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Smart Autonomous Multi-Purpose Trash Picking Robot

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ABSTRACT

This paper aims to design an autonomous multi-purpose trash picking robot. It is best suitable for shopping malls and metro railway stations. Two or more robots of this kind are placed in each floor for user convenience. These robots move around the mall and collects the trash. These are interlinked with each other through WIFI. Each of them goes to the customer who wants to throw waste which mainly includes paper and plastic. The customer can either wave hands at the robots or hold the empty glasses or bottles in a way which the robot can recognize. They have special mechanism under their bins which mops the floors of the mall as they move from one place to other. They have a navigation map of the mall to guide the visitors. These are displayed on a LCD screen and heard through a speaker situated on each of these robots. Each of them have a robotic arm which can pick up the waste that has fallen on ground. There is a crusher inside the bin which crushes the waste and can intake more waste. Once the waste is filled to a maximum limit it navigates and finds the main bin. It goes to it, empties itself and comes back to its original position. Batteries are provided for these robots and have to be charged periodically by the staff monitoring them.

Keywords: Autonomous, multi-purpose, trash picking robots, robotic arm.

1. INTRODUCTION

Robotics is an emerging field in the world which is bringing drastic changes in human life. Robots are designed in human interactive way and they are becoming part of lives. Human power is being saved by replacing it by robots in various fields. Cleaning public places is one such field where more human power is required. Autonomous trash collecting robots have been considered as benchmark for mobile robot design problem. These include several common tasks such as navigation, path planning, object detection and discrimination, obstacle avoidance, task sequencing and often multi-agent coordination [1].

Many of us have faced problem in finding a trash bin when we visit new shopping malls and railway stations. The robot described in this paper solves these kinds of problems. The robot consists of a wheeled platform on which a moderate sized bin is placed. Hardware is mounted in this bin such a way that when a customer wants to use this bin it senses the waving hand motion and moves towards the customer. It can also detect the empty plastic or paper bottles in customer's hand and moves towards him. The person can dispose the product into the bin.

Second major problem faced by the visitors is navigation through the mall or railway station. These bins are provided with a LCD screen which shows the map on visitors' request. It also includes the voice assistance and is more human interactive. GPS is incorporated to provide current location and guide the visitor. This map also describes the key information about the place which visitor selects through audio.

Two or more bins are situated on a floor depending on the dimensions of the place. These bins interact with each other through WIFI. Particular proximities are provided to avoid them going out of the boundary. These bins are designed with mopping cloth underneath. Whenever the robot moves from one place to other the floor is cleaned with this mechanism. Hence, human power is saved who periodically mop the floors.

The bin contains special kind of crushers inside to crush the waste and make space for more amount of waste. There will be a threshold level for a particular amount of waste. Once it reaches its maximum the bin alerts itself and finds its present location through GPS. The main garbage bin location would be fed previously and the robot goes to it by navigation. It empties itself and returns to the original location.

Robotic arms are provided for these bots for lifting up the bin and dump the waste into garbage bin. These arms can also pick up the waste that has fallen on the ground and put into the bin.

The batteries and hardware are placed under the bin and has to be charged by the staff periodically. These robots have to be monitored and maintained periodically for better performance [2].

2. NEED FOR AUTONOMOUS TRASH PICKING ROBOT

The major public problem faced by many developing countries, especially in India, is lack of uncollected trash littering the streets, roads, sidewalks, shopping malls, railway and bus stations and many other public places. Hence, realizing the seriousness of cleanliness the Indian government officially launched Swacch Bharat Abhiyan for clean India. The main aim of this campaign is to make India as one of the cleanest country by 2020. In the initial months, the campaign seemed to receive a great response throughout the country.

There were many programs across the country, led or inspired by the celebrities and governments, but quite often they were seen as photo opportunities for celebrities and lesser mortals to be seen cleaning streets with a long broom held in gloved

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hands. But somehow the campaign did not pick up great speed. There is need to bring up more awareness among the people about cleanliness.

