Automated Garbage Collection Rover

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Abstract : Efficient and cost-effective waste management is a requisite for major institutions all around the globe. Outdoor cleaning is labour intensive and thus adds up to the overall employment cost of the institution, which is a bane. Through our waste accumulating robot, we look to address and automate the outdoor waste cleaning process, thus providing an efficient and tangible way of managing such a tedious task.

We have a rover, fitted with a camera, thus guiding it around the designated area and avoiding obstacles; while the same camera is integrated with an arm via software for waste collection purpose. The rover is fitted with the arm, which is used to collect the garbage within its range. We use a bucket clamp as its end effector. A GPS (Global Positioning System) module shall guide the rover within the fore set cleaning range. To increase efficiency of collection and assimilation, the front part of the rover has a broom to accumulate the dirt as it moves. After a set distance the robotic arm shall pick the trash collected and place it in an overhead bin mounted on the rover. The whole process can be monitored remotely.

Index Terms **- Efficient, outdoor cleaning, GPS, garbage collection.**

I. INTRODUCTION

A clean environment is always a sight to behold. Manual labor has been the answer to our cleanliness and waste collection woes so far. In a world where menial jobs can be automated using technology, our project encompasses the integration of a rover, with an arm and camera, remotely controlled and monitored by a user. Here we focus on the automated movement of the rover using image processing and detection to identify, accumulate, pick and drop garbage within a designated area. The obvious outcome is technology brilliance, for a hassle-free collection and dumping of garbage.

The rover has a set path, where the GPS guides the rover around the designated area. Garbage is detected with object detection using OpenCV. The smaller debris are collected by the roller mechanism and dropped onto the segregation plate, where wet and dry garbage are disposed of into their respective bins mounted onto the rover. The larger debris like bottles shall be identified using object detection and the arm shall lift it and place it onto the segregation plate, from where it shall be dumped into its respective bin based on its moisture content.

II. OBJECTIVE

The purpose of building the Automated Garbage Collection Rover is to achieve the following:

- Efficient collection and segregation of waste
- Reducing human effort
- Time Saver

III. LITERATURE REVIEW

Before starting with the project, we need to know what have been done in the area of interest. We went through multiple papers in order to get a clear picture of what the field currently has to offer and how we can improve on it.

In one of the papers [1], the rover has arm-like mechanism wherein the garbage collected is scooped up in the arm and tossed in the bin behind the arm. This rover is manually controlled by the user via a Bluetooth connected device for its movement and object detection for identifying obstacles and garbage. The scoop and toss mechanism of the rover is inefficient as it sometimes pushes the garbage away rather than scooping it in.

The approach to the garbage collection idea is similar across all the papers. But there always is at least one drawback to the approaches we have seen. [3] has used rotating blade mechanism to collect the waste. Galvanized iron or stainless steel was used to make this rotating blade which may not be suitable for every purpose. We attempt to combat this by applying hard brush on the ends of the rotor blades in our approach.

In order for us to make automated rover, we had to come up with a way for the rover to move without any assistance from the user. We came across various ways of achieving this. Automating a drive can be cumbersome as many variables are to taken into account. Static and dynamic obstacles must be avoided. [4] has used RADAR, LIDAR and cameras to achieve self-driving and [2] has resorted to path following using just camera. We wanted the automation to be simple and inexpensive yet provide good movement accuracy. A GPS guided system similar to [5] is used to attain our autonomy goal.

IV. PROBLEM DEFINATION

Garbage around us is sickening and unpleasant. As we are using more and more one-time use products, and due to reckless behavior of the people, garbage can be found thrown everywhere, right from the footpaths, roads, play grounds, etc. The tedious work involved in hiring, and money involved in maintaining a cleanliness team for outdoor cleansing and waste collection within an institution or society is exorbitant. Moreover, irregularities and absence of cleanliness staff results in the job remaining pending and the place is in shambles. Thus, sole dependence on manual labor can be futile.

V. INEFFICIENCIES OF EXISTING MODELS

- Bereft of efficient image processing to detect garbage [1]
- Not entirely autonomous [2]
- Segregation mechanism is crude [3]
- GPS usage is a bare minimum, although blatantly efficient
- No dual collecting mechanism, as a result compromises on optimal efficiency

VI. SOLUTION FOR THE PROBLEM

We have designed an automated rover, with a garbage collecting arm attached to it. The rover moves about its designated path, directed by GPS and object detection. The camera module detects garbage and the rover mechanism and arm collects it and places it in the garbage bin atop the body of the rover. The rover is automated and moves about its path using GPS guidance. The entire rover can be monitored/controlled remotely. A moisture sensor shall be attached to the top of the bin to segregate the dry and wet waste. The efficiency of the process in increased by the use of dual collecting mechanism.

