Smart Trash Sorter

ITAI 1378 Final Project

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Tier 2 Project Model: MobileNetV3 + Custom Fine-Tuning

The Recycling Dilemma: Misclassification

The Problem: People frequently misclassify recyclable items due to the inherent difficulty in distinguishing between various materials such as glass, plastic, and cardboard. This confusion leads to significant inefficiencies in waste management.

Why It Matters: Improper sorting directly contributes to increased landfill waste, escalates processing costs for recycling facilities, and ultimately diminishes the overall effectiveness of recycling programs.

Who Benefits: Households, educational institutions, local communities, and waste management facilities all stand to gain from improved recycling accuracy.

Our Vision: A Smart Recycling Assistant

Image-Based Input

Accepts a photo of any item for classification.

Six Categories

Classifies items into one of six distinct recycling categories.

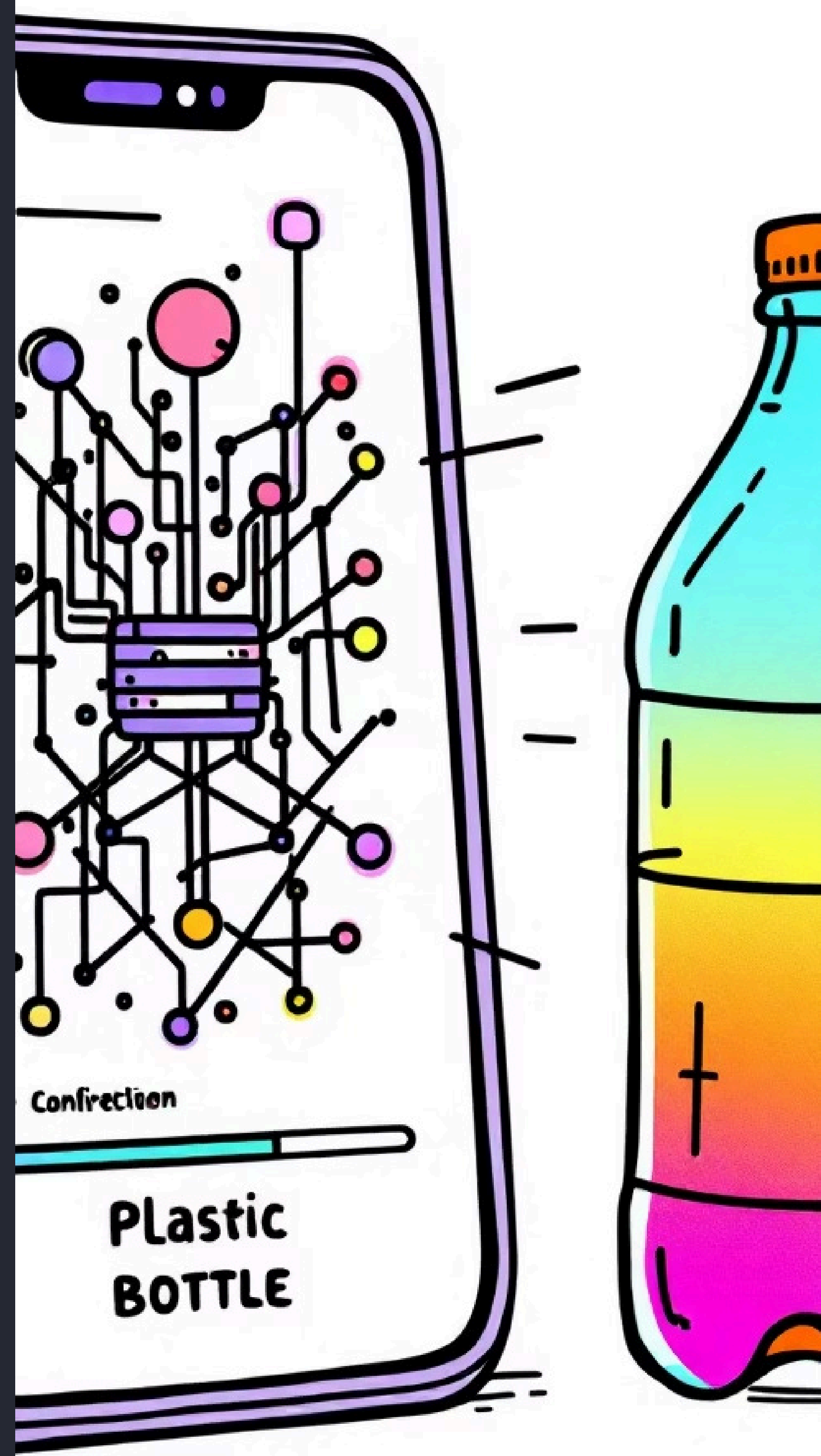
Confidence Scores

Provides clear probability scores for each classification.