An autonomous robot is a robot which performs behaviors or tasks individually with highest degree of autonomy. These are mainly desirable in fields such as household maintenance cleaning, waste water treatment spaceflight, delivering goods and other services. Some of the modern factory robots are allowed to be autonomous within the strict boundaries of their environment. Every degree of freedom may not exist in their surrounding environment, but the factory robot's workplace is challenging, can contain unpredicted variables and can be often chaotic. An autonomous robot can obtain information about its surrounding environment, work for more time without human intervention, move either all or part of itself throughout its operating environment without human assistance, avoid situations that are harmful to humans, public property, or itself unless those are specified in design specifications. They can also adapt to changing surroundings. Like other machines, these robots need regular monitoring and maintenance for proper performance [1].

3. SERVICES OFFERED

These smart robots can provide following services.

1) They can provide waste management services to the people moving around.
2) It moves towards the person who wants to use it and detects that person with his waving hand motion.
3) They provide a smart way of replacing paid labor by cleaning the area around.
4) They can act as portable smart guide for visitors at any new location.
5) They can be used for security monitoring purposes by capturing and wirelessly transmitting the video stream from a location to the base station nearby.
6) They can pick up the trash fallen on floor using the robotic arm provided.

4. METHODOLOGY

This class of robots can be designed by following below mentioned methodologies.

1) Choosing a rugged mechanical chassis for all time use.
2) Choosing a stable computational core for managing the robot.
3) Sensing physical world parameters and utilizing these parameters for offering services.
4) Algorithms to detect human motion and gestures.

The above methods can be integrated into a small system which serves the purpose of a smart trashcan & a guide.

4.1 MECHANICAL DESIGN AND CHASSIS

At the simplest level, a mobile robot whether on land, in air or under water is a mechanical base or platform actuated by electric motors. Therefore, the mobile robot platform can be constructed with a simple circular aluminum disc with two 12 or 24 volt DC electric geared motors at the rear and one or two casters at the front. The use of geared motors reduces complexity and investment cost at a great extent. Rubber wheels can be used for smooth drive quality which improves the robots mechanical life.

A commercial stainless steel trashcan sizes roughly around 12-14 inches wide and 32- 40 inches high. A similar design can be used but on wheels so that it can be a mobile trashcan which can move in a locality when commands are given. All the electronics required to help the trashcan navigate can be mounted behind or below the trashcan by considering the ground clearance. Necessary space and vents can be used to help air circulate rough the electronics compartment to provide cooling in hot weather, cooling fans can also be used to improve cooling.

A scrubber can be mounted below the chassis so that the robot mops the floor all the time it moves from one place to other. This kind of a design reduces the labor cost and is a smarter approach. The robotic arm can be built using 5 servo motor and some L and U brackets that fit servo motors. The design of the arm with only 5 degree of freedom can be considered in order to reduce the weight handled by the chassis. For controlling the entire robot, a power supply is designed such a way that it was able to produce enough power for motors and controller with all the sensors mounted on it [2].

4.2 COMPUTATIONAL CORE

A cost effective simple open source processor board like a Raspberry Pi 3 is a good solution for basic computations, Image processing and sensor data acquisition.

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.

4.3 SENSING PHYSICAL WORLD PARAMETERS

This kind of a smart trashcan should be able to sense the world around it and know where it is in order to provide uninterrupted services to its customers.

Cameras (dedicated cameras or USB cameras) can be interfaced to the Raspberry Pi onboard to acquire video and image which can later be processed to get the required fields from the footage. Precision long range ultrasonic distance sensors can be used to know the distance from obstacles around so that the robot can autonomously navigate around. A GPS module on board can be used for getting the accurate location of the robot. This helps to find the main garbage bin in which the location of it is pre saved. It also receives

