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BEACH CLEANING BOT

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Abstract - *A bot to be controlled wirelessly using an android application can be advantageous in the scenario of an unclean beach. A bot capable of collecting garbage in a beach environment can help reduce manpower. The usage of a camera to detect garbage can help in reducing the power consumed by the bot and can help intelligently collect garbage. Detection of garbage is acheived by using high efficiency tensor flow models whereas control of the bot and other actions is done with the help of a Raspberry PI.*

Key Words: Raspberry Pi, Object Detection, Android application, Beach cleaner bot.

1. INTRODUCTION

In countries like India which are known for their beaches, the main problem arises when the people overpopulate the beach and start littering the surface of the previously clean beaches tampering the beauty of those tourist spots. We were inclined towards this idea when we had worked for an NGO previous year during the Ganpati festival. The beaches were overloaded with litter and cleaning it required a team of 100 plus social workers. So, we realized the idea of making a beach cleaning robot that will be controlled via radio frequency and would reduce the work of 100s to a handful of people.

1.1 Problem Statement

Once a wise man said, "Cleanliness is next to Godliness", rightly said! We all love being in a clean, elegant and pleasant smelling surroundings. Who likes being in a dirty environment. However, in an overpopulated country like India, it can at times be difficult to maintain clean surroundings and with so many tourist spots in the country, it becomes all the more difficult to keep the places clean.

Cleaning beaches is a growing problem these days. NGOs and other non-profit organizations are working very hard to clean beaches. However, it takes a lot of manpower, volunteers, and motivation to clean beaches by hand. It is not possible to clean all the beaches in the country considering the number of NGOs taking part in the initiative. This leads to several problems with the environment. Lack of cleanliness in beaches leads to several environmental problems such as water body pollution. If this problem is not solved as early as possible, it will lead to many other problems such as mass water living creature deaths, that take place due to various non-decomposable waste such as plastic, thermocol, etc.

This problem arises mostly during the time of festivals such as Ganesh Chaturthi, Navaratri when large idols made up of Plaster of Paris(POP) are immersed in the water. The number of idols immersed is going up and POP does not do well with water. Idols after immersion appear again on beaches the next day, leading to a lot of garbage that has to be removed by hand by volunteers from NGOs. This task is very time consuming and requires a lot of manpower.

In spite of the number of organizations and NGOs that come to the scene to clean the beaches, the problems do not cease to stop. Hence it is necessary to build a system or a device that automates the entire cleaning process and can also be monitored.

This device will help the organizations largely to improve the beach cleaning process and hence will be a boon for the society. This device will also be helpful to monitor a lot of metrics that play an important part in making decisions by the organizations.

1.2 Objectives

Our main objective for building this project that is beach clean is to reduce the manual work of cleaning the beaches done by the cleaning officials. As the beaches in India are mostly littered and people do not through the garbage like plastics, bottles and many things and the especially during the time of Ganesh festival the people immerse the Ganesh idol in beach water, the idols are mostly made up of Plaster of Paris which does not dissolve or submerge into the water and float out the waters,and stack up that shores which increases the work of cleaning. Cleaning in that month is quite treacherous for the cleaning officials.

2. LITERATURE SURVEY

There are very few systems that have been developed so far. These systems basically use an entire mechanical mechanism to collect garbage. The systems use a lot of energy and do not provide remote monitoring and different modes of operation. Existing systems haven't done a lot for the well being of the NGOs as they are quite

costly.

On the other hand, our system provides features such as dual mode of operation, in-built garbage compression, automatic disposal, and an analytics dashboard. The system will be built on a small budget so as to help small organizations and NGOs use this to the best of use. This bot will be very handy in cleaning beaches and reducing manpower as it can also be left unattended finding its way out, finding garbage and collecting them for disposal, thus reducing manpower. Its automatic system also overcomes the problem of the user not having enough knowledge about the bot. Hence, it would be better than traditional systems.

The existing systems that implement an automatic beach cleaner bot, have to be operated manually using a remote control and do not have the feature of object detection and data analysis. In this system the main bot is divided into 2 main models :

The object detection: The bot will be trained to detect objects and differentiate between stones and litter. This will help to take only litter and leave all the stones

Data communication - We are planning to do analysis measures on the robot so that we can verify how much time the robot was, how much litter is collected and the distance traveled by the robot.

