



Automatic Garbage Classification in Images for Health and Recycling Using Deep Learning

Under the esteemed guidance of

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ABSTRACT

Effective waste management is critical for maintaining public health and environmental sustainability. Traditional methods of waste sorting are often manual, error-prone, and inefficient, hindering timely recycling and hazardous waste identification. This project presents an automated garbage classification system that leverages deep learning techniques to accurately categorize waste materials from images. Using convolutional neural network architectures such as ResNet50 and VGG16, the system classifies waste into recyclable, non-recyclable, healthy, and hazardous categories. The model is trained on a diverse dataset of waste images to ensure robustness across various garbage types and environmental conditions. By enabling real-time classification, the system facilitates improved waste segregation at the source, reducing human exposure to harmful materials and promoting effective recycling processes. The proposed solution supports municipalities and recycling centers in optimizing waste management workflows, ultimately contributing to healthier communities and sustainable environmental practices. This research highlights the potential of deep learning in transforming traditional waste handling through intelligent automation. Future enhancements may include integration with IoT-enabled smart bins and edge devices to enable large-scale deployment and real-time waste management.

Keywords: *Garbage classification, Deep learning, ResNet50, VGG16, Waste management, Recycling, Hazardous waste detection, Image classification, Public health.*

INTRODUCTION

Waste management is an important issue for both environmental protection and public health. Traditional waste sorting methods are mostly manual, making the process slow, inefficient, and prone to mistakes. Improper segregation of waste can cause serious problems such as pollution, health risks, and difficulty in recycling. With the increase in population and urban growth, there is a greater need for an effective system that can help in proper classification and disposal of waste materials.

This project introduces an automated garbage classification system that uses deep learning techniques to identify different types of waste from images. Convolutional Neural Network (CNN) models like ResNet50 and VGG16 are used to classify waste into four categories: recyclable, non-recyclable, healthy, and hazardous. The system is trained on a dataset of diverse waste images to ensure good accuracy in different conditions, such as variations in lighting or object appearance. By using this approach, the system can perform real-time classification, reducing the need for human involvement and minimizing exposure to harmful materials.

The main aim of this project is to make waste management smarter and more efficient. By helping in proper segregation at the source, the system supports recycling processes and contributes to environmental sustainability. It can also be useful for municipalities, households, and recycling centers to handle waste more effectively. In the future, the system can be combined with smart bins and IoT devices for wider applications in smart cities. Overall, this project demonstrates how deep learning can be applied to solve real-world problems in waste management.

Literature review

Recent research demonstrates that deep learning with CNNs such as ResNet50, VGG16, and hybrid models achieves high accuracy (up to 97%) in classifying waste from images, outperforming manual sorting and traditional algorithms. In comparative studies on multi-class garbage datasets, VGG16 slightly outperforms ResNet50, reaching around 97% accuracy versus 96%, while ResNet50 offers improved computational efficiency with faster training times. Attention mechanisms like CBAM, SENet, and ECA significantly enhance feature extraction and classification performance. Lightweight attention modules such as ECA enable real-time and edge-based deployments crucial for smart waste management systems. Additionally, model fusion and consensus-based approaches that combine multiple CNN and object detection models have achieved recognition rates approaching 98%, with practical systems increasingly deployed in real-world waste management scenarios (Yang et al., 2023; IRJAEH, 2024; Xiao & Sun, 2022; Mittal et al., 2020). However, challenges such as limited annotated datasets, domain adaptation across varied waste types, and the need for interpretable yet lightweight models remain critical areas for further research and development to ensure robustness and broad applicability in real-world waste management systems.

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