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Smart Waste Segregation using ML Techniques

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Abstract: ***According to the Press Information Bureau, India generates 62 million tonnes of waste (both recyclable and non-recyclable waste) annually. Landfill waste ranks third in terms of greenhouse gas emissions in India. To reduce this issue, we have come up with an idea using IOT and ML, that helps segregate waste into biodegradable and non-biodegradable. The fast growth in the amount and varieties of solid and hazardous waste due to burgeoning growth, industrialization, and urbanization, is becoming a growing hassle for the countries and national governments to heed to the powerful and sustainable management of waste. We have come up with an option to tackle this trouble from a lower level. We have centred our efforts to construct a smart bin exclusively for household purposes. Using a smart bin, we have a manner of identifying non-biodegradable and biodegradable waste with the assist of sensors and ML models built for figuring out the type of waste. The biodegradable waste is saved in its section of the bin and the non-biodegradable waste is further divided into landfill waste and recyclable waste. Since segregation on a large scale is hard to manage due to the cost and inaccuracies working at that scale. The smart bin should be able to solve these issues by segregating early rather than trying to segregate it at a larger scale.***

Keywords: Smart Bin, IoT, Machine Learning

I. INTRODUCTION

Increments in the populace, progress in mechanical headway, urbanization and advancement have brought about expanded development in buyer items. What's more, with this advancement comes a value, the age of waste. In an ongoing overview led by the World Bank, about 1.3 billion tons of waste is created every year. The number is relied upon to arrive at 2.2 billion by 2025. Waste is an issue looked at by a ton of social orders and networks. The measure of waste produced is undeniably more than squandering reused. Ill-advised waste administration has prompted an expansion at the expense of reusing and all the more working hours. This prompts overcapacity of dumping grounds and landfills, littered waste around the city. These conditions go about as a reproducing ground for infections. To take care of the issue of isolation of waste at the grass-root level, our idea can be actualized at home and office.

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The waste can be isolated dependent on whether it is biodegradable or non-biodegradable. Moreover, it isolates recyclable waste from non-biodegradable waste. The system empowers a without touch communication with the dustbin, which increments the cleanliness of the family unit. The paraphernalia and sensors utilized in the container guarantee that the waste is appropriately isolated. A camera is introduced at the highest point of the canister that recognizes a human nearness and opens the top. The image recognition in the container can recognize and process the waste and cautiously signal the flap to open the compartment where the waste is to be discarded. This grass-root isolation of waste will empower a quicker method to reuse and spare time and assets.

II. DESIGN & ARCHITECTURE OF OUR SYSTEM

In the smart bin, we have a process of identifying non-biodegradable and biodegradable material with the help of sensors and ML models built for identifying based on this data. The biodegradable material is stored in its section of storage and the non-biodegradable material is further divided into landfill waste and recyclable waste. Furthermore, it segregates recyclable waste from non-recyclable waste. The product enables a touch-free interaction with the dustbin, which increases the hygiene of the household. The equipment and sensors used in the bin ensures that the waste is properly segregated. A camera is installed at the top of the bin that detects a human presence and opens the lid. The image processing algorithm used in the bin can detect and process the waste and carefully signal the bins to open the compartment where the waste belongs. The dataset used for the model is mostly of all the generic waste produced in the household. This grass-root segregation of waste will enable a faster way to recycle the waste and save time and resources. The rough design of the smart bin is as shown in Fig 1. The sensors which we are planning to utilise are –

