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DEVEOPMENT OF AN AUTONOMOUS SMART VACUUM CLEANER USING IOT

Dr N.P.Lavanya Kumari, A. S. KrishnaVeni, B.Vyshnavi, Chilla Vaishnavi

1Assistant Professor , [2]Designation of 2nd Author, [3]Designation of 3rd Author
[1]Department of Computer Science and Systems Technology,
[1]Andhra University college of Engineering(A)1st Author, Visakhapatnam, India

Abstract: In the current hectic schedule, cleaning houses and surrounding environment is more arduous. At present, there are vacuum cleaners which require humans to handle it. Thus, there is a need to implement vacuum cleaner which works without human intervention. An efficient method to clean the desired area has been implemented through this project. By using this vacuum cleaner, hazardous places can be cleaned which thereby reduce risks to mankind. This is achieved by implementing an autonomous system.

Here, RC car which is embedded with a vacuum cleaner is used. This system has an ultrasonic sensor attached to it, that helps in avoiding large obstacles such as tables, chairs, walls etc. By measuring the distance via this sensor, the car takes the direction where the distance between obstacle and car is more, hence avoiding the collision with the obstacles. The vacuum cleaner is designed with a CPU fan and a pipe is attached to the mouth of the bottle. The entire system is run by batteries.

In our busy lifestyles, cleaning our homes and surroundings has become a tedious task. While vacuum cleaners exist, they still require human intervention to operate. Thus, there is a need for an autonomous vacuum cleaner that can clean areas without human intervention. This work aims to achieve that goal by implementing a new and efficient system. The system consists of an RC car embedded with a vacuum cleaner, making it an autonomous cleaner. To avoid collisions with obstacles like tables, chairs, and walls, an ultrasonic sensor is attached to the car.

IndexTerms **– Automated Smart Vacuum Cleaner, Microcontroller, RC car, Ultrasonic sensor, Aurdini UNO,**

I. *INTRODUCTION*

Environment around us to be cleaned is one of the important duty of each and every individual. In the current COVID situation since social distancing has to be maintained, a greater number of people cannot clean together. In this era where digital technology is rising rapidly, mankind is becoming more and more dependent on the same. So, the Arduino can be coded to cover specific areas, moving the vacuum cleaner in the desired direction and the time taken for the same can be saved as it is possible through the car carrying it.

An automated vacuum cleaner is designed consists of a RC car to which a vacuum cleaner is attached. Ultrasonic sensor is attached to the front of the car which is used to measure the distance if any obstacle is detected. If suppose there is an obstacle, the car changes its course as per the code. It consists of CPU fan which runs by a battery. At the front of cleaner, a pipe is attached to suck the dust from the floor.

With the advancements in technology, the future of cleaning may involve more automation and smart devices that can make cleaning easier and more effective. The robot is designed using operations as cleaning mechanism, directional control with automatic obstacle avoidance and less space consuming.

REVIEW OF LITERATURE

Irawan, Yuda, Muhardi, Ordila, Rian, Diandra, and Roni proposed "Automatic Floor Cleaning Robot Using Arduino and Ultrasonic Sensor" Journal of Robotics and Control(JRC). This paper discusses about information regarding several parts, namely of an Ultrasonic Sensor, Motor Shield L298, Arduino Uno microcontroller, Servo, and Dc Motor. This tool works when the Arduino Uno microcontroller processes the ultrasonic sensor as a distance detector and a DC motor as a robot driver, then the DC motor is driven by the Motor Shield L298. When an ultrasonic sensor detects a barrier in front of it, the robot will automatically look for a direction that is not a barrier to the floor cleaning robot.

