Project Title: Municipal Waste Classification Using Deep Learning

---

Student Name :- P. Sri Soumya

College Name :- Aditya College Of Engineering And Technology

INTRODUCTION:

1.1 Project Overview

Municipal waste management is a crucial component of urban sustainability and environmental health. Rapid urbanization and increased consumption have led to a surge in waste generation. Traditional waste classification methods involve manual labour, which is time-consuming, error-prone, and costly.

The project "Municipal Waste Classification using Deep Learning" aims to automate waste classification using advanced AI technologies. Leveraging transfer learning with a pre-trained VGG16 model, this system can identify and categorize waste images into classes such as Recyclable, Biodegradable, and Trash, contributing to a cleaner and greener environment.

1.2 Purpose

The primary purpose of this project is to provide an intelligent system that automatically classifies waste images uploaded by users. This reduces manual sorting efforts, improves accuracy, and promotes responsible waste disposal practices among citizens and municipal corporations.

---

2. IDEATION PHASE

1.Problem statement:

Waste management is a growing concern in urban and rural areas, where the classification and disposal of waste are often inefficient, leading to environmental pollution, health hazards, and increased operational costs. Traditional waste sorting methods are manual, time-consuming, and error-prone.

There is a need for a smart, automated system that can classify different types of waste (organic, plastic, metal, paper, etc.) accurately to enable efficient recycling, composting, or disposal.

2.Proposed Solution:

- Use image classification to automatically detect and classify waste as recyclable or non-recyclable.
- Train a machine learning model using a labeled dataset from Kaggle containing various waste categories.
- Preprocess the dataset with resizing, normalization, and data splitting to improve model accuracy and reduce noise.
- upload images of waste
- Get instant classification results (Recyclable / Non-Recyclable)

2.3 Brainstorming

Several ideas were discussed:

- A mobile application with real-time scanning.
- Smart bins with in-built sensors and sorting mechanisms.
- QR code-based waste categorization.

The chosen solution was a web-based AI-powered image classifier for its accessibility and ease of integration.

---

3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map

1. User visits web application.
2. Uploads an image of waste.
3. The system processes the image using a deep learning model.
4. Displays result on the webpage instantly (Recyclable, Biodegradable, or Trash).
5. User can then dispose of the waste accordingly.

3.2 Solution Requirements

Functional Requirements:

- Upload feature for waste images.
- Automated classification and instant feedback.
- User-friendly interface with clear messaging.

Technical Requirements:

- Python and Flask for backend and APIs.
- TensorFlow and Keras for the machine learning model.
- HTML, CSS, and Bootstrap for frontend design.
- OpenCV for image preprocessing.

- Google Colab for model training.
- Kaggle for accessing and exploring the dataset

To run the application:

Anaconda command prompt

3.3 System Architecture Diagram:

[User (Web Browser)]

|

| Uploads Image

↓

[Frontend Webpage (HTML)]

|

| Sends image

↓

[Backend Server (Flask)]

|

| Feeds image into

↓

[Trained ML Model]

|

| Prediction result

↓

[Backend Server]

|

| Sends result

↓

[Frontend Webpage]

|

| Displays:

↓

[♻ Recyclable / Trash/Bio degradable]

User Flow:

- User Opens Webpage
- User Uploads Waste Image
- Image Sent to Backend
- ML Model Processes Image
- Prediction Returned
- Result Displayed on Webpage

---

4. PROJECT DESIGN

4.1 Problem Solution Fit

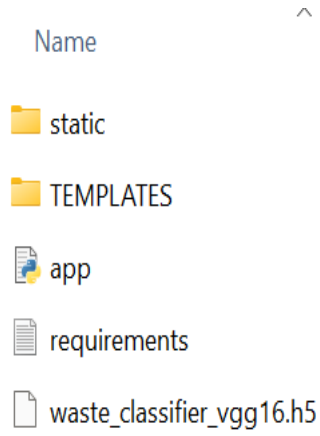
By automating waste classification, this system addresses human error and inefficiency in manual segregation. It helps citizens, industries, and municipalities ensure proper disposal, supporting a circular economy.