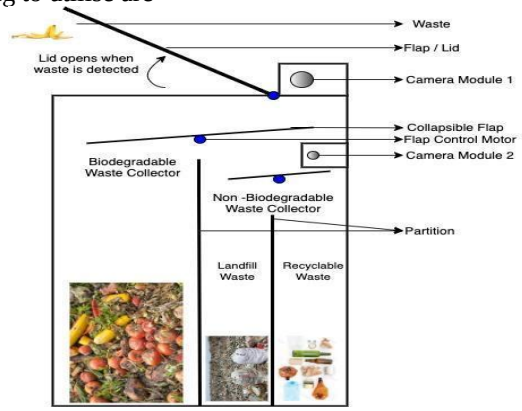

Fig. 1.Design of the System

(i) Raspberry Pi Board - The Raspberry Pi board is a series of single-board computers having a System On Chip (SoC). It has a multicore processor, GPU, ROM, I/O Peripherals, DDR RAM memory, Ethernet port, USB host and micro HDMI on it. The Raspberry Pi board is very efficient as it can help in various automation projects, smart agriculture and we will be using it in our system for smart segregation of waste. We will be using the Raspberry Pi 4 board for the smart bin.

(ii) Ultrasonic Sensor - The feature of the ultrasonic sensor is to detect any object nearing the dustbin. This will, in turn, open the lid of the bin and the trash can be discarded. We are planning to use the HC-SR04 module which is quite streamlined.

(iii) Raspberry Pi camera module - This raspberry pi camera module V2 is the apt camera module for this purpose of waste segregation. It has a fixed focus lens on board with an 8 megapixel native resolution sensor-capable of 3280 x 2464 pixel static images. These images will be used as input for the machine learning model which will determine the type of waste.

(iv) Servo Motors - These motors are small devices with the shaft attached and controlled by the raspberry pi board. It receives a certain amount of pulse, with which it turns clockwise or anticlockwise. It can turn from 0 to 180 degrees, as it has a gearbox and potentiometer, with which we can position the shaft. We might as well use the stepper motor for efficient output. The servo motor Tower Pro SG90 will be used for this project. When the garbage is brought near the lid of the bin, It is detected by an ultrasonic sensor which then opens the lib so that the garbage can be placed into the first collapsible flap righ below the opening lid. The person is only needed to place the garbage on the first collapsible flap of the smart bin. The rest of the process is automatically taken care of by the smart bin. There is not need for additional human interaction. The garbage is then separated into non-biodegradable or biodegradable garbage with the assitance of an ultrasonic sensor and a Raspberry Pi camera module. The segregation here is done with the help of convolutional networks and object dectection algorithms. When this classifiction is completed by the raspberry pi, a pulse is sent to the servo motor which can control the first colapseable flap. Depending on what he pulse is from the Raspberry pi, the servo motor flap tilts either clockwise or anticlockwise. If the garbage is classified as biodegradable there is no need for anymore further classification needed. If it is classified as non-biodegradable then it needs to go through another a secon collapsible flap that further classifies it as recycleable waste or landfill waste. After this the whole segregation is completed and the garbage is in it's designated category. Fig 2 shows the connections fo various sensors.

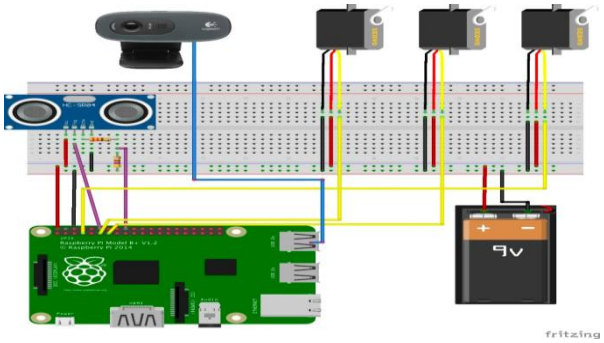

Fig. 2.Design of circuit connecitons

III. SYSTEM DESIGN

An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system. The architecture of the proposed system is shown in the Fig 3. The system architecture can be divided into two parts,

Detection: It deals with identifying a person approaching the bin and opening up the lid to the dustbin. Object identification: It deals with recognizing the trash based on the dataset used to train the model. The trash is captured by a camera sensor and is then segregated into different categories based on their degrading properties.

Object segregation: It deals with segregating trash based on their category into respective bins. The servo motor guides the trash into respective bins.