"Design and Manufacturing of Automatic Classroom Vacuum Cleaning Robot" by Aniket A Somwanshi; Sanjay B Matekar. This paper discusses that Robot an electromechanical device automates the work process in many areas like industries, military applications, domestic work, agricultural applications, etc. Robots are reliable means to carry objects, clean an area, etc. at places where human interventions are impossible or can cause hazardous effect on human health i.e., at chemical factories etc. The design prototype of Automatic Classroom Vacuuming Robot is discussed in this paper. This paper also summarizes the design of wheels, design of chassis, motor calculations for navigation, vacuum design in the implementation of automatic vacuum cleaner.

S Yatamono et al proposed a paper on "Development of Intelligent floor cleaning Robot". They have developed a smart floor cleaning Robot that can clean the place by navigating, sucking the dust and polishing the floor. The robot consists of an omni wheel which is equipped with a vacuum cleaner and floor polishing motor. It is coded in Arduino IDE by using Arduino microcontroller and it is equipped with Bluetooth so that it can work from smart phone connected via Bluetooth.

Smith, John, and Jane Doe. "Enhanced Navigation and Obstacle Avoidance Techniques for Mobile Robots." The authors explore innovative methods to improve navigation and obstacle avoidance, crucial for enhancing the autonomy and efficiency of these robots. Their research likely encompasses various strategies, such as sensor

fusion, machine learning algorithms, or advanced control techniques. By implementing these techniques, mobile robots can navigate complex environments with greater precision and safety, opening up possibilities for applications in fields ranging from logistics to search and rescue.

Li, Ming, et al. "A Review of Localization and Mapping for Autonomous Cleaning Robots." Robotics and Autonomous Systems. This paper likely offers a thorough examination of the current state-of-the-art techniques and methodologies employed in the localization and mapping processes specifically tailored for autonomous cleaning robots. It may cover various aspects such as sensor technologies, simultaneous localization and mapping (SLAM) algorithms, integration of odometer and inertial sensors, and other relevant Classroom Vacuuming Robot is discussed in this paper. This paper also summarizes the design of wheels, design of chassis, motor calculations for navigation, vacuum design in the implementation of automatic vacuum cleaner.

METHODOLOGY

The technology and components were elaborately discussed and plan made for implementation. Detailed study of requirements and functioning of various existing systems, components and its sub parts was undertaken for defining project methodology. Available technical literature and interaction with engineers working on these systems and components were carried out for finalization of efficient design at minimum cost and least time frame.

PROBLEM DEFINITION

Households of today are becoming smarter and more automated. Home automation delivers convenience and creates more time for people. Domestic robots are entering homes and people's daily lives, but it is yet a relatively new and immature market. However, growth is predicted and the adoption of domestic robots is evolving. This work can be very useful in improving life style of mankind. Our aim is to design the Automatic vacuum cleaner that will help to make household work convenient and much easier. It operates in autonomous mode. The flexibility, time saving and efficiency make the robot a clean choice for cleaning the floor.

REQUIREMENTS

HARDWARE:

ARDUINO UNO:

It is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc and initially released in 2010.The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

