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Smart Trash Bin Using Machine Learning and Internet of Things

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ABSTRACT

Health and hygiene are vital areas in the ever-expanding community that cannot be disregarded or compromised for the welfare of human communities. This idea uses the Internet of Things to separate biodegradable and non-biodegradable waste into smart dustbins. People can no longer separate their waste into biodegradable and non-biodegradable categories because of their hectic work schedules. By automatically identifying waste as biodegradable or non- biodegradable, smart dustbins with image recognition technology improve waste management by encouraging effective waste segregation and lessening the load on landfills. The goal of an IOT and machine learning-based waste management system for a green, smart society is to use the newest IOT technologies to improve the efficiency of trash management from every apartment in the community.

Indexterms: Arduino UNO, Servo Motor, Anaconda Distribution, Android Ide, Image processing, Python Programming.

1. INTRODUCTION

The amount of waste produced daily per person in India is still between 0.2 and 0.6 kg. For clean metropolitan areas, isolation at the source is important. India has a high per capita waste age, to the extent that a two- or three-day absence from a garbage jockey is considered an emergency. In numerous disposal sites across India, waste has been accumulating. Since most of this waste has a mixed structure, it cannot be disposed of properly.

The most common waste management strategy is either using the garbage as a landfill or consuming it. Isolating biodegradable trash from non-biodegradable garbage should be simple in terms of geographical location. After that, biodegradable wastes could be exposed to soil treatment. Trash such as plastic, metal, paper, and so on may also be subjected to recycling. Sometimes the trash can actually work to your advantage. We can realize forms that will encourage viable asset usage by classifying garbage. Currently, one of the primary materials used in urban life is Municipal Solid Waste (MSW) waste. About 1.3 billion tons of strong waste are produced annually, and it looks that this amount will steadily increase to 4.3 billion tons by 2024, which will account for half of the world's population. Additionally, managing the garbage collection forms is one of the trickiest tasks in the rural area due to the enormous amounts of solid waste generated by commercial and private modern sites. These are a troubling problem to transfer because of the massive quantities of different types of powerful wastes that are being delivered

every day. Accordingly, rather than concentrating just on transfer, a strong method is needed for the buildup of strong waste and usage of strong waste. Therefore, robust waste management encompasses the range of activities related to production, storage, gathering, moving and lifting, reusing and reusing, processing, and organizing, all of which must be environmentally sound and adhere to standards for economy, feel, and vitality preservation. Due to the rapid rise in both population and economic development, there has been a significant increase in garbage that we as a society have been producing. This has prompted a rigorous examination of waste management and the board. Here, in the biological community, it presents a significant problem and challenges the municipal corporation. This research presents a useful method for identifying and separating the serious wasters. Hardware inspection via IoT was designed to be crucial. Much like in the past, many people in India and other countries advocated for robust waste collection and management.

But it only had the secondary effect of generating waste and enforcing container limits; the present system was insufficient to regulate waste contamination, inevitable diseases, and asset consumption in rural and urban areas. To combat this, the new structure includes a detachment method that allows it to stay strategically apart from the concerns at hand. Sensors such as ultrasonic and capacitive proximity help identify plastics, and fitting information is sent to the city firm in both urban and rural areas to monitor and control container levels. METHODOLOGY **Data collection:**Gather a dataset that includes information about various materials. For each material, we should have features (attributes) and a label indicating whether it is degradable or non-degradable. **Model Selection:**Select an algorithm that can help the model distinguish between degradable and non-degradable materials.After distinguishing materials, with the help of IoT sensors trash bin box opens automatically This outline work can be completed for both rural and urban locations alike.

- Smart bins autonomously sort, compress, and collect waste using technologies like machine learning and the Internet of Things. This improves waste segregation, reduces the need for frequent pickups, and improves environmental sustainability.
- Machine Learning for Waste Classification: By analyzing photos or sensor data, smart trash cans employ machine learning to classify waste into categories such as biodegradable and non-biodegradable.
- Internet of Things Sensors and Actuators: Smart garbage cans use sensors and actuators to automate processes such as opening the box for different kinds of rubbish.

2. REQUIREMENTS

1. Hardware Components

1.1 Arduino UNO

Arduino Uno is a popular microcontroller board based on the ATmega328P microcontroller chip. It's widely used in electronics projects due to its simplicity and versatility. The Arduino Uno board provides digital and analog input/output pins that can be used to interface with various sensors, actuators, and other electronic components. It's commonly used by hobbyists, students, and professionals alike for prototyping, experimenting, and creating interactive electronic projects.

