SMART VACUUM CLEANER ROBOT

A Project Report

Submitted by

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PROJECT TEAM:

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1. ABSTRACT

In recent years, people are becoming more career oriented and due their irregular working schedule it becomes challenging to maintain both home and office together. Most of the cases, they hire the cleaners to clean the home, office etc., but no trust on cleaners. To overcome the problem, Smart Vacuum Cleaner has come up with the more advancement in technology and is designed to automate cleaning process. This intelligent cleaning device leverages state-of-the-art technologies to enhance the efficiency and effectiveness of household cleaning tasks.

The core objective of this research is to design and implement a cost-efficient robotic system capable of autonomously navigating and cleaning indoor environments, adapting to various surfaces, and incorporating smart features for user convenience. The widespread adoption of vacuum cleaning robots can be attributed to several key benefits. Firstly, they save users valuable time and effort by automating the cleaning process. The compact design of these robots enables them to access hard-to-reach areas, enhancing overall cleaning coverage.

Furthermore, their quiet operation and energy efficiency contribute to a seamless and environmentally friendly cleaning experience. These robots employ brushes, suction mechanisms, and filters to capture dirt, dust, and debris. The principles of vacuum cleaning technology and airflow equations are employed for the component selection of the vacuum cleaner. As the autonomous board-cleaning robot acts against gravity.

2. INTRODUCTION

In today life, time management is considered as one of the most important factors. A very notable household chore is floor cleaning which is often considered as difficult and boring job. In most cases, cleaners are hired to do the task rather than the household residents do it.

The discomfort posed by this recurrent chore necessitated development of a vacuum cleaner that could assist human with such a task. A vacuum cleaner is an electromechanical appliance commonly used for cleaning floors, furniture, rugs and carpets by suction. An electric motor inside the appliance turns a fan which creates a partial vacuum and causes outside air to rush into the evacuated space. This forces any dirt or dust near the nozzle into a bag inside the machine or attached to the outside.

The demand to reduce manpower level has led to the design and development of automatic control systems, which enables unattended operations of the machinery. The current automatic integrated systems cover all aspects of Automatic vacuum cleaner operations. But main disadvantage is that they are bulky and require large manpower. So, to reduce even more manpower robot vacuum clear is developed.

Robot vacuum cleaners are well-known products. Still there are continuously new products introduced on the market, products with new or improved functionality. Robot vacuum cleaners are mainly used in domestic areas for removing particles from indoor floors.

The aim of this project is to learn more about the design and its requirement, and hopefully improve the function and reduce the cost of owning by making it with low-cost parts without compromising the quality of the vacuum cleaner.

3. LITERATURE REVIEW

Our study includes the current knowledge, findings, as well as theoretical and methodological contributions for development of automatic vacuum cleaner using Arduino. It involves concept development, which is a set of activities carried out in the system engineering to collect parameters of operational needs and develop suitable system for implementation.

A smart vacuum cleaner robot is able to avoid obstacle and vacuum the floor.

- Four motors in the robot are used for the purpose of movement of the robot and motor driver is used to control all the four motor individually. Motor driver helps the robot to turn easily and to stop.
- Flat rubber tires are used to increase the friction between the robot and the floor.
- Ultrasonic sensor is used to calculated the distance and when the distance is less than the specified value, it stops the robot
- Servo motor is used to turn the ultrasonic sensor in both the directions and based on the distance calculated in both the direction, the Arduino signals the motor driver to turn in the direction with more free space.
- Another motor is used with a fan fitted to it to collect the dust.
- To satisfy the power requirement of the all the 6 motors, two 9-volt batteries are used.
- Two transparent acrylic sheets are used to build the body of the robot.

4. MOTIVATION

The motivation to undertake this project is to hone professional skills in software development and integration with hardware. The work has been undertaken with the usage of state-of-the-art technology to meet the project objectives.