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VII. WORKING AND COMPONENTS USED

7.1 General Block Diagram

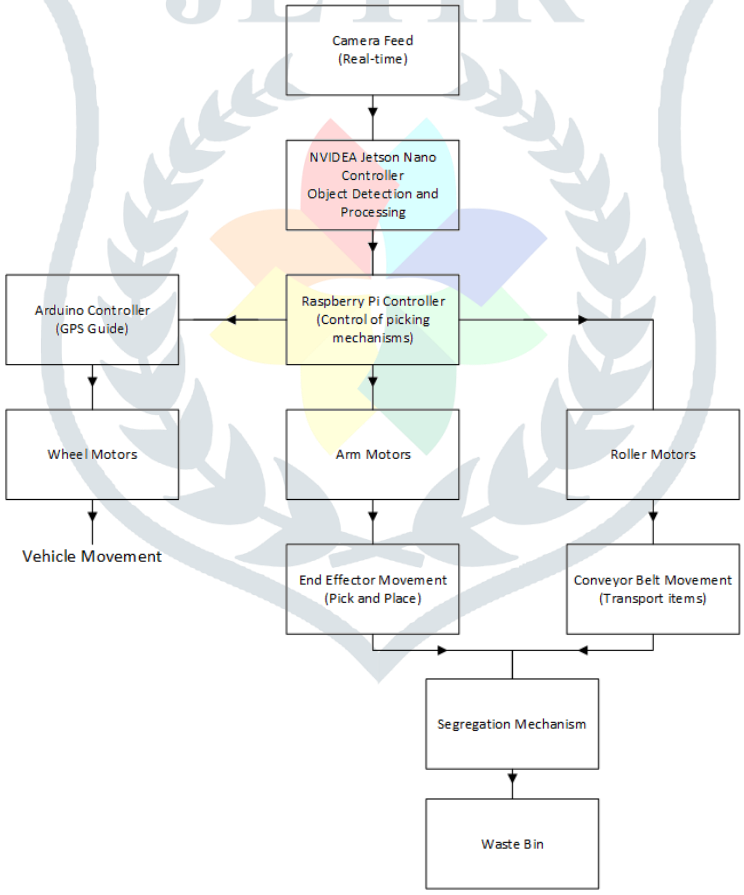

Figure 1: General Block Diagram

7.2 Hardware Components

- Frame
- Wheels
- Motors
- Conveyor Belt
- Waste Bin
- Ultrasonic Sensor

- Moisture Sensor
- GPS Module
- Roller
- Power Supply (Batteries)
- Vacuum End Effector
- Arm
- Nvidia Jetson Nano
- Raspberry Pi 3
- Arduino Uno
- Camera

7.3 Software Used

- Arduino IDE
- PyCharm IDE with Python v3.6.5
- Solidworks

VIII. METHODOLOGY

In our proposed rover, we profess the use of image detection to identify and efficiently segregate garbage within campuses. We use OpenCV for object detection and feature extraction. Our vehicle is GPS guided and the path has to set manually; following which no human intervention is needed. Once the rover sets into motion, it shall discretely identify obstacles and garbage. We use a dual collection mechanism, comprising a roller mechanism for smaller debris like leaves, twigs and paper waste; and an arm mechanism for collecting bottles, and comparatively larger debris. A segregation mechanism is used to segregate wet and dry waste using a moisture sensor. Accordingly, the waste is dumped into their respective bins, comprising a wet waste bin and dry waste bin.

Digital image processing is performed, under this we have 3 steps:

- Image acquisition: The image of the garbage is acquired using the camera, the image is acquired from a certain uniform distance with sufficient lighting for learning and classification. The sample images of the garbage are collected and are used in training the system. To train and to test the system, our concerned garbage images are taken. The images will be stored in some standard format.
- Image Processing: Pre-processing is heavily dependent on feature extraction method and input image type. The aim of Pre-processing is an improvement of the image data that remove the unwanted distortions.
- Image Segmentation: Partitioning of digital image into multiple segments for easy analysis. Image segmentation is one of the most important stage for accurate detection.
- Feature Extraction: Reducing the amount of resource required to describe large dataset. Here we extract shape feature. Using the dataset, the image classifies it as an obstacle or garbage; and under garbage it is classified into the one which can be picked by the roller or the one which the arm got to take care of.