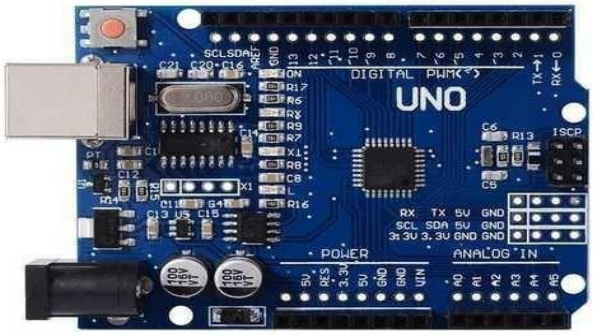

Fig 1: Arduino UNO

1.2 Servo motors

One kind of rotary actuator that enables accurate angular position control is a servo motor. Servo motors are different from regular motors in that they have the ability to be programmed to rotate at a precise angle and stay there. They are frequently utilized in many different applications, including robotics, RC vehicles, industrial automation, and aerospace, where precise control of movement is necessary.

A DC motor, gearing, control electronics, and a feedback mechanism (such an encoder or potentiometer) make up servo motors. A microcontroller or servo controller sends a signal to the control circuitry that indicates the intended position. This signal is typically in the form of a pulse- width modulation, or PWM, signal. After that, the motor stops and rotates to that position.

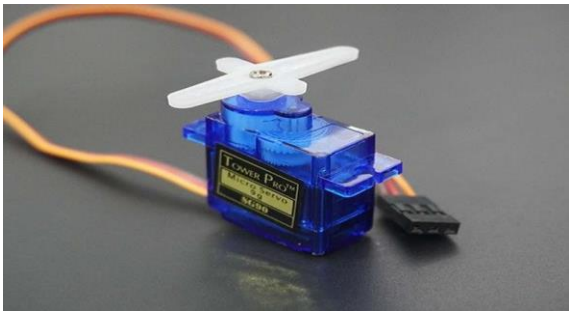

Fig 2: Servo Motors

1.3 Jumper wire

A jumper wire is an electrical wire, or group of them in a cable, with a connector or pin at each end which is normally used to interconnect the components of a breadboard or other prototype or test circuit.

Fig 3: Jumper Wire

2. Software Components

2.1 Arduino IDE

The Arduino Integrated Development Environment is a cross-platform application that is written in functions from Cand C++. It is used to write and upload programs to Arduinocompatible boards, but also,

with the help of 3rd party cores, other vendor development boards. The Arduino IDE employs the program avrdude to convert the executable code into a text file in a hexadecimal encoding that is loadedinto the Arduino board by a loader program in the board's firmware. In our project, we have used the Arduino IDE for NodeMCU and Arduino nano.

Fig 4: Arduino IDE

2.2 Anaconda Distribution

Anaconda Distribution is a platform for data science and machine learning. It includes Python And R programming languages with pre-installed packages like NumPy, pandas, and scikit- Learn. It features conda for easy package management. Popular among data scientists, it Simplifies setup and management of environments for various project.