During the project work, we could explore individual technical skills, knowledge, creativity and practical application of theoretical studies. It gave opportunity to learn from the best engineers, in encouraging working environment. The successful design and development of the project has fulfilled desired motivational objective for the team members

As a learning value, at the workplace, over view of component and systems functioning and its design process was provided including physical demonstration of each sub part. It was allowed to interact with engineers working on these systems and components, and see various facilities, used for design, development, integration and testing purpose. It has assisted individual in gaining valuable real work experience. It was possible to get insight into the way technical business activities take place and challenges faced on daily basis. It has provided opportunities to explore technical interest and develop professional skills and competencies for the individual. It has provided opportunity to learn balance between office work, college study and social life, thus capability to handle more responsibilities.

During the project work, we could apply academic knowledge and concepts in to real life professional environment. Overall, this project work, provided necessary technical skills and professional experience, which is essential for a successful engineer and career development. The project has helped, learn resolving practical problems encountered during applicability of academic knowledge in real technical world to design, develop, integrate, fabricate and assess its functionality.

5. OBJECTIVE

Objective of this project is to design and develop smart vacuum cleaner, that will help to make household work convenient and much easier.

In this project new type of home intelligent cleaner adopted the ultrasonic sensor , which has the function of the real-time environment perception, is introduced, and this cleaner driven by dc motor has the ability of autonomous working by itself and the functions of the automatic detection and obstacle avoidance.

In recent years, robotic cleaners have taken major attention in robotics research due to their effectiveness in assisting humans in floor cleaning applications at homes, hotels, restaurants, offices, hospitals, workshops, warehouses and universities etc. basically, robotic cleaners are distinguished on their cleaning expertise like floor mopping, dry vacuum cleaning etc. Some products are based on simple obstacle avoidance using infrared sensors while some utilize laser mapping technique. Each cleaning and operating mechanism of robotic floor cleaners has its own advantages and disadvantages. For example, robots utilizing laser mapping are relatively faster, less time consuming and energy efficient but costly, while obstacle avoidance-based robots are relatively time consuming and less energy efficient due to random cleaning but less costly.

6. METHODOLOGY

The project 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.