MobileNetV3 Powered

Ensures rapid and efficient processing for quick results.

Goal: Demonstrate a working prototype focused on robust Glass Jar and Plastic Bottle classification.



Dataset Foundation: Waste Classification

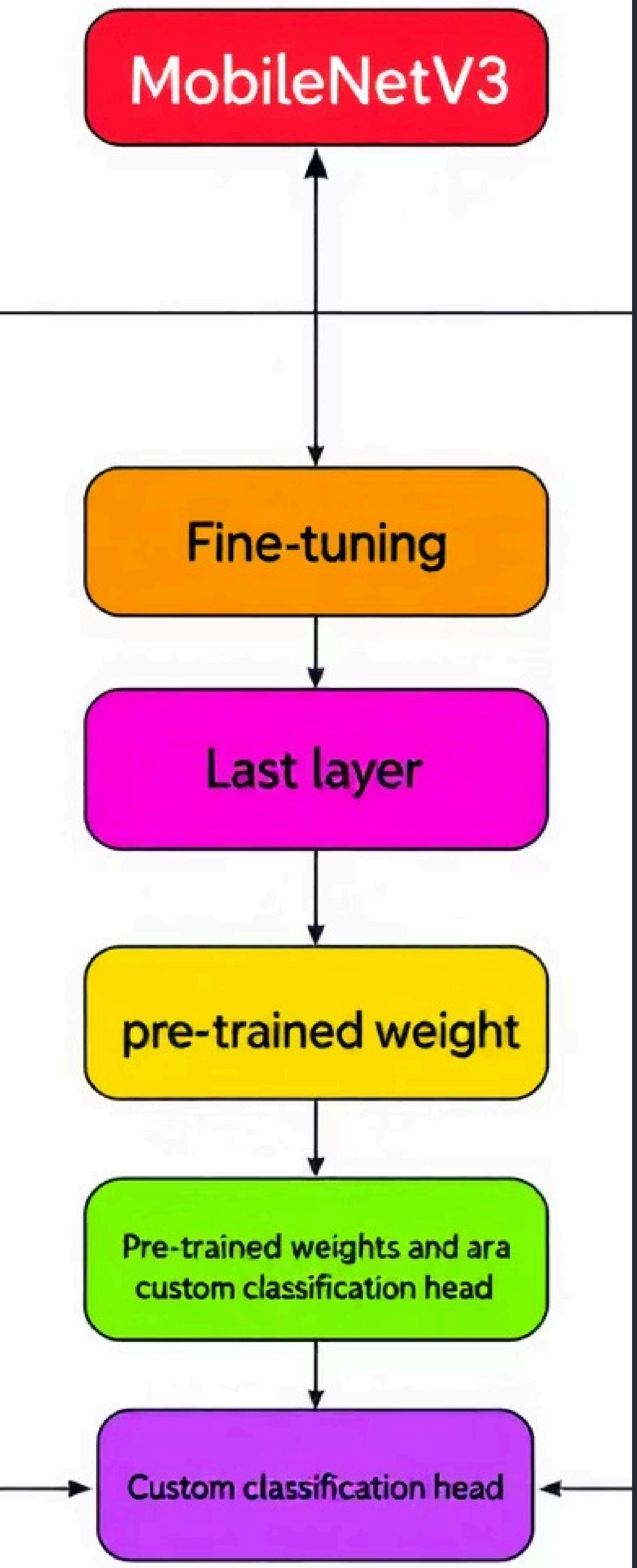
- Dataset: Waste Computer Vision Model by IPCVHome
- Source: Roboflow
- **Link to Dataset**

Total Images: 1160

Classes (6):

- CardboardBoxes
- GlassBottles
- GlassJars
- Laptops
- Phones
- PlasticBottles

The dataset was pre-split 80/20 for training and validation, and included built-in augmentation for enhanced model generalization.



