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Snoop Doggy: Automatic Robotic Floor Cleaner

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Abstract

Due to current technology advancements, researchers have been concentrating more on robots in an attempt to enhance human existence. Home automation and intelligence are growing in today's houses. People may simplify their lives and save time with home automation. Though the market is still young and developing, domestic robots are finding their way into people's homes and daily lives. Nonetheless, growth will be needed and the use of domestic robots is changing. The objective is to develop a robotic floor cleaner that uses border analysis to automatically cover a given room or area. The proposed work is named snoop dog as the device will walk in the house like a dog patrolling his territory. The device travels around the room in a zigzag pattern. To cover the whole room, the system detects boundaries using ultrasonic sensors and responds appropriately. In order to collect dust, the device also features a vacuum suction cleaner attached to its rear. Initially, the robot locates a corner and activates the vacuum. After then, it covers the entire region in a zigzag pattern. It functions best in a room free of obstacles, however this problem might be resolved in future enhancement.

Keywords: Autonomous Roaming, Vacuum, Floor Wash, Mop, Dry, Power Efficient, Cleaning Robot.

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1. Introduction

Robot vacuum cleaners are well-known products. Due to their capacity to assist people in cleaning floors in a variety of settings, including residences, restaurants, hotel rooms, work environments, clinics, workshops, storerooms, and college campuses, robotic cleaners have recently gained popularity in robotics research. Basically, robotic cleaners are categorized based on their cleaning functions, like mopping floors, dry vacuuming, and more. While some systems use laser scanning techniques, others use infrared sensors to elude obstacles. Every cleaning and operating mechanism in robotic floor cleaners comes with its own advantages and disadvantages. For instance, robots using laser scanning techniques are faster, saving time and energy, but they cost more. On the other hand, obstacle-avoidance robots are less efficient due to random cleaning, but they are cheaper. The "smart floor cleaning robot (Snoop Doggy)" has been built for consumer/office contexts in this work. The robot is completely autonomous and makes judgments based on the outputs of ultrasonic sensors. New cleaners employ better functional sensors as well as more advanced algorithms and sensors. We wanted to test ideas and make modifications to the demonstration.

1.1 Motivation

When cleaning floors manually, there's a chance of missing spots, making it time-consuming and tedious due to the human effort required. Moreover, in large workplaces, efficiently covering extensive floor space can be challenging. Additionally, exposure to chemical-based dust particles in some industries poses health risks for humans, making robots a convenient solution. These robots are compact and portable, allowing them to clean any desired area within the home. Furthermore, compared to manual labor, robots offer cost-effectiveness, flexibility, time savings, and enhanced cleaning effectiveness, making them an excellent choice for floor cleaning in organizations.

1.2 Objectives

To develop an autonomous robot designed to assist busy individuals, particularly families with children and elderly people living alone, who lack the time or physical strength to clean their floors regularly, aiming to address the inefficiency and high cost of current market robotic vacuum cleaners in terms of cleaning time and effectiveness. Additionally, the major goal is to create a floor cleaner capable of performing tasks beyond those of standard vacuum cleaners available on the market, such as cleaning and dusting. The robot is equipped with sensors to detect its surroundings and adjust its dimensions accordingly, enabling it to simultaneously clear dust and wash the floor

2. Related Work

The first Roomba [1] was thirteen inches in diameter and four inches tall. To identify any barriers or objects in its path, the Roomba utilised a big bumper attached to the front of the device. The top front center of the robot was outfitted with infrared sensors. It also employed a virtual wall that communicated infrared to the device so it didn't get lost cleaning other rooms. The original prototype had three settings. The options included selecting a room size (small, medium, or large). The Roomba's first function was the ability to identify whether or not it had enough power to clean the room size you selected. However, as technology has advanced, so has the Roomba. Now it can detect room sizes without a user input. It was launched on 2002 by iRobot(American) to perform dry vacuum using the IR, RF technology. Its price ranged about $500

Rodney Brooks[2], an MIT researcher and iRobot CTO, believes that robots should be like insects, having basic control systems that are adjusted to their environments. As a consequence, while Roombas are good at cleaning rooms, they take several times as long as a person would, generally covering certain areas multiple times and others either once or not at all.

