CleanTech: Transforming Waste Management with Transfer Learning

Abstract

The CleanTech project leverages deep learning and transfer learning to automate and improve waste classification using image data. Utilising a pre-trained CNN model, the system classifies waste into six primary categories and intelligently categorises them into three major segments: Recyclable, Biodegradable, and Trash. A Flask-based web application enables users to upload waste images and receive real-time predictions, supporting eco-friendly disposal behaviour and waste segregation.

Objective

- Automate the classification of waste into actionable categories.

- Improve accuracy using transfer learning on a pre-trained model.

- Correct frequent misclassifications using logic overrides.

- Build an intuitive web interface for public and institutional use.

Methodology

Transfer Learning

We use a pre-trained Convolutional Neural Network (CNN) model (such as MobileNet or ResNet) fine-tuned on a waste classification dataset comprising six classes: Plastic, Metal, Paper, Cardboard, Glass, and Trash.

Image Preprocessing

- Convert image to RGB.

- Resize to 150x150 pixels.

- Normalise pixel values to [0,1].

- Reshape to (1, 150, 150, 3) for model input.

Model Prediction & Post-Processing

- Predict the waste class from the image.

- Override frequent misclassifications: Metal → Plastic, Paper → Glass.

- Map final class into: Recyclable (Plastic, Metal, Glass), Biodegradable (Paper, Cardboard), Trash (Trash).

Team Members

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Tech Stack

- Python (Flask framework)

- TensorFlow / Keras (for model training and inference)

- Pillow (for image handling)

- NumPy

- HTML/CSS/JS (for front-end rendering)

Project Architecture

```
CleanTech/
├── model/
│   └── trash_classification_model.h5
├── static/
│   └── uploads/ (for user-uploaded images)
├── templates/
│   ├── index.html
│   ├── technology.html
│   ├── benefits.html
│   ├── contact.html
│   └── result.html
├── app.py (Flask app)
└── README.md
```

Web Application Features

1. Upload Interface: Users upload an image of waste.

2. Backend Inference: Flask backend preprocesses the image and runs inference.

3. Correction & Mapping: Adjusts prediction using logical overrides and maps to a 3-class category.

4. Result Display: Shows the user the predicted category, original label, confidence score, and image.

Sample Result Display (from Flask)

Prediction: Recyclable
Raw Label: Plastic
Confidence: 93.76%
Image: /uploads/abc123.jpg

Benefits

- Promotes eco-friendly waste segregation at the source.

- Reduces human error in manual sorting.

- Enables smart city solutions with IoT integration.

- Supports educational awareness through technology.

Limitations

- Accuracy may vary under poor lighting or unclear images.

- Real-time deployment on mobile devices may require optimisation.

- Limited to six predefined waste classes.

Future Enhancements

- Add support for multi-label classification (for mixed waste).

- Integrate location tracking for smart bins.

- Use YOLO/SSD for real-time object detection.

- Extend the dataset to support more granular waste types (e.g., organic vs cooked food).

Conclusion

CleanTech bridges the gap between deep learning and sustainable waste management. By using transfer learning and a clean UI, this system enables quick and reliable waste classification that can significantly enhance recycling efforts, reduce landfill overload, and promote a greener future.

GitHub link

https://github.com/ganithaavula0405/cleantech-transforming-waste-management-with-transfer-learning