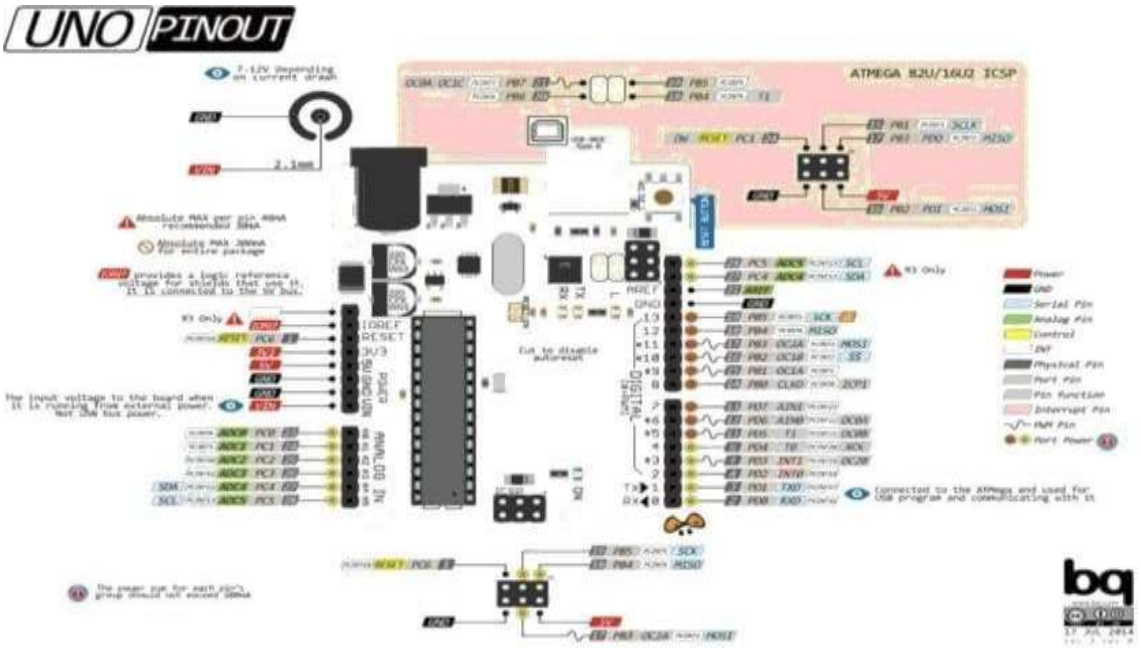


FIGURE:1 HARDWARE: ARDUINO UNO: PINOUT

(https://images.app.goo.gl/LCvMt7fUqy6Zym8Z7)

- *SOFTWARE:*

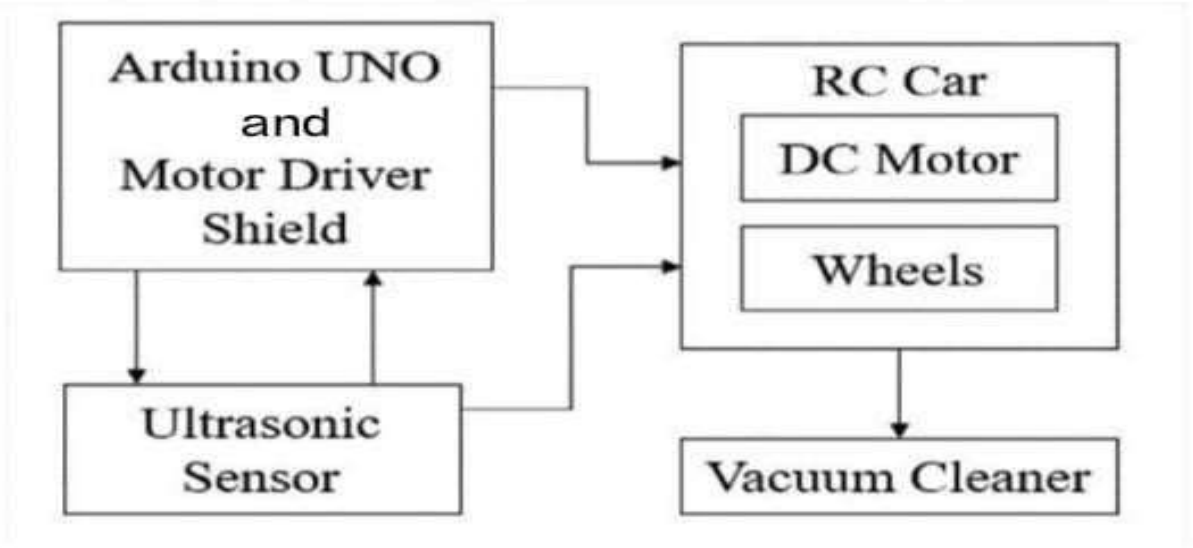
ARDUINO

The software used in this work, Arduino IDE. The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