Dyson[3]: Dyson created the DC06 robot vacuum in 2001, but it was never brought to the market owing to its expensive price. Dyson introduced the Dyson 360 Eye in 2014, which used a different path-finding technology than that used by products made by NEATO Robotics or iRobot. The EYE-360, was released in 2016 by Dyson (UK). It was equipped with a 360-degree panoramic vision camera for real-time environment monitoring and a turbo brush for effective cleaning. Priced at around $1000, it also features an auto-charging mechanism, setting a new standard in cleaning robot technology.

NEATO Robotics[4]: Since the introduction of robotic vacuum cleaners, numerous countries have started producing these devices. Joining this trend, China has also been creating robots with more sophisticated functions and dependable technology.

Manya Jain[5] Several participants discussed the Automatic Floor Cleaner project, which finds frequent use in both household and commercial settings for automatic and manual surface scrubbing. When activated, it efficiently collects dust particles while traversing the surface, such as floors or other areas. Incorporating driving force control systems to control the motors where robots navigate, along with sensors to detect and avoid obstacles. It is crucial in enhancing the quality of human life

Manreet Kaur and Preeti Abrol [6] developed an autonomous robot floor cleaning system using AT89S52 micro-controllers for hardware and software operations. It can sweep and mop, controlled manually or automatically within a 50m range using RF modules. The robot detects obstacles with an infrared sensor and automates water sprayer pumps. Four motors are employed: two for cleaning, one for the pump, and one for tires, powered by two relay circuits. In automated mode, it adjusts paths upon obstacle detection, and in manual mode, a keypad controls its functions and communicates with remote and automated robots through RF components, displaying data on an LCD. The circuit is powered by a 12V electrical device pack.

Rupinder Kaur[7 developed a new self-operating robot for cleaning for homes, offices, and industries focused on sanitation. Research firms are exploring effective solutions using artificial intelligence, which makes computers mimic humans. This device sweeps and mops floors, capturing dust and microscopic particles. It's easy to use, affordable, and cleans thoroughly. Being autonomous, it can work even when you're not around.

Table 1. Components Used

Sl.No	**Equipment**	**Purpose Of Use**	**Quantity**
1	Empty container	Making vacuum space	1
2	12V DC Fan	Collecting small objects	1

3	Board Cutter	Cutting the empty container and vero board	2
4	Soldering iron	To heat solder, usually from an electrical supply at high temperatures above the melting point of the metal alloy	1
5	Soldering wire	Joining metal parts to form a mechanical or electrical bond	1
6	Soldering paste	-----	1
7	Screw driver	-----	1
8	Net	-----	1
9	Glue gun	-----	1
10	Wash basin pipe	Draw small objects	1
11	Steel wire	-----	1
12	12V,2Amp Adaptor	Provides a wide input voltage range	1
13	6V 6Amp sansui battery	For supplying power to dc motor	1
14	Female Connectors	Use for electrical, physical or data transfer	As per requirement
15	Atmega_8	Microcontroller is used for motor control, sensor data processing etc	1
16	16 MHz Crystal	Create an oscillating signal at a frequency of 16 million hertz	1
17	22 pf	Used with crystals for loading purposes	2
18	Push button	To turn on and off the control circuit	1
19	1k resistor	--------	1
20	LED	--------	1
21	104 pf	--------	1

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22	Motor Shield	Allows to easily control motor direction	1
23	DC Motor	Allows the robotic vacuum cleaner to adjust its speed and direction based on sensor inputs	4
24	Servo Motor	Used for robotic applications that require precision positioning	1
25	Ultrasonic Sensor (HCSR04)	Range :2cm to 400cm , measures distance	1
26	Battery	12V 1.3ah battery 18650	4
27	Wheels	Differential steering, which uses separately driven wheels for movement	4
28	Jumper	Male to Female, Female to Male, Male to Male	30 (10 each)
31	Rainbow Wires	Rainbow Wire is ideal for neatly making multiple connections and extending controls across devices, especially in prototyping applications like robotics.	1.0m
32	Battery Holder	Securely hold cells in place while transferring power from batteries to the device.	1
33	Arduino cable	For connecting PC and Arduino	1
34	Relay Module	To switch electrical devices and systems on or off	1
35	DC Socket Terminal	A DC power jack receives power and is typically mounted on the PCB or device chassis.	1
36	L293D Motor Driver	Controls both the direction and speed of two DC motors simultaneously.	2
37	Servo Motor	Servo motors are used to control its speed when stepping on the gas pedal	1

