



# WASTEWIZARD

Efficient Waste Sorting through Computer Vision

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# MEET OUR TEAM



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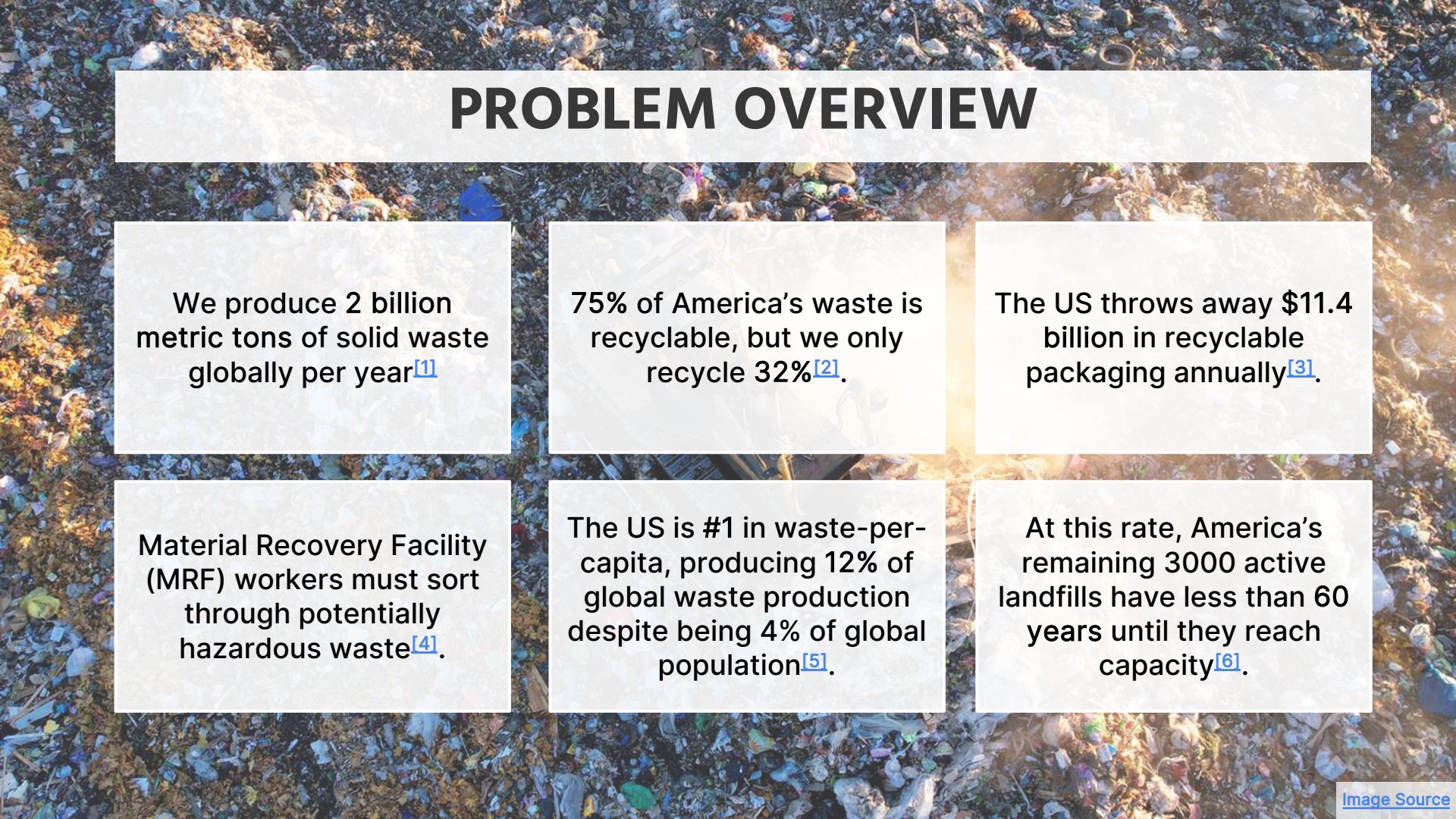
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# PROBLEM OVERVIEW

We produce 2 billion metric tons of solid waste globally per year<sup>[1]</sup>

75% of America's waste is recyclable, but we only recycle 32%<sup>[2]</sup>.

The US throws away \$11.4 billion in recyclable packaging annually<sup>[3]</sup>.

Material Recovery Facility (MRF) workers must sort through potentially hazardous waste<sup>[4]</sup>.

