

Robust and Efficient Autonomous Trash Cleaning Robot: A Novel Approach with Image Recognition Techniques

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Abstract

“Swachh Bharat Abhiyaan” is a national campaign initiated by the Government of India, which covers 4,041 cities and towns, to clean the streets, roads and infrastructure of the country. The main motto of the mission is to cover all the rural and urban areas of the country. With increase in population, the scenario of cleanliness with respect to garbage management is degrading tremendously. The overflow of garbage in public areas creates the unhygienic condition in the nearby surrounding. It may provoke several serious diseases amongst the nearby people. It also degrades the valuation of the area. To avoid this and to enhance the cleaning, ‘smart robotic dustbin’ is proposed in this paper. The proposed automated robotic dustbin can sense human being approaching towards it and opens the upper lid and alerts the user to use the dustbin. If the waste falls outside the dustbin it can sense and alert the user. The camera fitted above the dustbin captures the image in front and send to the server for processing. If garbage detected send instruction to the robotic bin to start the vacuum cleaner.

Keyword –Automated dustbin, Image processing, Sensor technology, Smart robotic dustbin

I. INTRODUCTION

Robotics is related to electronics, mechanics, and software technology. Today research on robotics is focused on developing systems which exhibit modularity, flexibility, redundancy, and fault-tolerance. A general and extensible software environment and seamless connectivity to other machines, are some of the characteristics some researchers focus on completely automating a manufacturing process or a task. Robots are normally designed by providing sensor based intelligence to the robot arm, while others try to solidify the analytical foundations on which many of the basic concepts in robotics are built. One special class of robot which finds wide application is the pick and place robot, which is a microcontroller based mechatronics system that detects the object and picks that object from source location and places at desired location.

The availability of easy-to-use software and hardware resources has sparked an increased enthusiasm in hobbyists, researchers, and enthusiasts to experiment with the Internet of Things. This has brought about a revolution, since automation can be introduced to almost anything in our life, making it more convenient. Everything is becoming “smarter” with the help of automation. If almost anything can be made “smarter”, then why not dustbins? Dustbins that can report if it is full, and request immediate cleanup! This can eradicate the problem of overflowing garbage in dustbins, which are breeding ground for disease-causing insects. This can make the place look and smell better, and greatly improve hygiene. Analyzing and learning from historical data may throw light on how to optimize the overall cleaning efficiency. Our proposed idea informs headquarters about the dustbin being full, and stores the times it was filled and cleaned up.

II. LITERATURE REVIEW

A literature survey or a literature review in a project report shows the various analyses and research made in the field of interest and the results already published, taking into account the various parameters of the project and the extent of the project.

Real Time Solid Waste Monitoring and Management System: A Case Study of Kanpur City [1]. Solid waste management is one of the most challenging issues, which are facing a serious pollution problem due to the huge quantities of solid waste. This paper presents a development work for solid waste monitoring and management system. This research developed a component monitoring system with the aim of achieving an effective waste management system. With this system we will be able to monitor the collection and transportation system and manage the process.

Prospects And Perspectives of Integrated Solid Waste Management in Smart Cities [2]. Authors have discussed regarding Zero Waste Management, Recycled Plastic Weaving, Community Based Solid Waste Management. These all techniques lead to integrated solid waste management in India. All smart techniques if implemented within cities, it will lead to Integrated Solid Waste Management. Surat like cities having growth at very fast rate, should improve with the future expected solid waste quantity management. It cannot be improved without adopting smart techniques like reduce, reuse, recycle (3R).

Garbage Monitoring and Management Using Sensors, RF- ID And GSM [3]. Entire project works at three levels as stated earlier. The first being the TRASH BIN UNIT is employed with different types of sensors. The first one is IR and PHOTO sensors to monitor the level of garbage. These are basically the light sensitive diodes which respond toward the intensity of light and generate the corresponding voltage output. Next is ULTRASONIC sensor which works on the principle of reflection of radiation. It is to improve the accuracy of the level detection. Third type of sensor is metal sensors which are meant to inform about the presence of metals so that the separation of harmful and heavy metals can be done on the initial stage of garbage management itself rather than to extend it to the later stages and thus saving a lot of amounts for the government.

