IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125211

Automatic Waste Segregation in Trash Bin using IoT and Machine Learning

Ravinarayana B [1], Madhu Shankar Moger [2], Nithish Prabhu [3], Palash Chiplunkar [4], Prathijna D S [5]

HOD & Associate Professor, Department of Computer Science & Engineering, MITE, Mangalore, India[1]

Student, Department of Computer Science & Engineering, MITE, Mangalore, India[2-5]

Abstract: The conventional waste management system has proven to be inefficient and costly, relying on a daily schedule. Similarly, the current recycling bin is ineffective because the public fails to segregate waste properly. However, with the advancement of Internet of Things (IoT) and Artificial Intelligence (AI) technologies, there is a potential to replace the conventional waste management system with smart sensors that can automate waste segregation and enhance the waste management process. The primary objective of this research is to develop a smart waste management system that incorporates IoT and machine learning models. The system features several compartments, which are controlled by servo motors, facilitating segregation of waste into categories such as metal, plastic, paper, wet waste, and general waste. Each compartment contains an ultrasonic sensor that monitors the waste filling level in real-time.

Keywords: waste classification, IoT, smart waste management.

I. INTRODUCTION

Proper waste management is vital for safeguarding the well-being of people, animals, and the environment. Implementing effective waste management techniques can lead to cost savings, better air quality, and reduced environmental pollution. Developed regions have already started adopting efficient waste management techniques, which have yielded positive results. However, with the projected surge in waste production over the next five years, the current approach may not be sufficient. Thus, it is essential to adopt the best practices and techniques for treating waste efficiently to ensure a healthy environment. The world generates a massive amount of waste daily, estimated at 1.9 billion tons annually, with at least 35% not adequately treated. Reports indicate that daily waste generation per person ranges from 0.17 to 4.67 kilograms. Effective waste management and disposal can be a lucrative source of income.

An efficient solution for mitigating environmental pollution involves the implementation of a waste management system that incorporates both Internet of Things (IoT) and machine learning (ML) technologies. ML empowers a system to autonomously learn and make decisions without explicit guidance. In contrast, IoT is a network of interconnected devices, both digital and analog, that enhances data transfer beyond traditional human-to-computer interactions. Employing such a system offers a technically advanced and understandable approach to address environmental pollution concerns.

The emergence of IoT technology has opened up new avenues for improving the existing waste management system. One significant development in this area is the implementation of sensors in waste bins, which, when connected to the internet, allows for real-time monitoring of waste disposal. This technology enables the collection of diverse data, including filling levels, temperature, humidity, and other pertinent metrics, which can be stored and processed in the cloud. By analyzing this data, it becomes possible to gain insights into the inefficiencies of the current waste management system and implement measures to improve its effectiveness.

The incorporation of IoT technology into waste management represents a critical step towards building a more intelligent city. The suggested system implements a smart framework that enables users to take necessary measures in waste management. The paper's contributions are as follows:

- A novel approach combining IoT and ML paradigms to optimize garbage management.
- An intelligent method to classify dry and wet waste via image classification utilizing ML.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023
DOI: 10.17148/IJARCCE.2023.125211

II. LITERATURE SURVEY

[1] G. Kumar and V. Gopal [1] The system employs ultrasonic sensors to detect waste and machine learning algorithms to segregate the waste into different categories, such as organic and inorganic. The system uses cloud computing to store and process the data, making it more efficient. The system also uses a wireless network to transmit the data to the cloud, making it accessible from anywhere. The authors claim that this system can help reduce the amount of waste that ends up in landfills by ensuring that the waste is properly segregated and processed.

[2] S. Jain, S. Kumar, S. Kumar .et al [2]. The system uses a camera and sensors to detect the waste, and the data is transmitted to a machine learning model for classification. The system segregates the waste into different categories, such as biodegradable, non-biodegradable, and recyclable. The system also uses a GSM module to send notifications to the authorities when the bin is full. The authors claim that this system can help reduce the workload of waste management authorities by automating the waste segregation process.

[3] P. Das, P. Kumar, and A. Bora [3]. The system employs ultrasonic sensors to detect the waste and machine learning algorithms to segregate the waste into different categories. The system is also equipped with a compactor, which reduces the volume of the waste and makes it easier to handle. The authors claim that this system can help reduce the amount of waste that ends up in landfills by ensuring that the waste is properly segregated.