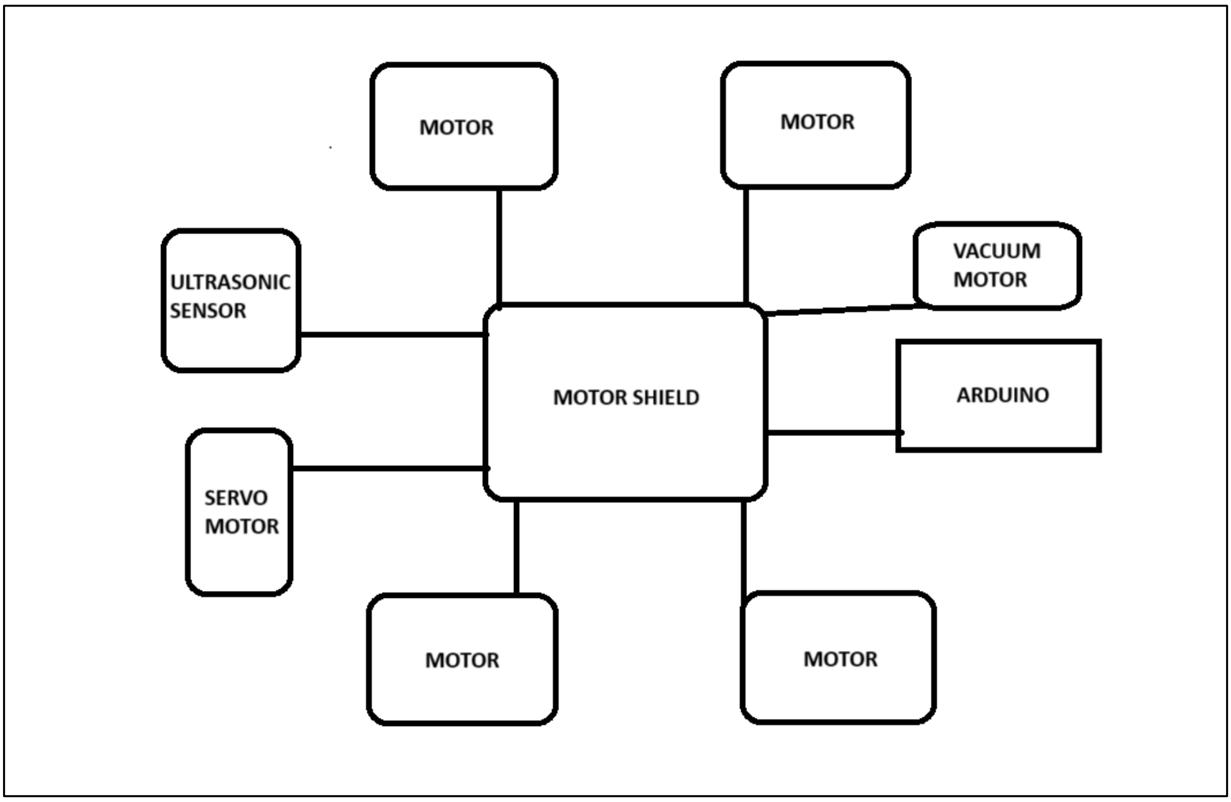

Fig:1 Basic Outline

7. 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 as well as in manual mode along with additional features like scheduling for specific time and dirt container with auto dirt disposal mechanism. The flexibility, time saving and efficiency make the robot a clean choice for cleaning the floor

7.1 SENSORS

Sensor is a device, which detects or measures a physical property and records, indicates, or otherwise responds to it. It is used to detect and respond to electrical or optical signals. It converts the physical parameter like temperature, pressure, humidity, speed etc, into a signal which can be measured electrically.

Sensors which we used in this project is:

- Ultrasonic Sensor

7.2 PROJECT IMPLEMENTATION

The project has combination of software and hardware components. The hardware used is Arduino with sensors like Ultrasonic sensor, Dc Motor and wheel. Arduino program for hardware integration is developed to process and transmit sensor signals, which is the software part. Apart from basic engineering knowledge , certain technologies cover Arduino and sensor, which is used for the project implementation .

8. COMPONENETS USED

8.1 DC MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with ac motor possible in many applications.

Dc motor is used in this project for the movement of wheel. High torque dc motor is used for the convenient movement of the wheel. As the weight of the automatic vacuum cleaner is approx. 3-4 kg we need a series dc motor which generate high torque. Dc motor is also used for controlling the speed of wheel of automatic vacuum cleaner. Dc motor is used to convert direct electrical energy into mechanical energy. DC motor work on the principal that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force". The direction of the mechanical force induced in a dc motor is given by Fleming's Left-hand Rule and its magnitude is given by F=BIL Newton.

Dc motor is connected with dc motor driver, which is further connected to the battery. Dc motor can rotate in both clockwise and anticlockwise movement of the wheel, as the load driven by Dc motor is more so armature current needed by it will also be more as a result high torque dc motor is required so that it can bear a heavy load.

Fig:2 DC Motor

8.2 DC MOTOR DRIVER

A dc motor driver is a device that serves to conduct in some predetermined manner the performance of a dc motor. A dc motor driver can be used to control the starting and stopping or in forward or reverse rotation of a wheel, regulating the speed of the wheel, limiting the torque and protecting against overloads and faults either a manual or automatic.

Common features of dc motor driver are:

• precise closed loop position control

• fast acceleration rates

• precise speed control dc motors may be made from several motor types, the most common being:

