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Solar Energy Equipped IoT Based Vacuum Cleaner

Vandana C P*[1], Aashika M Suresh[2], Nikita Nanju K[3], Sanjana V Nagvekar[4]

*[1]Assistant Professor, Department of Information Science and Engineering, New Horizon College of Engineering (Affiliated to VTU), Bangalore, Karnataka, India

[2-4]Department of Information Science and Engineering, New Horizon College of Engineering (Affiliated to VTU), Bangalore, Karnataka, India

ABSTRACT

The purpose of this project is to design and implement a Vacuum Cleaner which runs on solar energy and is operated by mobile application and uses machine learning algorithms to clean. This smart vacuum cleaner cleans both dry and wet floor as well. Its main objective is to maintain and keep your surroundings clean.

Keywords : Smart Cleaner, Smart Vacuum Cleaner, Eco-friendly, Sensors, Cleaning, Machine learning, Python, Internet of things (IoT), Mobile Application, Solar Panels, Bluetooth.

I. INTRODUCTION

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 and office environments. Households today are getting smarter and more automated. Several robotic vacuum cleaners are available in the market but there are only few smart floor cleaners implemented and the few that are implemented are not so affordable. This prototype uses Raspberry pi which is integrated to the machine learning algorithms, a camera that captures the floor and cleans the unclean surface using the cleaning objects, solar panels on which the vacuum cleaner will run on which makes it eco-friendly, 5V Relay, NXP pressure sensor that sucks dust in, IR sensors to prevent the sides of the cleaner from colliding against objects and an Ultrasonic Sensor to achieve the goal of this project. It will be controlled by a mobile application and can be accessed from anywhere. So, keeping in mind the economic condition of people a product is designed which would be cost efficient.

This vacuum cleaner also has a special machine learning feature i.e. it detects dark patches and understands that there is a stain and a bulb will glow. This project delivers convenience and saves more time for people and can be accessed anytime and from anywhere and can also be called eco-friendly.

II. LITERATURE SURVEY

In [1], the robot is controlled by an android app with four main functions i.e moving front, back, left and right. The main components are MCU, Bluetooth, LCD, Motors, Ultrasonic sensor. The survey paper [2] is a vacuum cleaner that is controlled by an android app by using a Bluetooth module and MCU. It has a special crystal circuitry that operates on the speed of the vacuum cleaner. In [3] the main motive of the robot is to implement wet cleaning and is controlled by an android app. It has a dual mode i.e. automatic mode and manual mode and uses Atmega328P.

The main motive of this robot in [4] is to ensure wet cleaning through a Bluetooth module. It uses an Arduino Uno for improving the performance of the

system. The vacuum cleaner in [5] is the one that uses an Arduino for collecting dust through a vacuum sensor. It is monitored by using laptop with GUI in Visual Studio via Bluetooth connectivity. In [6], the vacuum cleaner uses an Arduino for implementing the cleaning process. It has special rotating mechanism with brushes attached to it unlike other vacuum cleaner for an efficient cleaning process.

The vacuum cleaner on the other hand [7] aims on both mopping and collecting dust for obtaining a clean environment. It has a L293 Motor driver IC for controlling two DC motors simultaneously in any direction. In [8], this vacuum cleaner uses an Arduino module and it can work on both manual and automated mode. The vacuum cleaner aims on both mopping and collecting dust and is monitored through an android app. It has a DC Geared Motor for high speed and laser TOF sensor to efficiently detect obstacles.

This robot of [9] aims on both mopping and collecting dust and uses an Atmega328 module. It has an LCD display which will display the time taken and the equivalent cost. The robot in [10] is monitored through a Bluetooth module for wet floor cleaning. It has a special feature i.e. voice appliances which has not been implemented in most of the vacuum cleaners.

In [11], the robot uses an AT89C52 microcontroller for wet floor cleaning. It uses an android application called the BT Simple terminal to control the robot. The system of [12] uses an Atmega328P microcontroller and the speed of the motor is controlled by the PWM signals. It uses RF-ID tags for detecting the location of the vacuum cleaner and to also gain some additional information about it.

