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Utilizing Machine Learning for Waste Analysis

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Abstract

The Internet of Things can be expanded to include any physical object with an IP address that allows data to be transmitted over a network by installing electronic devices such as networking hardware, sensors, and software. The Internet of Things (IoT) offers enhanced connectivity for an array of devices, services, protocols, and applications. It is further defined by its diverse nature. Not just in houses and smart cities has IoT shown to be beneficial. Solid trash is produced in large quantities in urban areas and is made up of a variety of items, including paper, plastic, metal, glass, and organic garbage. These items need to be handled differently in order for waste management to be successful. Governments have enacted legislation requiring the separation of garbage into dry and moist categories in an effort to address this issue afterwards.

Keywords: Waste analysis, machine learning, artificial intelligence, Internet of Things (IoT), IP addresses

INTRODUCTION

Hence, any physical object that can be identified by an IP address to permit data transmission over a network can become a part of the Internet of Things by installing electronic gear like sensors, networking hardware, and software. Improved connectivity for a variety of devices, services, protocols, and applications is provided via the Internet of Things (IoT). It is also defined by its heterogeneous nature [1]. IoT has demonstrated efficacy not only in smart cities and home. With the help of machine learning and the Internet of Things (IoT), devices may now automatically distribute data over networks without the need for human-to-human or human-computer contact. Each device is given a unique identification, or IP address. India tops the list of countries with large populations that have developed in recent years in terms of producing enormous amounts of waste, whether it be hazardous or non-hazardous waste. This takes into consideration the waste's effects on the environment. According to a study, the amount of garbage produced in India alone increased from 92 million tons in 2016 to 50 lakh million tons in 2020. Given how quickly the population is growing, this will increase to three times the amount in the next years [1–5].

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Households, workplaces, enterprises, and other sources generate a lot of rubbish, paper, glass, plastic, metal, and other materials. Solid waste is the term for this kind of garbage. It has been proposed that when people become wealthier and move into cities, there is a corresponding increase in the amount of waste produced and the environmental damage caused by it [6–9].

One major obstacle is that municipal waste is disposed of in cities in one large pile without any kind of separation. This is due to the difficulty of waste segregation on such a large scale. It is necessary that there be no open area available for disposing of rubbish because the ones that do exist are hazardous. According to recent surveys, 74% of waste management expenses are devoted to collection and transportation, with only 26% of the budget going toward additional processing.

Solid waste includes organic materials, paper, glass, plastic, metal, and other commodities produced in huge amounts by residences, workplaces, businesses, etc. It is free of sewage and industrial waste. However, only waste that decomposes naturally will end up in landfills. This results in a great deal of wasted manual labor, high financial costs, and even more problems afterward [9–11].

Our government defines waste as non-biodegradable waste, biodegradable garbage, and home hazardous waste. For the public's easier understanding, the hazardous and non-hazardous rules were introduced. The waste management authority states that certain materials need to be handled differently, including plastic and thermo-coal. It is anticipated that the inhabitants will adhere to the designated waste segregation standards. Therefore, it is essential that the public be made aware of its requirements and that waste segregation practices be closely observed in order to identify and instruct residents who disregard them in the appropriate methods. Using the captured photos of trash, the main objective will be to approximate the contents of the dry and moist waste [12-15].

SYSTEMPROPOSED

The primary goal of the system is to distinguish between hazardous and non-hazardous waste components. The idea behind the recommended solution is to create an application that can recognize the type of waste and classify it as either hazardous or non-hazardous. The waste image from an Android device is sent to a web server that has been particularly created, after which the approximate amount of hazardous and non-hazardous waste content is determined. The Android smartphone will then receive the generated results from the web server.

Because of this, garbage will be produced generally in accordance with the guidelines set forth by the appropriate authorities. In particular, the TensorFlow platform will be utilized, and the Inception v3 architecture will be used to train the machine learning model (ML) that will be used to analyze the image. Subsequently, the web server will handle the images using this model. Work flow Diagram of the system is shown in Figure 1.