Fig 5: Anaconda Distribution

3. SYSTEM DESIGN

Flow Chart

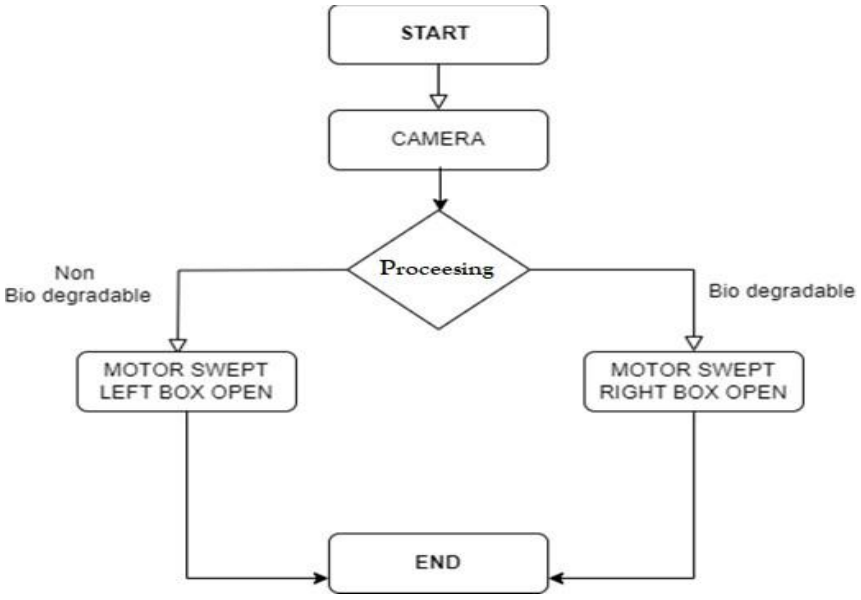

Fig 6: Flow Chart

System Architecture

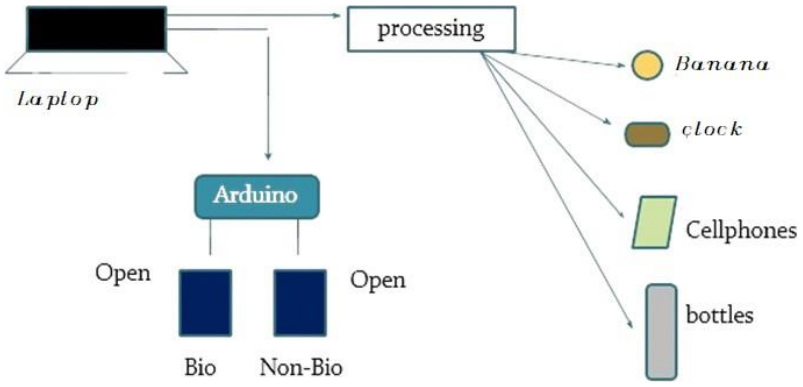

Fig 7: System Architecture

Here we are using laptop webcam through webcam it sense and identifies weather the item is degradable or non degradable once it findouts the arduino will be activated through servo motors the box will automatically opens

4. IMPLEMENTATION

The Project Is Divided Into Two Main Modules:

- **Software**
- **Hardware.**

Software Components: Utilizing the SSD MobilenetV2 algorithm and Tensorflow API, this module enables the system to differentiate between degradable and non-degradable materials.

SSD (SINGLE SHOT MULTIBOX DETECTOR).

SSD (SINGLE SHOT MULTIBOX DETECTOR).is a popular algorithm in object detection. It's generally faster than Faster RCNN. In this post, I will give you a brief about what is object detection, what is tenforflow API, what is the idea behind neural networks and specifically how SSD architecture works. Then I'll provide you the step by step approach on how to implement SSD MobilenetV2 trained over COCO dataset using Tensorflow API. In this tutorial you can detect any single class from the classes provided by COCO dataset. After this, I believe you can implement your own SSD with some patience. In this post, I will follow the original architecture from the paper.

What Are Covered

1. **Object Detection**
2. **SSD(Single Shot Detector) Architecture**
3. **TensorFlow API for object detection**

1. Object detection

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos. Well-researched domains of object detection include face detection and Pedestrian Detection. Object detection has applications in many areas of computer vision, including image retrieval and video surveillance.

Object detection as the term suggest is the procedure to detect the objects in real world. For example,

dog,car,humans, birds etc. In this process we can detect the presence of any still object with much ease. another great thing that can be done with it is that detection of multiple objects in a single frame can be done easily. For Example, in the image below the SSD model has detected mobile phone, laptop, coffee, glasses in a single shot. It detects different objects in a single shot.

Fig 8: Output from SSD Mobilenet Object Detection Model

2. SSD MobileNet Architecture

The SSD architecture is a single convolution network that learns to predict bounding box locations and classify these locations in one pass. Hence, SSD can be trained end-to-end. The SSD network consists of base architecture (MobileNet in this case) followed by several convolution layers:

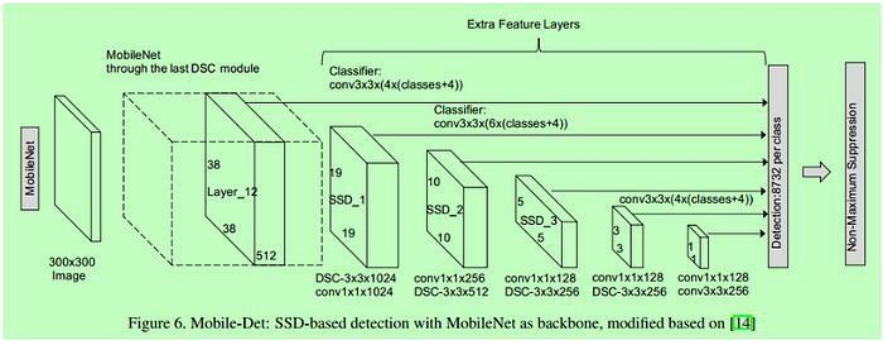

Fig 9: SSD MobileNet Layered Architecture

By using SSD, we only need to **take one single shot to detect multiple objects within the image**, while regional proposal network (RPN) based approaches such as R-CNN series that need two shots, one for generating region proposals, one for detecting the object of each proposal. Thus, SSD is much faster compared with two-shot RPN-based approaches.

