WEEK 4: MODEL BUILDING AND DEEP LEARNING

DAY 20 (18/07/2025)

PROJECT: AI-Powered Waste Classification and Recycling Suggestions

I worked extensively on my **waste classification project**, applying everything I've learned about Deep Learning, CNNs, and Transfer Learning to create a practical AI system that can classify and suggest proper disposal for different types of waste.

1. Project Objective

- Build an AI model to classify waste images into:
    1. Biodegradable vs Non-Biodegradable
    2. Specific waste types: **plastic, metal, paper, cardboard, biological, glass (green, brown, white), clothes, shoes, batteries, trash**
- Provide **reusability, recyclability, and disposal guidance** for each waste type.

2. Dataset and Preprocessing

- Used the **Garbage Classification Dataset** from Kaggle, consisting of 15,150 images across 12 classes.
- Preprocessing steps:
    - Resize images to **224×224 pixels** for EfficientNetB0 input.
    - Normalize pixel values to **[0, 1]** for better training.

    - Data augmentation: rotation, zoom, horizontal flips, width/height shifts.

- Created **binary labels** mapping classes to biodegradable or non-biodegradable categories.

- Split data into **training (80%)** and **validation (20%)** sets.

- Computed **class weights** to handle imbalance.

3. Model Architectures

A. Custom CNN Model:

- Three convolutional layers (32, 64, 128 filters) + MaxPooling.

- Flatten → Dense layer (256 units) → Dropout → Softmax (12 classes).

- Achieved **76.55% accuracy**.

B. EfficientNetB0 (Transfer Learning):

- Pre-trained EfficientNetB0 as base (trainable for fine-tuning).

- Global Average Pooling → Dense (256 units, ReLU) → Dropout layers (0.4 & 0.3) → Softmax (12 classes).

- Trained with categorical cross-entropy loss and Adam optimizer.

- Achieved **92.97% accuracy**, outperforming the custom CNN by a large margin.

Why Transfer Learning worked better:

- EfficientNetB0 already extracts **high-level features** from images.

- Fine-tuning on the waste dataset allowed it to adapt to new classes without needing millions of images.

4. Training and Evaluation

- Trained the EfficientNetB0 for **30 epochs** with early stopping and learning rate reduction.

- Visualized accuracy and loss curves: smooth convergence, low overfitting.

- Validation performance:

    - Accuracy: 92.97%

    - Precision, Recall, F1-score: 0.93 each

5. Prediction and Guidance System

- Input: single image → Output:

    - Waste type

    - Binary label (bio/non-bio)

    - Confidence score

    - Reusability, recyclability, disposal method

6. Tools and Libraries Used

- **Python**: core programming language
- **TensorFlow/Keras**: model building and training
- **EfficientNetB0**: transfer learning for feature extraction
- **Matplotlib**: visualization of training history
- **Scikit-learn**: class weights, evaluation metrics
- **Pandas and NumPy**: data handling

Reflection:

I successfully implemented an AI-based waste classification system using EfficientNetB0, achieving **92.97% accuracy**. The model not only classifies waste but also provides **recycling and disposal guidance**, making it highly practical for real-world waste management.