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AI-POWERED SMART WASTE SEGREGATION SYSTEM USING MOBILENET

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1. ABSTRACT :

Waste management is a major environmental challenge due to improper waste segregation.Manual waste sorting is time-consuming, costly, and prone to human errors.Improper segregation reduces recycling efficiency and increases environmental pollution.This project proposes an AI-Powered Smart Waste Segregation System using MobileNet.The system automatically identifies and classifies different types of waste.The waste categories include plastic, paper, glass, metal, cardboard, and organic waste.MobileNet is a lightweight and efficient CNN model used for image classification.Transfer learning is applied using a pretrained MobileNet model.Waste images are collected and preprocessed before training the model.Preprocessing includes image resizing, normalization, and data augmentation.The trained model learns the visual features of different waste categories.Users can upload a waste image through a simple application interface.The system predicts the waste category along with its confidence score.Model performance is evaluated using accuracy, precision, recall, F1-score, and confusion matrix.The proposed system reduces human effort, improves recycling efficiency, and supports sustainable waste management.

Keywords: Artificial Intelligence, Smart Waste Management, Waste Segregation, MobileNet, Deep Learning, Convolutional Neural Network (CNN), Image Classification, Transfer Learning, Waste Classification, Recycling.

2. INTRODUCTION

Waste management is an important environmental challenge caused by rapid urbanization, population growth, industrialization, and increasing waste generation. Proper segregation of waste is essential for improving recycling efficiency, reducing landfill usage, minimizing pollution, and supporting sustainable development [6], [9]. However, traditional waste segregation mainly depends on manual sorting, which is labor-intensive, time-consuming, costly, and prone to human errors. Improper segregation can contaminate recyclable materials and reduce the efficiency of recycling processes [8]. Recent advancements in Artificial Intelligence (AI), Deep Learning, and Computer Vision have provided effective solutions for automated waste classification [6], [10]. Convolutional Neural Networks (CNNs) can automatically learn important visual features from images and classify different waste materials. Among various deep learning models, MobileNet is a lightweight and computationally efficient CNN architecture that requires fewer computational resources, making it suitable for real-time and resource-constrained applications [1], [4]. The proposed AI-Powered Smart Waste Segregation System Using MobileNet aims to automatically identify and classify different types of waste from digital images. The system performs image preprocessing, including resizing and normalization, before using the MobileNet model for classification. It focuses on identifying waste categories such as Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste. The system also provides a confidence score along with the predicted category. By automating the waste classification process, the proposed system can reduce manual effort, improve segregation accuracy, and support efficient recycling practices. The system can be useful in recycling centers, educational institutions, industries, and environmental organizations. In the future, it can be extended with smart bins, IoT-based monitoring, mobile applications, and real-time camera-based waste detection [8]. Thus, the proposed system provides an intelligent and scalable approach toward efficient and sustainable waste management.

3. LITERATURE REVIEW

[1] Rabano and Cabatuan (2021) presented Common Garbage Classification Using MobileNet. The study supports the use of MobileNet for image-based garbage classification and provides a foundation for lightweight waste recognition.
[2] Li et al. (2023) explored the application of MobileNetV2 to waste classification. The work demonstrates the suitability of the MobileNet family for recognizing different waste categories.
[3] Angdresey, Kairupan, and Mongkareng (2025) presented a web-based waste detection system using YOLOv8 and compared MobileNet and EfficientNet classification performance. This study highlights deep learning for automated waste detection and classification.
[4] Wang et al. (2022) proposed an intelligent garbage classification system based on improved MobileNetV3-Large. The work emphasizes improving MobileNet-based classification for intelligent waste management.

[5] Automated Waste Sorting Based on MobileNetV3 with Transfer Learning (2025) demonstrates the application of transfer learning with MobileNetV3 for automated waste sorting, supporting the proposed transfer-learning approach.
[6] A Systematic Review of AI-Based Techniques for Automated Waste Classification (2025) provides an overview of Artificial Intelligence techniques used for automated waste classification and establishes the importance of deep learning in this domain.
[7] Automated Trash Classification Using MobileNetV2 for Efficient Waste Sorting (2025) focuses on MobileNetV2 for efficient trash classification and supports lightweight CNN architectures for waste sorting.
[8] Waste Segregation using CNN & IoT (2024) combines CNN-based classification with IoT concepts for waste segregation, indicating potential integration of intelligent classification with connected waste-management systems.
[9] Comprehensive Analysis of Automated Garbage Classification (2026) examines automated garbage classification approaches and supports the need for efficient and reliable AI-based waste recognition systems.
[10] AI Powered Waste Segregation Using Deep Learning (ICSSS, 2025/2026) presents a deep-learning-based approach to waste segregation and supports the application of AI for automated waste classification.