3. REQUIREMENT ANALYSIS

3.1 FUNCTIONAL REQUIREMENTS

- Wireless control of bot using android application.
- Collect garbage and dump it in a disposable bag.
- Intimate the user on reaching maximum capacity of garbage.

3.2 NON FUNCTIONAL REQUIREMENTS

- Reasonable capacity of the bot to collect garbage.
- Reasonable work to be done by the bot in a single charge.
- Simple and intuitive application.

3.3 CONSTRAINTS

- Reasonable capacity of the bot to collect garbage.
- Reasonable work to be done by the bot in a single charge.
- Simple and intuitive application.

3.4 SELECTION OF TOOLS

3.4.1 Hardware Requirements:

- Raspberry Pi 3: Microcontroller central processing unit to the bot. Instrumental in connecting all the components and controlling them.
- Camera: High definition camera to capture images of objects in front of the bot.
- 100 & 200 rpm Johnson motors: Motors to move the bot's tires and conveyor belt.
- L298N(dual-H bridge) motor driver: Motor driver to control the motors attached to the four tyres.
- L293D motor driver: Motor driver to control the conveyor belt.
- Tyres: 4.5mm bore tyres.

3.4.2 Software Requirements:

- Cherrypy: Python based Library to make a RESTful API.
- TensorFlow 1.13: For executing the learned Object detection Model on input image.
- ImageAI: Python based library to train the model and use it later for object detection.
- Java programming language and android studio: Native programming language and programming IDE to develop android applications.
- RaspAP: Linux module to enable Wi-Fi hotspots and visually control connections to the raspberry pi.

4. METHODOLOGY

The proposed method is to have a central device/system which will be instrumental in the cleaning process. The device will have four wheels, a container that will support most of the components of the device, a conveyor belt with hooks attached to collect the garbage. The structure of the bot is the shape of a container as it will protect the components from external objects and sand. The device will also have a garbage bag sealer that will seal garbage bags once they are full. The device contains a Raspberry Pi that serves a WiFi Hotspot and allows devices to control the bot. The Raspberry Pi will also control a camera and send data to a remote server for analysis.

The working of the system is as follows. The bot can be controlled using an Android mobile phone. The Raspberry Pi hosts a WiFi Hotspot and the android application will help the device help the user connect to the bot. Once the

user gets connected to the bot via the android application, he/she will be able to control the bot in several ways. The user will be allowed to move the bot in any direction and also manually turn on/off the conveyor belt. The user can choose not to manually control the conveyor belt, as the device has a camera that will help it in detecting garbage.

The bot will detect garbage by using its in-built camera module. The bot will make use of the TensorFlow python library to detect garbage and to differentiate it from other objects that can be found on the seashore. Once the bot classifies an object as garbage, it will start the conveyor belt and pick the garbage up and dump it in the garbage bag.

Frequently the Raspberry Pi will send data related to garbage, devices and various other data to the server for analysis that will be used by a database analyst to do analysis. The database analyst can use the data to create, analyze visualizations, reports, trends and patterns from the data to make better decisions in future.