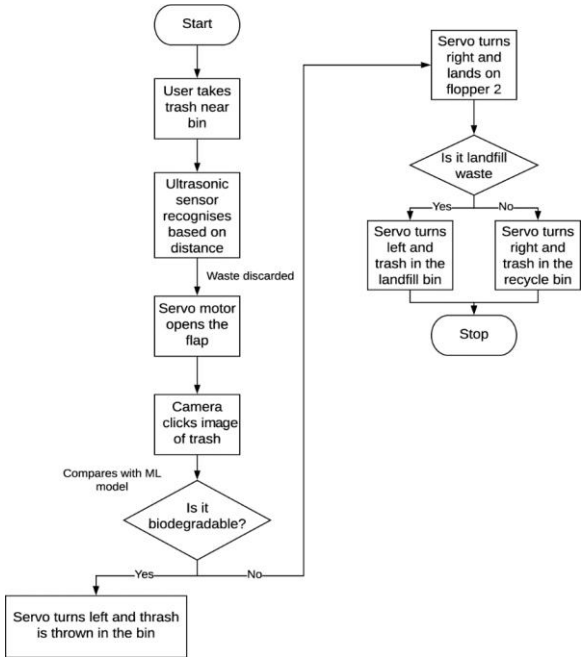

Fig. 3. System Architecture

IV. RESULTS AND ANALYSIS

In our implementation of the model we faced a lot of problems between plastic and glass since the visual features between the two are similar.

They are both translucent and similar in shape making it harder to identify. We figured out if we made changes to the background it made the glass easier to identify thus clearing out most problems between plastic and glass objects The Predictions relied on image quality.

Lower resolution cameras produced significantly lesser accuracy of 65.4%.

Increasing the resolution to 5 mega-pixels or higher helped improve the accuracy drastically.

Focus and lighting also helped improve the accuracy since more of the image can be scanned when there is better lighting. We ended up achieving an accuracy of 92.1% on the test data which includes all the types of waste materials it can classify. This is pretty great for a model that trained on objects with very little distinguishable features since it is waste.

Modules	Results
IOT	Ultrasonic sensor: worked 30cm distance from the sensor.
	Servo Motor: worked upon every instruction given by Raspberry Pi.
	Raspberry Pi: Managed the operations of various sensors efficiently.
	Camera module: Images were captured accurately under good lighting. Higher resolution helped improve the accuracy significantly.
ML	Biodegradable: accurately predicted wastes such as paper, carboard and kitchen waste with 91.3% accuracy
	Non-Biodegradable: Accurately predicted wastes such as plastic, metal with 92.9% accuracy

V. CONCLUSION

In this project we developed a system that uses machine learning to identify waste and its type so it can be classified into biodegradable or non-biodegradable waste. The machine learning model perceives the images from a live camera which takes high resolution photos on the top of the smart bin.

We use an Ultrasonic sensor connected to the Raspberry Pi which runs everything in the Smart bin. The ultrasonic sensor detects new objects and alerts the camera to take an image which is then feed to the machine learning model. This process then leads to Raspberry Pi which controls the motors to dump the waste into either biodegradable or non-biodegradable depending on the results.

The key feature of our project is identifying various waste such as plastics and glasses which are important for recycling.

They are also difficult to identify since they are visual similar, thus our results with the model able to identify them correctly is a successful machine learning model.

FUTURE WORK

In our current state we are capable of identifying and segregating waste one by one. In most real world cases waste is pretty diverse and large amounts are dumped at once.

Thus, there is a need for increasing segregation and larger scale implementation of the project with multiple cameras and sensors.

This would also require more compute power. In our system, we have only five types of wastes to classify.

When working with different regions we may come across different materials which need new classification thus increasing the number of items that the model can classify. This will require more training data with more diversity to increase the capacity.

The computing power will also need to be increased to accommodate better machine learning model. In our current system we use Ultrasonic for only identifying that there is an object.

In future this can be improved by using more sensors such as infrared and LiDAR sensors which give us more data to predict the waste more accurately. We would also be able to get more insight on what the object composition with better and more sensors.

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