PROPOSED BLOCK DIAGRAM

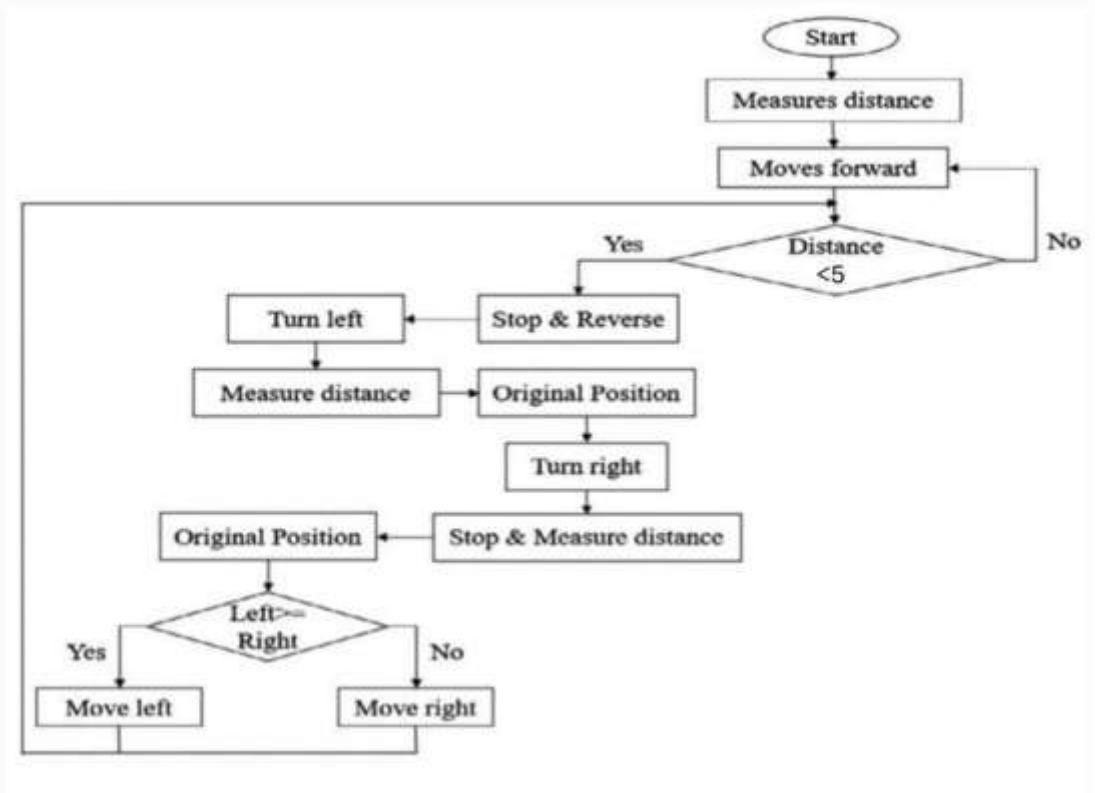
Motor Driver Shield is placed on top of Arduino Uno. In the front of the prototype, Ultrasonic sensor is attached which measures the distance. Towards the front of the car, vacuum cleaner is placed. The vacuum cleaner holds the CPU Fan. The wheels, DC Motor and batteries placement is as shown figure 2.

FIGURE:2 PROPOSED BLOCK DIAGRAM



WORK FLOW

Once the car is started, the distance is measured and moves forward. If distance is less than 5cm, it turns left and right respectively to measure distance and the prototype moves where the distance is greater. The same process repeats.