The US is #1 in waste-per-capita, producing 12% of global waste production despite being 4% of global population<sup>[5]</sup>.

At this rate, America's remaining 3000 active landfills have less than 60 years until they reach capacity<sup>[6]</sup>.

# OUR SOLUTION

Waste sorting is a crucial process in recycling to differentiate trash, recyclables, and toxic waste which end up in landfills, recycling centers, and trash incinerators.

WasteWizard makes waste sorting easier and more accessible, addressing these problems at the source.



# TARGET USERS

## Households (Primary Users)

US households with internet access + camera

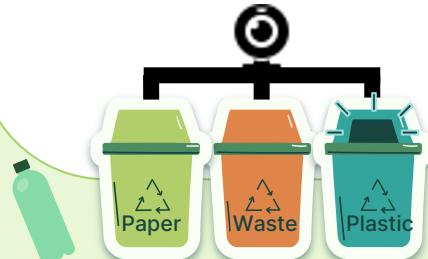
- Single-Family homes
- Multifamily residences
- HOA-managed complexes



## Commercial Product

Integrated the AI to hardware system to be a smart trash bin:

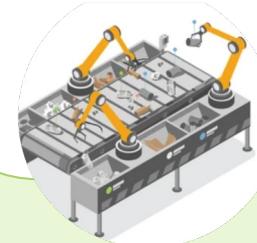
- Companies, Schools, Malls...



## Waste Management Facility

Equip with AI-based computer vision for enhanced:

- Efficiency, accuracy, and safety in waste sorting at the facilities



# PROJECT IMPACT

## Individuals

→ Reduce difficulty

73% of US households have recycling access but only 43% recycle[4].

WasteWizard can help the remaining 30% (40 million households) get involved.

## Recycling Industry

→ Improve safety (reduce manual sorting)

Over 300 waste management facilities in the US, with avg of 30 workers performing manual sorting.

Advanced waste sorting machines can relieve workers of unsafe working conditions.<sup>[3]</sup>

## Environment

→ Save resources

Reduce landfill waste, prioritize material reuse for a better environment.

We can reduce landfill waste to 28 million tons annually.<sup>[4]</sup>



A stylized illustration of a woman with long dark hair, wearing a green long-sleeved top and a purple skirt, walking towards the left. She is carrying a blue recycling bin filled with various plastic bottles and containers. The background is light green with abstract white shapes and scattered green leaves and bottle fragments.

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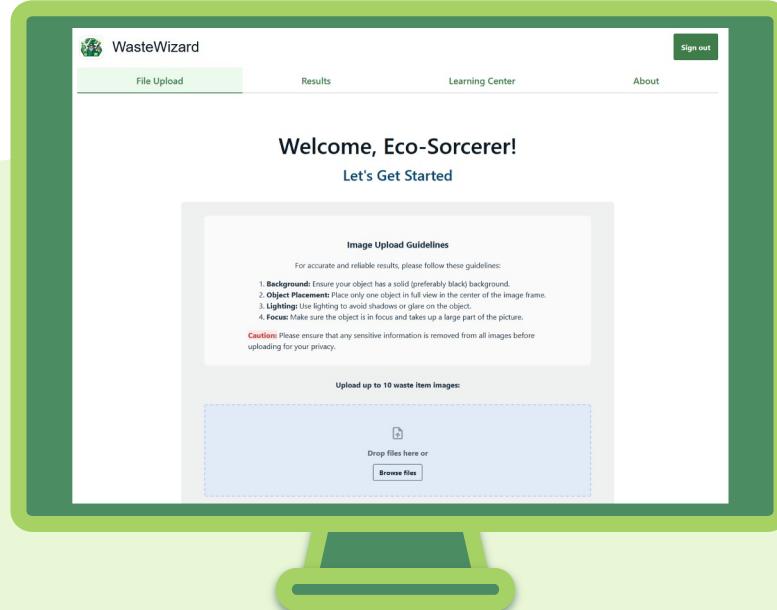
MVP