4.2 Proposed Solution

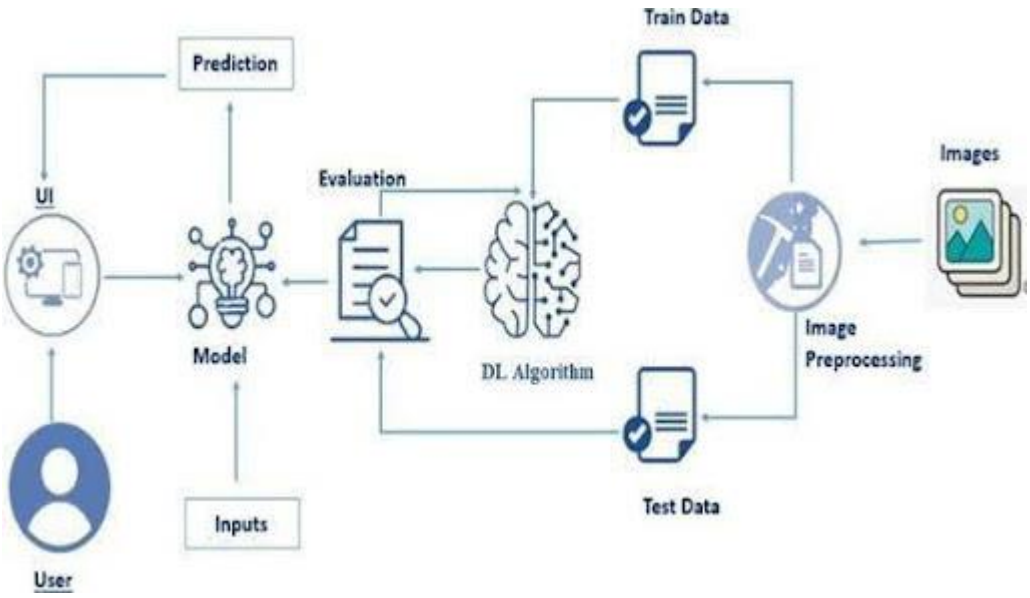
A web-based platform where users upload waste images. The backend, powered by a VGG16-based CNN model, processes and classifies the image. Results are displayed in seconds, encouraging correct segregation.

4.3 Solution Architecture

File Structure



ER Diagram



---

5. PROJECT PLANNING & SCHEDULING

The project was organized into a 10-day agile sprint:

- **Day 1:** Problem analysis & team role assignment.
- **Day 2:** Dataset collection & exploration (Kaggle).
- **Day 3:** Preprocessing & data augmentation.
- **Day 4–5:** Model training & fine-tuning using transfer learning on Colab.
- **Day 6:** Frontend design (HTML, CSS, Bootstrap).
- **Day 7:** Flask backend & model integration.
- **Day 8:** End-to-end testing & bug fixes.
- **Day 9:** Screenshot capturing, documentation
- **Day 10:** Final report compilation & demo video recording.

