

Waste Management Using Robotics

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Abstract

Robotics is the future. And the future is now. Robotics was first used in automation of large scale industries and then small scale industries. Now, robotics is being introduced into fields where there is a scope for reduction of human effort. Households of today are becoming smarter and more automated. Home automation delivers convenience and frees up more time for people. Domestic robots are entering the homes and people's daily lives, but it is still a relatively new and immature market. However, growth is predicted and adoption of domestic robots is evolving. Several robotic vacuum cleaners are available on the market but only a few specialize in wiping of floors with water. This paper presents a project that follows a product development process, includes the stages of project planning, market research, setting a requirement specification, concept building, concept evaluation and selection and embodiment design. It entails our journey to creating a compact yet powerful waste management robot that is capable of performing both wet and dry cleaning operations. The idea is to build a robotic device that sweeps while traversing the whole enclosed area in one phase and then wipes the area in the other. The constructed prototype serves as a learning tool that facilitates in revealing new aspects and recognizing features that should be developed in the robot. A technology-intensive product of this kind requires the end users to adapt to a new technology. Therefore, a user-centred approach is strongly recommended to ensure better marketability of the product.

Keywords: *Robotics, Automation, Arduino*

INTRODUCTION

Robotics technology has made remarkable contributions over the last few decades in various fields, from space to underground, from industry to household. By synergistic integration and combination of various disciplines of science and engineering, this interdisciplinary technology has made life easier, secure and enjoyable. Their applications are far reaching and encompass a variety of objectives. They are used in the manufacturing industry to perform repetitive or difficult tasks, in the military to travel and operate in dangerous areas, and in the medical industry to assist in procedures. Robotics has a lot of scope in household domain too. Sweeping and wiping is a monotonous job and human beings have to perform this daily at home. It is also time consuming and laborious. Hence, the goal of this paper is to present a conceptual solution that provides the user with automated vacuum cleaning and mopping of floors and to create a working prototype that demonstrates the solution. There are several problem areas that are required to be solved to introduce this type of product on the market e.g. path planning, detecting obstacles or the maintenance in between cleaning cycles, while keeping

the robot as small as possible to enable its mobility in any home. Section II discusses the study of past research and existing systems related to autonomous cleaning; Section III explains the mechanical construction of the device. Section IV elaborates the working principle of the robot. Section V summarizes the results obtained and it also proposes some possible improvements that can be brought about into the device in future.

BACKGROUND

There are many papers available on this particular robotic application. Paper [1] deals with **understanding the use of ultrasonic sensors** and has concluded that the algorithm proposed in the paper designs a kind of detection system based on ultrasonic sensor capable of both forward and backward movement. Paper [2] explains the need to make a compact design based on the design of an elementary and low cost device by applying modern robotic technology. Primary importance has been given to the size and dimensions of the device as it has to go very near the obstacle without actually colliding with it in order to properly navigate and clean the area.

It consists of two process algorithms which involve:

- a) Surface navigation which involves efficient floor traversing mechanism by detecting and avoiding obstacles.
- b) Cleaning the surface by wiping and/or sweeping it.
- c) Additional algorithm is provided to enable the robot to work on an elevated surface like the top of a table or near the staircase. For this, a cliff sensor kind of system was integrated.

Paper [3] describes the development of a multifunctional floor cleaning robot. It proposes a new mopping method to clean the floor by using a sponge, and also the design of a mopping module with its geometric parameters optimized by analyzing the amount of water to be pumped out or recycled. At present, the cleaning robot industry is witnessing rapid growth and there are varieties of cleaning robots on the market. With the development of the cleaning robot industry, the demands for better features of a cleaning robot are on the rise. Consumers demand functional diversification, more intelligence and lower prices.

Floor cleaning robots available in the market include Samba Intelligent Robot, Scooba iRobot, Icelob intelligent cleaning

robot, SR8855, Roomba-560. Most of them are sophisticated with individual functionality of automatic vacuum cleaning, mopping, sterilizing, time cleaning, speed selection, and wireless remote control. Although several robotic vacuum cleaners are available in the market, only a few can be used for wet cleaning of floors along with vacuum cleaning. Most of them perform only their inherent vacuum functions. It is hard to find another mopping robot product besides the two series of Scooba and Mint. If the floor needs to be washed, you have to buy an extra mopping robot. This way, cleaning the floor by using several different cleaning robots is not a good choice because more robots means more space will be taken. Besides, it will also increase manufacturing costs. The residual water in mopping technology has been another big challenge which hinders the development of the mopping robot industry. It is the need of the hour to find another highly feasible mopping method to bring new interest in the mopping robot technology.

DESIGN AND DEVELOPMENT OF A MULTIFUNCTIONAL CLEANING ROBOT

The purpose of the project is to implement an automated wet and dry cleaning system.

The proposed system is expected to:

- a) Remove the debris and large particles from the floor.
- b) Wet clean the floor with fresh water.
- c) Remove the dirty water and leave the floor as dry as possible.

