilized to collect environmental data and aid the robot in navigation. To identify barriers and prevent collisions, proximity or obstacle detection sensors (such as ultrasonic sensors) are frequently employed in robotic cleaners.

v. Power Supply: The Arduino board, motor drivers, motors, and other electrical components in the circuit are powered by a power source, which supplies the circuit with the appropriate voltage and current. Usually, it is a battery.

vi. Smartphone: The user interface for operating the robotic cleaner is a smartphone. It uses a wireless connection module (like Bluetooth) to communicate orders to the Arduino board to control the robotic vacuum cleaner's movement and other features.

vii. Wireless Communication Module: The Arduino board and the smartphone communicate thanks to the wireless communication module. The robotic cleaner may be remotely controlled thanks to a Bluetooth module.

These are the primary elements that are commonly shown in a circuit schematic for a robotic cleaner that is operated by a smartphone and is built on an integrated Arduino platform. Depending on the particular design and specifications of the robotic cleaner project, the connections and wiring will vary. To guarantee the safe and functional operation of the system, it is crucial to adhere to the project paperwork and follow the necessary wiring rules. If you are unfamiliar with electronics or circuits, it is also a good idea to double-check the connections and seek professional assistance.

6. Simulation results:

i. Obstacle Avoidance Simulation: The simulation displays the robot's real-time obstacle detection and avoidance abilities. It shows how the cleaner can successfully navigate and avoid collisions in a variety of conditions with diverse obstructions.

Distance	Left Distance	Right Distance	Result
40	NA	NA	Forward
25	35	20	Left
21	19	20	Right
25	19	30	Right
25	10	23	Backward
23	24	13	Backward
8	NA	NA	Backward
35	NA	NA	Forward
20	26	23	Left
21	16	19	Right

Fig 3. Obstacle Avoidance Simulation

ii. Remote Control Simulation: This simulation shows how the smartphone app works to operate the robotic cleaner. It highlights how easily the software and robot can communicate with one another, enabling consumers to start, stop, and monitor the cleaning process from their mobile devices.

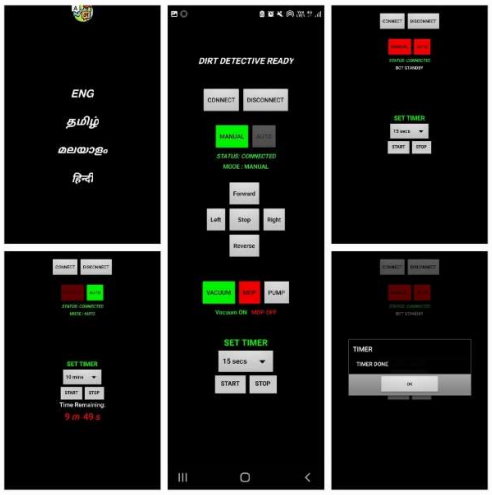

Fig 4. Remote Control Simulation: Smartphone Control – Wireless Simulation

7. Prototyping results:

i. Physical Prototype: A working robotic cleaner prototype is created, including the Arduino Uno microcontroller, motors, sensors, and other essential parts. The prototype displays the capacity for obstacle avoidance, collision detection, and dry and wet cleaning.

