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Smart Waste Management System Using AI

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ABSTRACT—Over the last few decades, Solid Waste Management (SWM) has become a dire problem for various urban and rural areas in India. Industrialization has led to urbanization. The resulting population shift has caused a drastic rise in Municipal Solid Waste (MSW) generation per person in metropolitan areas. Especially in the ones with high population density. The existing garbage disposal system employs manual segregation for an assortment of garbage. However, manual waste segregation is an arduous process. It can also bring about serious health hazards to the workers on top of being inefficient. Our work posits a machine learning model integrated with hardware devices that solves this predicament by identifying the waste instantaneously and segregating them accurately. This project would lead to lesser segregation time and subsequently facilitate waste processing. Our project also includes an appropriate safeguard against potential fires caused due to burning waste disposal (e.g., burning cigarette butts).

Additionally, our system also implements a waste level detection mechanism that would send real-time updates to a server. This information can be utilized by garbage collection agencies for timely collection and hence avoid overflow. This project is an effort to make the environment ecologically safe and habitable for future generations.

Keywords—Solid Waste Management; Municipal Solid Waste Management; Internet of Things; Machine Learning; 3R Challenges; Raspberry Pi; Image Processing; Classification; Automation; Data Mining; Artificial Intelligence;

I. INTRODUCTION

Waste is the result of niggardly thinking. We have been practicing traditional methods to manage waste by using the techniques such as flame, flush, or fling. But these futile methods did no good, and instead, they resulted in a large amount of waste accounting for inconvenient society.

Waste management includes all the actions and activities required to manage waste from inception to its final disposal. According to the statistics, India generates a tenth of the world's destruction. It produces 277 million tonnes of municipal solid waste. The waste generated has doubled in the last thirty years.

Conventionally the problem lies in the current waste management system. It is practiced based on pressure to handle the situation rather than the convenience of disposal. According to a study by the New Delhi Municipal Council, estimates show that about 88 square kilometers will have to be dedicated to waste disposal in the form of landfill sites by the year 2050 owing to poor waste management practices.

With the advancement of technology and the introduction of artificial intelligence and machine learning to every possible field, why not use them to solve the most significant global issue?

During our research, we found that with the help of raspberry pi, we can incorporate machine learning into the waste management process, which can work even with zero human intervention.

Due to the current pandemic situation, the previous estimates are assumed to go even higher. Increased use of masks, gloves, and PPE (Personal Protective Equipment) kits contributes to these stats. India alone contributed 18000 tons of Biomedical waste due to COVID-19. This, as a result, has burdened the already futile waste management system of India.

After witnessing the tragic incident of Delhi's Ghazipur landfill collapse in 2018, and going through the stats of the past few years of never-ending waste and poor waste management practices leading to wastage of lands, the spread of

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diseases, deterioration of soil and land, we were motivated to deal with this problem of ever-increasing waste management problem by adopting new technologies and innovations. So, to solve the problem of segregation of waste at the grass-roots level, our project can be implemented at home and office. The waste can be segregated based on whether it is biodegradable or nonbiodegradable. The equipment and sensors used in the bin ensure that the waste is properly segregated.

II. BACKGROUND AND RELATED WORKS

Folianto et al.; in their paper, presented a dustbin that indicated how full their dustbin is at any point in time. Additionally, their systems collect the data and send it over a mesh network. They used the data collected to obtain bin utilization and daily seasonality information to make better decisions.

Shyam et al.; presented a waste collection waste-collection management solution using an IoT prototype with sensors. Their prototype can collect and transmit a massive volume of data over the Internet. The data collected can be processed for the dynamic management of waste collection mechanisms. They carry out several simulations using real-life data to investigate the benefits of such systems over traditional ones.

Catania and Ventura proposed the M3 platform to enable data sharing and interconnection amongst the various smart-bin devices. The data shared primarily consists of the dustbin fullness level monitoring. Their proposed system helps in avoiding the collection of partially filled dustbins. Such a system is beneficial to both service providers and consumers.