4.1 FLOW DIAGRAM

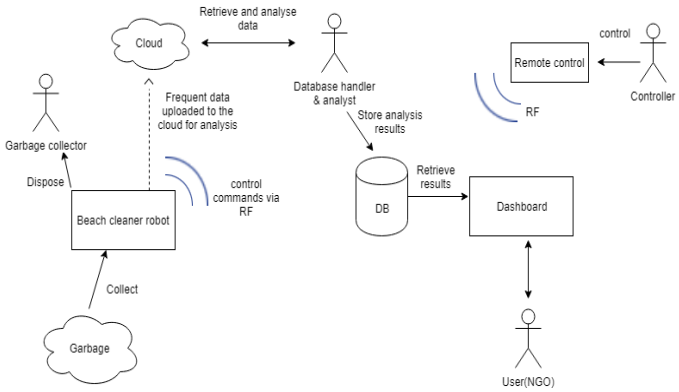

Fig -1: Top level flow diagram

5. IMPLEMENTATION

The different modules of the project are well studied and implemented as

5.1 BOT BODY CONSTRUCTION

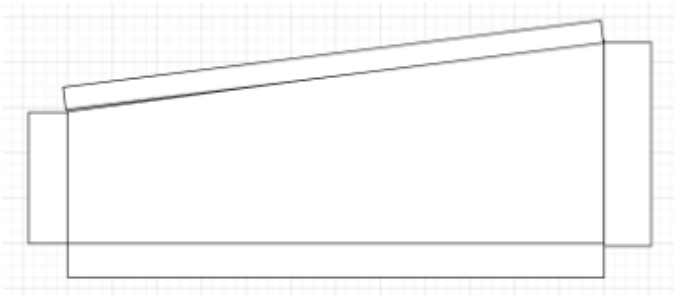

Fig -2: Bot side view

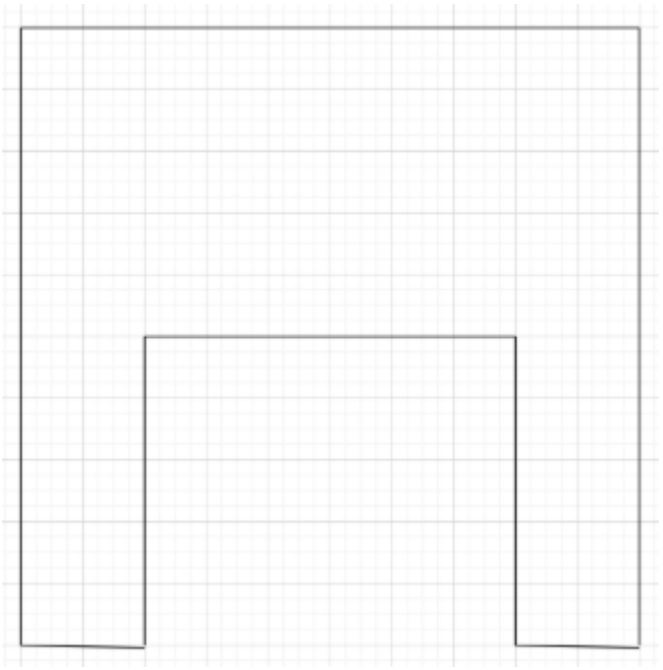

Fig -3: Bot top view

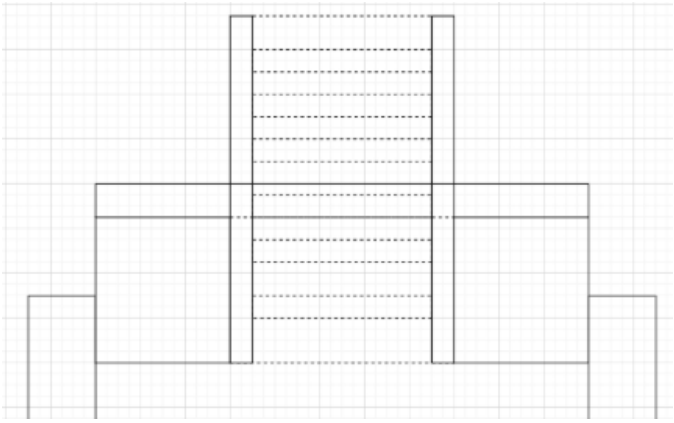

Fig -4: Bot front view

5.2 BOT MOVEMENT

This module involves all the components that contribute to the movement of the bot. The bot works on four wheels. Every wheel has a motor associated with it. The purpose of using one motor for every wheel is to ensure that the bot gets enough endurance to move in sand.

There are in total 6 motors in the bot. 4 motors for bot movement and 2 for garbage collection. The 4 motors used for movement are Johnson 100rpm motors. This motor operates in a voltage range of 6-18V and provides a torque of 5.7 kg-cm.

High performance DC geared Johnson motor with metal gear box used for high torque application and other automation purposes. The motor comes with 6mm off-centred shaft (side shaft) and M3 holes for mounting.

