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Vacuum Cleaning Robot and Cleaning System

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Abstract: *Manual work is taken over the robot technology and many of the related robot appliances are being used extensively also. Here represents the technology that proposed the working of robot for Floor cleaning. Households of today are becoming smarter and more automated. Home automation delivers convenience and creates more time for people. Vacuum Cleaner Robot is designed to make cleaning process become easier rather than by using manual vacuum. The main objective of this project is to design and implement a vacuum robot prototype by using Controller, Motor, Ultrasonic Sensor, and to achieve the goal of this project. The whole circuitry is connected with 12V battery. Vacuum Robot will have several criteria that are user-friendly. Although a robot vacuum cleaner is a well-known product, development is still interesting. Better working sensors and more sophisticated algorithms and sensors are used in new cleaners. The purpose with this thesis was to learn more about different sensors, algorithms, and designs of robot vacuum cleaners. The material required is knife cut plastic sheets, printed parts, and receiving motors, using this costs did not exceed the budget. Literature review in this area of interest was studied to find answers to some of the research questions. The development method used was iteration of finding useful information, testing components and codes. The components used were DC motor, stepper motors, ultrasonic sensors, Micro controller, switches and batteries. The different components required different voltage and the stepper motors used driver cards.*

Keywords: Vacuum Cleaner, Robotic Mechanism , Floor Cleaning, Automation, Controller

I. INTRODUCTION

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 these theories was to learn more about the design and its requirement, hopefully be able to improve some functions and finally have a functional prototype for testing. The research and development of an autonomous mobile robot and a Manual Phone Application Control prototype able to vacuum cleaning a room or even an entire house is not a trivial challenge. In order to tackle such a task, so that it could be completed in six weeks (the duration of the course), some simplifications and assumptions were made to the designers initial idea of an “ideal” autonomous vacuum cleaner. In this way some functional requirements that would improve the robot performance were not taking into account due either to their inherent complexity or to their mechanical implications. These robots operate semi- or fully autonomously to perform services useful to the well-being of humans and equipment. With the aim of keeping our robot as simple as possible, while able to perform the initial goals, i.e. an autonomous vacuum cleaner robot able to randomly navigate through a room or a house with the minimum human assistance, the following specifications were found:

- Obstacle avoidance
- Mobile operated
- Automatic system

Three motors have been used to perform respected operations like to move the robot, suction motor for cleaner. Relays have been used to drive the cleaner motor. LM293D IC has been used to drive wheel motor. These specifications correspond to some of the expected behaviours that will be programmed into the robot. Other behaviours that will increase the overall performance of the robot

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Objective: Identify and design an autonomous robot that will assist people at home who are too busy for daily or weekly floor cleaning, especially for families with children. In particular for the elderly who live by themselves and do not have the strength or ability to clean. Robotic vacuum cleaners in the market are expensive and inefficient in terms of cleaning time and cleanness. The goal is to design an Omni directional platform with infrared sensors, wireless sensors, lightweight, ultrasound, reshape, and best suction for cleaning on every side to improve the every site cleaning performance problems.

Advantages:

Robot controlling provides various advantages over human powered work. Following are some of them:-

- It gives accurate results and eliminates possibility of manual error.
- It is very first and efficient and the control system used in robot is 100 times efficient than human work.
- In some part of the work areas it reduces the human efforts. Like Washing machine comes under this category.
- It also plays the great role in bringing entertainment in human life in different work. Television is the live example of these types of robots.

II. LITERATURE SURVEY

For our project we are surveying some reports and references which are helping us to make it easy and simplest and they are as follows

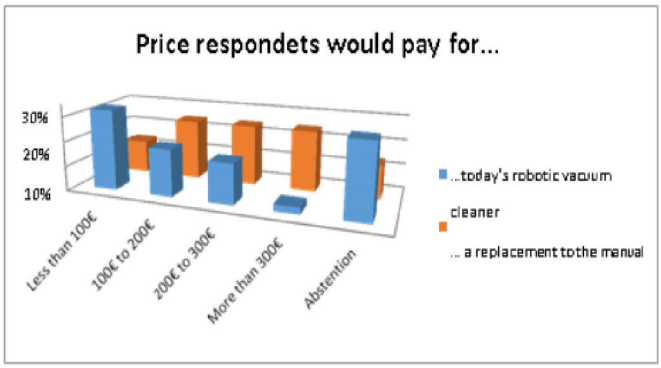

Fig. 2. Price Analysis

Figure 1- Price analysis' represents the amount of money a household is willing to spend on today's robotic vacuum cleaner in contrast to a vacuum cleaner that replaces the manual vacuum cleaner. The average household is willing to spend 7500 Rs. on a robotic vacuum cleaner that is a complement on their normal vacuum cleaner. If the robotic vacuum cleaner is a replacement of their normal vacuum cleaner, people are willing to spend more money. The average amount these people are willing to spend is 9000 Rs.[9]

- On the question if people are willing to buy a robotic vacuum cleaner we received a lot of useful input why people would or would not buy a robotic vacuum cleaner.
- The survey was useful, since the respondents gave a lot of useful input about their expectations. Many respondents said they are only willing to buy a robotic vacuum cleaner if it is able to replace there manual vacuum cleaner completely. This implies for them, that it is as efficient as their vacuum cleaner. Another big concern of the respondents is the price of the device. Their wish is a reasonable price for the product they get offered.

