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Trash Bot

A. Meghna[1], Merita S. Immanuel[2], Parvathy Subhagan[3], R. S. Roopak Raj[4], Elizabeth Varghese[5]
[1,2,3,4]*UG Scholar, Department of Electrical Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India*
[5]*Associate Professor, Department of Electrical Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India*

***Abstract*: A smart city is incomplete without a smart waste management system. For this purpose, we introduce trash collecting robots – TRASH BOT. This bot is aimed at collecting waste from public places and offices. It is intended to move towards the user by sensing the hand and allows the user to dispose the waste in the bin. They are easily accessed and controlled manually through mobile phones via Bluetooth. Additionally, the level of trash in the bin is detected and upon reaching the limits a warning message is sent to the concerned personnel. DC motors are used for achieving the desired movement of the bot, ultrasonic sensors are used for obstacle detection and IR sensors for detecting the level of waste. Signals from the sensors are given to the microcontrollers, which then generates commands that are given to the driver IC to achieve the desired motor operation. A camera along with image detection technology using Open CV is used for hand detection.**

***Keywords*: trash bot**

1. Introduction

In the past few decades there is a rapid growth in the rate of urbanization and thus there are a number of sustainable urban development plans. Waste management is one of the major problems that people are facing now a day's. Not only cities but also rural areas of India are facing waste management problems. To bring about a difference in the macro scale to eradicate this problem, we need to start measures from keeping our close surroundings like houses, roads, public paces etc. clean and tidy. There are various cleaning devices which are bulky that are used for cleaning industrial waste and domestic wastes; they are unsuitable for cleaning household and small areas of public places.

Many times it is hard to find any means of proper waste disposal bins near us and people tend to leave the garbage like plastics and cans on the roads, streets, pavements, pits and other open areas which tend to pile up and is a major cause of land, water and air pollutions. These non-degradable wastes reduce soil fertility over time and make the earth a barren land. It is not wrong to say that India is on verge of garbage crisis. The breeding of insects and mosquitoes causes the environment unclean and this may even cause dreadful diseases. These major public problems faced by many developing countries because of the lack of uncollected trash littering the streets, roads, sidewalk, shopping malls etc. So we aim to implement a prototype of a trash collecting bot – TRASH BOT with multiple attractive features for maintaining cleanliness in public places like malls, parks, airports and offices. We focus on reducing the amount of waste on the grounds through an innovative approach. Robots are designed in such a way that it interacts with humans and they are becoming part of lives. Robots support the workers work more efficiently than earlier. At present, they are working in our everyday life and are affecting our lives. Using the robotics human power is being saved in various fields. One such field where more human power required is the cleaning public places. Now using new age technologies and strategic approach, the concept of smart cities is coming up all around the world. Without a smart waste management system, a smart city is incomplete.

The iRobot Roomba and Neato are the most widely used robot for autonomous cleaning purpose. In 2002, iRobot launched a first vacuum cleaner robot named Roomba. After that a series of Roomba product were released. Initially its cost was $500. At present Roomba 980 is used for cleaning purpose with the cost of $150. In Roomba auto charging mechanism is used. After that Neato, a cleaning robot was developed. Its cost is $399. Here laser finder technology and SLAM algorithm is used for localization and mapping. These two robots are efficiently cleaning the entire area. But these two robots are not cost effective [3]. In our proposed project, we would like to implement a much more cost efficient trash picking bot which can be used for confined spaces that require to be cleaned. Our goal in this project was to create a prototype cleaning robot capable of moving towards the user detecting hand, identifying the obstacle during the course of motion and alerting the concerned personnel when the bin is filled.

The trash collecting bots can provide the following services,

i. Waste management services to the people moving around can be provided.
ii. Move towards the person when it identifies the hand.
iii. Helps in replacing paid labor by cleaning the area around; thus it is a smart way of method.
iv. Provides an interactive way for people in waste disposal and encourage kids and youngsters to appreciate the importance of the proper disposal of waste in order to protect the environment.
v. It can be used for security monitoring purposes by capturing

and wirelessly transmitting the video stream from a location to the base station nearby.

vi. They can pick up the trash fallen on floor if the robotic arms are provided.

vii. Interactive screens can be provided for people for navigation purposes in new and unfamiliar places. This is achieved by implementing GPS facility and a touch screen with voice and recording inputs.