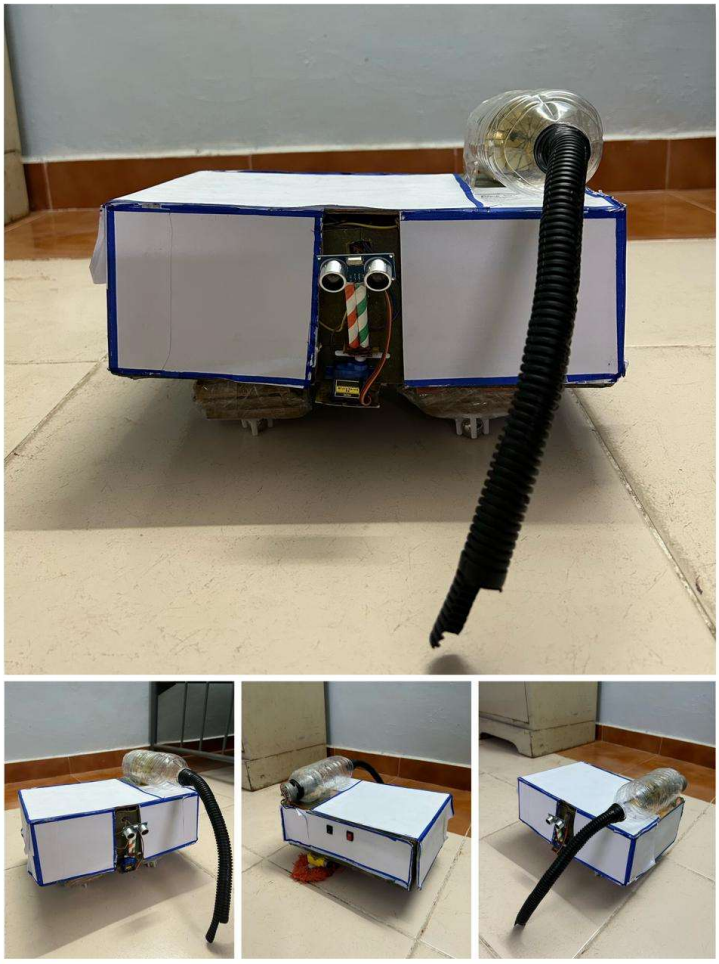

Fig 5. Physical Prototype

ii. Smartphone Control: The usage of a smartphone app enables customers to supervise and manage the robotic cleaner from a distance. To start, stop, and modify cleaning settings, the app offers simple options. Real-time feedback and cleaning progress tracking are effectively accomplished.

iii. Wireless Communication: The robotic cleaner and smartphone app effectively execute the wireless connection protocol. The prototype demonstrates dependable real-time communication, allowing for smooth device control and monitoring.

iv. Cleaning Efficiency and Reliability: The prototype's cleaning effectiveness and dependability are demonstrated through testing and assessment. The outcomes show that the robotic cleaner can successfully clean various floor surfaces, collect dirt and debris, and run consistently without experiencing many faults or malfunctions.

Floor Surface	Initial Waste Count	Waste Collected	Cleaning Efficiency
Tiles	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	60%
Carpet	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	55%
Hardwood	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	55%
Plastic	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	Paper: 20, Thermocol: 20, Dry Leaves: 20, Plastic: 20	60%
It's crucial to keep in mind that these presumptions are based on the available data and could not fully reflect the cleaning efficiency. For each floor surface, additional testing and assessment are advised to get more trustworthy findings.			

These results from implementation or prototype demonstrate the effective fusion of hardware elements, software algorithms, and user interfaces to provide a practical smartphone-controlled robotic cleaner system.

8. **Discussion & Conclusions**: The goal of the project was to use the Arduino Uno platform to create and install a smartphone-controlled robotic cleaner; to build an autonomous vacuum robot that could use a mop for both dry and wet cleaning tasks. The robot has characteristics including obstacle avoidance, collision detection, status display, and an autonomous system to move about a room or house with the least amount of human help.

   The team encountered several difficulties while working on the project and made some adjustments to meet the deadline. Due to their intrinsic intricacy or mechanical repercussions, several intricate functional needs were left out. Despite

these drawbacks, we succeeded in constructing an autonomous cleaner that is capable of cleaning and navigating.

Although the project's main goals were achieved, there is room for improvement. Future revisions could concentrate on adding other behaviors and features to improve the robot's overall performance. This may incorporate functions like enhanced obstacle detection algorithms, cleaner cleaning schedules, and room mapping. Further research and testing might be done to determine the dependability and cleaning effectiveness of the smartphone-controlled robotic cleaner.

Overall, this study contributes to the evolution of domestic robots and increases the convenience and effectiveness of home cleaning duties by laying the groundwork for the creation of more competent and advanced autonomous cleaners.