Traditionally floor is cleaned with the help of dry mop or wet mop using the hand as a potential tool. They have to scrub hard on the surface. The cleaning includes cleaning of various surfaces basically cement floors, highly polished wooden or marble floors. Among these floors the rough surface floor such as cement floor, mostly present in semi urban areas are covered with so much dust. From early human civilization human is increasingly dependent on the machines. Human is trying to reduce the workload upon him. By the help of machines also we can get huge efficiency because there is no chance of human error there. Now -a -days from 30 years intelligence and robotics growing with a

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vast pace. Every human is using 2-3 robots at least per day. If we look at past 30 years we will see robotics from large structure going to small and smaller in Nano range. Very complicated sensors have been designed to help the robot in various works .Complicated pneumatic and actuating systems have been designed.

• One of the best examples is the mobile phone. If we look at the floor cleaning robot we can see iRobot is dominating the market with its 90 sq. cm robot having indoor navigation as its principal controlling system. Also for many in-house mobile robots indoor navigation is a big issue. Also currently indoor GPS is evolving which uses unsupervised learning and determining its path in its first run. Since now indoor navigation has not been solved completely. Also now-a-days complicated artificial intelligence algorithms like unsupervised and supervised learning, Swarm optimization, ANT algorithm, natural heuristic search are playing a major role in designing control system of the most of the mobile robot [7]

• The body of the robot has many small components. Like all robots it has sensors, microcontrollers and actuators and other components. It has 2 vacuum pumps connected in backside as well as front side of the robot. A 300 rpm DC motor is connected in the middle of the robot with the scrubber. A bearing is attached to the axle of the scrubber. 2 DC motors of 100 rpm are connected to the wheels. One microcontroller with 4 ultrasonic sensors is attached to it. This has 2 bread boards for circuit connection which ultimately can be replaced after welding. 6 For scrubbing we are using the brushes instead of cloths .The scrubber rotates at very high speed which performs very good mopping action. Basically random straight path searches from one node to another by the help of natural heuristic search. After the spiral motion the robot if detects a collision then it follows the edge of the wall until it gets enough free space for spiral motion again. After some moment if it doesn't get any specific clear area for spiral motion then it will move in random path for some time and the obstacle detection and avoidance system will be carried out by the help of ultrasonic sensors [2]. After that robots stop rotating if the timer is over. In this process we can divide a particular area in the floor as grids and move accordingly so that it will have very confine control over the robot. So it will have grid based search over the floor for movement [4]. Finally we implemented computer vision by the help of ultrasonic imaging and analysing the image for the dust particles by the help of supervised learning and clustering the data [5]. We have implemented here a search algorithm for motion planning [7]. The breadth first search implemented here is very effective and provides efficient result for moving [9]

III. METHODOLOGY

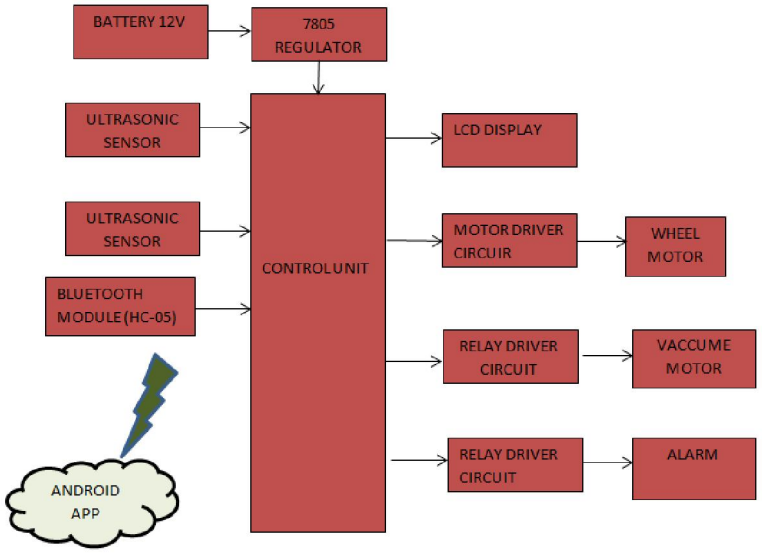

Fig. 2.Block Diagram

The Fig: 4.2 describes block diagram which includes components like ultrasonic sensors, motor drivers, Bluetooth module and vacuum cleaner which are connected to microcontroller and the power supply of 12V is given. The

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microcontroller controls the Ultrasonic sensors and motors for obstacle detection and to move in a particular direction. Bluetooth Module is used to control the robot through dashboards for ON/OFF by connecting to the Bluetooth terminal application.