The vacuum cleaner [13] uses a PIC microcontroller for the purpose of vacuuming and mopping. It has an additional UV germicidal lamp which helps to which helps to kill the indiscernible germs using UV rays. In [14], it constitutes of a shape shifting robot which uses tiling theory for maximum coverage while cleaning the floor. It uses an Arduino Mega platform and also has an android app with controls on it for implementing the cleaning.

The vacuum cleaner [15] uses Raspberry pi for collecting dust through a vacuum pressure sensor.
It has a raspberry pi webcam for image processing and also Air purifier for killing the harmful microbes.

The vacuum cleaner uses a raspberry pi interface for mopping and vacuuming [16].It has a L293 motor driver for operating two DC motors simultaneously over a H – Bridge.

In [17], the vacuum cleaner uses raspberry pi for analysing the extreme dirt zones and focus on them for efficient cleaning. The vacuum has a mechanism which allows it to sweep across the walls and also top steps top stairways.

The initial idea of this project [18] was to focus on cleaning solar panels which then gave rise to an idea of using solar panels in these cleaning devices in order to save energy. It uses an Arduino platform and is monitored through a remote controlling device.

This is a solar panel equipped dust collector [19] which uses a microcontroller for vacuuming.

It also uses a lead acid battery which is rechargeable and acts as an additional supply of power.

The paper [20] focuses on the implementation of solar panels in various application, vacuum cleaner being one in order to save huge amounts of energy. It also tells us pros and cons of these devices and how it can be used in future projects. Since solar energy is one of the best sources of energy, the solar plates need to be cleaned often for better performance. Instead of using

some batteries the same plate could be used for building a smart vacuum cleaner.

III. EXISTING SYSTEM

The present manual vacuum cleaner server s the purpose of cleaning with components like brushes, suction pumps, dust collector and wheels to move around the area. These function on electric current.

A few of the present vacuum cleaners work with Bluetooth connected to the mobile, therefore can be used only to a limited area which are covered by the Bluetooth range.

Another few varieties of vacuum cleaners consist of robotic arms to pick and drop objects which work on remote control.

I Robot Roomba

In 2010, iRobot launched its first, floor vacuum cleaner robot named Roomba. Initially, iRobot decided to manufacture limited number of units but Roomba immediately became a huge consumer sensation.

Cleans until the job is done: Roomba robot vacuum cleans continuously for up to 75 minutes*, then recharges and resumes cleaning until the job is done.
Dirt, meet your match: The Roomba robot vacuum removes dirt from high traffic spots of your home using patented Dirt Detect™ Technology. Sensors recognize concentrated areas of dirt and prompt the robot to clean them more thoroughly.

Cleans on a schedule: Roomba® can be preset to vacuum up to seven times per week, meaning your home can stay clean every day.

Neato Robotics:

The idea behind Neato Robotics – that robots can perform household chores as intelligently as humans – was born at Stanford's annual Entrepreneur's Challenge. Today, robot vacuums clean homes better than the competition – with smarter technology, more powerful suction, and better features that get the job done the way you would, or even better.

Cleaning System: Standard filters provide a cleaning performance.

Performance Filter Type: Ultra Performance filters provide a very high cleaning performance and excellent air filtration. Best for those concerned with allergies and for minimizing particulates in the air.

Dyson 360 Eye:

In 2014, Dyson built a robot vacuum known as DC06 which was never released to the market due to its high price. In 2016, Dyson launched a new product named as Dyson 360 Eye which uses a different technology for path finding as compared to products manufactured by NEATO Robotics or iRobot.

