GARBOT - THE GARBAGE COLLECTION ROBOT

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ABSTRACT
Nowadays garbage is one of the greatest issues in our society. Increasing human demand for resources has increased garbage production to a large extent. Whether it be our house, classroom or office, everything we do results in some form of garbage being produced. Even though there is regular waste-management in most of these areas, it is often observed that garbage is often littered. This paper aims at introducing a technique for garbage collection in offices by implementing robots to do the task. Here, robotics and image processing are combined to achieve the task. Robotics is applied for mobility and image processing can be used for a better and simpler user interface.

Keywords: *Garbage; Robot; Hand Gesture; Segregation*

1. INTRODUCTION

Solid waste management is an essential service in any society. Solid waste refers to the range of garbage materials that are discarded as unwanted and useless. Solid waste is generated from industrial, residential, and commercial activities and these wastes are handled in a variety of ways.

In this paper, we'll be focusing on wastes produced in offices (or hospitals) mainly metal wastes and non-metal wastes. Offices are chosen since it is one of the primary areas where garbage is littered and requires immediate action. Office workers produce different kinds of wastes like plastic, paper, soda cans, food cans etc during work hours. Separate bins are usually kept for different wastes, and many workers find it tiring to go towards these bins and separate the wastes manually. Hence, they usually keep the wastes in their cabins itself or just litter them. An untidy office cabin and surroundings might look unprofessional and affect the employee's work life. It is also necessary to get rid of the wastes getting littered on the floor and segregation is also a concern.

The collection of garbage poses various challenges like the requirement of human action to manually collect and dispose off the garbage by coming towards the garbage bin (if present). Also, bins need to be available at most places and waste level indication has to be somehow conveyed to the user. Segregation of garbage is another issue; to separate the different types of waste. A mechanism that can do all these actions effectively is not available in the market.

To tackle the various issues we face during garbage collection, we put our focus on creating a mobile garbage collection bin capable of collecting the garbage from the user whenever action is requested. Our design would also take segregation into consideration which is the first vital step in waste management.

The mobile garbage collection bin titled "GARBOT", would find application in collection and segregation of garbage from small sectors such as offices, schools and even houses. It will be mainly designed to serve indoors, and would be a portable and compact robot capable of moving in limited space without causing disturbance to the user.

GARBOT's main feature would be its capability to come towards the user's cabin when called; the user would not have to get up and move towards the bin. Upon reaching the user, GARBOT would detect the type of garbage (metal or non metal) and separate the different waste into different compartments. It would use sensors to monitor the garbage level. The level of garbage will always be notified by means of LCD display and coloured LEDs on the bin. The bin of GARBOT is detachable so that its contents can be emptied easily when authorities arrive for collection.

2. LITERATURE SURVEY

We have referred many papers related to garbage collection and segregation and have carefully studied the importance of waste management. Following are the conclusions we have reached:

An existing device is Dustcart which is a metropolitan garbage collection robot [1]. This robot works with the aid of GPS and Ambient Intelligence (AMI). This robot is a multipurpose robot and performs various actions other than garbage collection like atmospheric pollution level indicator. Dustcart goes from door to door for garbage collection. It uses touch-screen for interaction with humans. Every single action of the robot is controlled using AMI. The request for garbage collection is received by DustBot call centre which now dispatches the dustcart to the predefined location of the user. But the Dustcart is not suitable for household activity since GPS has low resolution and cannot work under small areas [10]. Also wireless communication calling for indoor garbage collection is inappropriate and unnecessary. The user interface provided by touch-screen requires more human energy usage hence can be replaced using Hand gesture detection using convex hull and contour detection [4][5].

We've adopted the technology of garbage level indication using ultrasonic sensors from Samann and Fady's " The Design and Implementation of Smart Trash Bin." [2][3]. Ultrasonic sensors are also useful for obstacle detection for the bin during movement [6]. Additionally a bluetooth application can be used from a phone which can control the movement of the robot [7]. Metal and non metal segregation is optable with separate compartments [8][9].

3. PROPOSED SYSTEM

Garbot is a mobile garbage collection robot which can work in small localities such as in households. For mobility wheels are provided. It uses image processing techniques of contour detection and convex hull for input. Hand gestures are used as input signals for the robot to do action. On receiving the input signal, the robot moves towards the user who can now put the waste inside the robot bin. The robot bin has two separate sections for separating wet wastes from plastic wastes and this is controlled using a button. After the garbage is dumped into the bin, the robot moves back to its initial position of rest. For additional control purpose, a mobile software application is provided to control the robot. Garbage level indication is also available in the form of LCD display.

Garbot offers a much more simpler yet powerful user interface and resolution of location is increased. But for long range application the technique is not suitable.

3.1 Methodology

3.1.1 Input signal

Hand gestures are taken as input signals. Contour detection and convex hull algorithm is used for hand gesture identification. Specific hand gesture is predefined as an input signal.