Technical Deep Dive: Model Architecture

Image Classification

Core task of the model.

MobileNetV3Small

Lightweight model, pre-trained on ImageNet.

Fine-Tuning

Unfrozen last layers for domain-specific learning.

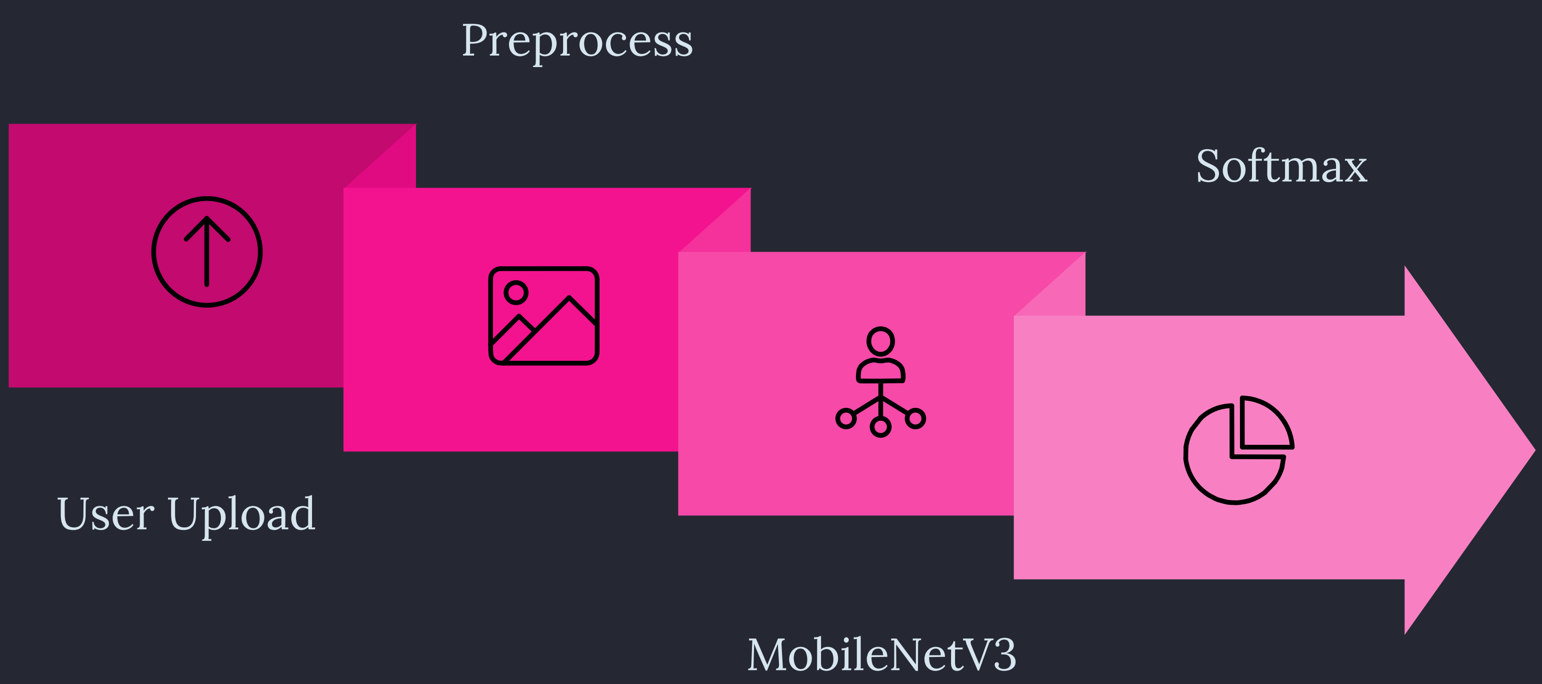
TensorFlow/Keras

Primary development framework.

Preprocessing Steps:

- Resize to 224x224: Standard input size for MobileNetV3.
- Normalize [0,1]: Scales pixel values for optimal model performance.
- Augmentation: Applied rotations, zooms, shears, brightness adjustments, and flips to enhance dataset diversity and model robustness.