Literature survey describes about the existing work on the given project. It deals with the problem associated with the existing system and also gives user a clear knowledge on how to deal with the existing problems and how to provide solution to the existing problems. different thing.

A. DRAWBACKS OF EXISTING SYSTEM

- i. Lack of the information about the collecting time and area.
- ii. Lack of the proper system for monitoring, tracking the trucks and trash bin that have been collected in real time.
- iii. There is no estimation to the amount of solid waste inside the bin and the surrounding area due to the scattering of waste.
- iv. There is no quick response to urgent cases like truck accident, breakdown, long time idling.

B. PROBLEM STATEMENT

- i. In our daily life we face many difficulties while moving on the streets, walking inside the park, walking on the roadside, market areas due to improper management of waste materials.
- ii. Most of the time not only human beings even street dogs tend to scatter the waste because of which the diseases spread easily.
- iii. Few reasons for this kind of situation are improper management of the waste material, improper adequate installation of the dustbin in various areas, as well as the untimely collection of waste which leads to unhygienic surroundings such as bad smell and spread of diseases.
- iv. One more important cause is the inherent habit of the humans to dump the waste due to lack of dustbins in the neighborhood.
- v. This leads to decomposition of the waste for prolonged time leading to certain chemical reactions in the environment.
- vi. Lack of knowledge about proper waste management

C. PROPOSED SOLUTION

- i. To solve the problems, IR, Ultrasonic Sensor, DC motor and robotics technologies could be used to reduce cleaner's workload and assure a clean environment.
- ii. The robotic dustbin can move on the specified path in the park. On the move if it detects any obstacle then it stops and then continue moving
- iii. In 'smart garbage management system' system, the level of garbage in the dustbins is detected with the help of Sensor systems

- iv. We are working to develop a robotic dustbin that will automatically collect the garbage using vacuum cleaner.

III. FEASIBILITY STUDY

Feasibility study is the study led to see if the proposed system can be worked with the given innovation and assets. It gives the time and cost requirements of the association and checks whether the innovation utilized is OK by the system. In more direct, the association needs to figure out what are advantages and disadvantages are engaged with the undertaking prior to taking up a task. Then project pioneer/chief needs to infer that whether they can satisfy the prerequisites given toward the end-clients or clients. The concentrated examination of the presence of mind and sensibility of the business thought joins all of the parts of data that assistants in recognizing lifts the ability of the endeavor and its flourishing level on a continuous scale.

Procedure for feasibility study:

- Feasibility study concludes the reasonableness of an idea or a business drive.
- Complete a major assessment program and get the contribution on the novel thought.
- Direct factual reviewing or outline to further develop the data variety through point-by-point information.
- Review the data and look at it.
- The reasonableness specialists from the cultivated guiding firms could help you in outfitting the possible examination with accuracy.
- Make a course of action of business utilitarian or progressive plan.
- Enlarging the expansion to recognize the new possibilities.
- Further develops the resources capacities while anticipating the hardships.
- Helps in reducing the potential risks and in finding courses of action.
- It perceives the aftereffects of the attempted venture with most outrageous accuracy

The aspects of feasibility study are:

- Economic feasibility
- Technical feasibility
- Operational feasibility
- Social feasibility

IV. SOLUTION REQUIREMENTS

A. FUNCTIONAL REQUIREMENTS

- It measures the obstacle distance
- Control the upper lid
- Capture and send images to the server for processing
- AI program to detect garbage and send instruction to the dustbin to control the vacuum.