3.1.2 Movement of robot

Direction in which the hand gesture was received by the camera is analysed from the angle of servo motor connected to the camera. This direction is used by the robot to control the motor driver to move the robot in this direction with the aid of wheels.

3.1.3 Segregation

A metal detector is used for separating metal wastes from non metal wastes.Bin is divided into two compartments: Metal and Non Metal compartment. Metal sensor is attached to the plate where the waste is dumped. If metal is detected by the sensor , then the waste is dropped to the metal compartment and if not detected, then to the non metal compartment.

3.1.4 Waste level indication

Waste level is measured using ultrasonic sensor and the level of waste present is displayed using an LCD display and LED. Ultrasonic sensor is predefined with a certain value and LCD will display the level of waste according to this reading.

3.2 Block diagram

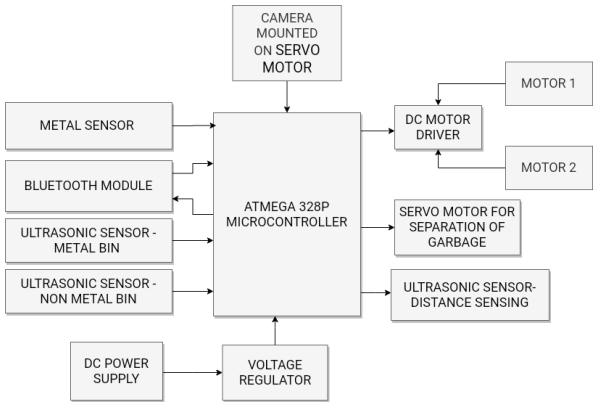

Figure 1. Block diagram

3.3 Working

Garbot rests at a specific place known as initial position. It has a webcam as an input image device mounted on top of the bin. This webcam is attached to a servo motor which rotates in 3 (or more as per the number of cabins) predefined angles each towards different cabins in the office, at a specific interval say 5 seconds. When a predefined hand gesture comes in range of camera's vision an input signal is recorded and the angle of servo motor at which the input signal was captured is locked. Two hand signals are defined- one for start action and the other for cancelling the action if necessary. The wheels of the robot are rotated in this direction and the robot moves towards this direction in a forward path. An ultrasonic sensor is mounted on the front portion of the bin which senses the user who is present in front of the robot. The sensor is programmed to stop at a distance of 30cm away from the user. The robot is programmed so that when it stops, the lid of the bin opens. Next the waste is dumped onto a plate to which a metal detector is attached. If the detector detects the waste as a metal, it drops the waste into the metal waste compartment, else the waste is dropped into the non metal compartment after a specific delay. After a specific interval the lid closes itself and the robot returns back to its initial position through the same path..

Additional features like garbage level indication and remote control using smartphones are provided. Garbage level is identified using ultrasonic sensor and is displayed using an LCD display. Smartphone application is provided which uses bluetooth connection for wireless control of the robot.

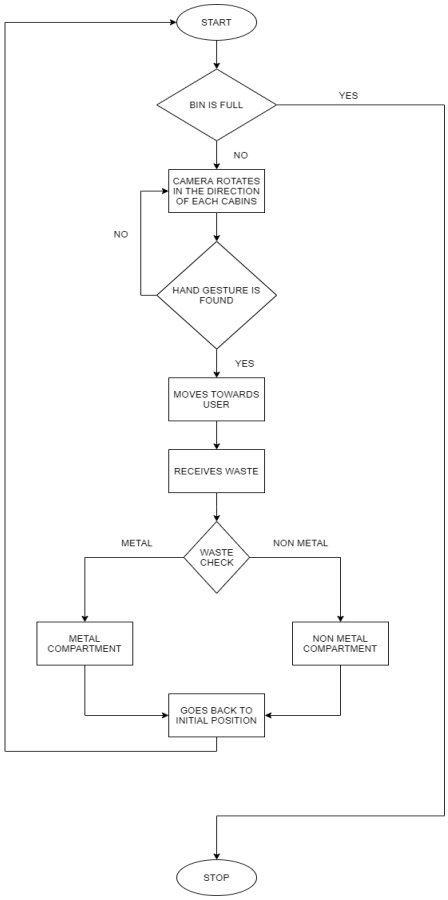

Figure 2. Flowchart

3.4 Hand Gesture as input signal

Gestures are defined as any movement of body parts (usually head or hands) to convey a message. Gesture recognition is a kind of perceptual computing interface, with the goal of capturing and interpreting human gestures as commands via mathematical algorithms. We are implementing image processing for gesture recognition and hand gestures are used as our input. Hand gestures are used since hand gestures are easier to detect and assign functions than any other gestures.