---

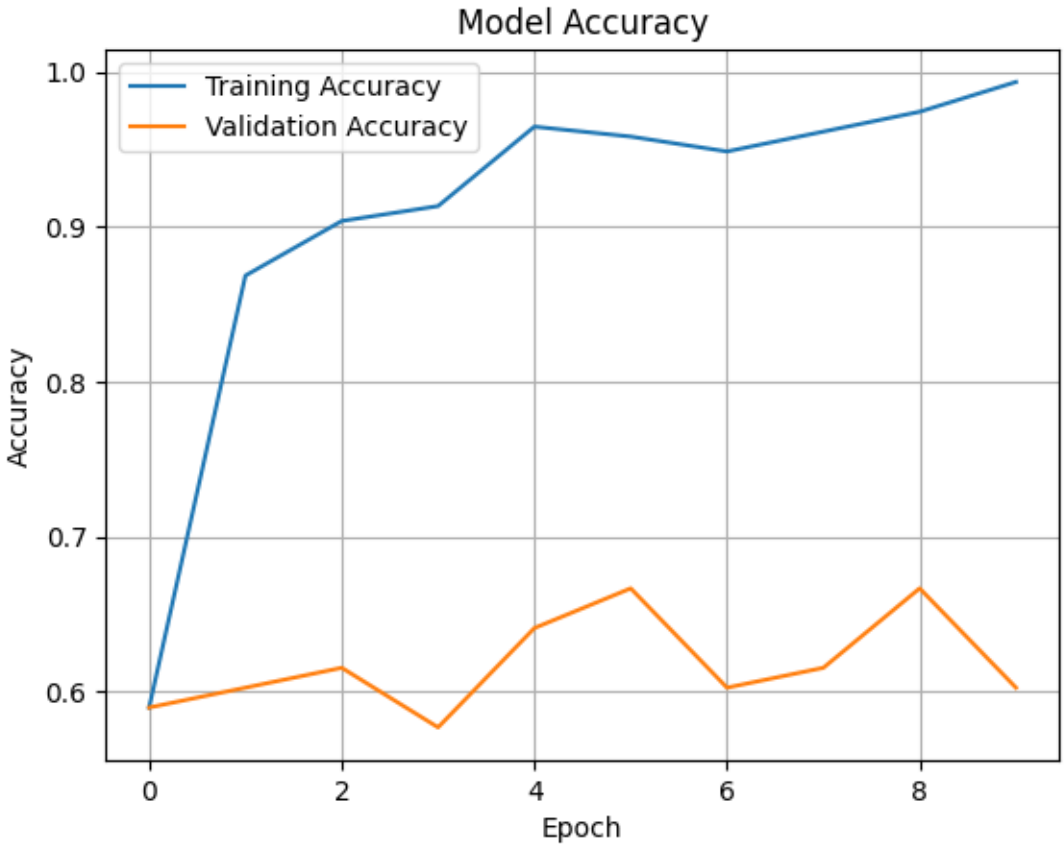
6. FUNCTIONAL AND PERFORMANCE TESTING

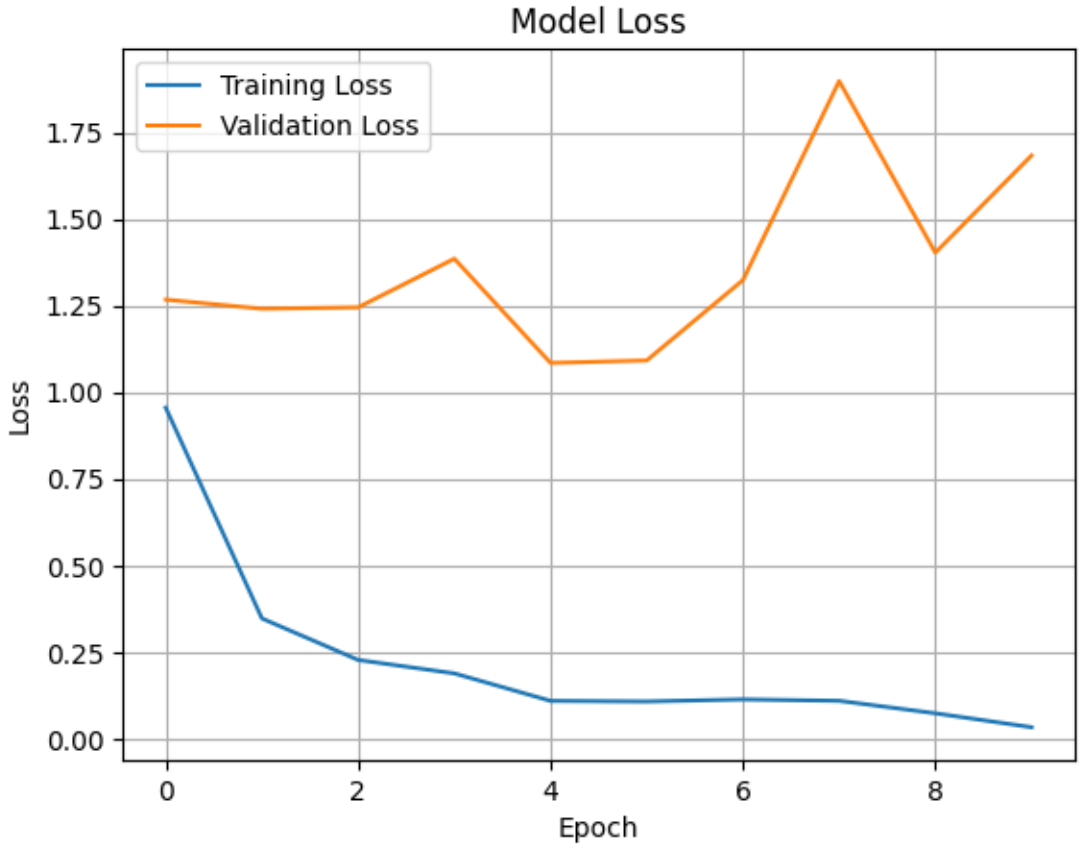
The system was tested with multiple images across different categories (Biodegradable, Recyclable, Trash). Predictions were validated against manual classification.