A. LIMITATIONS

Nowadays a lot of users are using manual vacuum systems that consume electricity. A vacuum cleaning robot works a lot like a manual vacuum cleaner. The main difference is that a robotic vacuum cleaner is equipped with brushes which move the dust to the nozzle. Some robotic vacuum cleaners have extra brushes which collect the dust on both sides of the robot and brush this dust right into the nozzle. This feature allows the robots to sweep along walls and clean thus more effective. The effectiveness of a robotic vacuum cleaner is also determined by the quality of the suction mechanism and the brushes. In comparison with manual vacuum cleaners, the cleaning process of robotic vacuum cleaners takes a longer time. It is slower and through its limited battery life it sometimes has to recharge within its cleaning round. Therefore, completing the vacuuming of an entire room takes

longer. This is something the consumer is well aware of and since the robot cleans mostly when the consumer is not at home, this should not be a problem. As efficient as the present system of vacuum cleaners are, it fails in terms of automation. In this project, we shall see what gaps are identified in the system of the already existing vacuum cleaners.

In the manual system, the vacuum cleaner is not compact and hence it cannot fit into small areas and restricts the cleaning to a limited free space.

It is time consuming as it requires an external monitoring and commands to be given to it by the user. Due to the absence of sensors, there are high chances of collisions with obstacles. This may lead to damage of the system.

Some cleaners use a Bluetooth source for the movement which restricts the vacuum cleaner to a specific Bluetooth range. This curbs the vacuum cleaner's movement to only short distances.

Vacuum cleaners that run on battery have a disadvantage, as they drain out quickly and must be changed on a frequent basis. The current cleaners do not permit mopping for wet patches as it collects only dust and does not allow multitasking. It does not incorporate ML algorithms; hence it cannot use reinforcement learning for intelligent functioning.

IV. PROPOSED SYSTEM

The proposed system consists of building a vacuum cleaner which runs on solar energy and can be monitored / controlled via a mobile application. The implementation will include a Raspberry pi, IR sensors, 5V relay, NXP pressure sensor and ultrasonic sensors to achieve the goal of this project.

The vacuum cleaner has solar panels incorporated which helps it run with the help of solar energy. It also consists of a special feature where it detects dark patches and cleans them up by mopping, using machine learning algorithms.

Controller Module

In the proposed system, IoT is implemented using components such as IR sensors, NPX pressure vacuum sensor, ultrasonic sensors, Raspberry Pi board, Raspberry Pi camera and solar panels.

The IR sensors are used to detect the presence of objects near and around the vacuum cleaner.

Ultrasonic sensors help in measuring the distance between the obstacles and displays the value on LCD. The Raspberry Pi is connected to Azure IoT hub and the Raspberry Pi camera, which runs on a python code and captures pictures of areas that must be cleaned. A gear motor is also incorporated to move the vacuum cleaner around in varying speeds.

Camera

The raspberry pi camera module is used to capture images of the floor as the vacuum cleaner moves, the captured images are stored and used for detection of dark patches. The camera board attaches to the raspberry pi through a 15-way ribbon.

Cleaning Module

This module consists of an ML algorithm that will be implemented. This algorithm will be given datasets in order to get trained and make real time decisions, based on the trained datasets.

The detection of dark patches can be done using this module. Whenever a dark patch is detected, it gives an indication that the area must be cleaned. The area is then cleaned with water and dried up.

Training Module

The vacuum cleaner consists of a mopping feature on detection of dark patches. The captured images will be compared to the trained data; consisting of images of different patterns and colours of floor. The Reinforcement learning concept of Machine Learning will be used here. The trained data and test data images are compared on spot and the algorithm helps in drawing conclusions on whether or not the floor must be mopped.

Mobile Application

A mobile app is developed in this module in order to be able to control the system and give it certain actions to perform.

The activity of the smart vacuum cleaner can be monitored within a range of 10m around the system.

The app also receives notifications indicating when the beaker of water needs to be refilled or dust collector must be emptied.