3. TensorFlow Object Detection API

The TensorFlow object detection API is the framework for creating a deep learning network that solves object detection problems. There are already pretrained models in their framework which they refer to as Model Zoo. This includes a collection of pretrained models trained on the COCO dataset, the KITTI dataset, and the Open Images Dataset.model. They are also useful for initializing your models when training on the novel dataset. The various architectures used in the pretrained model are described in this table

Model name	Speed (ms)	COCO mAP[^1]	Outputs
ssd_mobilenet_v1_coco	30	21	Boxes
ssd_mobilenet_v1_0.75_depth_coco ☆	26	18	Boxes
ssd_mobilenet_v1_quantized_coco ☆	29	18	Boxes
ssd_mobilenet_v1_0.75_depth_quantized_coco ☆	29	16	Boxes
ssd_mobilenet_v1_ppn_coco ☆	26	20	Boxes
ssd_mobilenet_v1_fpn_coco ☆	56	32	Boxes
ssd_resnet_50_fpn_coco ☆	76	35	Boxes
ssd_mobilenet_v2_coco	31	22	Boxes
ssd_mobilenet_v2_quantized_coco	29	22	Boxes
ssdlite_mobilenet_v2_coco	27	22	Boxes
ssd_inception_v2_coco	42	24	Boxes
faster_rcnn_inception_v2_coco	58	28	Boxes
faster_rcnn_resnet50_coco	89	30	Boxes
faster_rcnn_resnet50_lowproposals_coco	64		Boxes
rfcn_resnet101_coco	92	30	Boxes
faster_rcnn_resnet101_coco	106	32	Boxes
faster_rcnn_resnet101_lowproposals_coco	82		Boxes
faster_rcnn_inception_resnet_v2_atrous_coco	620	37	Boxes
faster_rcnn_inception_resnet_v2_atrous_lowproposals_coco	241		Boxes
faster_rcnn_nas	1833	43	Boxes
faster_rcnn_nas_lowproposals_coco	540		Boxes

Hardware Components:

This module employs servo motors to control the opening mechanism of two boxes. If an object is identified as degradable, the left box will open. Conversely, if an object is non-degradable, the right box will open.

Fig 10: DUSTIN BINS

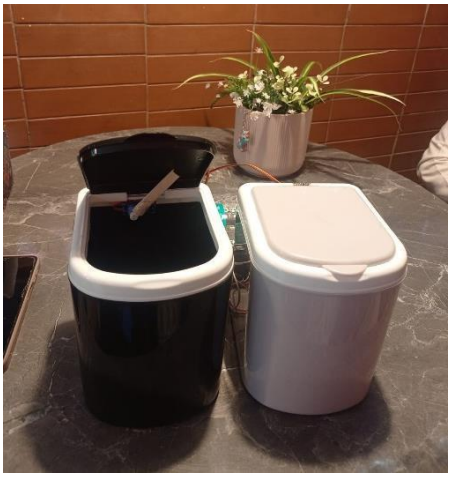

Fig 11: BIO DEGRADABLE BOX OPENS

Fig 12: NON BIO DEGRADABLE BOX OPENS

5. CONCLUSION

The suggested system, as presented in the paper, is predicated on a wide range of IoT sensors, machine learning programming, and the necessary hardware and software for execution. There will be two stages to the work: Waste segmentation comes after object detection. Direct entry of the waste materials will be used to test the product. The suggested device would be able to accurately identify waste materials and dump them into the appropriate biodegradable and non-biodegradable bins in the smart trash can. We conclude that by using this technology it is very helpful and needful to our environment to maintain eco-friendly environment. Through this technique garbage segregation can be reuse and recycle. It reduces the amount of waste in reaches in landfills. It plays an important role in protection of the environmental along with the health and human beings.Smart bins can monitor internal capacity and send notifications for timely waste collection, preventing container overspill. By incorporating a external webcam, we can enhance the monitoring frequency of classification of image in the bin.

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