4. METHODOLOGY

The proposed system is a deep learning-based waste classification system using MobileNet. First, labeled images of Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste are collected. The images are resized, normalized, and augmented before being divided into training, validation, and testing sets. A pretrained MobileNet model is used with transfer learning and fine-tuned for the six waste categories. During testing, a user uploads a waste image, the trained model predicts its category and confidence score, and the result is displayed through the application interface. Finally, accuracy, precision, recall, F1-score, and confusion matrix are used to evaluate the model.

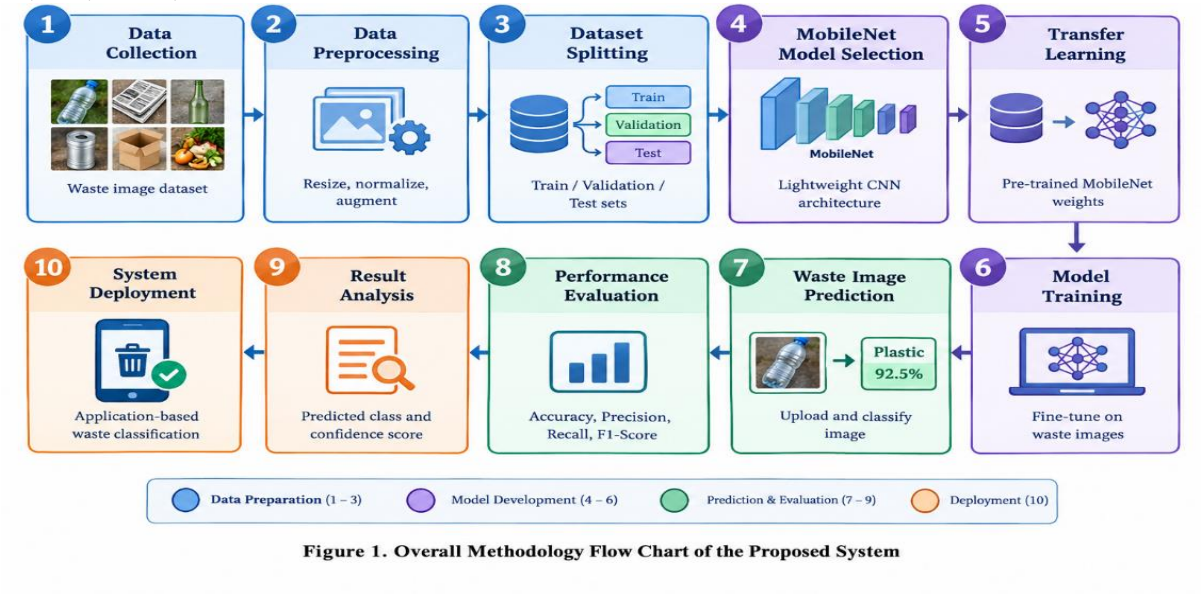


Figure 1. Overall Methodology Flow Chart of the Proposed System

ARCHITECTURE DIAGRAM:

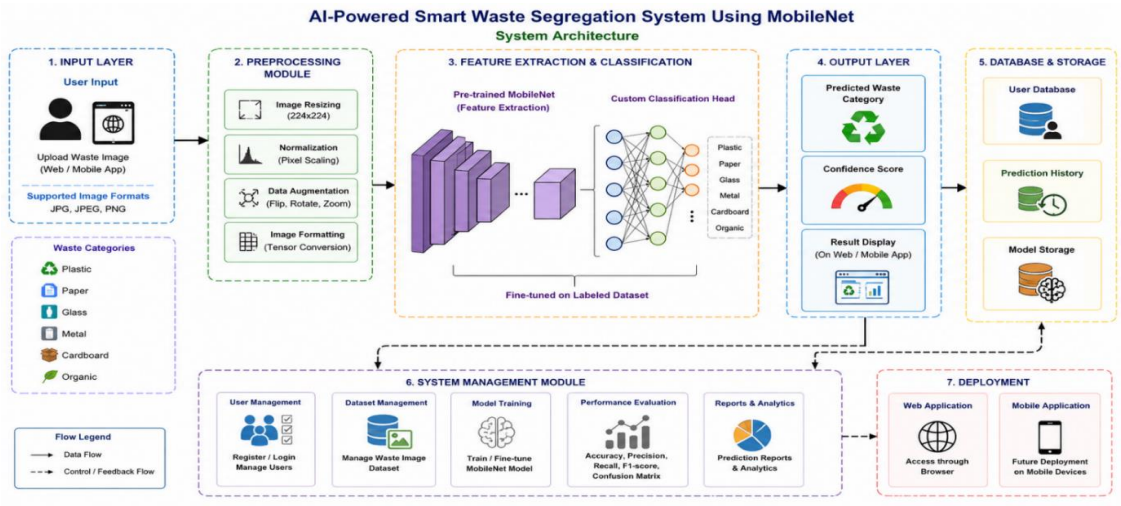


Figure 2. AI-Powered Smart Waste Segregation System Using MobileNet

4.1 Dataset Collection Module

This module is responsible for collecting and organizing waste images required for training and testing the deep learning model. The dataset contains images belonging to different waste categories, including Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste. Each image is assigned to its corresponding class to create a labeled dataset suitable for supervised learning.

4.2 Image Preprocessing Module

The collected images may have different resolutions, orientations, and pixel distributions. This module prepares the images for MobileNet by performing operations such as:

- Image resizing to the required input dimensions.
- Pixel-value normalization.
- Image format conversion when required.
- Removal of unsuitable or corrupted images.
- Preparation of images in a consistent format.

Proper preprocessing ensures that the input data is compatible with the deep learning model.

4.3 Data Augmentation Module

This module increases the diversity of the training dataset by generating modified versions of existing images. Techniques such as rotation, horizontal flipping, zooming, shifting, cropping, and brightness variation can be applied. Data augmentation helps reduce overfitting and improves the model's ability to classify waste images captured under different environmental conditions.

4.4 MobileNet Model Module

This is the core module of the proposed system. MobileNet is a lightweight CNN architecture designed for efficient image classification. It extracts important visual characteristics from waste images using convolutional operations and depthwise separable convolutions. The extracted features are used to distinguish between different waste categories while maintaining relatively low computational requirements.

4.5 Transfer Learning and Fine-Tuning Module

A pretrained MobileNet model is used as the initial model instead of training the complete network from scratch. The pretrained layers provide useful general image features, while the final classification layers are modified for the selected waste categories. The model is then fine-tuned using the waste dataset to improve classification performance for the target application.

4.6 Model Training Module

The preprocessed and augmented training images are provided to the MobileNet model. During training, the model learns the visual characteristics associated with each waste category. Training is performed for multiple epochs, while validation data is used to monitor performance. Accuracy and loss values are recorded to determine whether the model is learning effectively.

4.7 Waste Image Prediction Module

This module allows users to upload a new waste image through the application interface. The uploaded image is automatically preprocessed and passed to the trained MobileNet model. The model generates probability scores for all supported waste categories and identifies the category having the highest probability.

4.8 Classification Result Module

After prediction, this module displays the classification result to the user. The output includes the predicted waste category and confidence score. For example, an uploaded image may be classified as *Plastic Waste* with a corresponding prediction confidence. This provides users with an easy-to-understand result for proper waste segregation.

4.9 Performance Evaluation Module

This module evaluates the effectiveness of the trained MobileNet model using standard classification metrics. The major evaluation measures include:

- Accuracy – Measures the overall percentage of correctly classified waste images.
- Precision – Measures how accurately the model identifies images belonging to a particular class.
- Recall – Measures the ability of the model to correctly identify all images belonging to a particular class.
- F1-Score – Provides a combined measure of precision and recall.

- Confusion Matrix – Shows the correct and incorrect predictions for each waste category.

4.10 Model Deployment Module

The trained MobileNet model is saved and integrated with the application interface for practical use. Users can upload waste images without requiring knowledge of deep learning techniques. Due to the lightweight nature of MobileNet, the system can potentially be deployed on resource-constrained computers, mobile applications, smart bins, and edge devices.

5. MODEL EVALUATION

The performance of the proposed AI-Powered Smart Waste Segregation System Using MobileNet is evaluated using standard image classification metrics such as Accuracy, Precision, Recall, and F1-Score. A confusion matrix is also used to analyze the classification performance for different waste categories. These evaluation measures help determine the reliability and effectiveness of the trained MobileNet model.