RC CAR AND ITS WORKING

The RC car designed is shown in Figure. Sheets have holes in specific areas. To these places, using nuts and bolts, the motor is fitted, motors are attached with wheels. Motors are soldered with wires – positive and negative. RC car is built by using 4 DC motors they run with the speed provided in Arduino IDE code, it uses motor shield to work in desired speed and direction. Ultrasonic sensor attached to RC car detects the distance at which obstacle is present in front of it. So, whenever it encounters any obstacles such as walls, tables, chair or any big things that cannot be considered as garbage or dust, RC car which carries vacuum cleaner changes its direction so that it won't crash and destroy itself. The code fed to the Arduino runs continuously and the cycle repeats in regular intervals whenever the obstacle is detected. The batteries are placed on the acrylic sheets. The robot works as a general RC car. Nothing new in this, it is just the same as a general car available in the market, the only difference being that we are making use of the Arduino software to detect obstacle and control the robot. There can be different obstacle encountered and based on the signals received from sensor, the robot changes its position. Adding to it we also attached a vacuum cleaner by using recyclable plastic bottle to clean the dust by providing it with sufficient voltage.

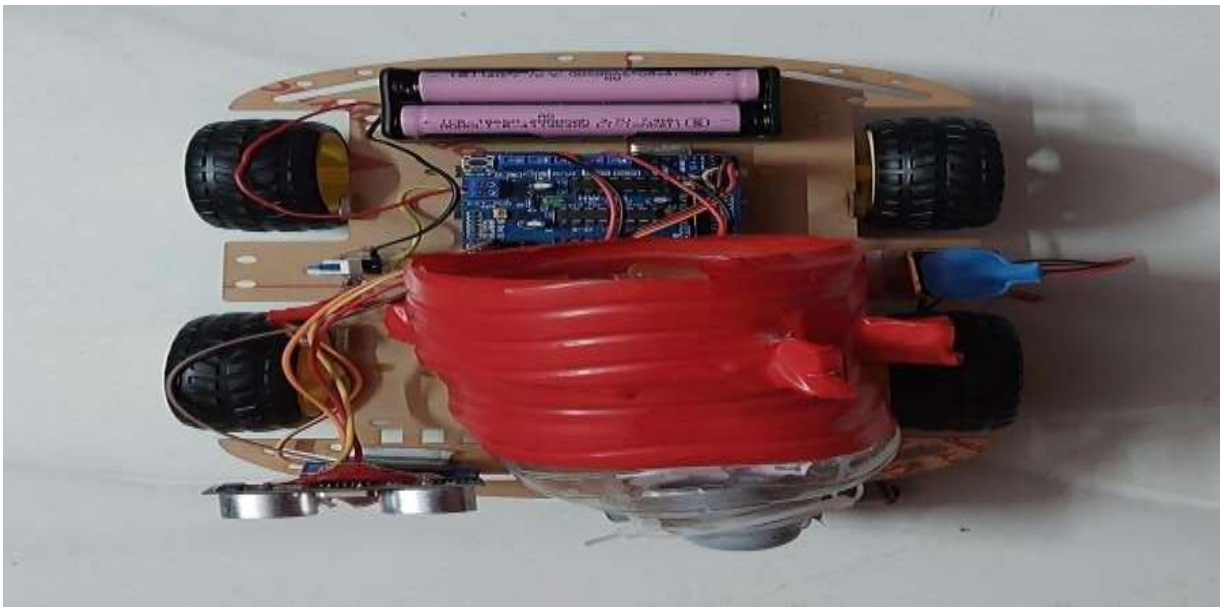


FIGURE:3 DEVELOPED RC CAR

COMPARISON

Table shows the comparison between the manual mode of cleaning and automatic mode. In manual cleaning, as the word says, human is required. Whereas, in automatic mode there is no human intervention. Automatic mode is helpful as it doesn't cause any health risks.

Comparison between manual and automatic system.