# Minimum Viable Product (MVP)

**Step 1:**  
Users Upload Photo(s)

**Step 2: Computer Vision**  
Real-time image  
classification

**Step 3: Toss/Recycle**  
Inform user of appropriate  
disposal method

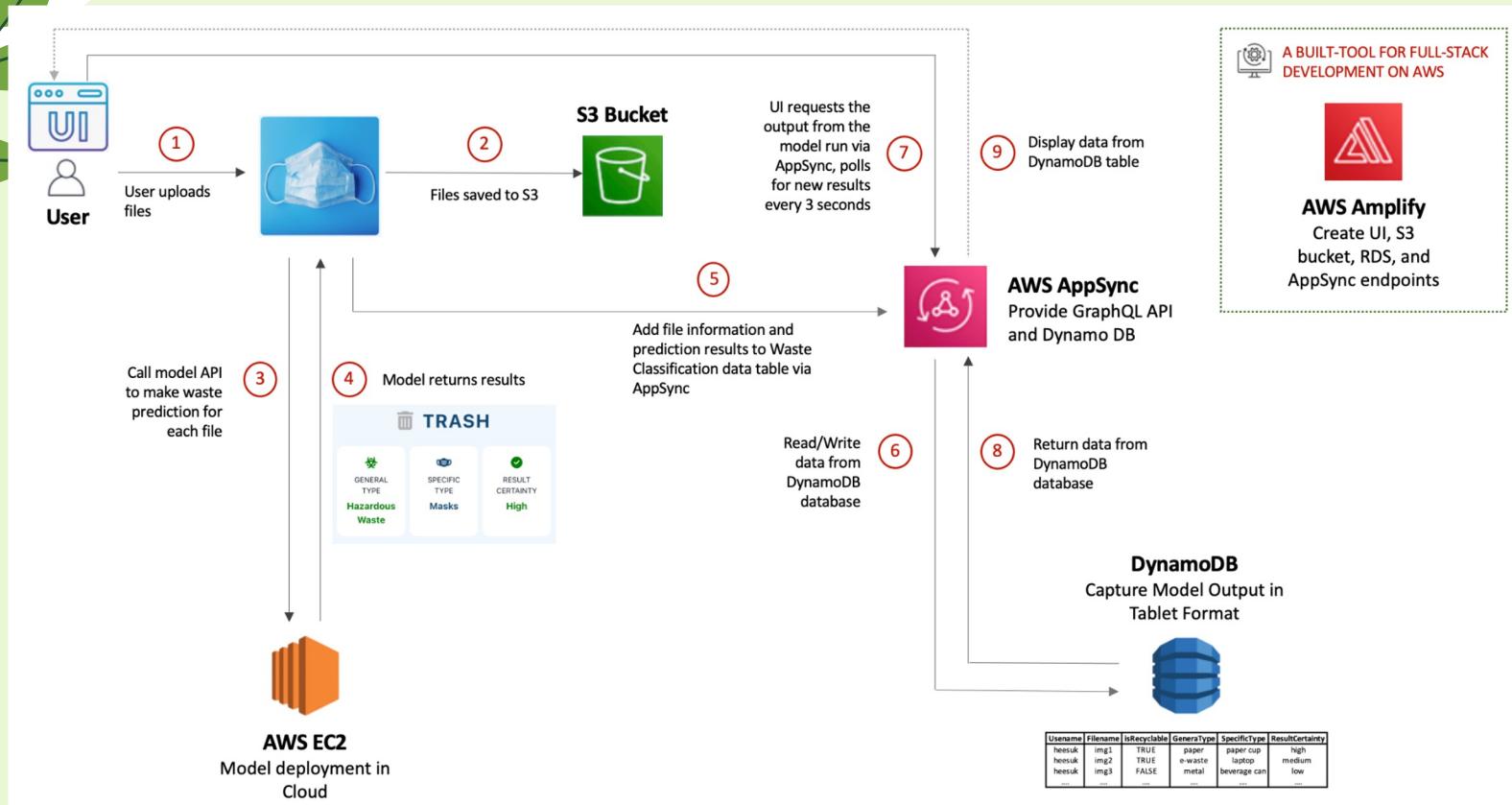


**MVP Addresses  
Key Question:**

*How can I recycle  
this item?*

# Data Flow Diagram

Here is the architecture and technical components we used for our MVP:



# Web App – Waste Wizard

## With React Router



## Live Demo

# USER FEEDBACK

User testing feedback helps us assess the response of our target audience.