System Architecture: From Photo to Prediction



This pipeline ensures a seamless process from image capture to an informed recycling decision, providing users with clear feedback.

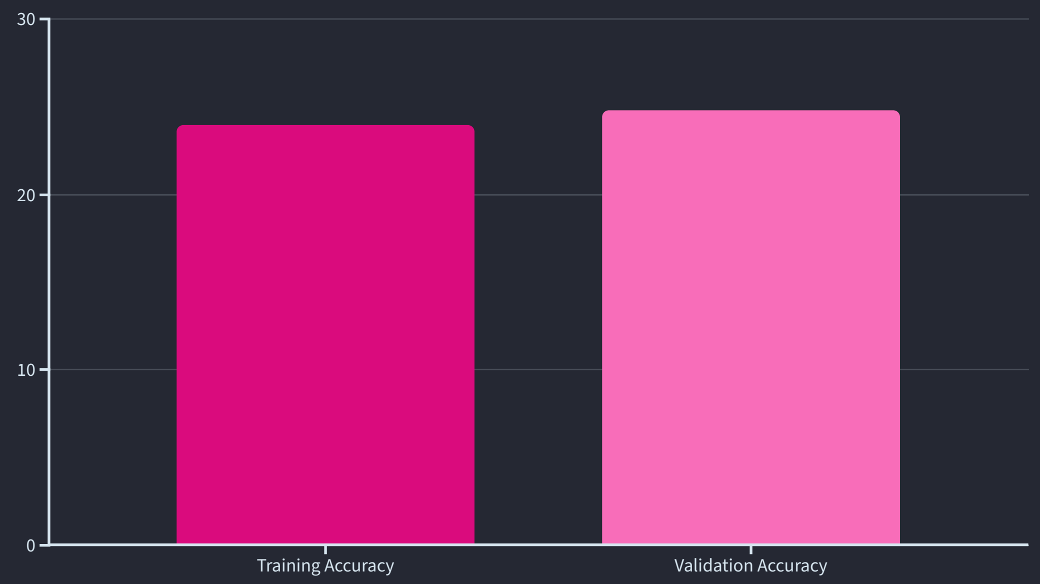
Model Performance: Initial Observations

Final Training Accuracy: 23.96%

Final Validation Accuracy: 24.82%

> Observations: Both training and validation accuracies remained low, indicating a clear case of underfitting.

Despite the low overall accuracy, the model demonstrated stable confidence trends specifically for **GlassJars** and **PlasticBottles**. This consistency allows for a focused demonstration on these categories.



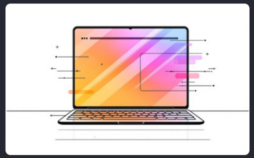
Demo Results: Strengths & Limitations

Successful Example: Glass Jar

The model confidently and accurately classified a typical glass jar, demonstrating its capability where visual features are distinct.

Second Example: Plastic Bottle

Plastic bottle images often yielded a strong primary prediction, sometimes with glass bottles as a close second, highlighting subtle ambiguities.



Failure Case: Reflective Surfaces

A laptop with a significant reflection was misclassified as a glass jar, illustrating a key limitation with reflective materials.

Challenges & Future Improvements

Key Challenges Encountered:

- **Dataset Imbalance:** Uneven distribution of images across categories skewed model learning.
- **Visual Ambiguity:** Certain items, like different types of bottles, share visually similar characteristics.
- **Limited Training Variation:** Insufficient diversity in image angles, lighting, and backgrounds led to underfitting.

Strategic Improvements:

Balance Dataset

Collect more diverse and balanced images per class.

Add "Unknown" Class

For items that don't fit existing categories or have low confidence.

Object Detection

Transition from classification to more precise object detection.

TensorFlow Lite

Convert model for mobile application deployment.

AI's Role & Project Conclusion

AI Usage Summary: AI tools were instrumental throughout this project, facilitating the resolution of technical errors, guiding the selection of appropriate datasets, refining model architecture, aiding in result interpretation, and proposing key improvements for future iterations.

> Conclusion: The Smart Recycling Classifier successfully demonstrates a functional computer vision pipeline. It provides a robust foundation for developing a more accurate and practical real-world recycling assistance system, addressing a critical environmental need.