Image processing is a method which performs certain operations on an image, to extract some useful information from the image or it enhances the image itself. It is a type of signal processing in which input is an image and the output may be an image or characteristics / features associated with that image. OpenCV- Python library is used for gesture recognition and the techniques used are contour detection and convex hull.

3.4.1 Contour Detection

Contours are basically an outline bounding the shape or form of something. Contour detection is a process which can be explained simply as a curve joining all the continuous points (along with the boundary), that have the same colour or intensity. Here contours are drawn along the boundary of hand. Skin colour is predefined as the threshold colour around which contours are formed.

Contour detection is done using OpenCV tool in Python. To do contour detection, OpenCV provides a function called 'cv.findContours' which intends to find contours in the image. Some treatment should be applied to the picture to detect a good contour ie, for example the image which is in RBG (Red Blue Green) color is first converted to HSV (Hue Saturation Value) and contour detection is done on this image. Now after specifying boundary, contours are detected using 'cv.findContour' command. We can also draw contours using the 'cv.drawContours' command. Various properties for contours like contour area and contour perimeter can be defined for further accuracy.

3.4.2 Convex Hull

Convex hull is the smallest polygon that can be drawn around the given contour points. This enclosure contains all the points in the plane. The defects or spaces between contour and convex hull are used for forming the gesture of hand.

Convex Hull is similar to contour approximation, but it is not (even though both may provide the same results in some cases). The 'cv.convexHull()' function checks a curve for convexity defects and corrects it. Convex curves are the curves which are bulged out, or the curves that appear at-least flat. If it is bulged inside, it is called convexity defects.

3.4.2 Hand gesture recognition process

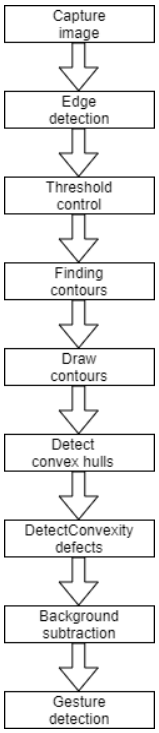

Figure 2. Hand gesture recognition

First the live image of the hand is captured through the camera and edges of the hand are drawn around the detected threshold colour of skin. Contours are found and drawn and convexity defects are identified. Background is blurred and erased. Finally the gesture is obtained.

4. RESULTS

We had assigned two commands:

- Hand gesture with two fingers will be the trigger signal for the Garbot to start action. These are the simulation results we obtained from our program.

- Hand gesture with 3 or more fingers will cancel the trigger signal. This signal is used if a signal was accidentally accepted by the robot. If this gesture is simply shown, there won't be any significant action by the robot.

Following are the simulation results we obtained from our program:

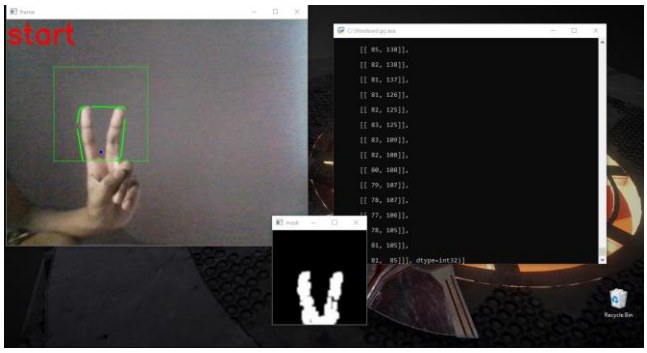

Figure 3. Gesture with two finger for "Start"

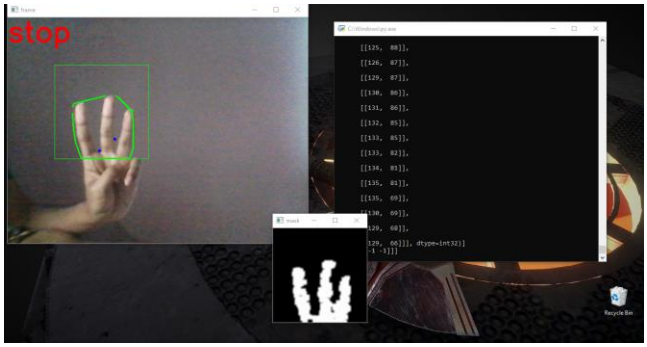

Figure 4. Gesture with three finger for "Stop"

5. CONCLUSION

In this paper we have focused completely on the software part of the Garbot. We aimed at creating a perfect and user friendly input to our robot and we successfully achieved this. Introducing this robot in offices can create a huge impact in improving human productivity by getting rid of the wastage of time previously utilized for cleaning and waste management. This would also reduce the disturbance caused to employees during work time. Janitor's work can also be reduced since now they don't have to clean each and every cabin and can provide privacy to employees. We are concluding this paper keeping a possibility for further modifications and improvements in the robot with changes in technology.

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