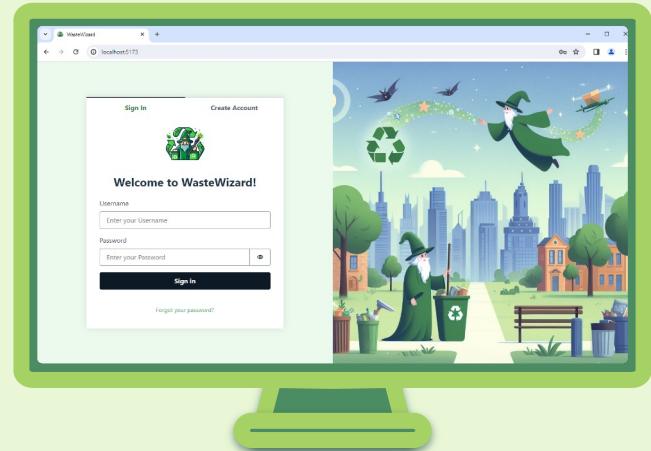
*"The UI is straightforward and easy to use! I found the specific tips for disposal really helpful." – Daisy*



*"This website has a lot of useful information, especially the Learning Center!" – David*



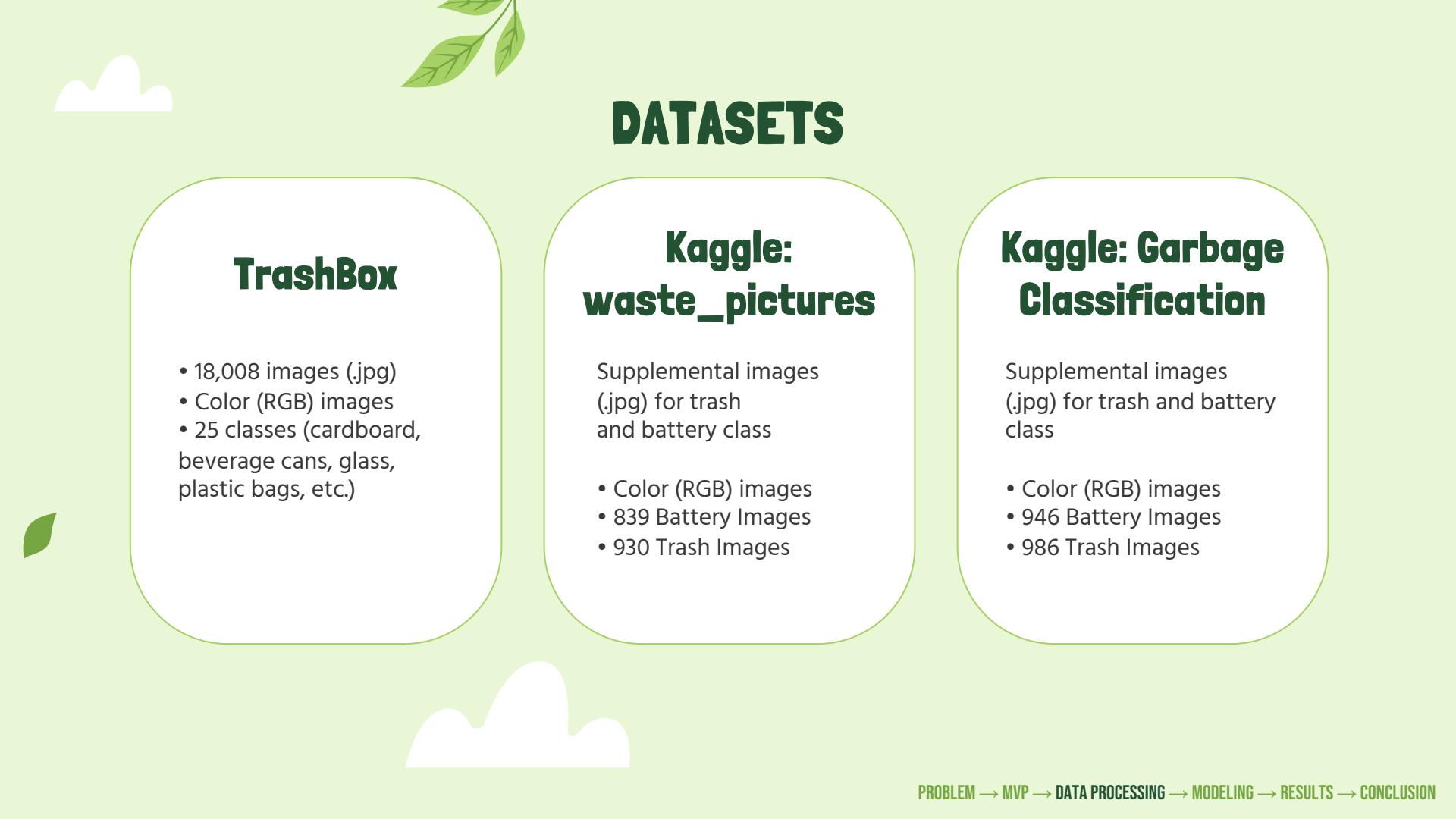
*"There were some waste items I didn't know were recyclable, so I would usually throw them in the trash. Now I know they are recyclable and the steps to take to throw them away. Thanks, WasteWizard!" – Beth*