- brushed DC motor
- brushless DC motors

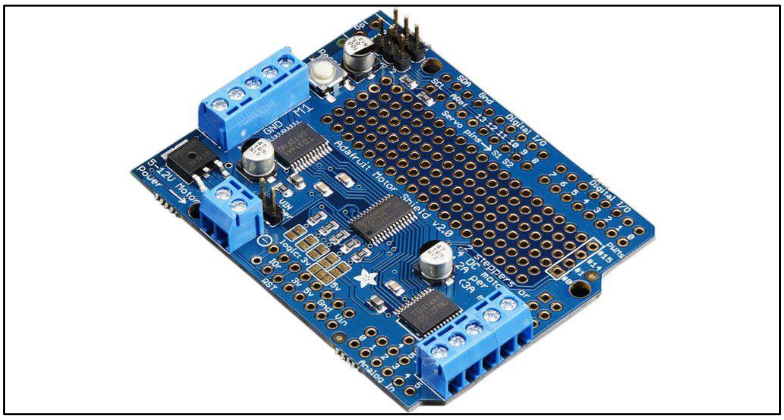

Fig:3 Motor Driver

8.3 ARDUINO UNO

The Arduino Uno is based on the ATmega328P microcontroller, which serves as the brain of the board. Arduino Uno has a total of 14 digital input/output pins, with 6 of them capable of PWM (Pulse Width Modulation) output. There are 6 analog input pins on the Arduino Uno, allowing it to read analog signals from sensors and other devices. Arduino Uno can be powered and programmed via a USB interface. It can be connected to a computer for programming and power supply. The analog input pins on Arduino Uno are connected to an ADC(analog digital converter), allowing the microcontroller to read analog sensor values and convert them into digital values.

Motor shield is connected to the Arduino uno for the operation.

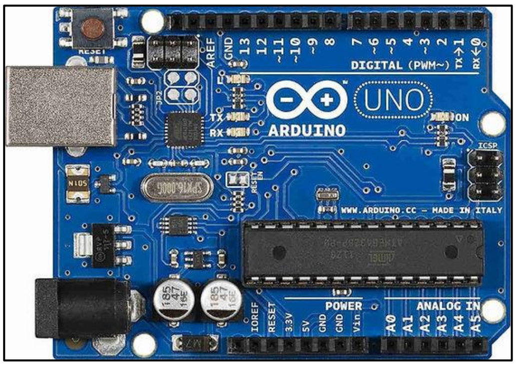

Fig:4 Arduino Uno

8.4 WHEEL

Wheel is used for the movement of the body from one place to another with the help of Dc motor. A wheel is usually of circular shape and hard and made up of durable material whose centre has a circular hole through which an axle bearing is placed about which the wheel rotates and when a moment is applied by the torque to the wheel about the axis, thereby making together and also easy movement of the automatic vacuum machine. When wheel is placed vertical axis under a load-bearing platform , the wheel turning on the horizontal axis makes it possible to transport heavy loads efficiently, when placed horizontally, the wheel turning on its vertical axis makes it possible to control the spinning motion used to shape materials , when mounted on a column connected to a chassis mounted on other wheels, one can control the direction of a automatic vacuum cleaner, when connected to a engine, a wheel control, release, or transmit energy.

Fig:5 Wheel

8.5 Ultra Sonic Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns. Ultrasonic sensors are a reliable, cost-effective solution for distance sensing, level, and obstacle detection.

How it Works?

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse. The working principle of this module is simple. It sends an ultrasonic pulse out at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor. By calculating the travel time and the speed of sound, the distance can be calculated.

Why Ultrasonic Sensor?

Ultrasound is reliable in any lighting environment and can be used inside or outside. Ultrasonic sensors can handle collision avoidance for a robot, and being moved often, as long as it isn't too fast. Ultrasonic are so widely used, they can be reliably implemented in grain bin sensing applications, water level sensing, drone applications and sensing cars at your local drive- thru restaurant or bank. Ultrasonic rangefinders are commonly used as devices to detect a collision

Ultrasonic Sensors are best used in the non-contact detection like presence, level, position, distance. Non-contact sensors are also referred to as proximity sensors.

Ultrasonic are independent of light, smoke, dust, colour, material (except for soft surfaces, i.e. wool, because the surface absorbs the ultrasonic sound wave and doesn't reflect sound.)

Long range detection of targets with varied surface properties. Ultrasonic sensors are superior to infrared sensors because they aren't affected by smoke or black materials, however, soft materials which don't reflect the sonar (ultrasonic) waves very well may cause issues. It's not a perfect system, but it's good and reliable.