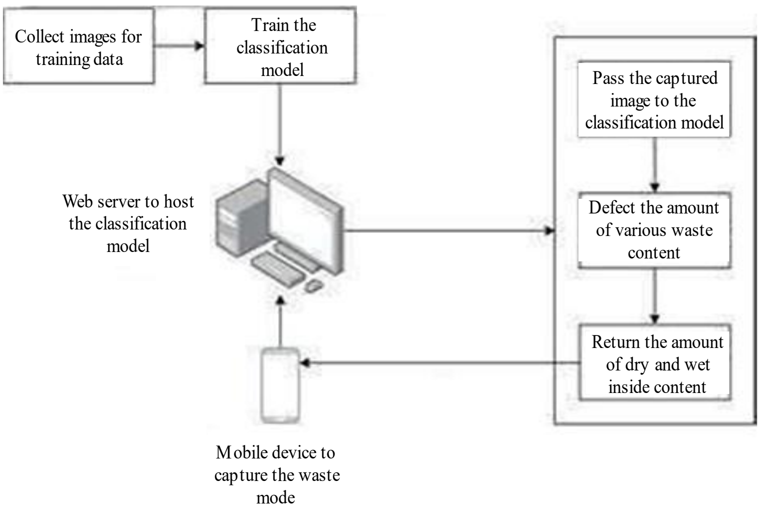

Figure 1. Workflow Diagram of the system.

METHODOLOGY

Considering that waste can be classified as non-biodegradable, biodegradable, or mixed as shown in Table 1., the following has been completed for typical household waste materials in accordance with legal requirements:

Table 1. Classification of Waste materials.

Category	Items
Hazardous Elements	• Metal Scrapes • Batteries • Glass pieces • Sharp material • Explosives • Bulbs • Leaves/Leftover food
Non-Hazardous Elements	• Normal Papers, newspapers • OilCans • Waste clothes • Metal Equipments • Scrap Metals • Broken glassware • Unused medicines Shampoo-toilet cleaner bottles • Toothpaste/cream tubes • Broken plastic toys • Broken house hold plastic items • Damagedcredit / debitcards and Thermocoal

Data used and the Training of ML Model

The first step in implementing any machine learning system is to create a model, which calls for the gathering of data, in this case, a dataset of images. This step is crucial since the kind and quantity of data that are gathered will determine how effective the processing model is [5]. Figures 2 and 3 display pictures of several types of hazardous and non-hazardous waste.

Figure 2. Images of Non-hazardous elements

Figure 3. Images of Hazardous elements.

The two categories—hazardous waste and non-hazardous waste—as they appear in the table will be used to create the model. We use the Kaggle dataset, which has been modified according to our standards for the dataset's structure, to take pictures of non-hazardous waste. As Table 1 illustrates, hazardous images are taken of many types of trash. In this way, a dataset including roughly 9000 photos will be generated. After all of the data has been loaded, it goes through a number of preparation steps, such as converting PNG photos to JPGs. In this study, Tensorflow and Google Colab will be the training environments.

Colab

This tool is a hosted Jupyter Notebook service that offers free access to processing resources, such as GPUs and TPUs, and doesn't require any setup. Colab works particularly effectively in the fields of education, data science, and machine learning. This enables programmers to create diverse machine learning models using resources such as Pytorch and additional Python-related modules and frameworks. This facilitates simple development and implementation. Over the past ten years, Colab has shown to be a highly helpful tool for development.

TensorFlow

A free and open-source software library for artificial intelligence and machine learning is called TensorFlow. Although it may be used for a wide range of applications, deep neural network training and inference are its primary areas of interest. The aforementioned versions are appropriate for use and training. The Google Brain team developed it for Google's internal use in research and production. It has been planned to employ the InceptionNet architecture for classification inside a variety of items.

Trainingthe modelandOptimization

After the dataset has been properly uploaded, the following step will be to train the dataset using pre-existing libraries and models so that the images may be used to confirm the classification accuracy. This is essentially done to progressively improve our model's forecast accuracy. As previously stated, the YOLO-v3 architecture is used to train the model. YOLO-v3 is trained for the image recognition challenge using the data. In this popular computer vision task, models try to classify entire images into 999 classifications, like "Dishwasher," "Dalmatian," and "Zebra."

Working of the webserver

The Framework, written in Python, will be used to build a custom web server that will house the ML model. It is classified as a framework because it doesn't require any particular tools or libraries, with the exception of a few basic standard libraries like bottom.py. While it offers common and functional functionality, it does not have form validation. However, Flask enables extensions to add features to the program as if they were included in Flask itself. Results from webserver is shown in Figure 4.

Figure 4. Results from webserver.

InceptionV3Model

As mentioned earlier, our model is trained using the processing, training, and analysis framework that Tensor Flow offers. Based on several ideas built over time by different researchers, the picture recognition algorithm Inception v3 has shown accuracy scores exceeding 78.1% on the ImageNet dataset.