3. Proposed Work

3.1 Design Approach

- We opted to modify the design from a circle to a square since our major goal was to increase overall cleaning efficiency. The rectangular shape (as shown in Fig 8)of our vacuum cleaner will help it to clean the corners of rooms more effectively.
- The robotic cleaner's movement is determined by the ultrasonic sensor's input. It moves until it detects an obstacle. When the ultrasonic sensor senses an object in front of it, it searches for a path that is free of obstacles and advances in that direction.
- The body of the robot is made up of several tiny components. A 300 rpm DC motor is attached to the scrubber (as shown in Fig 4) in the middle of the robot. The scrubber rotates(refer Fig 7) at a fast speed, providing excellent mopping action. The wheels are powered by four 60-rpm DC motors. It is equipped with one servo motor along with an ultrasonic sensor.

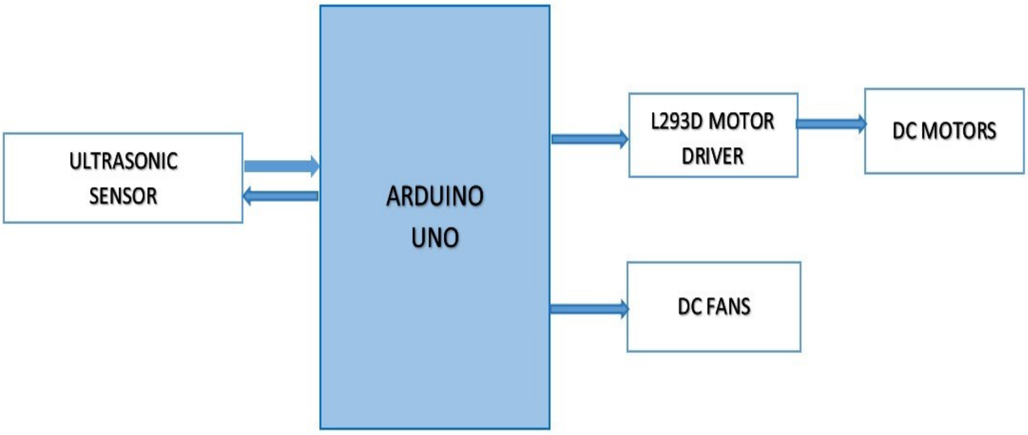

Figure 1. Schematic Diagram of Snoop Doggy

3.2 Working Methodology

- The Arduino microcontroller controls four DC motors connected through the L293D Motor Driver Shield, enabling automated robotic and mopping functionalities as illustrated in Fig 1. The motor driving regulator feature facilitates precise motion control, with adjustments possible through the Arduino microcontroller.

- The shield's main components include two L293D motor drivers and a 74HC595 shift register, which serve as its brains. The shield supports a motor voltage range of 4.5 to 25 volts (see Table 1 for component specifications), which can be used either independently or in conjunction with the Arduino.
- Adjacent to the two-terminal power connector is a unique jumper marked PWR, allowing selection between power sources. When the jumper is in place, electricity from the Arduino DC power jack powers the motors. In this setup, the motors and Arduino are not physically separated. This method simplifies shield usage, but is applicable only when the motor supply voltage is less than 12V (see Fig 2)
- The motors can be physically isolated from the Arduino when the jumper is removed, which also disconnects the motor power from the Arduino. But in this instance, the two-terminal power connector with the designation EXT_PWR requires a separate motor power source.Up to 600 mA (1.2A peak) of current can be supplied to the DC motor by each channel on the module. Yet, the motor power supply's capacity determines how much current is delivered to the motor.
- Two stepper motors can alternatively be connected to the output terminals. M1–M2 is connected to one stepper motor, and M3–M4 is connected to the other.