The robot is designed keeping in mind following modules of operation:

- Cleaning mechanism directional control with automatic obstacle avoidance
- In time monitoring

The cleaning is inspired from the conventional stages of any wiping or sweeping operation, which are blend with the design and placed in the operational order of working stages.it consist of four dedicated wipers that are attached to the platform. Among them, one of the wipers is cylindrical and the others are flat in geometry. The flat wipers are symmetrically placed at the bottom of the Platform arranged in 'V' shape so as to ensure efficient cleaning and collection of dust. The roller wipers are placed at the end of the platform using proper links and a driver motor. The cleaning is made efficient using wet wiping system. This system employs a small bottle that carries water in it. This ensures a complete cleaning of the surface. Only the wipers in the front are made wet. This ensures that the wiper from the back remove the water from the surface when sweeping again on the surface.

Movement

Direction control 30 rpm geared motors provide the necessary forward motion on the floor, powered by 12V batteries and the directional control is established using a programmable microcontroller, manually controlled using Radio Frequency transmission. Infra-Red sensors are fitted on the edges for obstacle detection.

Chassis Construction

Wood base since it has light weight. The thickness of the chassis is 3mm. The dimensions were decided according to the design requirements considering complexity of construction and overall weight of the setup. The steps carried out are explained as follows. Two 100mm diameter tiers are fixed in symmetry to balance the centre of gravity of the chaise Provision for roller wiper was made by making holes. The thin flat wipers that are circle shaped were screwed to the chassis to adjust the height. The roller wiper is placed at the back inside the chassis. The two thin flat wipers are attached to the middle portion of the chassis. These two wipers are attached in a circle shape, inclined to each other. The v shape ensures that the dust is transferred to same spot after cleaning, making the duct collection part for floor cleaning very easy. The bumper present at the front collects big particles. The wiper at the front that wets touches the ground lightly to apply water. The next wiper collects dust that is larger in size. The third wiper collects dust smaller than the previous one and so forth. These vipers are provided with a screw attachment such that it allows an advantage of adjusting height as per the surface unevenness. The roller wipers are rotated using 100rpm motors. This cleans the dust along the path that the vehicle moves.

Motor Driver Board

A very easy and safe is to use popular L293D chip. It is a 16- pin chip. The pin configuration of a L293D along with the behaviours of motor for different input conditions is given in fig. 4.3 The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. When an enable input is high, the associated drivers are enabled. Also their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.[11] a. Motors cannot be operated directly from the signal obtained from the controller. b. This is because the power obtained from the controller is very small. c. It is only about 5 volts. d. But the motors require 12 volts for their operation. So the motor driver board acts as the intermediate component. e. L293D IC used in this driver board.

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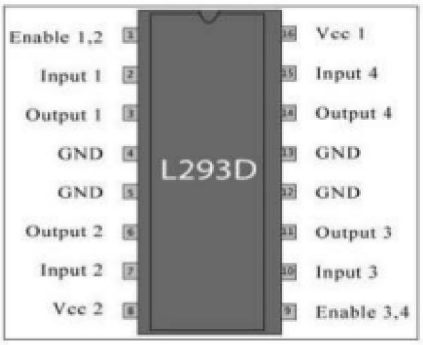

Fig. 2. Motor Driver IC

DC Motor

Almost every mechanical movement that we see around us is accomplished by an electric motor. Electric machines are means of converting conventional energy. Motors take electrical energy and produce mechanical energy. Electric motor is used to power hundreds of devices we use in everyday life. An example of motor used in day to day life is automobiles, food blenders and so is vacuum cleaner. This DC motor provides the movement to the Direction control 30 rpm geared motors provide the necessary forward motion on the floor, powered by 12V batteries and the directional control is established using a programmable microcontroller, manually controlled using Bluetooth control module. Ultrasonic sensors are fitted on the edges for obstacle detection

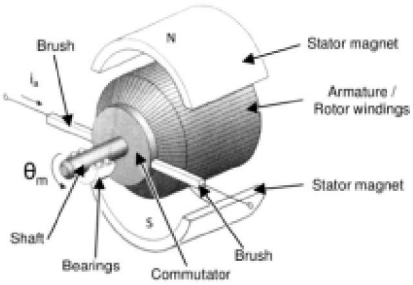

Fig. 3. DC Gear Motor

Ultrasonic Sensor

The human ear can detect frequencies in a range from about 20 to 20 000 Hz [Arthout and Freedman, 2016]. Everything above 20000 Hz is called ultrasonic and everything below 20 Hz is called infrasonic. An ultrasonic sensor uses a frequency of approximately 40000 Hz. The sensor has one transmitter that emits a sound wave and one receiver that detects the wave that have bounced back from an object. The transmitter and the receiver together is a type of a transducer. A transducer converts physical energy to electrical and vice versa.