Features	Manual	Automatic (Designed Prototype)
Human intervention	Yes	No
Economic	No	Yes

FIGURE 4: CIRCUIT DIAGRAM 1
(https://images.app.goo.gl/MdarHW1773wecJJd9_)

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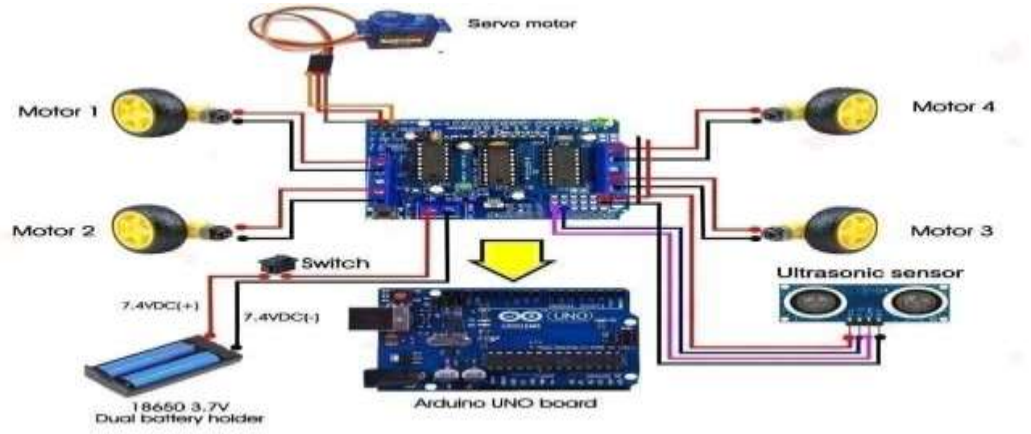
(https://images.app.goo.gl/MdarHW1773wecJJd9_)



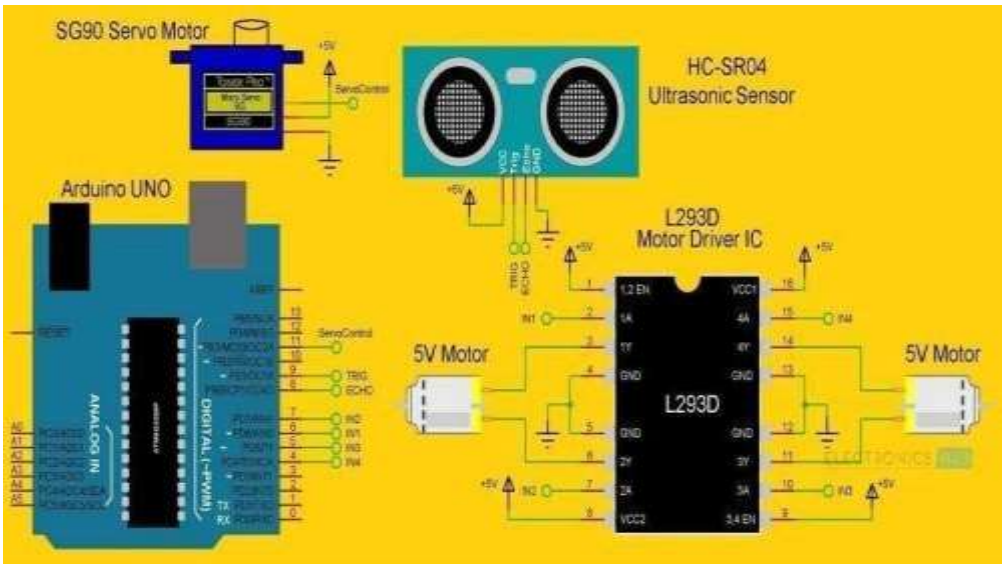


FIGURE 5: CIRCUIT DIAGRAM 2
(https://images.app.goo.gl/MdarHW1773wecJJd9)