B. NON - FUNCTIONAL REQUIREMENTS

- **Usability**
The client acknowledges be typical nearly the buyer interfaces and committed to ask for ambush pressure in relocating to a unique framework with another condition.
- **Reliability**
The progressions made by the Programmer ought to be obvious both to the Project pioneer and in addition the Test design.
- **Security**
Counting bug following the framework must give important security and must secure the entire procedure from slamming.
- **Performance**
The framework will be facilitated on a solitary web server with a solitary database server out of sight, consequently execution turns into a noteworthy concern.
- **Portability**
This is required when the web server, which is facilitating the framework stalls out because of a few issues, which requires their framework to be taken to another framework.
- **Reusability**

The framework ought to be separated into such modules that it could be utilized as a piece of another framework without requiring a lot of work.

V. COMPONENT DESCRIPTION

DC Motor

The DC Motor or Direct Current Motor to give it its full title, is the most commonly used actuator for producing continuous movement and whose speed of rotation can easily be controlled, making them ideal for use in applications where speed control, servo type control, and/or positioning is required. A DC motor consists of two parts, a “Stator” which is the stationary part and a “Rotor” which is the rotating part. The result is that there are basically three types of DC Motor available.

Servo Motor

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate an object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which runs through servo mechanism. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight package. Due to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

H-bridge

One of the most exciting things you can do with electronics besides blinking LEDs is make things move. What's the most common way to make things move? Motors. If you've done much with motor control, you've probably heard of H-bridges. But what exactly is an H-bridge?

As it turns out, an H-bridge is a super simple circuit in theory:

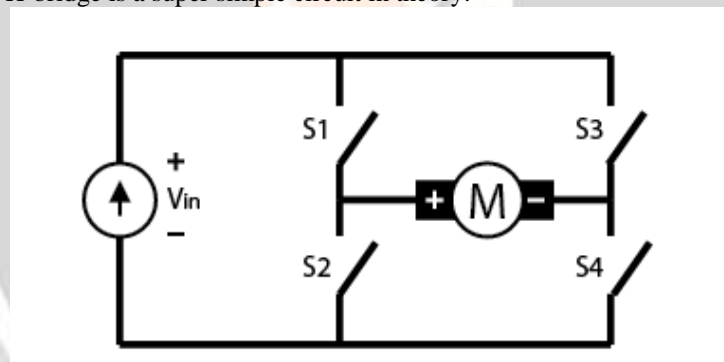


FIGURE 1 THE CIRCUITRY BEHIND A SIMPLE H-BRIDGE.

An H-bridge is built of four switches that control the flow of current to a load. In the image above, the load is the M connecting the two sets of switches. Using one current source, you can drive current in two directions by closing two switches.

L298N Dual H Bridge Motor Driver - General Specifications

Dual H Bridge Motor Driver
L298N motor driver IC
Drives up to 2 bidirectional DC motors
Integrated 5V power regulator
5V – 35V drive voltage
2A max drive current

Rechargeable 12-volt battery

Model No: AT12-7.6
Nominal Voltage: 12V
Nominal Capacity: 7.6Ah
Length mm: 151
Width mm: 65
Height mm: 94
Total Height (mm): 99

Weight (Kg): 2.05kg

Distance sensor

The HC-SR04 ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1" to 13 feet.

The operation is not affected by sunlight or black material, although acoustically, soft materials like cloth can be difficult to detect. It comes complete with ultrasonic transmitter and receiver module.

ESP8266 NodeMCU Board

The ESP8266 NodeMCU CP2102 board has ESP8266 which is a highly integrated chip designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other application-specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 NodeMCU development board – a true plug-and-play solution for inexpensive projects using WiFi. The module arrives pre-flashed with NodeMCU firmware so they're ready to go – just install your USB driver (below). ESP-12 Lua Nodemcu WIFI Dev Board Internet Of Things board contains a full ESP8266 WiFi module with all the GPIO broken out, a full USB-serial interface, and a power supply all on the one breadboard-friendly package.