2. Methodology

We are aiming at creating a prototype model of the proposed idea. Here we have used two microcontrollers in order to avoid any cases of delay and for smooth functioning of the bot when a lot of components are integrated together – RaspberryPi 3b+ and Arduino ATMEGA328. They are highly cost effective and is a good solution for basic computations, image processing etc.

Arduino is an open source computer hardware and software company, project community that designs and manufactures kits for building digital devices and interactive objects that can sense and control the physical world.

RaspberryPi supports Linux a Raspberry pi is a credit card sized onboard computer which consumes very less power and so advantageous in a portable device like a smart trashcan. Raspberry Pi supports Linux operating system which can run python tools for simple yet powerful user friendly applications. This computational core comes with a bunch of General Purpose Input & Output pins or GPIO for short so that one can easily interface a good number of sensors to sense the physical world parameters which makes it suit for this application. The Python programming language which can be run easily on a Linux system has good amount of powerful libraries. The OpenCV library for python is a powerful yet simple to use program for onboard image processing. OpenCV comes with ample amount of image transformation algorithms which can be used to process the captured image/video stream. Raspberry pi 3 comes with 1 GB of RAM which is sufficient to perform simple image / video processing [1].

A. Colour identification

A web camera of good resolution is placed on the top of the trash bot which constantly check its field of view for the target item. Here we have trained it to detect color yellow instead of hand movements. Every time the camera detects the colour yellow, the bot moves towards the user by calculating its distance using coordinates of the identified colour. Using the onboard computer (Raspberry Pi 3b+) which would be running OpenCV, we can capture and process the live video stream to extract the features of interest. These results can be used to help navigate the trash bot. Image processing is a technique to perform some actions on an image, in order to obtain some useful information from it [4]. An image is nothing more than a two dimensional matrix (3-D in case of coloured images) which is defined by the mathematical function f(x,y) where x and y are the two co-ordinates horizontally and vertically. The value of f(x,y) at any point gives the pixel value at that point of an image, the pixel value describes how bright that pixel is, and/or what color it should be.

To represent color images, separate red, green and blue components must be specified for each pixel (assuming a RGB color model), and so the pixel `value' becomes a vector of three numbers. Often the three different components are stored as three separate `grayscale' images known as color planes (one for each of red, green and blue), which have to be recombined when displaying or processing [4]. For representing the colour yellow, RGB value is 255, 255, 0. Image processing in our project is done using OpenCV. OpenCV-Python is the Python API of OpenCV. It combines the best qualities of OpenCV, C++, API and Python language. Python is a general purpose programming language which is simple to use because of its easy code readability.

B. Wheel movement

There are 4 wheels provided on the base of the bin. The geared motors used to drive the wheels are of 60 rpm. Two wheels on each side are connected using a shaft and then to the motor driver. The L293D Motor Driver IC allows DC motor to drive on either direction. L293D works on the concept of H-bridge. H-Bridge is a circuit which allows the voltage flow in either direction. Voltage has to change its direction for being able to rotate the motor in clockwise or anti clockwise direction, hence H-Bridge IC are ideal for driving a DC motor. In a single L293D there are two H-Bridge circuit inside the IC which can rotate the two DC motors independently. The motor driver gets its instructions to move forward on the detection of an image (from RaspberryPi 3b+); and to stop the wheel movement on detection of an obstacle using ultrasonic sensors (Arduino ATMEGA328).

When the bot has to go in reverse direction, the motor driver commands the four wheels to rotate in anti-clockwise direction. When it requires to move left both the wheels on the left side are halted and driver commands movement of the wheels on the right side. Similarly, the motion towards right side can be achieved. Since the wheels on either side are connected via a shaft, the wheels move in synchronism whether clockwise or counter clockwise.

C. Lid functioning

A lid is provided on the top of the bin to dispose waste from the user. Servomotor is used to control the lid functioning. When camera detects the user and moves towards it, the lid is closed and on reaching the user, the lid is opened. After a delay of 10 seconds provided for the garbage disposal, the lid is closed. The lid opens only when the camera detects the user, hence it receives its instructions from RaspberryPi 3b+.

