PET-PERPLEXITY

Intelligent Waste Sorting Pipeline

Automating Circular Economy with Hybrid Computer Vision

Sustainability | AI-Powered | Real-Time Analytics

THE PROBLEM STATEMENT

Sorting is the Bottleneck

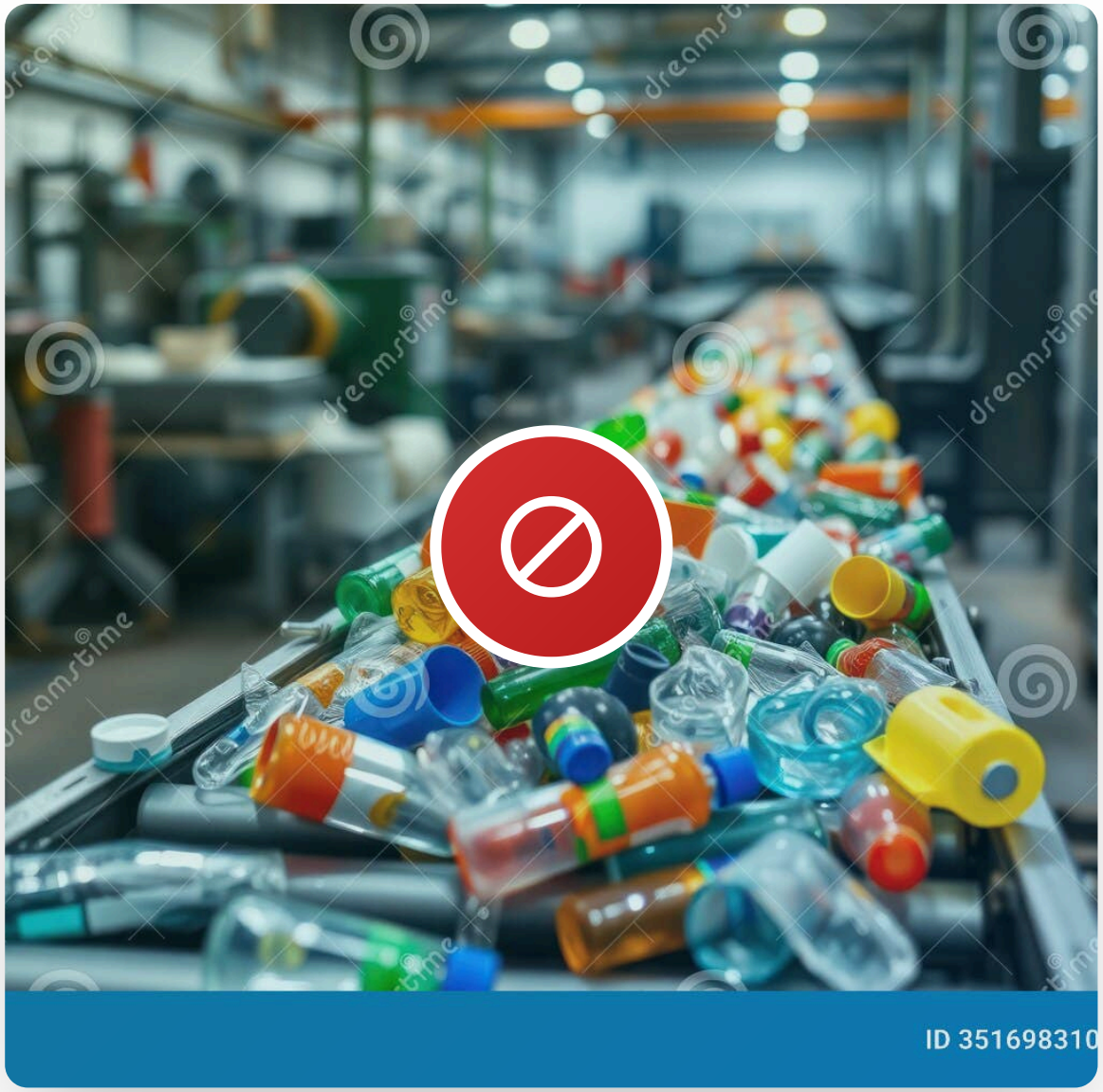
Plastic pollution is a global crisis, but efficient sorting remains the critical barrier to circular economy adoption.