This type of product must bring more convenience for the customers using it, apart from good cleaning. Hence, the functional part is independent from cleaning robot such that the cleaning robot can connect several functional modules e.g., mop, dust collection etc. to incorporate several primary and secondary cleaning functions in a single robot. The device not only has to avoid an obstacle but also has to go very near the obstacle almost touching it without actually colliding with it in order to properly clean the area. For this kind of application, the size and circular shape of the robot is of primary importance.

A. Design of chassis

The design of chassis is the first step taken to build the rest of the robot. The design of

chassis involves procurement of an acrylic sheet of 35 mm diameter and 5 mm thickness. This acrylic sheet acts as the chassis of the robot. Many mechanical and electrical components need to be mounted on the chassis. Acrylic chassis was selected considering the weight constraint of the bot as it is required to be light and portable for household cleaning. In order to seal the acrylic chassis, we melt the tube with heat. The wheels are fabricated using simple plastic frame and rubber grip on it.

Once the chassis was selected and the required drill holes and cut outs were made, the next stage was to place the components. The placement of the components is discussed below.



Fig 1: Final Chassis material selected – Acrylic

B. Design of components

The side gear box motor used for motion of the robot is placed along the diameter. For balancing the weight, if the components and centre of gravity of the body motors are offset by a few mm, it is rectified by trial and error method which involved positioning the motors in various settings and allowing the chassis to balance itself on its two side wheels.

However the chassis may still not balance itself on its two wheels. When this happened, an additional caster bearing was attached in such a way that the load was distributed on all three wheels. This led to positioning the wheels in a triangular formation with each of the two wheels and the caster bearing at the vertex of this formation.

The vacuum system was made from scratch using a cylindrical container of 90 mm diameter and a height of 120 mm. The container was pre-equipped with a cap which provided complete enclosure to the system. A plastic ring containing a thin film of a wire meshed material was fixed into the cylindrical container at a distance of 30 mm from the top portion. Atop this the meshed material of the suction mechanism was placed.

The suction mechanism consists of BLDC motor of A2208/14T configuration and a propeller fan attached to its shaft. This mechanism is mounted on the cap, such that the propeller blade faces the wire mesh. Before permanently affixing this mechanism, a hole of 20 mm was drilled onto the cap to allow the wires of the motors to come out of the cap and be connected to the power supply.

At the other end of the cylindrical container, a hole of 30 mm was drilled to enable a pipe of 30mm to be tightly fit into the hole by means of an adhesive which also acts as a cementing element. The cylindrical container was tested to check if the components within it were able to withstand the suction pressure, by connecting the motor to a lithium polymer power supply. The system passed this stage of testing which enabled us to place the other supporting components onto the chassis.

The next stage is to drill a hole of 30 mm in the acrylic chassis to allow the protrusion of the suction pipe through this hole as this enables successful suction action. The system was then checked whether it would withstand the load of the cylindrical container consisting of the vacuum mechanism. The system passed

the test.

C. Design of sensory equipments

There are two types of sensors used in this project. The ultrasonic sensors are placed in front and two at 45° from the one in the middle. They are used to detect the obstacles around the body of the robot.

This enables the robot to navigate its way through the debris but avoid the hard surfaces such as walls and doors, which may cause harm to the body of the robot.

The infrared sensors are placed below the chassis. They are used to detect the depth i.e., cliffs and valleys that aren't normally detected by ultrasonic sensors. These sensors come to use in cases where the robot moves at an elevated surface that has abrupt ends or isn't enclosed completely.

D. Design of cleaning functions

The next stage was to affix the brushing mechanism. The placement of the brushes is such that the spinning action of the brushes would bring the dust particles or any debris collectively to the mouth of the suction pipe.

Hence, it disallows any means of escape for the debris in the region of the robot's motion. The brushes, since made out of

sturdy yet fine material, have the capacity of brushing over debris of up to 15mm in size into the mouth of the suction pipe.

There are two sponges used in this robot and they are placed at the bottom of the rear portion of the chassis. These sponges are controlled by the BO series gear motor. The sponges are used to perform the wet cleaning action which includes scrubbing of dirt off the floor by circular motion of the sponges.

The sponges are strategically placed at the bottom of the rear portion of the robot. This way, the sponges also provide a cushion to the robot. This is beneficial in more than one way.



Fig 2: Final arrangement of the components on the chassis

WORKING PRINCIPLE AND ALGORITHM

The cleaning function is carried out in a three-step process:

Firstly, the cleaning robot starts to move, at the same time spraying the cleaning fluid to the front of the cleaning robot. Secondly, brush will scrub the floor which has been sprinkled with cleaning fluid. Thirdly, the pump will extract the cleaning fluid from the ground. The leftover cleaning fluid, which can cause damage to the ground (e.g., real wood, etc.), is absorbed by the sponge. The idea is that the robotic device sweeps while traversing the whole enclosed area in one phase and

then wipes the area in the other. While traversing the area, ultrasonic sensors are used to detect obstacles. Based on the input from the sensors, output from the processor is fed to the motors to control the movements of the connected wheels. For sweeping, the motor with the brush rotates continuously, and the dirt, on the ground that is pulled by the brush, is dragged along the surface of the box and thrown into the box. The function of the robot includes transportation and containment of dust, dirt and debris as well as emptying the contents. The entire system needs to be capable of carrying out these functions for the project to be successful.