D. Bluetooth connectivity

The trash bot is controlled using Bluetooth by a mobile application when the user is beyond the visibility range of the camera. We can customize the application based on our

functions of usage, modes of wheel movements required etc. Since we are focused on a prototype, we have used a simple version of Arduino Bluetooth Controller application.

Here, we can manually control the wheel movement of our trash bot like a toy car and direct the motor to us. Commands can be given to the wheels for forward (F), backward (B), left

(L) and right (R) movements for approaching the desired location of the user. The Bluetooth module used is HC-05. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. It is integrated with Arduino ATMEGA328.

When an obstacle is detected in the front of the path the bot moves towards right; if an obstacle is on the right side and detected by the ultrasonic sensor on the right, the bot can be moved to the left or reversed using the specific controls.

E. Obstacle detection

Ultrasonic sensors are placed on the front and either sides of the base of the bot for detecting any obstacle- people or otherwise on the path of the bot. Obstacles up to 5-15 centimeters are detected. Ultrasonic sensor transmits the ultrasonic waves from its sensor head and again receives the ultrasonic waves reflected from an object and distance is calculated accordingly. Ultrasonic sensors are connected to the Arduino ATMEGA328.

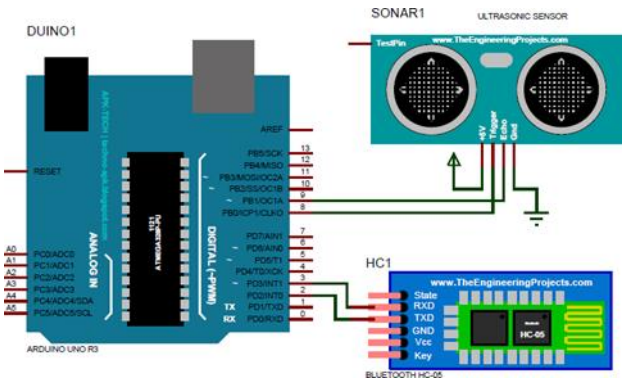

Fig. 1. Integration of Arduino ATMEGA328 with ultrasonic sensors and Bluetooth module

F. Level Detection

IR sensors are provided in the body of the bin to detect the level of trash. Up on reaching the limit, an LED mounted on the lid glows to allow the user to realize that no more trash can be placed; also a concerned personnel is notified for timely removal and proper disposal of the waste collected by the bin.

G. Suction Fan

A suction fan is placed beneath the bin to draw minute dust particles on its path and using a pipe dispose it in the bin.

H. Integration with LCD screen

An LCD screen integrated with Arduino is fixed on the base to show the movement of the bot as it is limited in the case of this prototype.

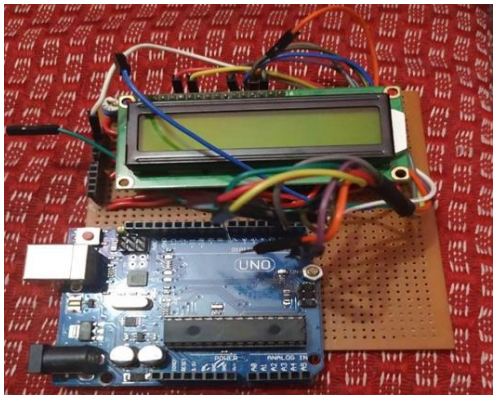

Fig. 2. Integration of LCD with Arduino ATMEGA328

3. Working

The working principle of the trash bot can be explained as follows:

There are two modes of operation in this bot – auto mode and manual mode.

In auto mode, the bot detects the hand when the camera is constantly scanning using Open CV which is programmed in raspberry pi and command the wheels to move towards the person. In our project, we have trained the bot to detect the colour yellow instead of the hand as it is a prototype of our proposed idea.

Once the bot reaches the user, the lid is opened. The lid remains opened for a specific time during which the user disposes the trash inside the bin and the lid is closed.

In manual mode, the bot can be controlled using Bluetooth technology. Trash is then disposed inside the bin when the lid is opened after colour is detected by the camera.

During the motion of the bot towards the user, ultrasonic sensors placed in the front and either sides of the trash bot helps to detect any obstacle in the range of 5-10cms. When the obstacle is detected the bot stops its movement at once; in auto mode for further motion the obstacle has to be removed manually. Whereas in the case of manual mode, we can control the wheel movement and overcome the obstacle in order to reach the user.