High performance dc geared motors with robust metal gear box for heavy duty applications, available in wide RPM range and ideally suited for robotics and industrial applications.

Features:

1. Rotations per minute: 100 rpm with gear box.
2. Output torque range: 5kg-cm to 7kg-cm.
3. No-load current = 800 ma(max).
4. Load current = upto 9.5 a(max).

In addition to the motors the bot movement module includes a motor driver which is responsible for the coordination of the motors for perfect movement. The motor driver used her is a L298N motor driver. This motor driver is capable of controlling four motors in either direction. It works on a voltage of 2V and produces current upto 35mA.

The l298N motor driver (dual h-bridge) is connected to the raspberry pi and the four output pins are connected to the four motors as shown in the diagram below.

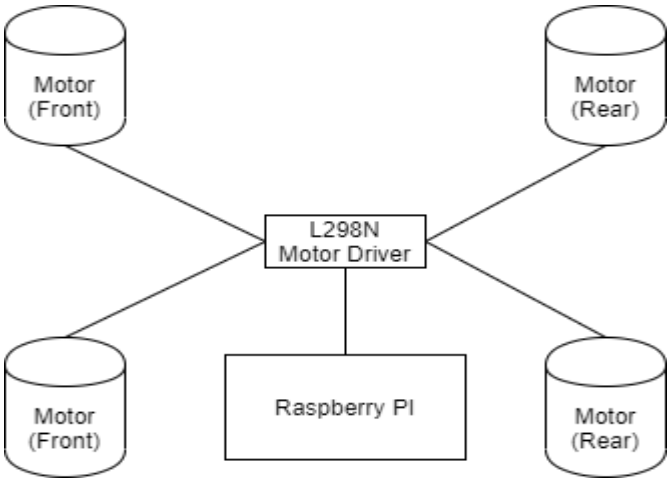

Fig -5: Motor driver connection with the motors

5.3 GARBAGE DETECTION

This module includes detection of garbage.The camera component placed at the front of the bot captures image at regular intervals and the raspberry pi processes it. The Raspberry pi uses machine learning pre-trained models to detect garbage. The models used in this process are trained on a sample dataset. Also the model is trained with the help of transfer learning on the YOLOv3 model.

YOLOv3 is an object detection algorithm that uses features from the entire image to predict each bounding box. It also predicts all bounding boxes across all classes for an image simultaneously. Predicts the bounding boxes and the class probabilities for these boxes.

In addition to the models used for training, a library by the name ImageAI is used to speed up and ease the object training and detection process. This module provides us with several classes and methods to help custom object detection training and prediction.

Some of the methods and classes provided by the library are as follows:

- imageai.Detection.Custom.CustomObjectDetection - class used for Custom object detection
- imageai.Training.CustomDetectionModelTrainer - class for Custom object training

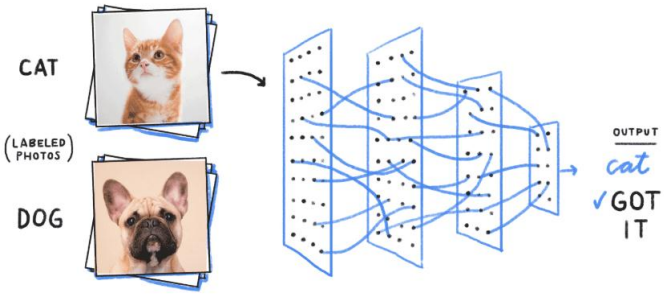

Fig -6: Image detection process

ImageAI is a python library built to empower developers, researchers and students to build applications and systems with self-contained Deep Learning and Computer Vision capabilities using simple and few lines of code. This documentation is provided to provide detailed insight into all the classes and functions available in ImageAI, coupled with a number of code examples. ImageAI is a project developed by Moses Olafenwa and John Olafenwa, the Deep quest ai team.

ImageAI provides the simple and powerful approach to training custom object detection models using the YOLOv3 architecture. This allows you to train your own model on any set of images that corresponds to any type of object of interest.

You can use your trained detection models to detect objects in images, videos and perform video analysis.