8.1 Vehicle motion and GPS

Our vehicle is GPS guided. The human operator has to set the coordinates which the vehicle has to follow. Then the rover traverses the designated path. The rover is driven by four DC motors, and we use differential steering to maneuver the rover around.

8.2 Arm Mechanism and end effector

We use a linear mechanism arm to pick the bigger waste. Here we use a screw mechanism to move the links. It's a two-link arm mounted at the front end of the rover. The end effector used is a vacuum pump to hold the bigger debris until dumped.

IX. TECHNOLOGY USED

- Object detection
- Robotic Arm
- GPS mapping
- Segregation

9.1 Object Detection

When fed an image, the system will identify the objects in the image. Then system can create a bounding box around the objects, so that it can pinpoint where in the image the objects are, and then accordingly make a decision. Our objective behind this is to identify what all objects are present in the image and where they're located and filter out the object of attention.

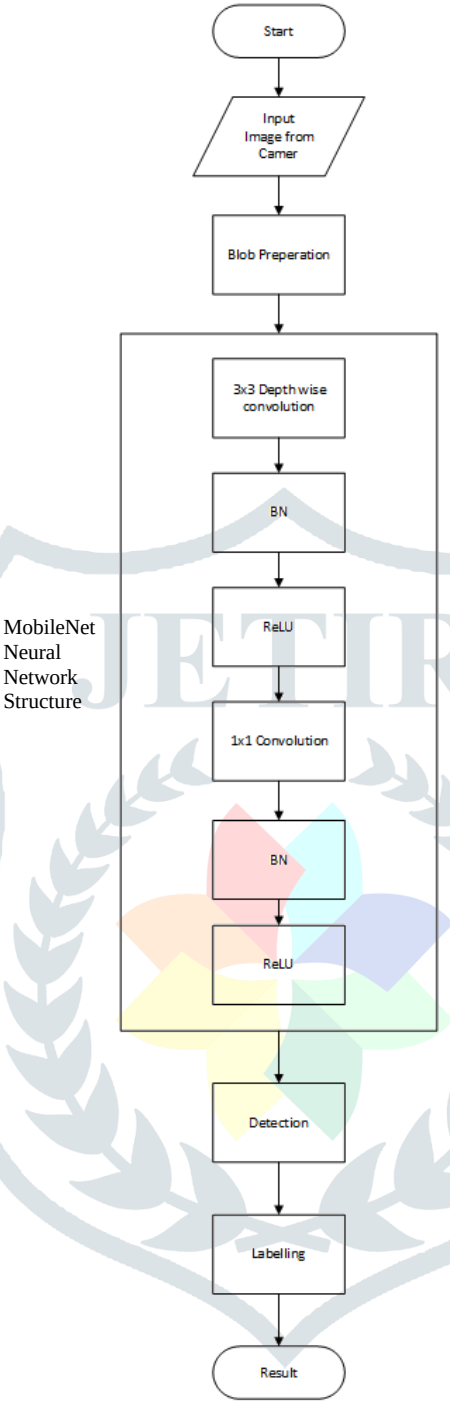

Figure 2: Object Detection Flowchart

- A deep learning-based object detection method called Single Shot Detector (SSD) and MobileNet neural Network is used since combining these is more efficient for resource constrained devices.
- MobileNet uses a depth wise convolution followed by batch normalization (BN) and ReLU non-linearity.
- MobileNet SSD and deep neural network (dnn) module of OpenCV is used to build object detector.
- Image from the camera is the input and a blob (part of the image having similar characteristics) is created. The blob is small portion of our image of about 300x300 pixels. The result is stored in a detection variable.
- The detection is looped through the network to determine what and where the object is.
- A text label containing the CLASS name is built and using the label, the output image is boxed with a colored rectangle around the object in the image.

9.2 Robotic Arm

- We use the linear actuator mechanism in designing the robotic arm. Here the servo motors are mounted on the mounts and the motion of the arm is based on the screw rotation; which when rotates, moves the entire arm along.
- The end effector is a vacuum, which shall aid in lifting the bigger waste. The arm is 3D printed, and the servos are programmed using Python.