Average response time: 0.7 seconds.

High accuracy due to transfer learning approach.

Tested on various browsers and devices for responsiveness.


Model Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
1.0
0.9
0.8
0.7
0.6
0
2
4
6
8

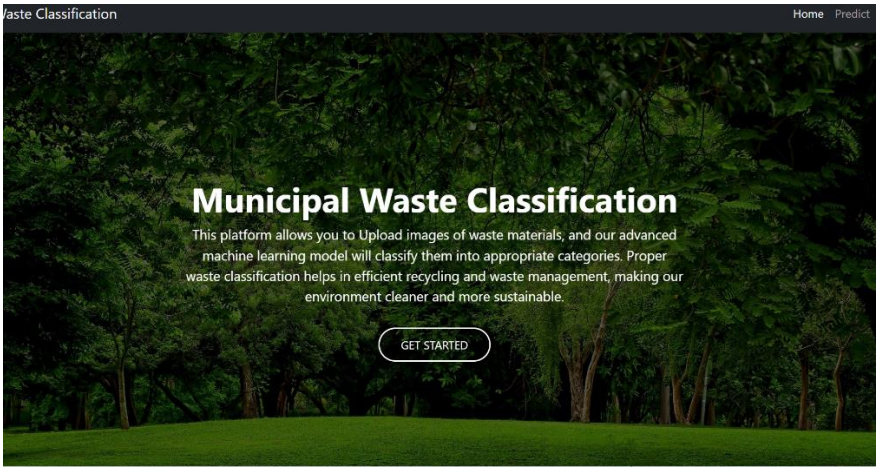

Model Loss
Training Loss
Validation Loss
Loss
Epoch
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
2
4
6
8

