SMALL MODULAR GARBAGE SORTER

- An Automated System for Detecting and Sorting General Waste Using Webcam-Based Machine Vision

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Group 16

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Problem Statement

Global waste management crisis: Over 2 billion tons of municipal solid waste generated annually, with only 13% recycled [1]

Manual sorting is inefficient, labor-intensive, and error-prone, leading to contamination in recycling streams.

Focus on common recyclables: Cardboard (paper-based), plastic (polymers), glass, and metal (ferrous/non-ferrous)

Challenge: Need for affordable, modular systems for small-scale use (e.g., homes, small businesses) to promote sustainable practices.

Project idea

- Primary: Develop a real-time detection system using a webcam for demonstration to identify glass, paper, cardboard, plastic and metal.
- Secondary: Create a modular sorter concept for the presentation, integrating machine vision with simple mechanics (e.g., conveyor or actuators).
- Goal: Achieve >75% accuracy in material classification; Ensure system is low-cost and scalable; Demonstrate environmental impact through waste diversion metrics.
- Scope: Focus on visual detection via video feed; Future extensions could include robotic sorting arms.

Background

- Historical context: Traditional sorting relies on human labor or large industrial machines (e.g., optical sorters in recycling plants).
- Environmental impact: Improper sorting leads to landfill overflow and pollution; Recycling reduces CO2 emissions (e.g., 1 ton of recycled plastic saves ~1.5 tons of CO2).
- Technological gap: Small-scale solutions are rare; Existing systems like AI-powered bins are expensive and non-modular.

Theory – Machine vision fundamentals

- Machine vision uses cameras and algorithms to interpret visual data.
- Key concepts: Image acquisition (webcam feed), preprocessing (noise reduction, edge detection, background removal), feature extraction (color, texture, shape), and classification.
- Theoretical basis: Based on digital image processing (e.g., Fourier transforms for frequency analysis) and pattern recognition theories from AI pioneers like Rosenblatt (perceptrons).
- For materials: Cardboard (textured, matte), plastic (shiny, translucent), metal (reflective, rigid) differ in visual properties like reflectivity and edge sharpness.

Theory - Machine Learning Models for Detection

- Supervised learning: Use pre-trained models (e.g., CNNs like ResNet or YOLO) fine-tuned on datasets such as TrashNet or TACO for object detection and classification.
- Background: Convolutional Neural Networks (CNNs) mimic human visual cortex; Layers extract hierarchical features (low-level: edges; high-level: objects).
- Metrics: Precision, recall, F1-score; Overfitting addressed via data augmentation (rotations, flips).

Proposed System Architecture

- High-level overview: Webcam → Video Capture → Processing Pipeline → Output (Detection Labels + Sorting Signal).
- Components:
  - *Hardware: Standard webcam, Raspberry Pi or PC for processing.*
  - *Software: OpenCV for video handling, TensorFlow/PyTorch for models.*
  - *Dataset: Garbage Image Dataset (Kaggle)*

Problem solution proposal

- Webcam integration: Use libraries like OpenCV to stream live video at 10 FPS.
- Preprocessing steps: Edge detection, noise reduction, gray scale.
- Theory: Based on signal processing; Preprocessing reduces variance in input data, improving model robustness (e.g., Canny edge detection for outlines).

Implementation plan

Week #	Planned tasks description
38	Determine project topic and content
39	Plan software architecture
40	Pre-processing and edge detection development
41	Train and optimize model
42	Deploy to edge device
43	Optimization
44	Write report
45	Write report
46	Prepare presentation
47	Demonstration

References

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