- Distance between rover and object is calculated and arm movement is programmed such that the arm moves to the calculated distance.

9.3 GPS Mapping

- Here, we use a GPS module to pin down our location. Then the coordinates of the desired points are set with the help of Google map layout of the area to be traversed.
- A compass module is used to align the vehicle in accordance with its path. The set path is then fed to the Arduino microcontroller which in turn controls the steering functions.

9.4 Segregation

- We use a moisture sensor to segregate waste as wet and dry based on its moisture content.
- When the sensor detects the waste as wet waste, the segregation flap tilts inward the wet bin.
- When the sensor detects the waste as dry waste, the segregation flap tilts inward the dry bin.
- An ultrasonic sensor is used for the detection of waste.
- So, in totality, the amalgamation of the ultrasonic sensor, moisture sensor and the stepper motor used to control the flap, are concomitant in a smooth process.

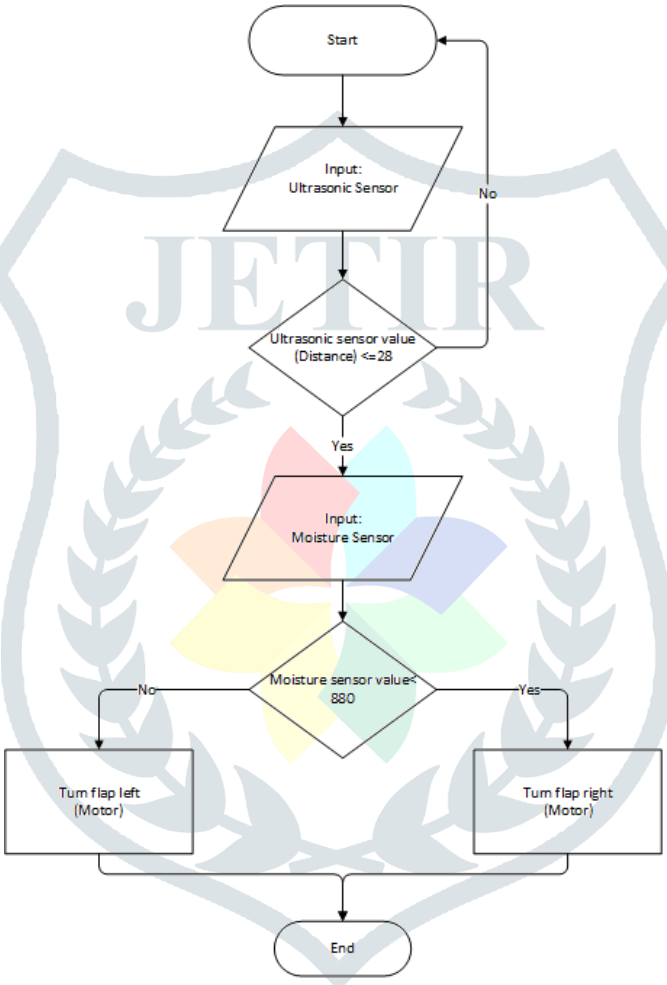

Figure 3: Segregation Mechanism Flowchart

X. CAD DESIGN

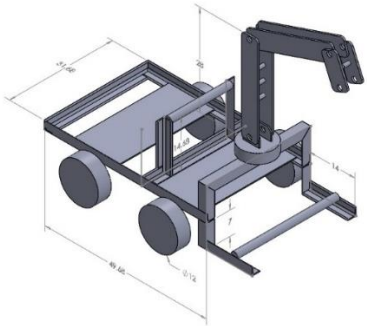

Figure 4:Isometric View of CAD Model

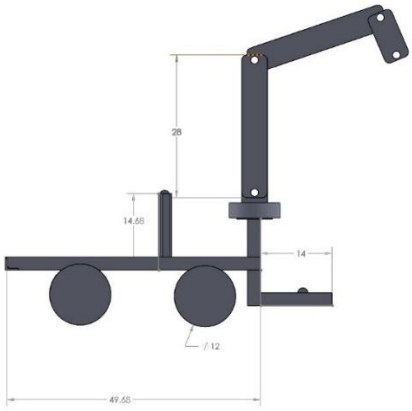

Figure 5: Side View of CAD Model

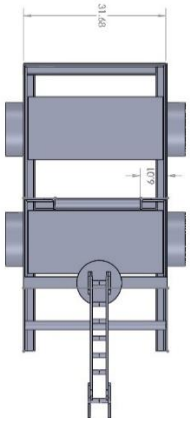

Figure 6: Top View of CAD Model

XI. MODEL PROTOTYPE

