WASTE CLASSIFICATION & IMAGE GENERATION

USING DEEP LEARNING AND COMPUTER VISION MODELS

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INTRODUCTION

Waste management is a major challenge today with large amounts of recyclable materials ending up in landfills. This project uses the TrashNet dataset and applies six AI models to classify waste and support better recycling.

DATASET: TRASHNET

Source: Kaggle – Garbage Classification (TrashNet)

- It contains 2,527 images categorized into 6 classes: cardboard, glass, metal, paper, plastic, and trash.
- Images are collected under different lighting and backgrounds, making the dataset slightly noisy and realistic.
- Widely used for waste classification tasks in computer vision and machine learning research.

MODELS USED

Model 1: Convolutional Neural Network (CNN)

Model 2: ResNet50(transfr learning)

Model 3: YOLOv8 (Object Detection)

Model 4: Generative Adversarial Network (GAN)

Model 5: autoencoder for image denoising

Model 6: multimodal fusion (image+text)

MODEL 1: CONVOLUTIONAL NEURAL NETWORK (CNN)

The Convolutional Neural Network was our first model and it was trained from scratch to classify the six types of waste. It reached an accuracy of about 82 percent which gave us a strong baseline. At the start the model showed signs of overfitting during the early training epochs. To overcome this challenge we applied data augmentation which helped the model generalize better. Overall the CNN gave us reliable results and served as a foundation for comparing the performance of more advanced models.

MODEL 2: RESNET50(TRANSFR LEARNING)

ResNet50 was used with transfer learning to classify waste images and it gave the best results in our project with about 88 percent accuracy. Since it is a large model training was slower and required more resources. To handle this we froze most of the layers and only fine tuned the last 30 layers which balanced performance and efficiency. This approach allowed ResNet50 to outperform the other models and become our strongest classifier.

MODEL 3: YOLOV8 (OBJECT DETECTION)

The YOLO model was applied to detect waste in images and achieved high accuracy for real time classification. It was more complex to train than the classifiers since it required careful annotation and hyperparameter tuning especially with the small dataset. Despite these challenges YOLO proved effective in detecting and localizing waste items which makes it suitable for real world applications such as smart bins and automated sorting systems.

MODEL 4: GENERATIVE ADVERSARIAL NETWORK (GAN)

The GAN model was used to generate synthetic waste images to help balance and expand the dataset. It was able to produce realistic images for classes like plastic paper and glass which supported training other models. At first the outputs were blurry and unstable but after training for more epochs and tuning the parameters the quality improved. The generated images helped reduce overfitting and gave the project a stronger dataset for classification.

MODEL 5: AUTOENCODER FOR IMAGE DENOISING

The autoencoder model was used to clean noisy waste images and improve their quality before classification. It worked by encoding the images into smaller representations and then reconstructing them back with reduced noise. At first the reconstructions were blurry but after adjusting the layers and training longer the results improved. This helped produce clearer images for other models and showed how denoising can support waste classification tasks.

MODEL 6: MULTIMODAL FUSION (IMAGE+TEXT)

The multimodal model combined both images of waste and short text descriptions to improve classification. By fusing visual and textual features the model reached an accuracy of 91.7 percent. One of the main challenges was creating meaningful text inputs and handling the added complexity of combining two data types. Despite this the model proved the value of hybrid AI systems that use more than one source of information to make better predictions.

ETHICAL & SOCIETAL IMPACT

- AI can reduce human exposure to harmful waste.
- Automates tedious sorting jobs safer for workers.
- Helps cities move towards sustainability goals.
- Enables smart bins and AI-powered recycling plants.
- Contributes to UN Sustainable Development Goals (SDGs).

ENVIRONMENTAL BENEFITS

- Reduces landfill waste by improving recycling efficiency.
- Encourages circular economy.
- Cuts CO_2 emissions by reusing materials.
- Example: Separating plastics helps create recycled PET bottles.
- Example: Sorting metals saves energy in production.

REAL-LIFE APPLICATIONS

- Smart Cities: AI-powered public bins.
- Recycling Plants: Faster, automated sorting.
- Mobile Apps: Scan waste items to classify.
- Manufacturing: Sort production waste efficiently
- Education: Raise awareness through interactive AI apps.

CONCLUSION

This project tested different AI models for waste classification including CNN ResNet GAN YOLO Autoencoder and a Multimodal model. The results showed AI can classify waste effectively and support recycling centers smart bins and municipal waste systems helping reduce landfill waste and promote sustainability.

THANK YOU