The shield exposes two 3-pin headers for connecting 16-bit PWM output lines, which can be used to connect two servo motors. However, it is not advisable to power servo motors directly from the Arduino's 5V supply, as this may risk damaging the Arduino's internal 5V regulator and introduce electrical noise to the supply. Nonetheless, the inclusion of a 100uF capacitor on these power pins provides some assistance

The circuit design of the project is as follows:

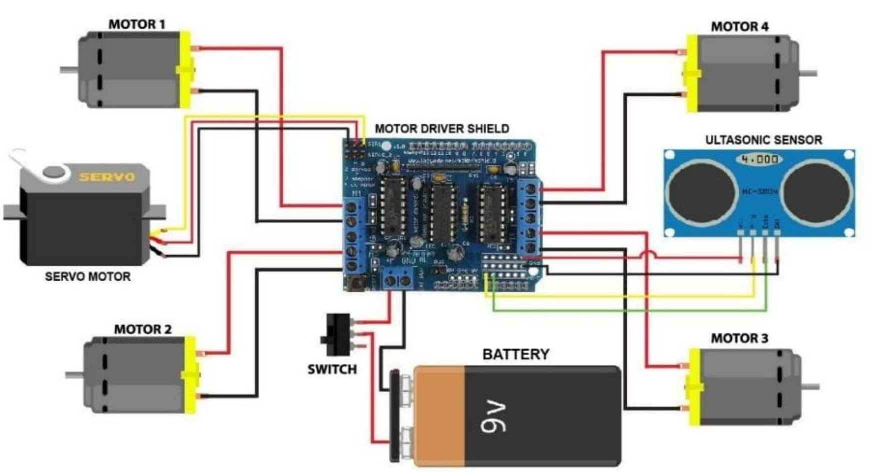

Figure 2. Circuit Design [16]

- The Ultrasonic Trig pin should be connected to pin number twelve on the Arduino, the Echo pin to pin number thirteen, the voltage pin to pin five, and the ground pin to pin zero. The Arduino and the sensor can communicate through the Echo and Trig pins.
- The voltage and ground pins supply power to the sensor, and the trig and echo pins enable data (refer Fig 6) transmission and reception between the sensor and the Arduino.
- The two motors should be connected to the motor shield's minimum of two outputs. These outputs are typically identified as "M1" and "M2," or "Motor 1" and "Motor 2."
- Connect the power bank and batteries to the Arduino and motor shield, respectively. Keep them apart from one another. There ought to be an input channel on your motor shield. Use AC adapters to connect any wires you may be using.

3.3 Experimental Setup

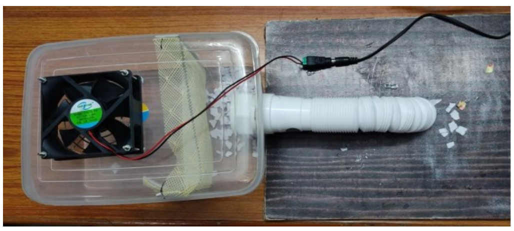

Figure 3. Working Module 1

Figure 3. represents the design of the part of the project that will be drawing the dirt present on the floor.

Figure 4. Working Module 2

Figure 4 represents the design of the part of the project that will scrub the dirt present on the floor and clear the patches of water present on the floor.

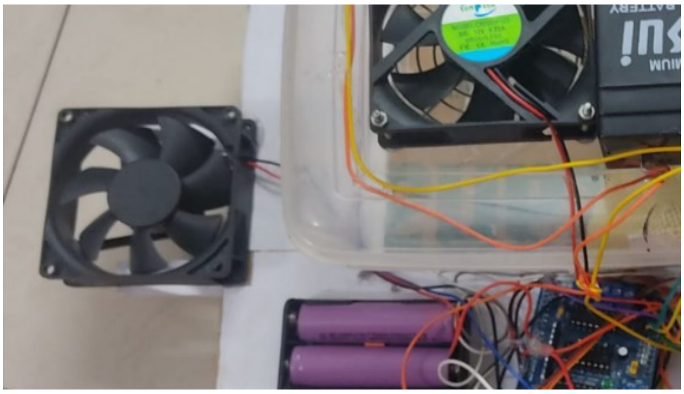

Figure 5. Working Module 3

Figure 5 represents the design of the part of the project that will dry the patches of water left behind after mopping the floor.

