Automated Waste Segregation using Machine Learning

Manikandan V[1*], Arjun S[1], Athira Visweswaran[1], Sruthi N.[2]

[1]Department of ECE, NSS College of Engineering, Palakkad, Kerala

[2]Assistant Professor, Department of ECE, NSS College of Engineering, Palakkad, Kerala

*Corresponding author's e-mail: manikandanv312002@gmail.com

doi: https://doi.org/10.21467/proceedings.160.33

ABSTRACT

Waste segregation is an essential process in managing and reducing waste. With the increasing amount of waste generated globally, there is a need for efficient and automated waste segregation techniques to reduce the burden on environment. Computer vision technology has shown greater potential in waste segregation, as it can automate the process, increase accuracy, and reduce human error. Computer vision-based waste segregation uses videos of waste and computer algorithms to detect and classify different types of waste materials. The system uses machine learning techniques to train and recognize various categories of waste, including metal, plastic, e-waste, paper, and glass waste. The algorithm identifies and classifies the waste materials based on colour, texture, shape, and other visual cues. This approach has several advantages over traditional waste segregation techniques including faster processing time, reduced labour cost, and increased accuracy in identifying and classifying waste materials. It also reduces the chances of human error and ensure that the waste is sorted correctly, which can ultimately lead to improved waste management practices and a cleaner environment. This is a promising technique that helps to reduce pollution due to waste disposal and create a sustainable environment.

Keywords: Waste Segregation, Computer Vision, Convolutional Neural Network

1 Introduction

Automated waste segregation using machine learning is a technology that uses advanced algorithms to sort and separate waste materials based on their physical characteristics. This technology enables the efficient and accurate segregation of waste, which lowers the quantity of waste that is dumped in landfills and promotes recycling.

The process of automated waste segregation begins with the use of sensors, cameras, and other hardware devices. The images of wastes are captured in real time and Convolutional Neural Network algorithm is used to classify the wastes into various categories. These images are then processed by machine learning algorithms that analyse the characteristics of the material, such as, shape and texture. Based on this analysis, the algorithms determine the category of waste material and sort it into appropriate groups, namely plastic, glass, metal, paper, and e-waste. The segregated wastes are then deposited into respective bins using servo motors that are actuated by a NodeMCU microcontroller.

Automated waste segregation technology offers several benefits. Primarily, it aids in lowering the volume of trash dumped in landfills, which in turn lowers the environmental impact of garbage disposal. Additionally, this technology can increase the efficiency of waste management processes by reducing the time and labour required for manual sorting. It can also help to improve recycling rates by ensuring that materials are properly sorted and sent to recycling facilities.

2 Work Retrospective

Automated waste segregation using machine learning is a rapidly growing field, but there are some research gaps that need to be addressed.

Despite the presence of numerous industrial waste segregators, it is always preferable to separate the trash at the source. The benefit of using this method of segregation is that rag pickers are not required to separate the waste [1].

Proceedings DOI: 10.21467/proceedings.160; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-965621-9-9

One of the major challenges in developing machine learning models for automated waste segregation is the lack of large- scale, diverse, and labelled datasets. Most of the existing datasets are small, limited in scope, and may not reflect real-world scenarios. Collecting and annotating large-scale datasets that capture the variability of waste composition and environmental conditions can help improve the accuracy and generalizability of machine learning models. Data augmentation techniques such as scaling, moving, and enlarging of images can be applied to further improve variation of the images [2].

Waste segregation involves identifying and categorizing different types of waste into multiple classes, such as plastics, metals, paper, e-waste, and glass [3]. Classification is performed based on the features that are derived from the contour. Real-time photos are taken directly from the camera and processed using OpenCV tools before being used to create a model using computer vision [4]. Multi-class classification is a complex problem that requires sophisticated algorithms and architectures. There is a need for research that explores novel approaches to multi-class classification in the context of waste segregation.

Microcontrollers such as NodeMCU are used to control the dumping of wastes into respective bins. Dc/ac servo motors are used to drop the waste in their respective compartments automatically, according to the signal from microcontroller. Ultrasonic sensor can be utilised to determine how full the bin is [5].

While machine learning models for automated waste segregation can help reduce the human effort and error in waste management, their environmental impact needs to be evaluated. The energy consumption and carbon footprint of waste segregation systems need to be quantified and compared with manual methods. Moreover, the potential risks and unintended consequences of machine learning-based waste segregation, such as misclassifying hazardous waste, need to be investigated.