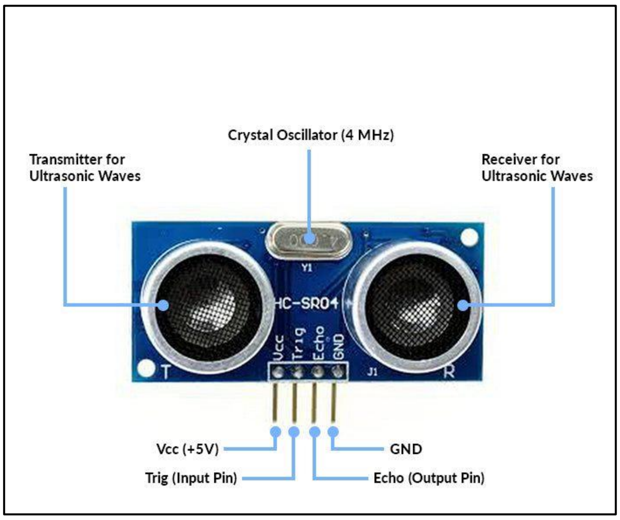

Fig:6 UltraSonic Sensor

9. VACUUM CLEANER PART

A vacuum cleaner, also known simply as a vacuum, is a device that causes suction in order to remove debris from floors, upholstery, draperies and other surfaces. It is generally electrically driven.

The dirt is collected by the chamber. Vacuum cleaners, which are used in homes as well as in industry, exist in a variety of sizes and models—small battery-powered hand-held devices, wheeled canister models for home use, domestic central vacuum cleaners, huge stationary industrial appliances that can handle several hundred litres of dust before being emptied, and self-propelled vacuum trucks for recovery of large spills or removal of contaminated soil. Specialized shop vacuums can be used to suck up both dust and liquid.

Most vacuum cleaners are supplied with numerous specialized attachments, such as tools, brushes and extension wands, which allow them to reach inaccessible places or to be used for cleaning a variety of surfaces.

The most common of these tools are:

- Hard floor brush (for non-upright designs)
- Powered floor nozzle (for canister designs)
- Dusting brush
- Crevice tool
- Upholstery nozzle

NOTE: This attachments may be included in the future.

The performance of a vacuum cleaner can be measured by several parameters:

- Suction
- Input power
- Output power

SUCTION

The suction is the maximum pressure difference that the pump can create. For example, a typical domestic model has a suction of about negative 20 kPa.

INPUT POWER

The power consumption of a vacuum cleaner, in watts, is often the only figure stated. The rated input power does not indicate the effectiveness of the cleaner, only how much electricity it consumes.

OUTPUT POWER

The amount of input power that is converted into airflow at the end of the cleaning hose is sometimes stated, and is measured in air watts: the measurement units are simply watts. The word "air" is used to clarify that this is output power, not input electrical power.