Kumar et al.; posit an alert system for garbage management using an ultrasonic sensor interfaced with Arduino UNO. Their paper also suggests using RFID (Radio Frequency ID) to verify the timely garbage collection process. This process also sends a garbage cleanup completion notification to a server. Moreover, they propose an android application that can receive and monitor the regular updates from the server.

III. LITERATURE REVIEW

Ansari et al. (2015) aim to describe a security alarm system using low processing power chips using the Internet of things, which helps monitor and get alarms when motion is detected and sends photos and videos to a cloud server. Moreover, Internet of things based applications can be used remotely to view the activity and get notifications when motion is detected.

Mahajan et al. (2017), in their proposed system, public dustbins will be provided with embedded devices which help in real-time monitoring of the level of garbage in garbage bins. The data regarding the garbage levels will be used to provide an optimized route for garbage collecting vans, which will reduce the cost associated with fuel.

In their paper, Agarwal et al. (2018) discussed one of the most challenging issues - municipal waste-collection within the Smart City. To optimize the logistical approach of waste collection, they used their algorithm.

IV. METHODOLOGY ADOPTED

Figure 1: Methodology Adopted

The segregation problem is solved using a supervised learning approach [8]. Firstly, images of cardboard, glass, paper, plastic, metal, and random trash (soda cans) were collected. Each of these categories has around 500 images. Each of the photos was reshaped to 64x64 dimensions and converted to grayscale. This is essential for reshaping that would decrease the time and computational complexity of the neural network. Converting to grayscale allows the network to work with black and white images, and RGB is eliminated. This is implemented considering that the color of the trash is not an essential factor. Once we have the data ready, we create output labels for each dataset class. This is done to predict the output category.

DEEP LEARNING

CNN

Deep learning neural networks are of prime importance in image recognition, classification, and detection. Different layers of the neural network work together to achieve the given output. Each layer can either reduce the dimensions or work on sampling the image. A convolution neural network (CNN) is a type of neural network where a multilayer perceptron is used. It helps identify a general 2D image and collect the

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information. The web is made up of:
· input layer
· convolution layer
· sample layer
· output layer

For the pre-processing stage, the data augmentation method was performed on the images because of the small size. This technique was chosen because of the different orientations of the waste materials. Some ways include randomizing the image, translating the image, randomly scaling the image, image shearing, and arbitrary scaling of the picture. This technique maximizes the dataset size. The proposed method was developed based on the ResNet-50 pre-trained model.

ResNet

In CNN, several layers make up the network. The layers in CNN implement some actions, which allow it to classify input images. The convolutional layer convolves the inputted image using a sequence of filter window sizes of 3 x3; this was used because what differentiates the objects are small and local features. The essential elements are extracted from the input images. The primitive features are removed with the help of the first few layers. As the training goes down, the layers become more complex, and detailed parts are extracted, with the loss function probability, that is, the Softmax function.

Our model was developed based on the ResNet-50 pre-trained model; this model was pre-trained on ImageNet images with 256 x 256 and classified into 1000 classes. The features are passed to the Multi-Class SVM model, where the classification occurs based on the extracted features.

V. TOOLS USED

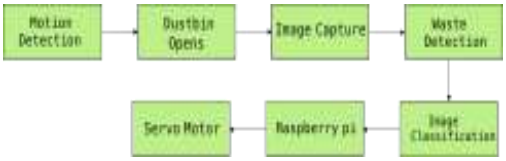

Figure 2: Working

Software Used

We are using Python Coding Language and its various libraries like Keras, GPIO, cv2, and Glob. We are using Keras Module to build and train our Machine Learning Model. GPIO module is for communicating with Camera Module. Glob is for defining the path of the images, and cv2 is for image recognition. We are using image recognition which is frequently used in Computer Vision. We are using ImageDataGenerator and Randomly flipping inputs horizontally. After that, we are randomly flipping the inputs vertically. We are then reserving a fraction of images for validation (strictly between 0 and 1). The scaling is done on the input images after the verification. We are setting the shear range, zoom range, width shift range, and height shift range to 0.1. Also, we are creating 32 batches of our input data to improve the training of our Keras model.