3 Methodology

The segregation of wastes using machine learning involves the following processes:

3.1 Dataset Creation

The dataset contains images of wastes categorised into four folders comprising of glass, paper, e-waste, and plastic wastes. The images were captured using the ESP32 camera module and different angles and lighting scenarios were taken into consideration while creating the dataset. Data diversity is ensured by taking pictures of different varieties of wastes belonging to the four categories. This helps the model to be robust and generalize to new data. The dataset is also a balanced one with equal number of samples belonging to each category. In order to improve the quantity and diversity of the dataset, various data augmentation techniques like flipping and rotating the images are also used.

3.2 Preprocessing

Data preprocessing helps to convert the initial dataset into a format that is best suited for a machine learning model to process. Preprocessing of data involves several steps such as cleaning, normalisation, and feature extraction. The various preprocessing techniques used include canny edge detection, histogram equalisation, median blur and resizing. By pre- processing the data, we generate two pickle files, one storing the features of the data and the second storing the labels of the data.

3.3 Training the Model

The model is trained using the Convolutional Neural Net- work algorithm. A max pooling layer is added after the model's three convolutional layers of increasing depth to lower the output's dimensionality. The output of the convolutional layers is converted into a one-dimensional vector, that is fed into two dense layers that are completely linked. The probability that the input image belongs to each of the four classes is output by four neurons in the output layer, which has a softmax activation function. ”Adam” optimizer is used to compile the model with ”sparse categorical crossentropy" as the loss function. "Accuracy" is used as the evaluation metric. The model is trained by setting the validation split parameter as 0.2, indicating that 20 percent of the training data will be used for validation.

3.4 Data Prediction

Ultrasonic sensor detects presence of waste in the container by calculating the variation in distance. To identify metal waste, an inductive proximity sensor is utilised. If the detected waste is not metal, then the real-time image of the waste is captured using ESP32 camera and is pre-processed using the same techniques used for preprocessing the dataset. The pre-processed real-time image is passed into the trained model which predicts the category of waste and assigns the corresponding label to it.

3.5 Waste Segregation

The predicted data is sent to the NodeMCU which controls the hardware components. For each category of waste, the NodeMCU is programmed to rotate the servo motors in a specified direction corresponding to their respective bins. Of the two motors, one is used for dumping the waste and the other for turning the container in the direction corresponding to the type of waste.

4 Results and Discussions

A dataset containing photos of the four waste categories such as plastic, e-waste, paper and glass has been developed. The pre-processed dataset is subsequently trained using the Convolutional Neural Network (CNN) algorithm, which results in the creation of a classifier model file. The accuracy for various training parameters is shown in Table 1.

Table 1: *Accuracy & Training Parameters*

Epochs	Batch size	Validation split	Accuracy
10	16	0.2	78%
15	16	0.2	87%
20	32	0.2	82%
50	32	0.2	60%

The trained model is able to predict the category of wastes with a best accuracy level of 87% for an epoch of 15 with a batch size of 16 and validation split 0.2.

The accuracy and loss for training and validation are depicted in Figures 1 and 2, respectively.