10. CIRCUIT DIAGRAM

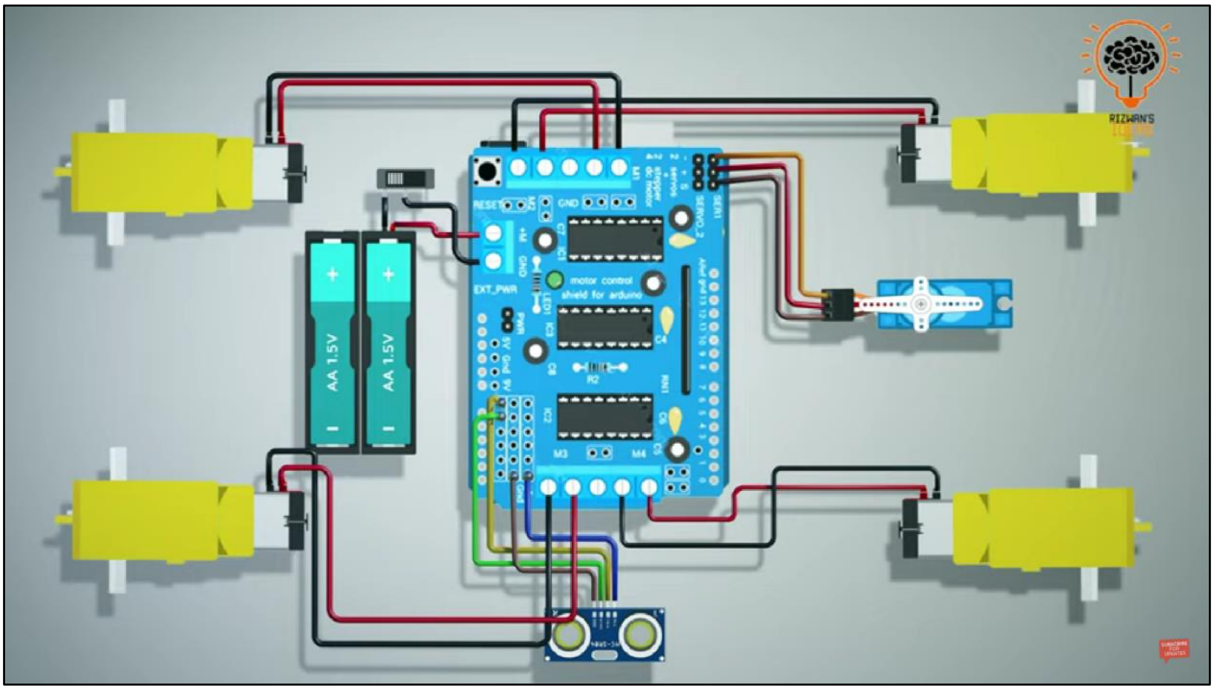

Fig:7 Circuit Diagram

11. WORKING OF MODEL

1. At the starting, the ultrasonic sensor checks the distance ahead and if the there are no obstacle, then the robot starts to move.

2. It slowly accelerates from 0 to max speed assigned.

3. After the acceleration the robot continuously checks the for any obstacle ahead, if it encounters one the robot slowly decelerates from max speed to 0.

4. With the help of the servo motor, ultrasonic sensor reads the obstacle distances in both the directions, and depending on the readings the robot turns the wheels.