[4] M. S. Miah, M. S. Islam,.et al [4]. The system uses ultrasonic sensors to detect waste and a machine learning algorithm to classify the waste into different categories, such as recyclable, biodegradable, and non-biodegradable. The system also uses a GSM module to send notifications to the authorities when the bin is full. The authors claim that this system can help reduce the amount of waste that ends up in landfills by ensuring that the waste is properly segregated and processed.

[5] R. Prasad, A. B. Pandey, R. K .et al [5]. The system employs ultrasonic sensors to detect the waste and a machine learning algorithm to segregate the waste into different categories. The system also uses a GSM module to send notifications to the authorities when the bin is full. The authors claim that this system can help reduce the amount of waste that ends up in landfills by ensuring that the waste is properly segregated and processed. The authors claim that this system can reduce the workload of waste management authorities by automating the waste segregation process and provide real-time monitoring of the waste level.

[6] P. S. Gogoi, P. Kalita, and J. Deka,.et.al[6]. The system uses ultrasonic sensors to detect the waste and a machine learning algorithm to segregate the waste into different categories. The system also uses a camera to detect any unclassified waste and alerts the authorities. The authors claim that this system can help reduce the workload of waste management authorities by automating the waste segregation process. The paper provides a detailed description of the system architecture, algorithms used, and experimental results The results show that the system can accurately segregate the waste into different categories, making it a promising solution for efficient waste management.

[7] S. B. R. Palanichamy, M. Chandrasekar et al[7]. The system uses ultrasonic sensors to detect the level of waste in the bin, and machine learning algorithms to classify the waste into different categories. The authors claim that this system can help reduce the workload of waste management authorities by automating the waste segregation process, while also promoting sustainability and cleanliness. The paper provides a detailed description of the system architecture, algorithms used, and experimental results. The results demonstrate that the system can accurately classify waste into different categories and provide efficient waste management. The proposed system is an effective solution to improve waste management practices and can contribute to a sustainable future.

[8] M. K. Jena, S. P. Mishra.et al[8]. The paper by Jena et al. proposes an IoT and machine learning-based automated waste segregation system. The system employs ultrasonic sensors to detect the level of waste in the bin and machine learning algorithms to classify the waste into different categories such as biodegradable, non-biodegradable, and recyclable.

The authors claim that this system can help reduce the workload of waste management authorities and promote sustainability. The paper provides a detailed description of the system architecture, algorithms used, and experimental results.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125211

III. METHODOLOGY

The proposed system consists of development of a smart waste management system that incorporates IoT and machine learning models. The system features several compartments, which are controlled by servo motors, facilitating segregation of waste into categories such as metal, plastic, paper, wet waste, and general waste. Each compartment contains an ultrasonic sensor that monitors the waste filling level in real-time.