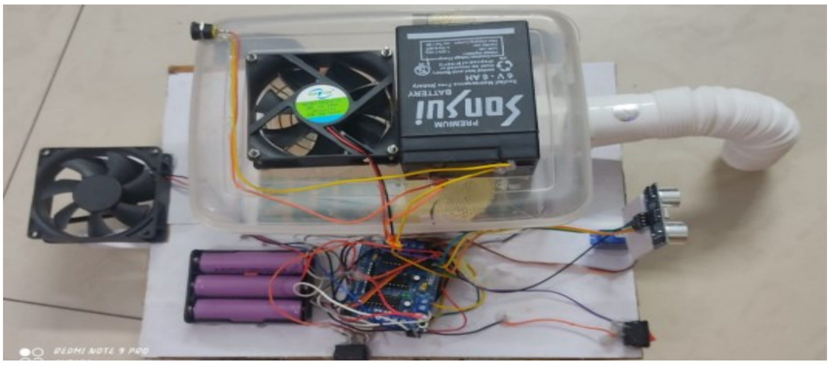

Figure 6. Top View

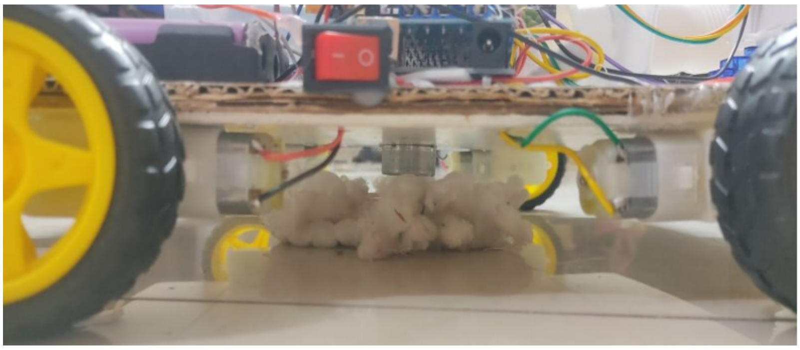

Figure 7. Side View

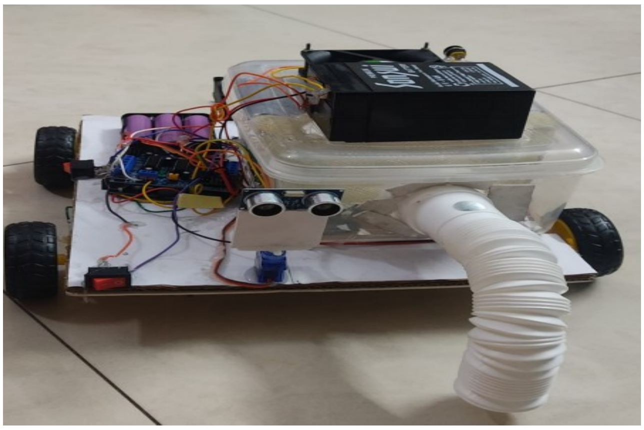

Figure 8. Front View

3.4 Challenges and Remedy

3.4.1 Challenges Faced

- We attempted to add Dirt Sensors. We need to be able to detect the amount of dirt entering the vacuum since dirtier regions must be cleaned for a longer period of time. If we do not clean these dirty regions for a longer period of time by slowing down the speed of the vacuum, the room will not be thoroughly cleaned at the end of the cleaning procedure.

- The vacuum cleaner's (refer Fig 5) fan runs at a modest speed. As a result, the suction range is rather limited. In other words, the vacuum generated is little.

- There was a lot of power usage due to a lot of component implementation. Only three lithium-ion batteries were unable to supply the necessary power.