Figure 7: Isometric View of Prototype

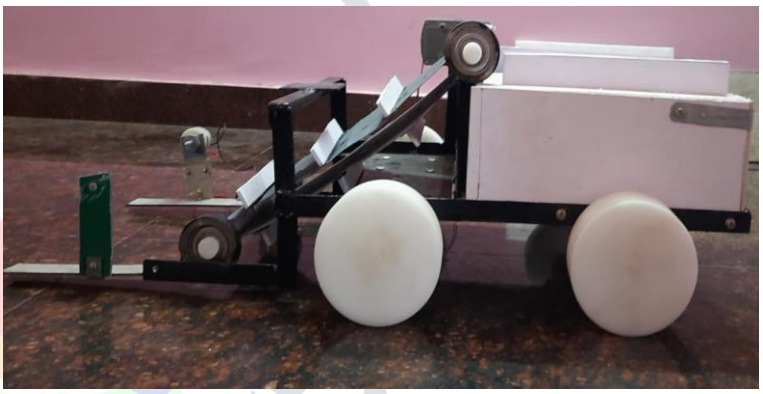

Figure 8: Figure 8: Side View of Prototype

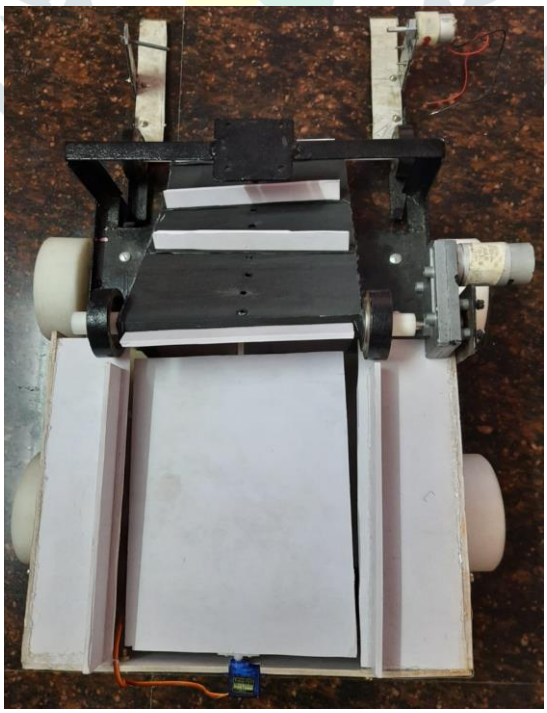

Figure 9: Top View of Prototype

XII. APPLICATION & ADVANTAGES

12.1 Application

- Used in outdoor cleaning of campuses: The rover is trained to move around campuses such as tech parks, educational institutions, etc. It performs its cleaning duties along the set path and then shall return to its initial position either after ending its ritual or for emptying the dustbin.

12.2 Advantages

- Saves time: The rover performs its tasks diligently and efficiently and can perform it any number of times as long as it is powered.
- Saves Labour cost: The investment in the rover is a one-time investment, with negligible service cost. Thus, saving the organization from recurring labor cost.
- Can perform its task anytime: No fixed work hours; can be deployed anytime as and when needed.

XIII. RESULTS AND DISCUSSIONS

13.1 Object Detection

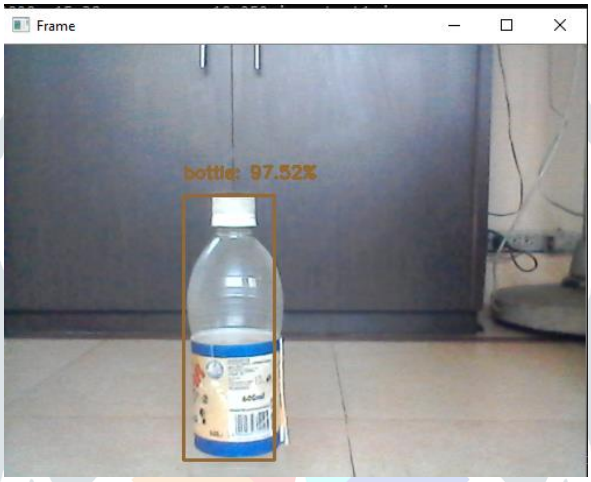

Figure 10: Object Detection

Here, the camera detects what type of an object is detected and if it is categorized as waste, the software instructs whether the arm should pick the bottle or the roller mechanism. As can be seen from the above image, the camera has detected the bottle image accurately. Similarly, it applies to other objects as well.