Slow
Manual processing takes hours

Error-Prone
Human mistakes common

Hazardous
Exposure to chemicals

Current solutions struggle to distinguish Clear PET vs. Clear Glass



CORE SOLUTION IDEA

End-to-End Computer Vision API

Real-time detection, classification, and characterization of waste materials

CAMERA INPUT

Real-time visual feed from conveyor system

AI PROCESSING HUB

Hybrid intelligence engine

GRANULAR DATA JSON

Structured output for real-time analytics

BEYOND SIMPLE DETECTION

- Material
- Brand
- Color
- Size
- Weight

TECHNICAL ARCHITECTURE

The Hybrid Intelligence Pipeline

Four-stage process combining deep learning with rule-based logic

1 YOLOv8-Seg

Instance Segmentation

Isolates individual bottles from the conveyor feed through precise mask generation

2 EfficientNet-B0

Material Classification

4-Class Custom Model distinguishing: PET, Glass, Metal, HDPE

PET · Glass · Metal · HDPE

3 Heuristic Engine

Color Detection

OpenCV HSV analysis for "gap-free" color recognition beyond RGB limitations

4 Physics Engine

Weight Estimation

Volume × Material Density calculation for accurate mass determination

Image Input → Multi-Model Inference → Final JSON Output

KEY INNOVATION POINTS (USP)

Standard AI vs. PET-Perplexity

Superior accuracy in weight and material differentiation

Standard AI

Detects: "Bottle"

Simple detection only
No material differentiation
No weight estimation

PET-Perplexity

Detects: "500ml Clear PET Bisleri Bottle (18g)"

Granular analysis
Material classification
Accurate weight estimation

Hybrid Intelligence

Combining Deep Learning with Rule-Based Logic eliminates common AI hallucinations

Density-Aware Weighting

Volume × Material Density calculation distinguishes same-sized materials accurately

Test-Time Augmentation

Robustness against varying camera angles and lighting conditions

Superior Accuracy in Weight & Material Differentiation

Enabling precise waste management and EPR tracking

SALIENT FEATURES

Real-Time Analytics Dashboard

Instant waste composition tracking

Granular Brand ID

Identifies specific brands (Bisleri, Coke, etc.) for EPR (Extended Producer Responsibility) tracking

Transparency Detection

Distinguishes between High-Value Clear PET and colored plastics for premium recycling streams