- Initially, we used 120 rpm motors for the wheel. It moved when we held it in the air, but it couldn't move when we set it on the floor.

3.4.2 Remedial Strategies

- Dust, filth, and high-moisture conditions have little effect on ultrasonic sensors. As a result, we are unable to put it into action. As a result, we've decided to exclude it.
- We have included separate batteries for the vacuum cleaner, mopping, and dryer.
- We utilized three 3.7V lithium ion batteries for running the vacuum cleaner, mopping, and dryer. A 6V battery is required for the wheel and ultrasonic sensor to work.
- We decreased the revolutions per minute from 120 to 60 rpm and we were able to make it by locomotive.

4. Results and Discussion

4.1 Project Analysis

The project was finished based on the conclusions of the analysis, design, and execution. We are working hard to create a robot that can do the following things:

1) Determine the straight path and avoid obstacles.

2) Vacuum to collect dust

3) Clean the floor.

4) Air blower.

The autonomous floor cleaning robot prototype, equipped with Arduino Uno Microcontroller and ultrasonic sensors, facilitates efficient floor cleaning, reducing labor costs and saving time. It navigates with a front caster wheel and two rear wheels, identifies obstructions, and is suitable for institutes. Additionally, it is user-friendly and cost-effective, and if it is IoT-enabled.

4.2 System Evaluation

Within the following procedures, the Arduino Uno machine may be tested on an automatic ground cleansing robotic prototype:

1. Connect the battery to the hardware assembly of the automatic floor cleaning robot prototype and activate the switches, including one for the ultrasonic sensor and DC motor, and another for the vacuum cleaner, scrubber, and dryer.

2. The automatic floor cleaning robot prototype should then be turned on, together with any necessary accessories like an Arduino Uno, an ultrasonic sensor, an L293D motor driver shield, and a DC motor.

3. The ultrasonic sensor is connected to its supporting equipment after the automatic ground cleaning robotic prototype receives its last polish. It will identify the area between variables that presents a challenge.

4. Once the autonomous floor cleaning robot prototype identifies a challenging distance, it examines its surroundings to find an unobstructed path for cleaning.

5. Conclusion

The new product is unquestionably a game changer in the field of robotics and floor cleaning. If we clean the floor manually, there is a chance that the operator may leave some of the floor. Cleaning the floor is both time-consuming and annoying owing to the human effort needed. Also, in large workplaces, the floor space is quite large, and the staff involved in cleaning it cannot clean it very effectively. This is when the robot comes in handy. The robot is very tiny and compact in size. So we can take it around the home and put it anywhere we like. In addition, when compared to manual labor, robots are more cost-effective in enterprises. The flexibility, time saving and efficiency make the robot a good choice for cleaning the floor. The robots currently designed utilize a single vacuum cleaner, leading to significant power loss, and the proposed algorithm is ineffective. There is room for improvement and optimization until the most efficient product is achieved. Enhancing the algorithm, such as moving to a heuristic-based search like the bee algorithm, could greatly improve the product's potential to revolutionize the industry. With further development, it can be made cost-effective and energy-efficient. Measuring 33*30*20 cm, the robot is compact and mobile, fitting easily under furniture. Enhancements like battery level warnings and automatic charging detection could further improve its functionality.

5.2 Future Scopes

Today's households are growing smarter and more automated. Home automation provides ease and frees up people's time. Domestic robots are making their way into people's homes and daily lives, although the market is still young and immature. However, development is expected, and domestic robot usage is evolving. Aside from the functions like determine the straight path and avoid hazards, Vacuum to collect dust, Clean the floor, Air blower etc. It may be improved further by adding features such as alerting when the battery's goes below a specific level, and automatically detecting its charging station and searching its course appropriately. It may conduct a variety of cleaning duties and runs on environmentally friendly power sources such as solar or wind energy without the need for human interaction. The cleaner should be trained to ascend and walk down the stairs while cleaning them. It can be made sophisticated enough to recognize the quantity of filth on the floor and accordingly will wait and clean the floor until it is cleaned. It may also detect pathogens and spread sanitizer on the floor occasionally.

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