13.2 Segregation

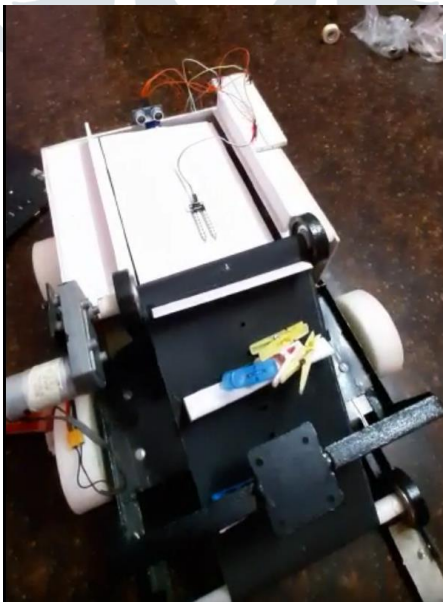

Figure 11: Conveyor Belt lifting the waste

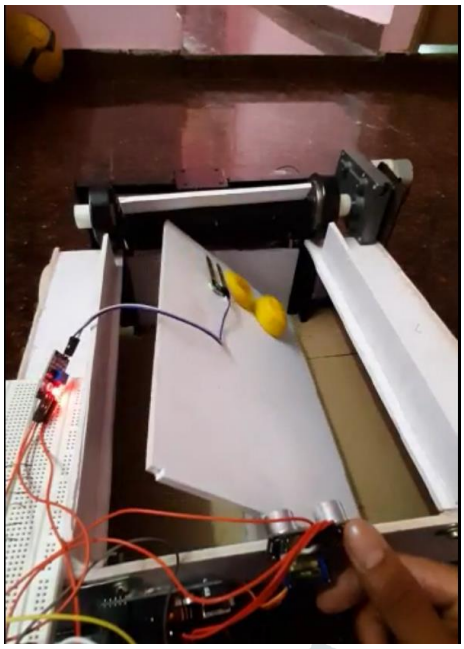

Figure 12: Segregation of Wet Waste

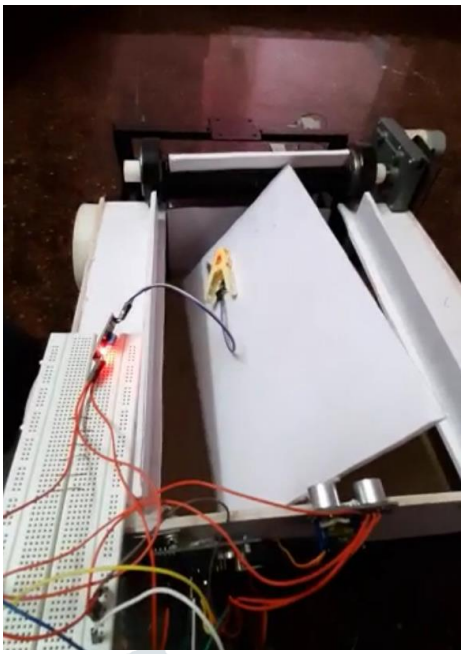

Figure 13: Segregation of Dry Waste

The segregation mechanism detects the moisture content in the substance and segregates it accordingly. Here in the above images we can see that as the roller picks up the waste, and places it on the segregation tray, the tray dumps garbage into the wet or dry bin according to the feedback from the moisture sensor. This mechanism makes it easier for dumping as the garbage has already been segregated.

XIV. CONCLUSION

Through this machine, we shall achieve the objective of automated efficient cleaning, using image detection and segregation. There is minimal human intervention, thus utilizing technology to the fullest.

The model has minimum human interference and thus we achieve our end goal of having an automated rover. The practicality of this rover is what makes it ideal. The utilization of technology like object detection, navigation and segregation thus make it a unique proposition.

This idea was conceived after lots of deliberation and discussion from all our team members and our guide, with practicality being the fulcrum of our discussion. We solely believe that with the integration of technology, human life can improve manifold and our proposition is just one of the innumerous ways of technological boon.

XV. ACKNOWLEDGEMENT

We would like to thank Prof. Bhagirathi V, our parents and friends who have helped and guided us in this journey.

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