This is the Detection Model training class, which allows you to train object detection models on image datasets that are in Pascal VOC annotation format, using the YOLOv3. The training process generates a JSON file that maps the objects names in your image dataset and the detection anchors, as well as creates lots of models.

Whenever the bot is powered on, an object of the type Custom Object Detection is created, this object is then used

whenever there is an image capture. Whenever this object detects garbage it triggers the garbage collection module to collect garbage.

5.4 GARBAGE COLLECTION

This module is triggered by the garbage detection module which was explained previously. The garbage collection module consists of a conveyor belt with prongs on it. This conveyor belt is controlled by two 200rpm Johnson motors. The usage of higher capacity modules for conveyor belts is because the prongs may have to break the resistance being offered from the sand at the beach.

The conveyor belt is welded with prongs at even distances. The surface behind the prongs and conveyor belt is perforated so that sand that might have been lifted by the prongs gets filtered and the trash bag at the end gets a minimum of sand and maximum of garbage.

The motors used for the conveyor belt are controlled by a l293d motor driver. This motor driver is connected to the raspberry pi which at the end sends control signals to the conveyor belt. The choice of using L293D motor driver for the conveyor belt is that it is a 2-motor motor driver and consumes much less power than the L298N motor driver. Additionally this motor driver has a smaller set of configurations for controlling the motors.

L293D motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor drivers act as an interface between Arduino and the motors. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consists of two H-bridges. H-bridge is the simplest circuit for controlling a low current rated motor. We will be referring to the motor driver IC as L293D only.

5.5 ANDROID APPLICATION

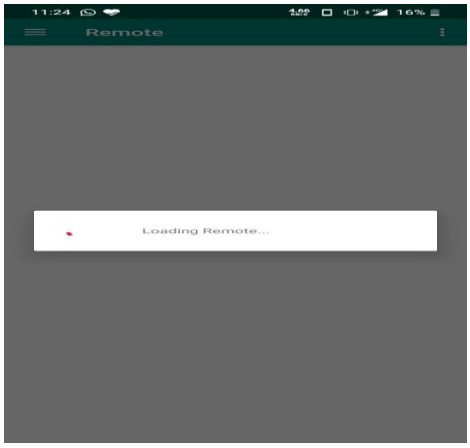

Fig -7: The Android application developed, loading the UI for controlling the bot.

For controlling the bot an android application is developed, which wirelessly connects to the bot on startup and can be used in movement of the bot.

The android application is developed using android studio using the Java Programming language. The application connects to the bot via wifi and allows the user to control the bot as per his/her requirements.

The android application not only helps the user in controlling the bot, but can also be used by developers to get information regarding the bot such as access log, error logs, etc. The application also has an option to test the bot which simply tests various operations on the bot.

5.6 WIRELESS COMMUNICATION

Wireless communication between the bot and the android application is done by using various wireless technologies. The raspberry pi hosts hotspot to which the nearest android application connects and control is given to the user with the smartphone.

To enable hotspot service on the raspberry pi an application named RaspAp is installed on the Pi. This application provides several features that make wireless endpoints a breeze.RaspAP can be installed with the help of pip(linux package manager).

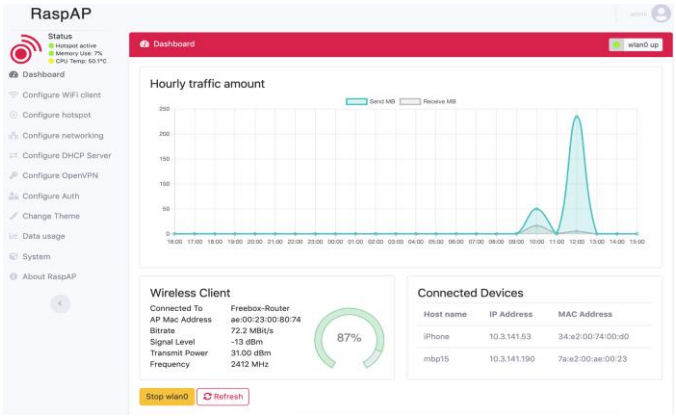

Fig -8: RaspAp Web interface

Using the above interface we create a wireless hotspot for the Raspberry Pi which is available to the nearby devices to connect. The android application discussed previously discovers the wifi network started by the Pi and tries to connect it. Once the smartphone gets connected to the raspberry pi, control commands can be sent to the bot via an interface on the android application.