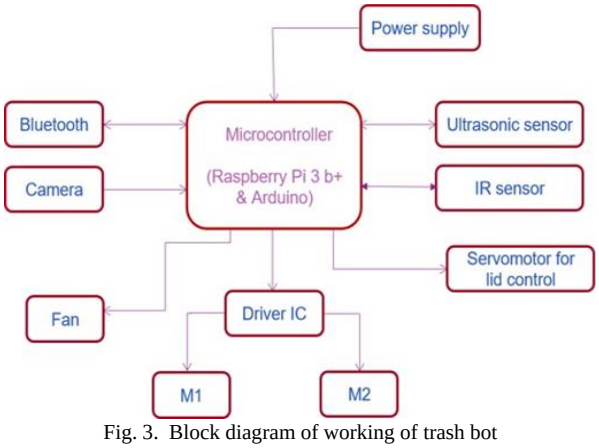

Fig. 3. Block diagram of working of trash bot

The functioning of the lid is controlled by a servomotor upon commands from the Raspberry pi 3b+ i.e., lid opens when bot reaches the user by identifying the coordinates of the detected color using image processing and closes after a 10 second delay during which the user can dispose the trash inside the bin.

The suction fan placed beneath the bot in order to absorb small dust particles and dump it inside the bin through a pipe. Additionally, a level detection using IR sensor is employed in the body of the bot which sends a message to the concerned personnel for timely removal of waste upon reaching the limit. An indication light is provided on the top of the Trash Bot so that the user is also aware of the limitation of the bin.

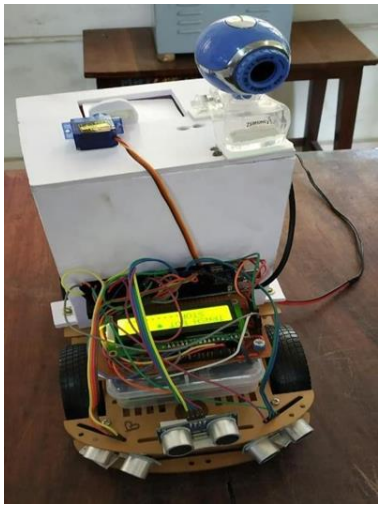

Fig. 4. Prototype model of the Trash Bot

4. Result

It is observed that the bot moves forward when an article of yellow color is in the visibility of the camera in the range of 30cms; the lid is opened upon detecting the person in the range of 5cms using the ultrasonic sensors in the front and when the colour is detected by the camera, lid stays open for 10 seconds and closed after the disposal of trash.

On its path of motion, all small dust particles are sucked and placed in the bin. It is controlled manually via the Bluetooth application; obstacle detection on either side or the front is tested in the range of 5-15cms. An LED glows when the specified level of trash is reached and the concerned personal is alerted for the removal of waste.

5. Applications

Many a times when people need to dispose waste they are unable to find a bin especially in public places like malls, railway stations, etc. In these cases, we can implement Trash Bot which is extremely user friendly and is easily accessible. Through manual control provided by the mobile application we aim to provide a fun platform for encouraging people especially kids and youngsters to actively participate in proper waste management for better environment and a greener future.

Trash Bot can be used effectively in offices as it is highly interactive, employees are keen to use the services provided by the bot. Moreover, the bot can be used for security purposes as the camera can be used to record everything the bot comes across thereby spotting crimes, theft etc.

6. Conclusion

This project work is an implementation of an automated garbage collection and level detection system. The work is completed by using components like Raspberry Pi, Arduino ATMEGA328, ultrasonic sensors, servo and geared motors, IR sensors etc. This system uses its camera mounted on the top of the bin to identify the user who wish to dispose trash and thereby moving towards them. It can also be controlled manually when the user is beyond the visibility range of the camera.

Our project finds its applications in offices and malls but by further technological improvements, it can be used for various other purposes like security services by recording and live streaming through the camera; interactive location finder and navigation through GPS; by providing robotic arm pick and place of waste is possible. Also by complex image processing techniques we can identify waste objects, distinguish it and dispose it.

We aim to increase the efficiency of the overall waste management system. Trash Bot ultimately helps to maintain cleanliness in our society in a much interactive way than its traditional counterparts.

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