This board is pre-flashed with NodeMCU – a Lua-based firmware for the ESP8266 which allows easy control via a neat scripting language – Lua – so you're ready to go in just a few minutes.

The ESP-12 Lua NodeMCU WIFI Dev Board Internet Of Things with ESP8266 is an all-in-one microcontroller + WiFi platform that is very easy to use to create projects with WiFi and IoT (Internet of Things) applications.

The board is based on the highly popular ESP8266 WiFi Module chip with the ESP-12 SMD footprint. This WiFi development board already embeds in its board all the necessary components for the ESP8266 (ESP-12E) to program and upload code. It has a built-in USB to serial chip upload codes, 3.3V regulator, and logic level converter circuit so you can immediately upload codes and connect your circuits.

VI. MODULES

Controlling Lids

The dustbin is fitted with ultra sonic sensor. When it detects someone is approaching towards it, opens up the upper lid so that we can dump the waste inside the dustbin and smells would not come out.

Moving in a Path

The robotic dustbin can move on the specified path in the park. On the move if it detects any obstacle then it stops and then continue moving. It helps us to get the dustbin near to us most of the time.

Object detection

An Ultrasonic sensor is a device that measures the distance of an object with the help of sound waves. It measures distance through sending out a sound wave at a particular frequency and listening for that wave to bounce back. It is possible to measure the distance between the sensor and that object by recording the elapsed time between the sound wave being generated and the sound wave bouncing back. In other words, the sensor head emits an ultrasonic wave and receives the wave that is reflected back from the target. The distance can be calculated with the following formula: $\text{Distance} = 1/2 \times T \times C$ Where T is the time between the emission and reception, and C is the speed

Image Processing

The ESP32 camera fitted on the dustbin captures image in front and send the images to the server for further processing. There are two categories for the images, garbage and no garbage. The densenet121 CNN model has been used to train. The trained model is loaded and used for prediction. If garbage is detected, server send instruction to the dustbin to on the vacuum so that it can collect the garbage while moving.

vacuum cleaner

We are working to develop a robotic dustbin that will automatically collect the garbage using vacuum cleaner.

Architecture of DenseNet-121

In a traditional feed-forward Convolutional Neural Network (CNN), each convolutional layer except the first one (which takes in the input), receives the output of the previous convolutional layer and produces an output feature map that is then passed on to the next convolutional layer. Therefore, for 'L' layers, there are 'L' direct connections; one between each layer and the next layer.

DenseNets resolve this problem by modifying the standard CNN architecture and simplifying the connectivity pattern between layers. In a DenseNet architecture, each layer is connected directly with every other layer, hence the name Densely Connected Convolutional Network. For 'L' layers, there are $L(L+1)/2$ direct connections.

VII. ARCHITECTURE DESIGN

The architectural configuration procedure is concerned with building up a fundamental basic system for a framework. It includes recognizing the real parts of the framework and interchanges between these segments. The beginning configuration procedure of recognizing these subsystems and building up a structure for subsystem control and correspondence is called construction modeling outline and the yield of this outline procedure is a portrayal of the product structural planning. The proposed architecture for this system is given below.

VIII. CONCLUSION

In conclusion, In this paper an Arduino sensor based automated garbage monitoring system is developed to monitor the garbage through the city. The system is more effective in cleaning the area automatically.

In this project the implementation of smart dustbin management system using IoT as a hardware and ionic framework as our software insures the cleaning of dustbins soon when the garbage level reaches its maximum. If the dustbin is not cleaned in specific time, then the record is sent to the higher authority in our case the admin who can take appropriate action against the concerned employee.

For our lucrative part that is shoe polish we have used ultrasonic sensor and to rotate the brush we have used the DC motor. The smart garbage management system makes the garbage collection more efficient. These dust bin model can be applied to any of the smart cities around the world. A waste collecting and monitoring team which is deployed for collection of garbage from the city can be guided in a well manner for collection

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