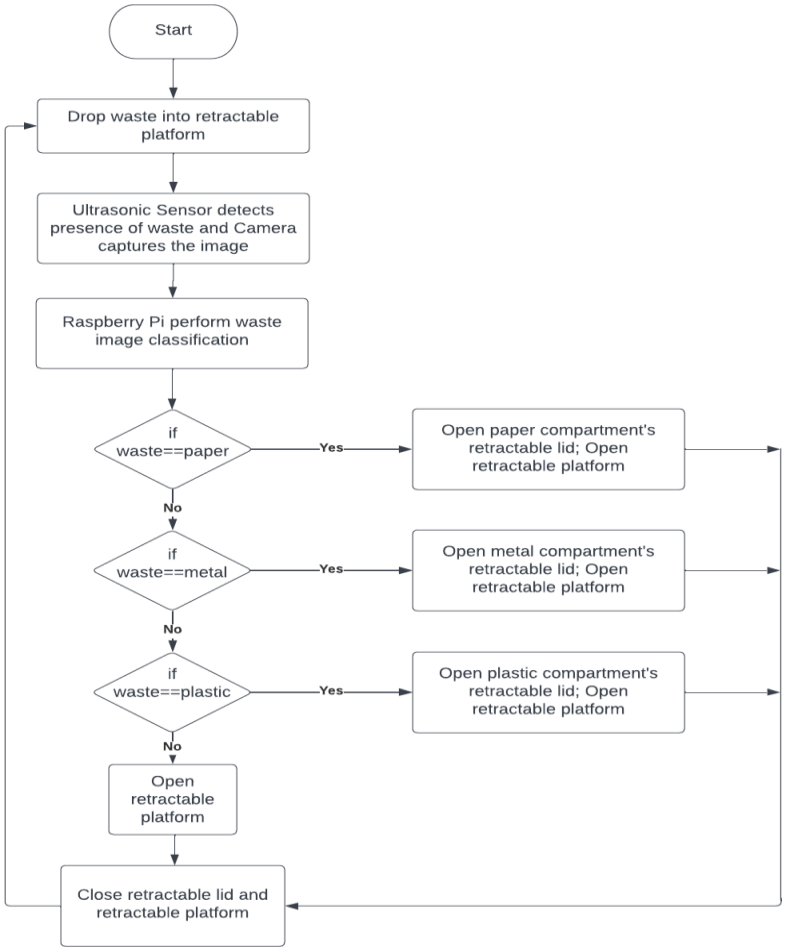


Image classification is a machine learning technique that involves training a computer algorithm to recognize patterns and classify images based on those patterns. The idea here is to train a machine learning model using a set of labeled images of plastic, paper and other waste. The model then uses this training data to learn the distinguishing features of plastic and paper waste, and can be used to automatically classify new images of waste.

We used the EfficientNet-Lite model for image classification. EfficientNet-Lite belongs to the family of EfficientNet classification models. It is specifically designed to be optimized for low power devices without losing accuracy of classification. EfficientNet-Lite belongs to a family of mobile-friendly neural networks that are designed to be small, fast, and efficient for deployment on mobile and embedded devices. These networks are based on the EfficientNet architecture.

EfficientNet-Lite models use a combination of depth wise separable convolutions, linear bottlenecks, and swish activations to achieve high accuracy while minimizing computational cost and memory usage. The Lite versions are designed to be even more lightweight than the original EfficientNet models, making them suitable for deployment on devices with limited resources.

We used TensorFlow Lite Model Maker, which is a tool that allows to convert existing TensorFlow models with a user's input data and export to a TensorFlow Lite format.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125211

TensorFlow Lite (TFLite) is a lightweight version of TensorFlow, which is an open-source machine learning framework developed by Google. TFLite is designed to be used for deploying machine learning models on mobile and embedded devices, such as smartphones, tablets, and microcontrollers. TFLite provides a set of tools and libraries for converting TensorFlow models into a format that can be used on mobile and embedded devices.

The model generated thus was then imported into Raspberry Pi. Raspberry Pi is a small size, low-cost computing device suitable for IoT devices.

We have used Ultrasound proximity sensors to detect when a waste is dropped into the bin. It is also used to check the fill percent of the collection bins. Ultrasound sensors work by sending out high frequency sound waves and then analyzing the echo coming in after hitting the target.

A camera module is used to capture pictures of the waste and is sent to Raspberry Pi. Each Raspberry Pi computer consists of a single board with a microprocessor, memory, input/output interfaces, and other components required for basic computing tasks. The boards are designed to be low-cost, energy-efficient, and small.

The model and metal sensor then classifies the type of waste. We used a metal sensor for detecting metal contents in the waste. Metal detectors work by transmitting an electromagnetic field from the search coil into the ground. Any metal objects within the electromagnetic field will become energized and retransmit an electromagnetic field of their own. The detector's search coil receives the re-transmitted field and alerts the user by producing a target response.

The waste bin prototype has been built by cardboard. And strengthen by sticks and hot glue. The bin has 4 compartments, 3 compartments for plastic, paper and metal respectively. The bottom component is for any other general wastes. Each of the first three compartments have a door and a main door where the waste is placed. The three doors are moved with the help of servos.

Servos, short for "servomechanism" or "servomotor", are devices used to control the movement of objects with precision and accuracy. They consist of a motor, a feedback mechanism, and a controller. The motor rotates the output shaft, which is connected to the object being controlled, and the feedback mechanism measures the position of the object and sends this information to the controller. The controller then adjusts the motor's speed and direction to move the object to the desired position. When a waste type is detected, then the door of that compartment if opened first. The main door than opens to drop the designated compartment. The doors are then closed.