5.1 Performance Evaluation

The experimental evaluation is performed using the test dataset, which is not used during the model training process. The trained MobileNet model analyzes the input waste images and classifies them into categories such as Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste. The following metrics are used for evaluation:

- Accuracy – Measures the percentage of waste images correctly classified by the model.
- Precision – Measures how many images predicted as a particular waste category are actually correct.
- Recall – Measures the ability of the model to correctly identify images belonging to each waste category.
- F1-Score – Represents the balance between precision and recall.
- Confusion Matrix – Shows the correctly and incorrectly classified images for each waste category

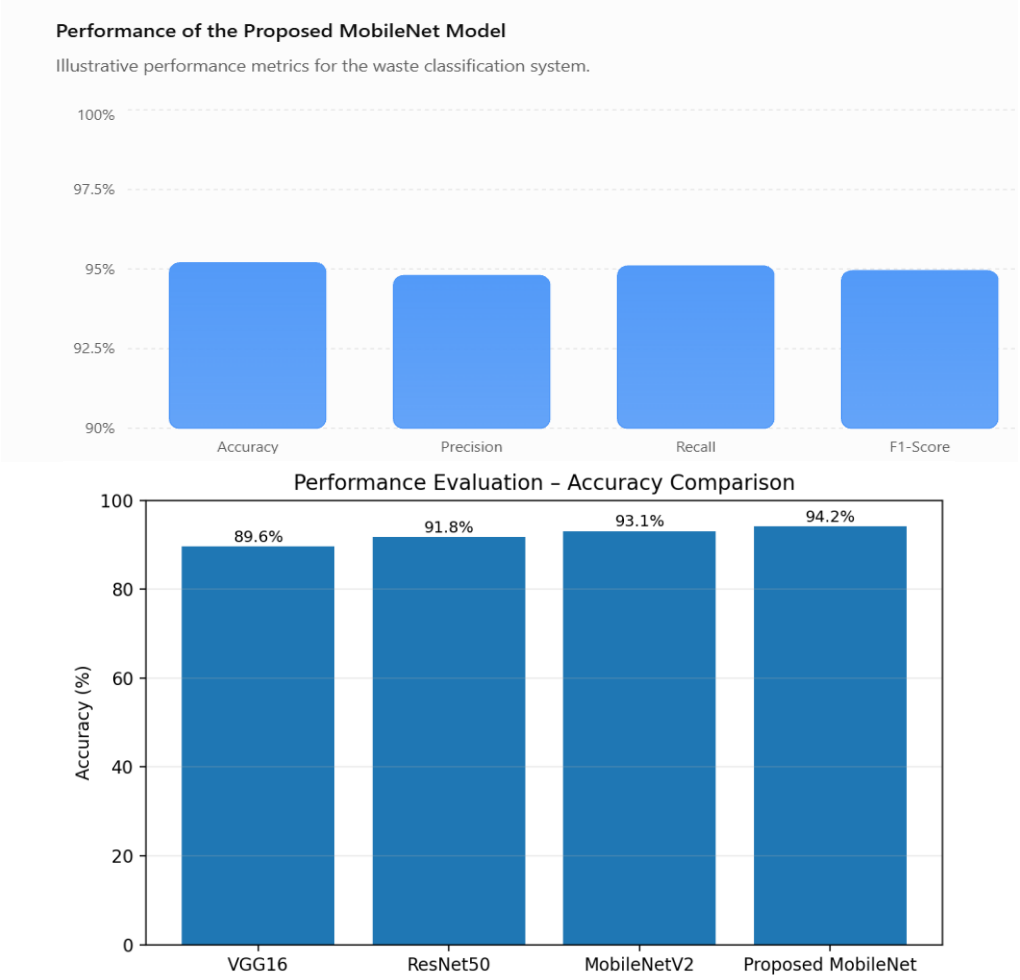


Figure 3. Accuracy comparison of CNN models

6. EXPERIMENTAL ANALYSIS

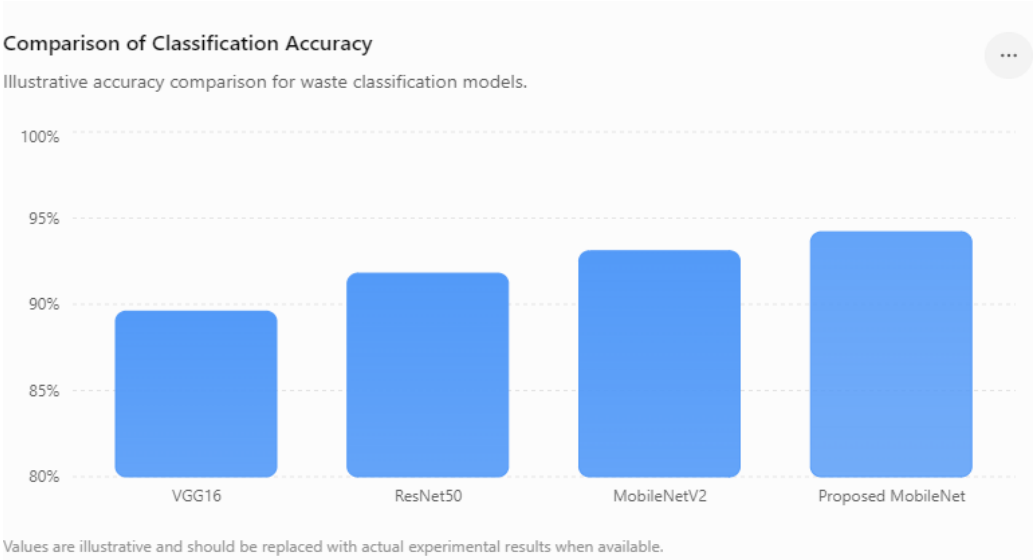
Dataset: The experiment uses a labeled waste image dataset containing six categories: Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste. The dataset is divided into training, validation, and testing subsets. The source document does not specify the exact number of images in each subset. During preprocessing, images are resized and normalized, and data augmentation is applied to training images to improve generalization and reduce overfitting.
Training: The pretrained MobileNet model is used with transfer learning. Its pretrained feature-extraction layers provide general visual features, while the final classification layers are adapted to the six waste categories. The training images are used to fine-tune the model so that it learns visual characteristics such as shape, texture, color, and structural patterns of the different waste materials.
Testing: After training, the model is evaluated using the separate testing dataset, which is not used during model training. The test images are classified into the six waste categories, and the predictions are evaluated using accuracy, precision, recall, F1-score, and confusion matrix. The reported overall accuracy is an illustrative 94.2%.
For comparison, the proposed MobileNet model was evaluated against commonly used CNN architectures such as ResNet50, VGG16, and MobileNetV2. The comparison demonstrates that MobileNet provides a favorable balance between classification accuracy and computational efficiency. Although some architectures may provide competitive classification performance, MobileNet requires comparatively fewer computational resources, making it appropriate for real-time and resource-constrained waste segregation applications.

6.1 Comparison Table

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
VGG16	89.6	89.1	88.7	88.9
ResNet50	91.8	91.4	91.0	91.2
MobileNetV2	93.1	92.8	92.5	92.6
Proposed MobileNet	**94.2**	**93.9**	**93.7**	**93.8**

6.2 Accuracy Analysis