The raspberry pi additionally runs a web server, that helps in providing web pages for controlling the bot. The android application connects to the pi and requests web pages from it. These webpages are then displayed in the android application. Any interaction on the interface leads

to corresponding code on the bot to execute. For example: If the user clicks the forward button, the code corresponding to sending commands to the four motors to move forward is executed and the bot moves forward.

The webserver for the bot is created using Cherrypy. Cherrypy is a minimal python framework for building web applications. Cherrypy can be installed by using pip(python package manager).

```
pip install cherrypy
```

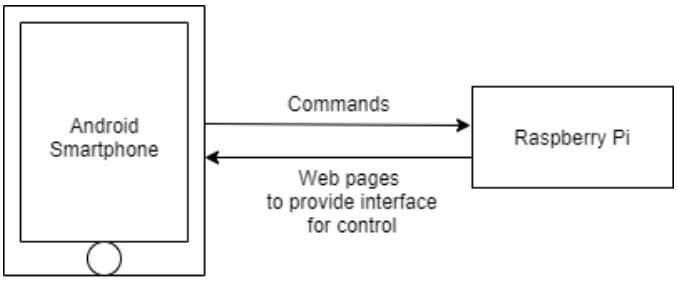

Fig -9: Interfacing the bot with an android smartphone.

6. RESULTS

The bot is broken down and implemented as three different modules. The bot movement & control, object detection and garbage collection modules.

6.1 BOT MOVEMENT & CONTROL

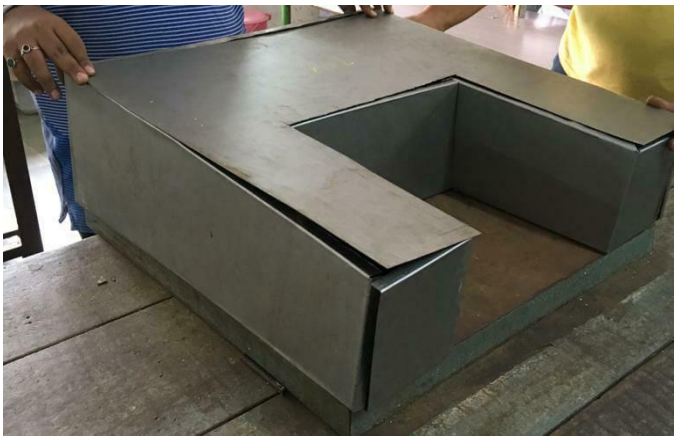

Fig -10: Initial construction of the bot(without the components)

The bot is built using metal thin but durable metal sheets, capable of absorbing shocks caused by the bot's fast motors.

Fig -11: The bot, with top lid open(with components installed)

6.2 OBJECT DETECTION

Object detection for the beach cleaner bot is achieved with an accuracy of 92% . Object detection is done with the help of image AI. The model detects common kinds of garbage found on beaches viz. plastic, cardboard, glass, rubber.

Fig -12: Sample input image

Fig -13: Output generated for sample image.

However, the type of garbage detected is of little use to the hardware, as the hardware does not need to know what kind of garbage it has to collect. Just detecting that there's garbage in front of the bot is to be known. However to

increase future scope, the idea to find the type of garbage has ben implemented. The type of garbage detected can help in analyzing the data.

6.3 GARBAGE COLLECTION

The garbage collection module is currently under development, the shape of the prongs and the size of the conveyor belt have already been finalized. The attachment of the prongs to the conveyor belt and the conveyor belt to the movement motors is yet to be completed. Along with the installation of the conveyor belt, electrical wiring for controlling the prongs has to be done.

7. CONCLUSION

The increase in population has resulted in large gatherings of people at tourist spots like beaches. This leads to people littering these places a lot. Littering at beaches is becoming a tremendous problem these days and cleaning it has become a difficult job for a lot of NGOs.

The use of the beach cleaning bot can help reduce the strain on such NGOs and can reduce a lot of manpower.

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