5. After turning the same process repeats from step 1.

6. All through the processes the robot continues to suck the dust and impurities from the floor simultaneously.

12. ARDUINO SOURCE CODE

```
#include <AFMotor.h>                    //Import library to control motor shield

#include <Servo.h>                      //Import library to control the servo

AF_DCMotor rightBack(1);                //Create an object to control each motor

AF_DCMotor rightFront(2);

AF_DCMotor leftFront(3);

AF_DCMotor leftBack(4);

Servo servoLook;                        //Create an object to control the servo


byte trig = A0;                         //Assign the ultrasonic sensor pins

byte echo = A1 ;

byte maxDist = 150;                     //Maximum sensing distance (Objects further than this distance
are ignored)

byte stopDist = 50;                     //Minimum distance from an object to stop in cm

float timeOut = 2*(maxDist+10)/100/340*1000000;         //Maximum time to wait for a return signal

byte motorSpeed = 55;                   //The maximum motor speed

int motorOffset = 10;                   //Factor to account for one side being more powerful

int turnSpeed = 50;                     //Amount to add to motor speed when turning

void setup()

{

  rightBack.setSpeed(motorSpeed);              //Set the motors to the motor speed

  rightFront.setSpeed(motorSpeed);

  leftFront.setSpeed(motorSpeed+motorOffset);

  leftBack.setSpeed(motorSpeed+motorOffset);

  rightBack.run(RELEASE);                  //Ensure all motors are stopped

  rightFront.run(RELEASE);

  leftFront.run(RELEASE);

  leftBack.run(RELEASE);

  servoLook.attach(10);                    //Assign the servo pin
```

```
  pinMode(trig,OUTPUT);                    //Assign ultrasonic sensor pin modes
  pinMode(echo,INPUT);
}
void loop()
{
  servoLook.write(115);                    //Set the servo to look straight ahead
  delay(750);
  int distance = getDistance();            //Check that there are no objects ahead
  if(distance >= stopDist)                 //If there are no objects within the stopping distance, move
forward
 {
   moveForward();
 }
while(distance >= stopDist)                //Keep checking the object distance until it is within the
minimum stopping distance
{
   distance = getDistance();
   delay(250);
  }
  stopMove();                              //Stop the motors
  int turnDir = checkDirection();          //Check the left and right object distances and get the
turning instruction
  Serial.print(turnDir);
  switch (turnDir)                         //Turn left, turn around or turn right depending on the instruction
  {
   case 0:                                 //Turn left
    turnLeft (400);
    break;
   case 1:                                 //Turn around
    turnLeft (700);
    break;
   case 2:                                 //Turn right
```

```
      turnRight (400);
      break;
  }
}

void accelerate()                          //Function to accelerate the motors from 0 to full speed
{
  for (int i=0; i<motorSpeed; i++)              //Loop from 0 to full speed
  {
    rightBack.setSpeed(i);                     //Set the motors to the current loop speed
    rightFront.setSpeed(i);
    leftFront.setSpeed(i+motorOffset);
    leftBack.setSpeed(i+motorOffset);
    delay(10);
  }
}
void decelerate()                          //Function to decelerate the motors from full speed to zero
{
  for (int i=motorSpeed; i!=0; i--)             //Loop from full speed to 0
  {
    rightBack.setSpeed(i);                     //Set the motors to the current loop speed
    rightFront.setSpeed(i);
    leftFront.setSpeed(i+motorOffset);
    leftBack.setSpeed(i+motorOffset);
    delay(10);
  }
}

void moveForward()                         //Set all motors to run forward
{
  rightBack.run(FORWARD);
```

```
  rightFront.run(FORWARD);
  leftFront.run(FORWARD);
  leftBack.run(FORWARD);
}

void stopMove()                              //Set all motors to stop
{
  rightBack.run(RELEASE);
  rightFront.run(RELEASE);
  leftFront.run(RELEASE);
  leftBack.run(RELEASE);
}
void turnLeft(int duration)                              //Set motors to turn left for the specified duration then
stop
{
  rightBack.setSpeed(motorSpeed+turnSpeed);                //Set the motors to the motor speed
  rightFront.setSpeed(motorSpeed+turnSpeed);
  leftFront.setSpeed(motorSpeed+motorOffset+turnSpeed);
  leftBack.setSpeed(motorSpeed+motorOffset+turnSpeed);
  rightBack.run(FORWARD);
  rightFront.run(FORWARD);
  leftFront.run(BACKWARD);
  leftBack.run(BACKWARD);
  delay(duration);
  rightBack.setSpeed(motorSpeed);                        //Set the motors to the motor speed
  rightFront.setSpeed(motorSpeed);
  leftFront.setSpeed(motorSpeed+motorOffset);
  leftBack.setSpeed(motorSpeed+motorOffset);
  rightBack.run(RELEASE);
  rightFront.run(RELEASE);
  leftFront.run(RELEASE);
```

```
  leftBack.run(RELEASE);
}
void turnRight(int duration)                    //Set motors to turn right for the specified duration then stop
{
  rightBack.setSpeed(motorSpeed+turnSpeed);          //Set the motors to the motor speed
  rightFront.setSpeed(motorSpeed+turnSpeed);
  leftFront.setSpeed(motorSpeed+motorOffset+turnSpeed);
  leftBack.setSpeed(motorSpeed+motorOffset+turnSpeed);
  rightBack.run(BACKWARD);
  rightFront.run(BACKWARD);
  leftFront.run(FORWARD);
  leftBack.run(FORWARD);
  delay(duration);
  rightBack.setSpeed(motorSpeed);                 //Set the motors to the motor speed
  rightFront.setSpeed(motorSpeed);
  leftFront.setSpeed(motorSpeed+motorOffset);
  leftBack.setSpeed(motorSpeed+motorOffset);
  rightBack.run(RELEASE);
  rightFront.run(RELEASE);
  leftFront.run(RELEASE);
  leftBack.run(RELEASE);
}
int getDistance()                               //Measure the distance to an object
{
  unsigned long pulseTime;                      //Create a variable to store the pulse travel time
  int distance;                                 //Create a variable to store the calculated distance
  digitalWrite(trig, HIGH);                     //Generate a 10 microsecond pulse
  delayMicroseconds(10);
  digitalWrite(trig, LOW);
  pulseTime = pulseIn(echo, HIGH, timeOut);     //Measure the time for the pulse to return
```

```
  distance = (float)pulseTime * 340 / 2 / 10000;    //Calculate the object distance based on the pulse
time
  return distance;
}
int checkDirection()                                            //Check the left and right directions and decide which
way to turn
{
  int distances [2] = {0,0};                                //Left and right distances
  int turnDir = 1;                                          //Direction to turn, 0 left, 1 reverse, 2 right
  servoLook.write(180);                                     //Turn servo to look left
  delay(500);
  distances [0] = getDistance();                            //Get the left object distance
  servoLook.write(0);                                       //Turn servo to look right
  delay(1000);
  distances [1] = getDistance();                            //Get the right object distance
  if (distances[0]>=200 && distances[1]>=200)               //If both directions are clear, turn left
    turnDir = 0;
  else if (distances[0]<=stopDist && distances[1]<=stopDist)    //If both directions are blocked, turn
around
    turnDir = 1;
  else if (distances[0]>=distances[1])                      //If left has more space, turn left
    turnDir = 0;
  else if (distances[0]<distances[1])                       //If right has more space, turn right
    turnDir = 2;
  return turnDir;
}
```