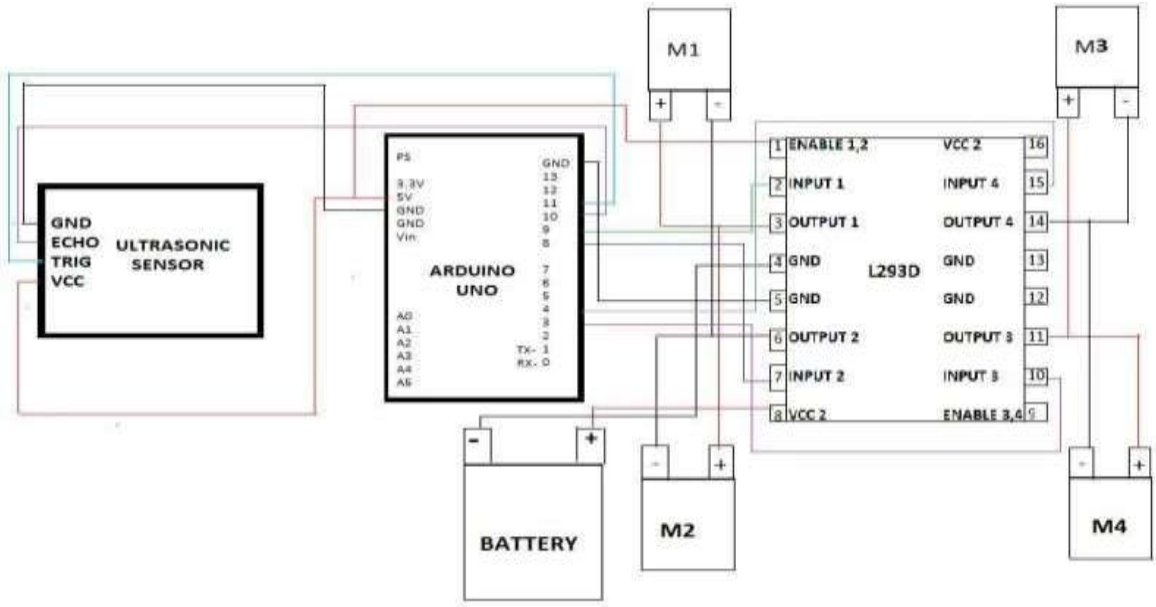


FIGURE 6: ARCHITECTURE
(https://images.app.goo.gl/wsPxzub5JtneCiBd6)

We have three ultrasonic sensors that detect obstacles. So, we need to connect all grounds of ultrasonic sensors and connected them to common ground. Also, we connect all the three Vcc of the sensor and connect that to the common VCC pin. Next, we connect the trigger and echo pins to the PWM pins of the Arduino. We also connect the VCC of the IR module to 5V and ground to the ground pin of Arduino, the output pin of the IR sensor module goes to the digital pin D2 of the Arduino. For the motor driver, we connect the two enable pins to 5v and also the driver voltage pins to 5V because we are using 5volt motors. In a previous article, we have made an Arduino Motor Driver Shield, you can check that out to learn more about L293D Motor Driver IC and its operations. The Arduino, Ultrasonic modules, motor driver, and motors work on 5 Volt, the higher voltage will kill it and we are using the 7.4-volt battery, to convert that into 5 Volt, the LM7805 voltage regulator is used. Connect the vacuum cleaner directly to the main circuit. To connect the ultrasonic sensors to the Arduino, we need to connect all the ground pins of the sensors together and then connect them to the common ground of the Arduino. Similarly, we connect all the Vcc pins of the sensors together and then connect them to the common Vcc pin of the Arduino. The trigger and echo pins of the sensors are then connected to the PWM pins of the Arduino.

For the IR sensor module, we connect the Vcc pin to the 5V pin of the Arduino and the ground pin to the ground pin of the Arduino. The output pin of the IR sensor module is connected to the digital pin D2 of the Arduino.

To control the motors, we need a motor driver. We connect the two enable pins of the motor driver to the 5V pin of the Arduino and the driver voltage pin to the 5V pin as well since we are using 5V motors. The Arduino, ultrasonic modules, motor driver, and motors all work on 5V, so we need to use a voltage

regulator like LM7805 to convert the battery voltage (which is 7.4V in this case) to 5V.