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information about other robots present in and around. These robots can have a load cell along with a proximity sensor to tell the amount of waste in the trashcan. A resistive strain gauge can be used as a load cell which can be used to constantly measure the mass of contents in the bin. As we know that the bin doesn't fill completely but reaches the maximum permitted mass threshold by putting some high density objects, a secondary sensor can be used to know whether the trashcan is full or empty. When the trashcan is filled up to the neck, the proximity sensor raises a priority interrupt. This interrupt will command the robot to go to a nearby main garbage bin to unload. A 7" LCD display screen is mounted on the top to display map and other animations about the location and prominent places of the city. The onboard microphone and speaker can be used to interact with the robot user by using simple voice to text recognition, converting the text messages to robotic voice and so on. Voice over internet protocol can be used for the bidirectional communication between the robot and the operator. A private branch exchange can be set up using Asterix open source communication server on the Raspberry Pi. The audio output of the Raspberry Pi can be converted to robotic voice using HT8950 voice modulator IC. The air quality can be sensed using low cost sensors like MQ2 (methane), MQ7 (carbon mono oxide), MQ9 (carbon dioxide) [1].

4.4 IMAGE PROCESSING ALGORITHMS

As this robot can have onboard cameras with pretty decent resolution the onboard computer (Raspberry Pi 3) which would be running OpenCV, we can capture and process the live video stream to extract the features of interest. These results can then be used to help navigate the robot to the required destination. The basic image processing algorithms which a robot of this kind would be pedestrian detection and hand gesture detection.

Hand gesture detection using OpenCV

The hand following depends on shading acknowledgment. The program is along these lines introduced by examining shading from the hand. Refer fig.1 for the flowchart for hand gesture recognition [3,4].

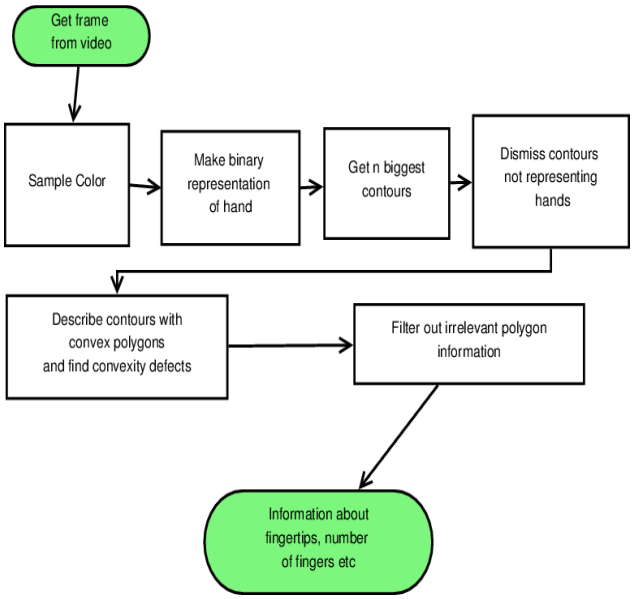

Fig. 1 Flowchart for hand gesture recognition

The hand is then extricated from the foundation by utilizing an edge utilizing the tested shading profile. Each shading in the profile creates a double picture which thus are altogether summed together. A nonlinear middle channel is then connected to get a smooth and clamor free parallel portrayal of the hand.

At the point when the parallel portrayal is produced the hand is prepared in the accompanying way as shown in fig 2.

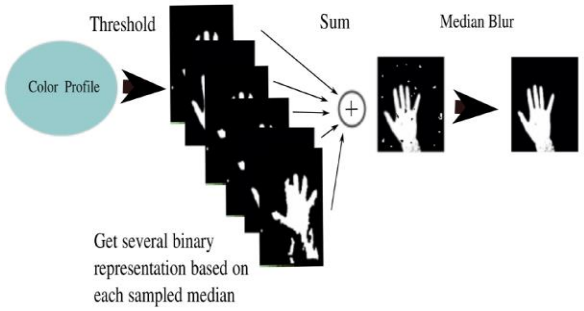

Fig.2 parallel portrayal of hand

The properties deciding if a convexity imperfection is to be rejected is the edge between the lines going from the deformity to the neighboring arched polygon vertices as shown in fig 3.