FUTURE SCOPE OF THE PROJECT

- **Advanced Navigation Systems:**

  Implementing more sophisticated navigation algorithms using machine learning and computer vision to enhance the robot's ability to navigate complex environments, avoid obstacles, and adapt to changing layouts.

- **Multi-Room and Multi-Floor Capability:**

  Designing robotic vacuum cleaners that can seamlessly navigate between multiple rooms and floors, possibly using advanced mapping and localization technologies to create efficient cleaning routes.

- **Integration with Smart Home Ecosystems:**

  Enhancing connectivity and integration with smart home ecosystems, allowing users to control and monitor the robotic vacuum cleaner through voice commands, mobile apps, or other smart home devices.

- **Object Recognition and Manipulation:**

  Introducing features that enable the robot to recognize and handle objects on the floor, such as picking up small items, avoiding delicate obstacles, or adapting cleaning patterns based on the type of surface.

- **Enhanced Cleaning Capabilities:**

  Developing improved cleaning mechanisms, including advanced suction technologies, brush systems, and the ability to tackle a wider range of floor types and surfaces.

- **Self-Cleaning Mechanisms:**

  Introducing self-maintenance features, such as the ability to empty the dustbin automatically, self-cleaning brushes, and sensor calibration to ensure optimal performance over time.

- **Energy Efficiency and Battery Life:**

  Improving energy efficiency and extending battery life to allow for longer cleaning sessions and reduce the need for frequent recharging.

- **Collaborative Cleaning:**

  Exploring the potential for multiple robotic vacuum cleaners to collaborate and work together to clean larger spaces more efficiently.

- **Customizable Attachments and Accessories:**

  Designing robotic vacuum cleaners with modular and customizable attachments to address specific cleaning needs, such as mopping attachments for hard floors or specialized brushes for pet hair.

CONCLUSION

In conclusion, the development and implementation of the robotic vacuum cleaner project represent a significant stride towards revolutionizing household cleaning. Through the integration of advanced sensors, intelligent algorithms, and user-friendly design, our robotic vacuum cleaner not only streamlines the cleaning process but also enhances user convenience. The incorporation of cutting-edge technology ensures efficient navigation, thorough cleaning, and adaptability to various home environments.

Moreover, the project underscores our commitment to sustainable, eco-friendly solutions, cost efficient, as the robotic vacuum cleaner optimizes energy consumption and minimizes waste. The positive impact on users' daily lives is evident through time savings and the reduction of manual labour, allowing for a more relaxed and enjoyable living experience.

As we move forward, continuous innovation and updates will further refine the capabilities of our robotic vacuum cleaner, ensuring its relevance in the dynamic landscape of smart home technologies. The success of this project is a testament to our dedication to enhancing the quality of life through intelligent and accessible solutions, marking a significant milestone in the realm of home automation.

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