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

Series: AIJR Proceedings
ISSN: 2582-3922

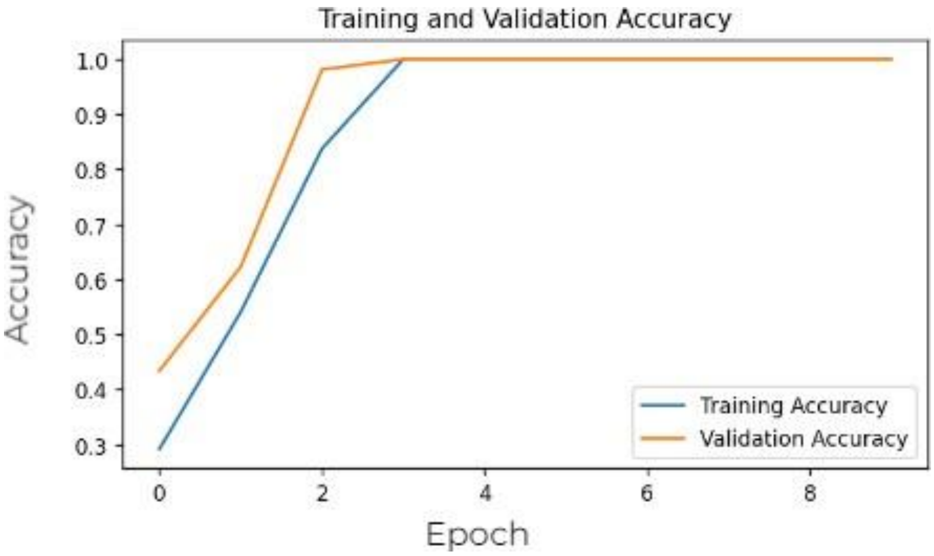

Figure 1: *Training and validation accuracy*

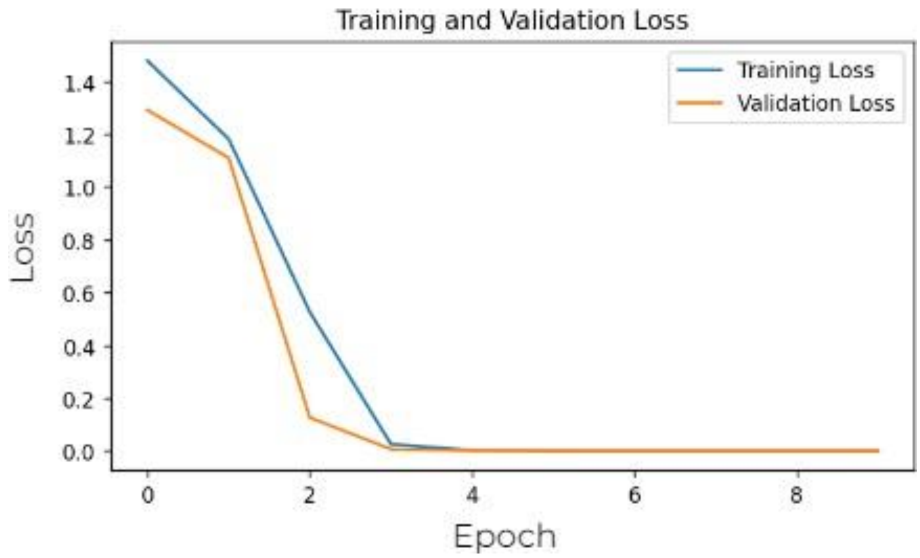

Figure 2: *Training and validation loss*

The developed system model is able to categorise the wastes into five categories, consisting of metal, plastic, e-waste, paper, and glass. However, the system fails to accurately predict images on a background that is different from the one in which it was trained. The accuracy of the system can be improved by expanding the dataset with more diverse pictures of various types of wastes captured in different backgrounds. Future developments can be made to incorporate more categories of wastes in the system.

5 Conclusion

Waste management is an ever growing crisis in our present world and proper waste segregation is the foremost step in efficient handling of wastes. Automated Waste Segregation using Machine learning offers an apt solution to this crisis. Using machine learning algorithms, wastes can be segregated into various categories which makes their further processing easier. Automated segregation reduces the time and labour required in manual segregation. It also helps in preventing the risk caused by contact of toxic wastes. It makes the recycling of wastes easier and more efficient, thereby reducing the amount of wastes dumped in landfills and water bodies. Thus, this system aids in reducing the environmental impact caused by wastes and promotes a cleaner environment.

6 Declarations

6.1 Acknowledgment

We wish to show our genuine appreciation to NSS College of Engineering Palakkad for providing us with the necessary facilities and resources to complete this project. We also extend our sincere thanks to our project guide, Sruthi N, Assistant Professor in the Department of Electronics and Communication Engineering, for her guidance and valuable insights all through the project. Finally, we want to thank everyone in our team for their hard work and dedication in completing this project.

6.2 Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in institutional affiliations.

How to Cite

Manikandan *et al.* (2023). Automated Waste Segregation using Machine Learning. *AIJR Proceedings*, 264-268. https://doi.org/10.21467/proceedings.160.33

References

[1] Lakshmi V, Prof. Maheshan C M, "Review on waste segregation using different techniques", *JETIR,* vol. 8, no. 2, February 2021.

[2] Myles Joshua Toledo Tan, Albert Anthony O.Fuentes, Alfed Edrian D. Ama, Neil Laurence Z Ortaliz, "Automated Waste Segregation System using Trained Optical and Material Sensors with User Communication Capabilities", *In Proceedings of The 814th International Conference on Science, Technology, Engineering and Management*, Kuala Lumpur, Malaysia, May 2020.

[3] Nadish Ramsurrun, Geerish Suddul, Sandhya Armoogum, Ravi Foo- gooa, "Recyclable Waste Classification Using Computer Vision And Deep Learning", *In Proceedings of The Zooming Innovation in Consumer Technologies Conference (ZINC),* Novi Sad, Serbia, 2021.

[4] Sruthy V, Akshaya, Anjana S, Sai Supriya Ponnaganti, V Gokul Pillai, Preetha P K, "Waste Collection and Segregation using Computer Vision and Convolutional Neural Network for Vessels*", In Proceedings of The International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), 2021.*

[5] Jacklin Gounder, Rosy Caunder, Shivam Baikerikar, Sejal Chopra, "Waste Segregation using Smart bin and Optimization of Collection Routes", *Measuring Waste Recyclability Level Using Convolutional Neural Network and Fuzzy Inf International Journal of Intelligent Information Technologies (IJIIT)*, vol. 18.1, pp. 1-17, 2022.