Finally, the vacuum cleaner is connected directly to the main circuit.

APPLICATIONS

The applications are as follows:

- Automated lawnmower.
- Smart room cleaner etc.
- Obstacle avoiding robots can be used in almost all mobile robot navigation systems.
- They can also be used in dangerous environments, where human penetration could be fatal.
- Unmanned vehicle driving.
- Mining Vehicle that uses Obstacle Detection.

TESTING AND OBSERVATIONS:

Stage 1:

Test of Climbing Capacity of robot was performed.

OBSERVATIONS:

1. Robot climbed the rod successfully.
2. The rpm provided during test was too high for the process.
3. The robot was observed to deviate to right side. The PWM of right front motor was increased. Still the deviation continued at a certain scale.

Stage 2:

The linearity issues of robot motions during first test were sever. In order to improve that, PWM was changed but still the problem remained. Later it was observed that the torque providing capacity of a front right motor was reduced. More over due to some current rating issues we had to change all the four motors and replace them with new 200rpm Johnson's geared motors. The linearity of the robot was corrected and the robot stopped deviating towards right.

Observations:

During the first test of the robot's motion, it was observed that there were significant issues with the linearity of its movements. Despite attempting to correct the issue by changing the pulse width modulation (PWM), the

problem persisted. Upon further investigation, it was discovered that one of the motors, specifically the front right motor, was not providing enough torque. Additionally, there were some current rating issues, which prompted the decision to replace all four motors with new 200rpm Johnson's geared motors. This replacement ultimately resolved the issue of the robot deviating towards the right, and the linearity of its movements was corrected.

Stage 3 & its observations:

The Vacuum arrangement was tested with an 8 V battery and it worked satisfactorily.

Stage 4 & its observations:

The entire assembled robot was tested. After assembling all the parts on the robot, the testing of feedback code was performed.

OBSERVATIONS:

1. Robot navigation was tested and found to be satisfactory.

2. The robot accumulated almost 55 to 65 percent of the dirt samples.

3. Reduced suction capacity of the vacuum was observed which may have happened due to following two reasons.

- Due to distribution of same current from 9V battery to the navigation motors as well as vacuum motor, navigation motors draw more current and thus the capacity of the vacuum motor is found to reduce.

- The motor drivers use PWM to control the vacuum motor, the signals of which vary between its maximum and minimum value. The dc motor used found it difficult to draw more voltage from the motor driver. And hence motor driver was observed to heat at extreme level.

4. During this testing phase the gears of the motor were observed to slip multiple times. This was due to jerk observed during the entry and exit of the robot from the rod.

5. The average time for robot to clean and navigate through one bench was observed to be 22 sec.

CONCLUSION AND FUTURE SCOPE

The goal of our project is to create an autonomous robot which intelligently detects the obstacle in his path and navigate according to the actions we set for it and collect dust along path.

The autonomous vacuum cleaner is not yet ready for commercialization, which was never the goal of the project. Many of the achieved result are very promising. The shape of the robot is well suited for the application specially for the task like cleaning along the ball, along legs and corners.

The ultrasonic sensor is able to identified obstacles. The combination of the robot shape and ultrasonic sensor system and its algorithm play well together and make the task of cleaning an unknown and un structure environment feasible.

The aim of the project is to develop a robot that can navigate autonomously, detect obstacles in its path, and clean the surrounding area. While the robot is

not yet ready for commercial use, the results achieved so far are promising. The robot's design is well-suited for cleaning hard-to-reach areas such as corners and along the baseboards.

THE FUTURE WORK OF ROBOT MAY INCLUDE AS FOLLOWS:

- Image/video captured of a objects can be fed to the controller so that the robot can clean the entire house according to the input fed.
- The cleaning mechanism on the robot can be replaced by a hand like structure so that it can lift things from one place to another.
- Voice controlled or remote controlled locomotion of robot

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