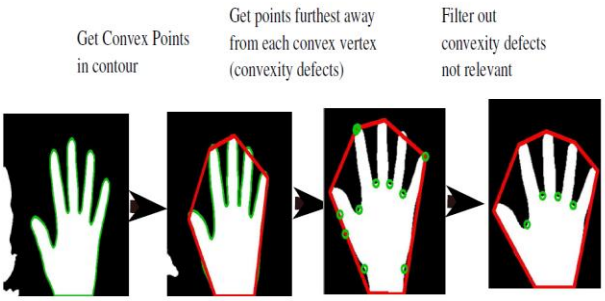

Fig. 3 Convexity imperfection based on polygon

The imperfection is rejected if:
length<0.4lbb
angle>80°

The analysis brings about information that can be of further use in motion acknowledgment:
Fingertip positions
Number of fingers
Number of hands
Region of hands.

Pedestrian detection using OpenCV

OpenCV ships with a pre-trained HOG + Linear SVM model that can be used to perform pedestrian detection in both images and video streams. The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible.

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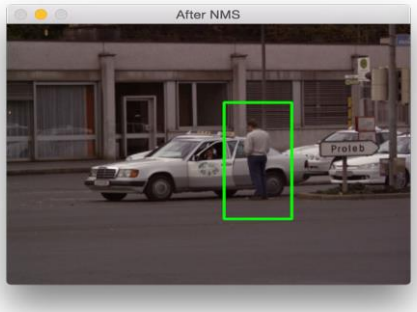

Fig. 4 The above image shows the versatility of our HOG + SVM pedestrian detector

5. FUNCTIONAL BLOCK DIAGRAM

Fig.5 shows the functional block diagram of the smart autonomous trash picking robot. The heart of the system is Raspberry Pi 3 of 1GB RAM which runs on LINUX operating system along with the host of programs running on it. Raspberry Pi doesn't come with an inbuilt ADC. External peripherals like analog to digital converters are to be interfaced to Raspberry Pi in order to make functional with the analog devices. Analog proximity sensor, analog resistive load cell and air quality sensors provide analog voltage output which can be sampled, quantized and encoded using an external 12-bit ADC like ADS1115 easily. These sensors provide the trash bin with important physical parameters which will enable us to monitor the status of the trashcan.

The system can be interfaced with a low cost GPS module to get the accurate location of the trashcan which will enable it to navigate autonomously back to the base station once the trashcan is filled. Course correction can be done with the help of data obtained from the high precision distance sensors which helps the robot to navigate to its destination.

The floor plan of the location can be fed into the Pi and can be displayed on any typical HDMI LCD display.

A USB camera or dedicated Raspberry Pi camera can be used for image and video acquisition. Thus, the acquired video can be processed by OpenCV for extracting further information. An advanced open source artificial intelligence software like Jasper can be used to implement a cheap AI system which will help the robot to communicate with the customers by taking the audio input via USB microphone. The audio output response of the AI can be heard through the analog speakers. The AI learns itself how to communicate with its customers as the time prolongs. Advanced audio filtering and noise cancellation techniques can be easily used on the system to make it more anthropomorphic. Typical high current motor driver like VNH motor driver which has peak current ratings of 30 Amps is a desirable option to drive high torque DC motors which help in locomotion. Lithium polymer batteries can be used to power the entire system as they have a very good power to mass ratio compared to other chemical cells.

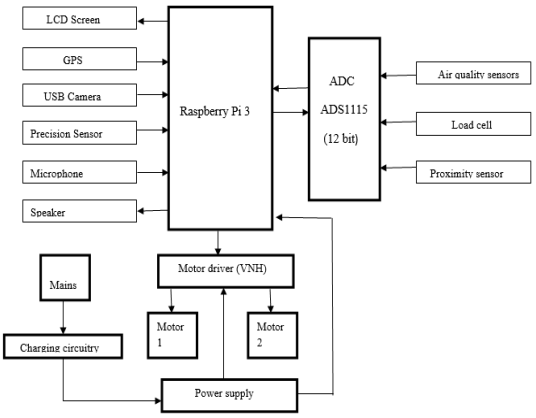

Fig.5 Functional block diagram.

6. CONCLUSION

A low cost smart trashcan cum guide can be implemented by following such a kind of procedure mentioned above which can help reduce the human effort in cleaning the public places. These can also help people finding the way, knowing about the location in an interactive way. These also provide the security service by recording the footage of the location.

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