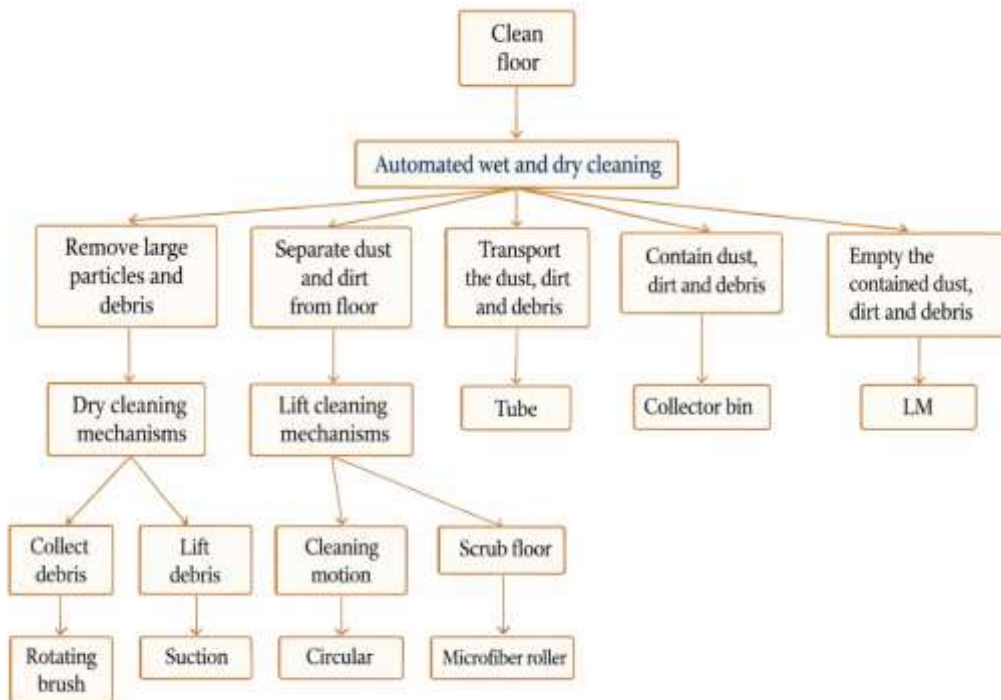


Fig 3: Framework of project

Programming

In order to control and automate the robot, it is necessary to program the robot to tackle any and all ambiguity that may arise during the cleaning operation. For this purpose, we used Arduino, an open source and low cost software, which uses programmable microcontroller boards (like Arduino Uno used for our project) to create devices that interact with their environment using sensors and actuators.

A part of the programming used for movement of the robot and performing different cleaning functions is described below:

```
#define trigPin1 6
#define echoPin1 7
// Motor 1
Int dir1PinA = 2; int dir2PinA = 3;
Int speed PinA = 10; // Needs to be a
PWM pin to be able to control motor
speed
Void setup ()
{
  Serial. Begin (9600);
  Pin Mode (trigPin1, OUTPUT);
  Pin Mode (echoPin1, INPUT);
}
Void loop ()
{
```

```
  Long duration1, distance1, duration2,
  distance2, duration3, distance3;
  Digital Write (trigPin1, LOW); // Added
  this line
  Delay Microseconds (2); // Added this line
  duration1 = pulse in (echoPin1, HIGH);
  distance1 = (duration1/2) / 29.1;
  Serial. Print (distance1);
  Serial.println (" cm 1 "); Serial. Print
  (distance2);
  If (distance1 < 8 && distance2 > 8 &&
  distance3 > 8) { // this is where the LED
  On/Off happens
  Analog Write (speed PinA, 80); Digital
  Write (dir2PinA, HIGH); digital Write
  (dir1PinA, LOW);
  Delay (1000); return;
  }
  If (distance1 < 8 && distance2 < 8 &&
  distance3 > 8) { // this is where the LED
  On/Off happens
```



Fig 3: Working model prototype

CONCLUSION AND POTENTIAL FUTURE WORK

An economic version of the robots available in the market today has been successfully built, and this version of the robot is compact and easily controlled by an android application, which makes it easier to control the semi-automated robot.

There are certain limitations to the robot that has been built to complete this study. The size of debris that can be lifted into and stored in the container is small due to restrictions of the size of the suction pipe mouth. Also, the problem of the life of the battery persists due to the requirements of different loads at different points of the cleaning operation.

The other limitation is that the wet cleaning action hasn't been as successful in the trial runs.

Despite the limitations, there is a lot of scope to take this prototype forward by extensive research and testing. The scope for this project includes:

- Increase the diameter of the suction pipe to increase the amount and size of debris, dust or dirt being cleaned up.
- The control of the robot may be further

refined to include other methods of controlling the robot than just by means of Bluetooth.

- Experimentation on size and thickness of brushes can be done to increase the collection of debris.
- A solution of soap and water can be introduced into the water pump and a provision to wipe the soapy solution and dry the surface after cleaning can be provided.

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