Development of website

Millions of websites have been launched and are currently operational as of right now. Our website needs an image to be uploaded (as shown in Figure 5) from anywhere, which could be an image taken directly from the internet or in real time. Optimal image quality is essential for accuracy.

Once the image is uploaded as shown in Figure 6, it is sent to the server. The server uses the algorithm it was trained on to process it and offer the output.

Figure 5. Image Uploading

Figure 6. While image uploading.

RESULT ANALYSIS

The following pictures are provided, and non-hazardous garbage is the outcome. In this manner, the photos are classified as dangerous or non-hazardous by the server. A key factor in accuracy is the degree of picture separation and photo clarity.

Figure 7. Sample image.

As can be seen in Figure 7, the image has a considerable amount of organic garbage, or non-hazardous waste, mixed in with some dry debris. After analyzing the uploaded image to determine the model's accuracy, the following results were discovered.

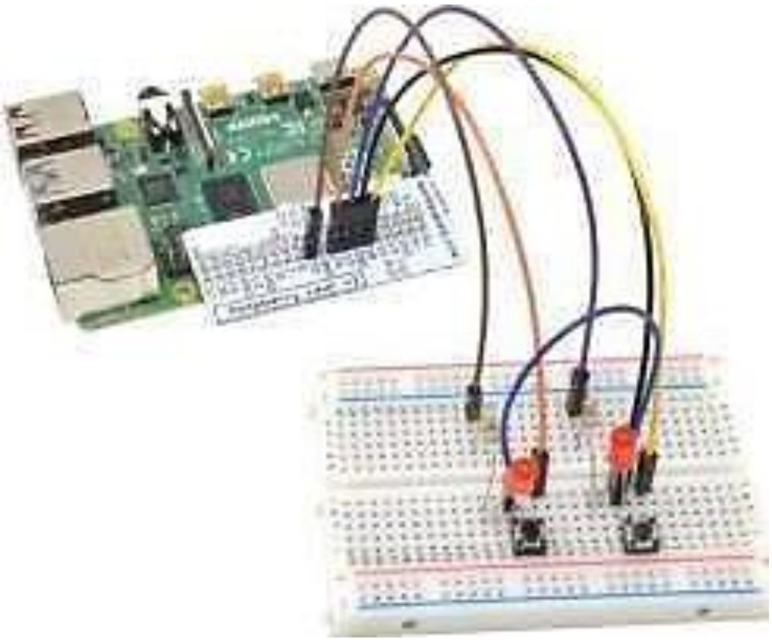

Figure 8. Results.

Analysis of the results might be done using the above Figure 8. A Raspberry Pi, a breadboard, and a few LEDs are used as Internet of Things components to make one or more of the bulbs glow, which produces the desired effect. Once more, creating a server and connecting the Raspberry to the real processing model are required.

Figure 9. City wise rating for garbage Analysis.

The area-wise waste ratings that can be generated for the selected time period are shown in Figure 9. Ratings can be assigned based on elevant facts, and then they can be reviewed for possible improvements. Determining whether or not waste material is dangerous is made simple by the algorithm.

Our proposed system performance eparameters can be seen in the Table 2 below which is evaluated against existing system. Defined system seems to be much faster than existing system.

Table 2. Performance.

Dataset	**Proposed System**		**Existing System**	
	Accuracy	***Execution time***	***Accuracy***	***Execution time***
Non-Hazardous	88%	1.3 seconds	88%	3.02 seconds
Hazardous	84%	1.56 seconds	84%	3.56 seconds

CONCLUSION

The system that may categorize garbage into non-biodegradable and biodegradable waste categories is constructed in accordance with the suggested idea. The model was trained on around 2700 pictures, yielding 380 continuous operations. When evaluated on a set of photos, the system achieved an 83.30% classification accuracy. Increasing the quantity of training data images can lead to a higher number of constant operations and ultimately improve the model's accuracy. The system's total processing time of 1.3 seconds is determined to be appropriate for use in real-time applications.

Future work

A significant amount of space is opened up in the direction of lowering the enormous budget spent on simply segregating the garbage at the later stages of the waste management process thanks to the successful implementation of the application that detects the amount of contents in waste and classifies them as dry waste or wet waste based solely on the image of the garbage taken.

This application can serve as the foundation for the development of a system that tracks individuals' habits about the disposal of waste in various areas. It will continue to do so, significantly lowering the demand for human labor. Based on this information, we might potentially keep a sufficient but insufficient amount of data.

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