				
A)	B)	C)	D)	E)

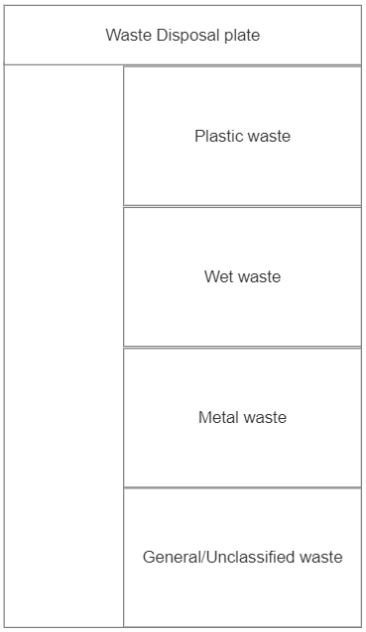
No.	Device	Specification
A)	Ultrasound sensor	HC-SR04, 5V DC
B)	Camera module	Pi camera, 8MP
C)	Servo motors	SG90
D)	Servo Motor Driver	PCA9685, 16 channels
E)	Raspberry Pi	Model B, 8GB

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023

DOI: 10.17148/IJARCCE.2023.125211



IV. RESULTS

This project has yielded significant results in revolutionizing waste management practices. The integration of advanced technologies has transformed the waste segregation process, offering numerous benefits for efficiency, environmental sustainability, and user convenience. First and foremost, the project has successfully developed a smart trash bin capable of automatically detecting, classifying, and segregating different types of waste materials. The use of IoT sensors, including ultrasonic sensors and camera modules, combined with Machine Learning algorithms, has resulted in accurate and reliable waste classification. This has greatly reduced manual labour and human error associated with traditional waste segregation methods. The Automatic Waste Segregation system using IoT and Machine Learning has significantly streamlined waste management processes, leading to enhanced efficiency, reduced environmental impact.

Front view of the prototype

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 12, Issue 5, May 2023
DOI: 10.17148/IJARCCE.2023.125211

V. CONCLUSION

This project has successfully demonstrated the potential to revolutionize waste management practices. By leveraging advanced technologies, including IoT sensors, Machine Learning algorithms, and smart devices, the project has achieved significant advancements in waste segregation and disposal. The integration of ultrasonic sensors and camera modules has enabled the system to accurately detect the presence of waste and capture images for further analysis. The implementation of Machine Learning algorithms has facilitated the classification of waste into different categories, such as plastic, wet waste, or metal, without the need for manual intervention.

REFERENCES

[1] G. Kumar and V. Gopal, "IoT and Machine Learning-Based Automated Waste Segregation System," in International Journal of Engineering and Advanced Technology, vol. 9, no. 2, pp. 2664-2669, 2019.
[2] S. Jain, S. Kumar, S. Kumar, and S. Aggarwal, "Automatic Waste Segregation System using IoT and Machine Learning," in Proceedings of the 3rd International Conference on Internet of Things and Connected Technologies (ICIoTCT), pp. 183-187, 2018.
[3] P. Das, P. Kumar, and A. Bora, "Smart Trash Bin for Waste Segregation using IoT and Machine Learning," in Proceedings of the 2nd International Conference on Advances in Electronics, Computers, and Communications (ICAECC), pp. 1-4, 2019.
[4] M. S. Miah, M. S. Islam, M. S. Ali, and M. S. Uddin, "IoT and Machine Learning-Based Automated Waste Sorting and Segregation System," in Proceedings of the International Conference on Industrial Electronics and Electrical Engineering (ICIEEE), pp. 1-5, 2020.
[5] R. Prasad, A. B. Pandey, R. K. Dwivedi, and A. Singh, "Smart Waste Segregation System using IoT and Machine Learning," in Proceedings of the International Conference on Communication and Signal Processing (ICCSP), pp. 214-219, 2020.
[6] P. S. Gogoi, P. Kalita, and J. Deka, "A Smart Waste
[7] Segregation System using IoT and Machine Learning," in Proceedings of the International Conference on Intelligent Computing and Control Systems (ICICCS), pp. 808-812, 2020.
[8] S. B. R. Palanichamy, M. Chandrasekar, and S. S. Sivanandam, "Smart Waste Segregation System using IoT and Machine Learning," in Proceedings of the International Conference on Computing and Communication Technologies (ICCCT), pp. 1-6, 2021.
[9] Smart Dustbin with Automated Waste Segregation using IoT and Machine Learning" Authors: S. K. Parida, P. Kumar, P. S. Sahoo, and S. Panda