A. System Diagram

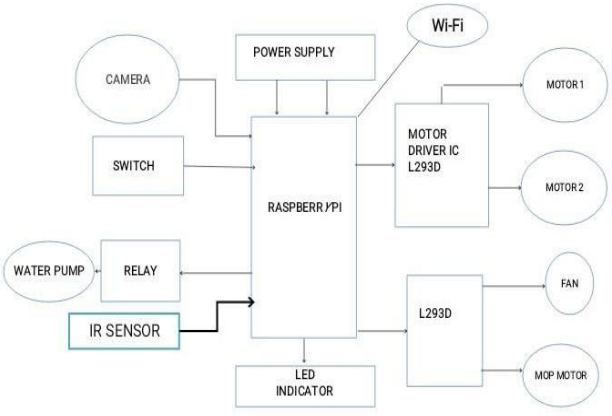

Figure 1. Representation of The Vacuum Cleaner System With Components

B. Algorithm

Extended Kalman filter

The algorithm used for the proposed system is extended Kalman filter. As discussed in [21], it allows probably distribution of two main factors that is the input measurement and output measurement. By doing so, the vacuum cleaner can understand its position and based on the velocity heading and previous measurements the robot gets a clear picture to make decisions by using associated probability distribution. According to [22], the algorithm is very efficient as the calculation of the measurements is instantaneous and more accurate. It considers the smoothest path that can be taken for efficient cleaning and ensures the corners that are circular are vacuumed properly.

C. Components

Raspberry pi- The raspberry pi is a module in which we can integrate various other languages and make a working model. Here we use the raspberry pi as the main component, it is a miniature form of a computer. The inbuilt components such that camera module, Wi- Fi module, USB ports, HDMI, Ethernet, Bluetooth, speaker, mica, etc. Its data transfer rate is high as its size is less.

Camera- The camera that's connected to the Raspberry pi by using a built-in camera module present in the pi controller. The camera that's connected on the robot captures the front view of the floor and the captured image is displayed on the mobile app.

Solar panel- Here, the solar panel is used instead of electricity to charge or run. This prototype runs on solar energy which also makes it eco-friendly.

NXP Pressure sensor- This acts as a suction pump to clear the dust.

IR Sensors- IR sensors avoid collision

5V Relay- It is used to control the power supply to the raspberry pi.

Ultrasonic sensor- This sensor is high performance ultrasonic range finder. Its range is 2 cm to 4 cm. It is connected directly to the microcontroller and distance can be measured. It shows the value on the LCD connected on robot and also in android application.

Bluetooth- It is a wireless communication protocol running at the speed of 2.4GHZ. It is designed for devices such as mobile phones. Bluetooth protocol uses the MAC address of the Bluetooth gives the connectivity between two devices using their MAC address.

Motor driver- A gear motor is a type of electrical motor. It uses the magnetism induced by an electrical current to rotate a rotor that is connected to shaft. The energy transferred from the rotor to a shaft is then used to power a connecting device. It can be replaced with solar energy as well.

Robot chassis- The chassis comprises of the base of the vacuum cleaner that holds the components together.

Buzzer- The buzzer is a device which is used to produce a sound signal which indicates the completion of a particular task. The buzzer used in this device is a 5V buzzer.

D. Specifications

Hardware Specifications
Speed- 2.5 GHz RAM- 8 GB (min.)
Hard disk- 1 TB

Software Requirements Operating System- Windows 10 Programming Language- Python
IDE- Android Studio, Python IDE

V. CONCLUSION & FUTURE WORK

The proposed system is efficient in terms of cost, time and management. Its user - friendly feature enables us to access it from any place through the mobile application. Compared to the existing systems, it has higher efficiency by overcoming the drawbacks as mentioned in the previous slides. Therefore, it is a well proposed system that can be implemented in households and office environments
The project aims on developing a vacuum cleaner that is very efficient for both dry and wet cleaning. The vacuum cleaner has a suction pump which collects the dust present on the surface. The vacuum cleaner has IR sensors present on its sides which help in avoiding collisions with obstacles. It is both battery and solar panel equipped which acts as a source of electricity. The vacuum cleaner is controlled through an android application and can be accessed from any place. The raspberry pi module and camera is used for capturing the floor. The ML algorithm helps detecting dark patches indicating the heavy dirt on the floor and sprays water to clean it. The ML algorithm is trained with a few datasets for black, white and printed floor.

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