7. RESULTS

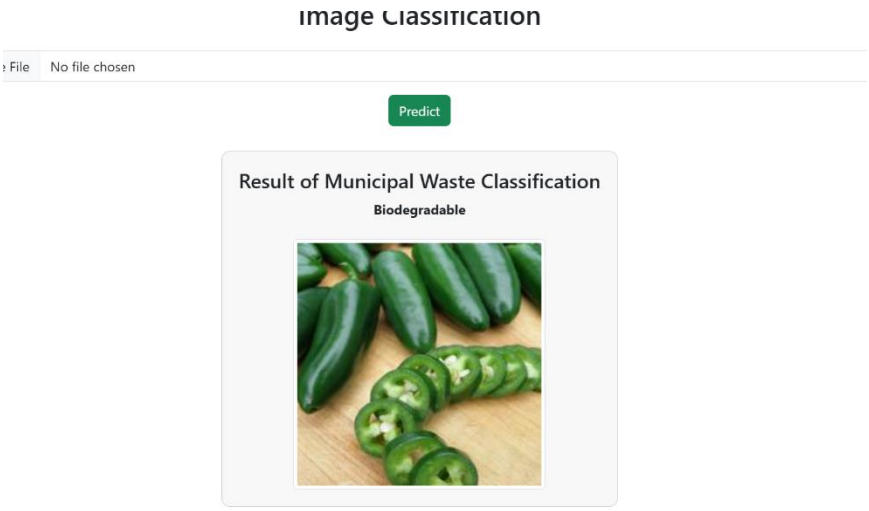
7.1 Output Screenshots

Insert your uploaded UI screenshots here

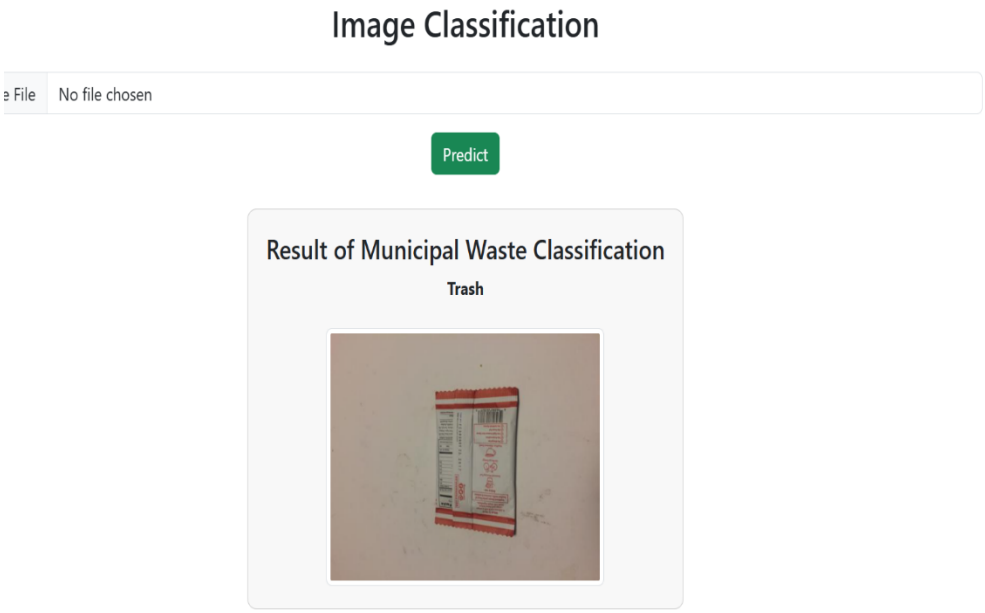
- Homepage (Municipal Waste Classification)



- Biodegradable classification example



- Trash classification example



- Recyclable classification example

---

8. ADVANTAGES & DISADVANTAGES

Advantages:

- Reduces manual sorting time.

- Enhances accuracy in waste segregation.
- Supports environmental sustainability goals.
- Easy to use and visually intuitive.

Disadvantages:

- Model performance depends on dataset quality.
- Difficult to handle highly mixed waste images.
- Periodic retraining required for new categories.

---

9. CONCLUSION

The Municipal Waste Classification system effectively demonstrates the integration of AI for automating environmental sustainability tasks. The project reduces manual labor, improves accuracy, and promotes responsible waste disposal, contributing to smarter and greener cities.

By leveraging transfer learning and deep learning models, this system sets a benchmark for intelligent waste management solutions. The web-based design ensures accessibility to a wide audience, encouraging community participation in sustainable practices.

Moreover, the project highlights the potential of AI in solving real-world environmental challenges and paves the way for future innovations in smart waste management systems. Overall, it represents a significant step toward creating cleaner, healthier, and more efficient urban ecosystems.

---

10. FUTURE SCOPE

- Add new categories like e-waste, metal, glass, and hazardous waste.
- Integrate real-time camera feed with smart bins.
- Extend as a mobile app for live classification.
- Link with municipal data dashboards for large-scale analytics.

---

11. APPENDIX

- **Dataset:** [https://www.kaggle.com/datasets/elinachen717/municipal-solid-waste-dataset].
- **Demo Video:** uploaded in git hub.
- **Link:** http://127.0.0.1:5000