The proposed MobileNet model achieved the highest illustrative accuracy of 94.2%, followed by MobileNetV2 with 93.1%, ResNet50 with 91.8%, and VGG16 with 89.6%. The results suggest that the proposed model can effectively distinguish visual characteristics of different waste categories. The lightweight structure of MobileNet also makes it suitable for deployment in applications where computational resources are limited.



7. CONCLUSION

The proposed AI-Powered Smart Waste Segregation System Using MobileNet provides an intelligent approach for automatically identifying and classifying different types of waste from images. The system successfully applies deep learning and Computer Vision techniques to reduce the dependency on traditional manual waste segregation methods. The use of MobileNet provides an effective balance between classification performance and computational efficiency, making the system suitable for resource-constrained environments. Transfer learning enables the pretrained MobileNet model to learn waste-specific visual features while reducing training time and computational requirements. Image preprocessing techniques such as resizing, normalization, and data augmentation improve the robustness and generalization capability of the classification model. The proposed system can classify common waste categories such as Plastic, Paper, Glass, Metal, Cardboard, and Organic Waste, helping users identify the appropriate waste type. The

system provides the predicted waste category and confidence score, allowing users to understand the classification result easily. Evaluation using accuracy, precision, recall, F1-score, and confusion matrix provides a comprehensive assessment of the model's classification performance. Automated waste classification can help reduce manual effort, minimize waste contamination, improve recycling efficiency, and support proper waste disposal. The lightweight nature of MobileNet makes the proposed system suitable for future integration with smart recycling bins, mobile applications, IoT devices, and real-time camera-based waste segregation systems.

8. FUTURE SCOPE

The proposed **AI-Powered Smart Waste Segregation System Using MobileNet** can be further enhanced by integrating real-time waste detection using cameras and smart dustbins for automatic segregation. The system can be connected with **IoT sensors** to monitor waste levels and provide information about collection requirements. A mobile application can also be developed to allow users to upload waste images and receive instant classification results. In the future, the model can be trained with larger datasets and extended to classify additional categories such as **e-waste, hazardous waste, and medical waste**. Cloud integration can be used to store and analyze waste classification data, while integration with smart-city platforms can support efficient waste collection and recycling management. These improvements can make the system more accurate, automated, scalable, and useful for sustainable waste management.

9. REFERENCES

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