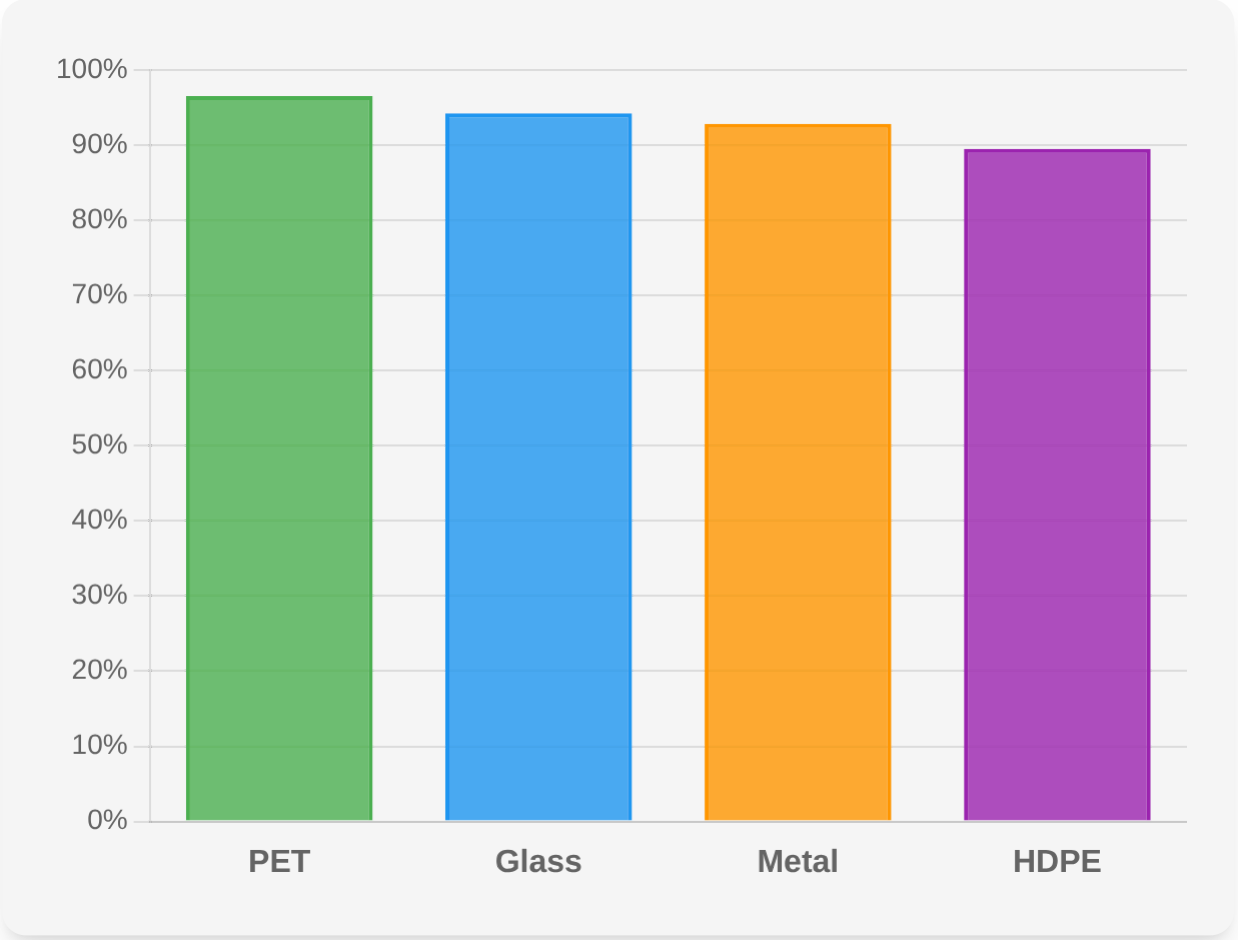
Real-Time Analytics

Sub-second inference time suitable for high-speed conveyor belts and industrial applications

PERFORMANCE & VALIDATION

Confidence Scores by Material

High accuracy across all waste categories



PET vs. Non-PET Distinction

Excellent accuracy in differentiating PET bottles from other materials including clear glass

Handles "Hard Negatives"

Successfully identifies shiny metal cans that appear similar to clear bottles in color

Consistent Performance

Maintains high accuracy across varying lighting conditions and camera angles

LIMITATIONS & SCOPE FOR IMPROVEMENT

Current Limitations

Areas requiring enhancement

Extreme Lighting Changes

Affects color heuristics in HSV space, requiring adaptive thresholding

Crushed/Deformed Logos

Brand identification struggles with heavily damaged or compressed containers

Future Roadmap

Planned enhancements and integration

LiDAR Integration

Depth cameras for exact volume measurement and 3D reconstruction

Robotic Arm Integration

Physical sorting system connected to classification results

Enhanced Deep Learning

Larger datasets and transformer architectures for improved accuracy

REAL-WORLD IMPACT

Enabling Circular Economy

Sustainable waste management ecosystem

Gold Level Recycling Standards

Enables premium recycling facilities to meet stringent quality requirements for high-value recycled materials

Brand-Specific Waste Audits

Empowers governments to enforce Extended Producer Responsibility (EPR) compliance through accurate waste tracking

Enhanced Market Value

Reduces contamination in recycling streams, significantly increasing the market value of recycled plastic bales

PET-PERPLEXITY isn't just a classifier;

it's the digital infrastructure for a cleaner planet.

Team Members

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