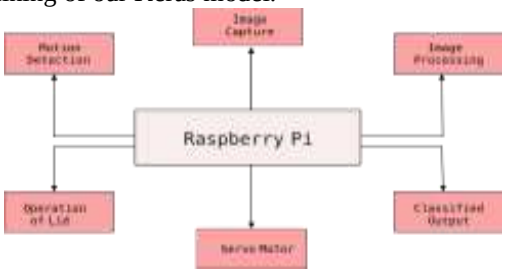

Figure 3: Raspberry Pi

Hardware Used

We are using Raspberry Pi, which is a single system on a chip. It has its RAM, ROM, and I/O ports. Raspberry Pi is ideal for this project since it is well suited for running python code on it, coded and compiled on a different, comparatively powerful computer system. In this project, the Raspberry Pi will be primarily used to run a light, stripped-down version of our trained machine learning model to classify the captured image of the waste into biodegradable or nonbiodegradable. The Raspberry Pi will also be used to control several major 27 processes such as motion detection, image capture, image processing, image classification, servo motor control, and lid operation.

We are using the camera module to capture raw images to process the images and give instructions to the motor with raspberry pi and the GPIO module.

We use a smoke sensor that will alert and warn the user against throwing burning waste items into the bin, especially lit cigarettes that can cause a smoldering fire, resulting in a conflagration.

We are using a servo motor to tilt the platform according to the instructions received. The DH22 sensor detects temperature and humidity; we are using this module for additional features only. The Proximity sensor will enable the intelligent dustbin to open its lid when it senses the gesture of an approaching user and remains open until the user puts all the garbage on the platform.

VI. ADVANTAGES

It is possible to reduce the number of waste collections to reduce fuel consumption, human efforts, and traffic congestion. We can stop

the overflowing of bins and unpleasant odors. We can place the containers more effectively with the help of data analysis. We can also measure fill level capacity, collection efficiency, and whether the garbage material belongs to the non biodegradable or biodegradable category. This smart bin also has an LED-backlit option through which we can display advertisements and generate additional revenue. It will also be visible at night time.

VII. APPLICATIONS

Municipal corporations can use it for effective waste collection and waste management. We can use it to update waste levels in real-time. We can add an odor-controlling feature to deal with foul-smelling substances. It also empowers Swachh Bharat Mission. It can contribute to the "SMART CITY" project and "DIGITAL INDIA."

We can use this to segregate waste more effectively, not just in biodegradable and nonbiodegradable. As we know,broken glass is menacing so, there is a need to segregate the garbage more effectively.

VIII. RESULT AND DISCUSSION

Automation of waste segregation process without human intervention using image processing algorithms and machine learning model

IX. CONCLUSION

This project aims to help collect garbage and segregate waste through sensors for garbage collection and machine learning for waste segregation. With the current build of the monitoring system, it recorded and interpreted data, which helped determine when and where to collect the trash. The machine learning model was used to separate known types of biodegradable and nonbiodegradable waste at 80%. However, in the future, the training images of the machine learning model could be more than 2,433. A much better standard for those images could also mean better accuracy most of the time. For example, the color of the light must be the same for all photos. More kinds of waste should also be given to training the model. For the monitoring system, RFID can be put to monitor who collects the trash and what time. More sensors could also be used, although the ones used here are supposedly sufficient.

With Artificial Intelligence, the Internet of Things(IoT), and Machine Learning, we can overcome the significant issue of waste management. Using our Smart Waste Management System, one can curb land pollution and overcome all its derivatives. Waste segregation, real-time based monitoring of waste, and proper disposal of garbage are possible with this waste management system.

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