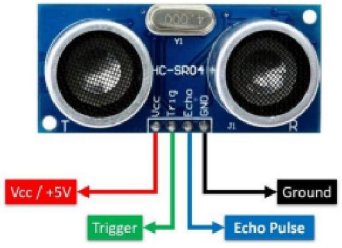

Fig.4. Ultrasonic Sensor.

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Bluetooth Module

For the communication of the robot with the cell phone or a mobile we are using the Bluetooth device. The Bluetooth device (HC-05) is attached to the robot that receives the data from the mobile and also it can transmit the data. It is used for converting serial port to Bluetooth. It has two modes: Master and Slave. Bluetooth is a wireless communication protocol running at the speed of 2.4 GHz with the architecture of client-server and which is suitable for forming personal area networks.

Mechanical Design

The robot is designed keeping in mind following modules of operation: • Cleaning mechanism directional control with automatic obstacle avoidance. •In time monitoring.• The cleaning is inspired from the conventional stages of any wiping or sweeping operation, which are blend with the design and placed in the operational order of working stages.it consist of four dedicated wipers that are attached to the platform. Among them, one of the wipers is cylindrical and the others are flat in geometry. The flat wipers are symmetrically placed at the bottom of the Platform arranged in 'V' shape so as to ensure efficient cleaning and collection of dust. The roller wipers are placed at the end of the platform using proper links and a driver motor. The cleaning is made efficient using wet wiping system

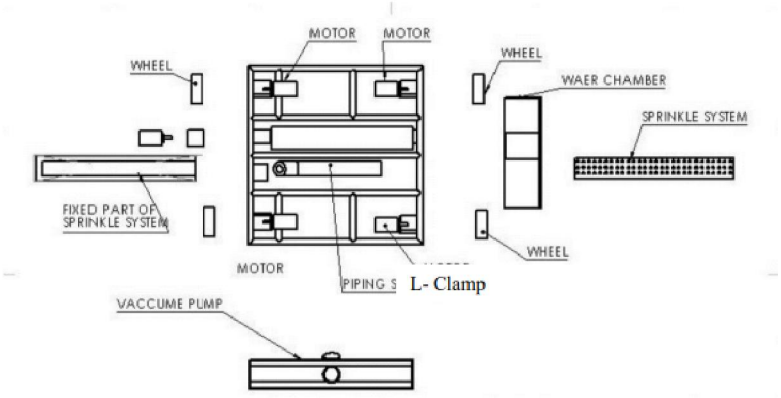

Fig 6.Mechanical Design

Result of bending fatigue behavior of composite drive shaft

All of the robot's functions have been tested, the obstacle and stair sensors worked, in the test that was made the robot vacuum cleaner avoided all the obstacles and stairs. The biggest problem with the prototype is that the robot goes very slow. This is because of the weight of the robot vacuum cleaner, 2.6 kg. With this kind of weight, the stepper motor needs high torque to make it move forward. When the stepper motors have high torque, it goes slow and when it has low torque, it goes fast. Therefore, the robot goes slow. We could solve this problem by ex-changing stepper motors to bigger ones. If we had more time, we would do the exchange. On the other hand, maybe if the robot did go faster the robot could not detect the obstacle or stairs as good as it does now. Probably the robot cleaner could go a bit faster than it does now but at the same time sustain how it detects obstacle and stairs. Because of the robot vacuum cleaner weight, the bottom plate that is made of acrylic plastic and is only three mm thick is very fragile. If we had more time, it would be smart to change the materiel or have at thicker bottom plate. Because of the time limit we could not make a program that did the recommended driving pattern. Instead we made a program that was semi random.

IV. CONCLUSION

This research facilitates efficient floor cleaning with sweeping and mopping operations. This robot works in two modes automatic and manual for user convenience. This proposed work provides the hurdle detection in case of any obstacle that comes in its way. The obstacle detection range is 1ft. RF modules provide wireless communication between remote and robot and their range is 50m. A mechanical setup is designed with the synergies of pneumatics and electronics to

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provide efficient cleaning system both at ground and as well as window levels. This contemporary design helps to overcome the limitations of the existing technologies and surpass them in terms of robot capability, modularity and payload. These components determine how well the dirt is collected. As of now, we feel that by adding brushes and increasing the motor size will do the job. Instead of the one brush underneath Roomba, we will be using two brushes to maximize cleaning on each side of the robot

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