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# Data Exploration & Preprocessing





# DATASETS

## TrashBox

- 18,008 images (.jpg)
- Color (RGB) images
- 25 classes (cardboard, beverage cans, glass, plastic bags, etc.)

## Kaggle: waste\_pictures

Supplemental images (.jpg) for trash and battery class

- Color (RGB) images
- 839 Battery Images
- 930 Trash Images

## Kaggle: Garbage Classification

Supplemental images (.jpg) for trash and battery class

- Color (RGB) images
- 946 Battery Images
- 986 Trash Images

# Waste Sorting Categories

## Recyclable

Paper

Metal

Glass

Plastic

## Non-Recyclable

e-Waste Disposal

Hazardous Waste

General Trash

ML Task: Classification of Waste Disposal into 26 Categories

Cardboard

Beverage Cans

Glass

Plastic Bottles

Electrical Cables

Syringes

Trash

News Paper

Construction Scrap

Plastic Containers

Electronic Chips

Masks

Medicine

Paper Cups

Metal Containers

Plastic Cups

Laptops

Spray Cans

Cigarette Butts

Paper

Small Appliances

Gloves

Plastic Bags

Tetra Pak

Smart Phones

Batteries

# Exploratory Data Analysis

## EDA FINDINGS:

### Image Shape

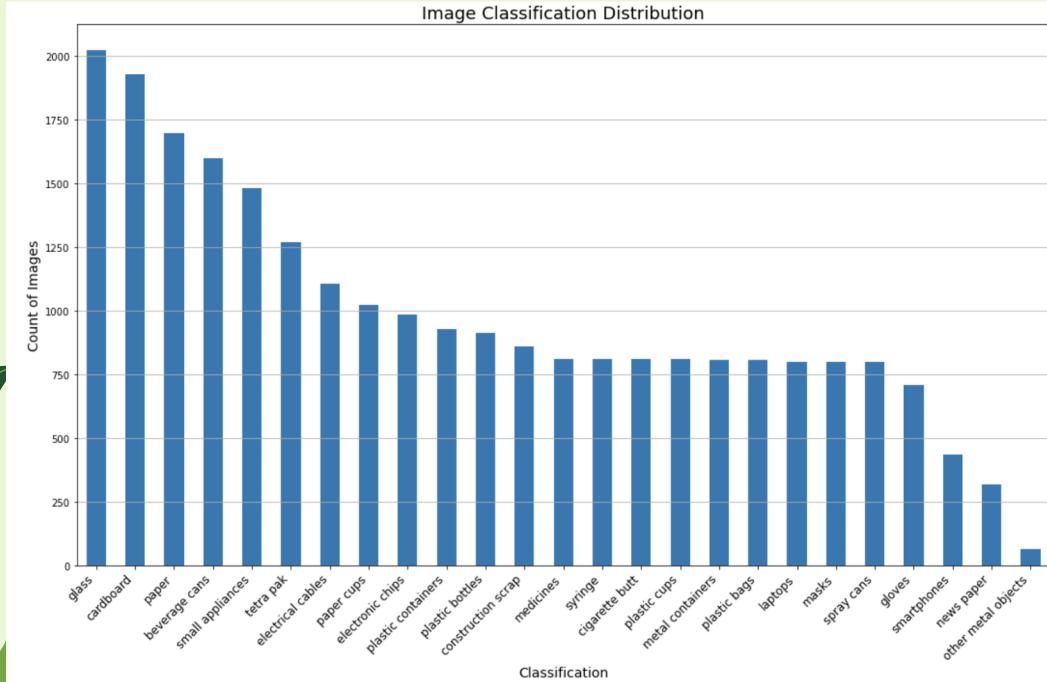
Computer Vision model expects inputs of a fixed shape (num sample, height, width, 3)

### Image Size

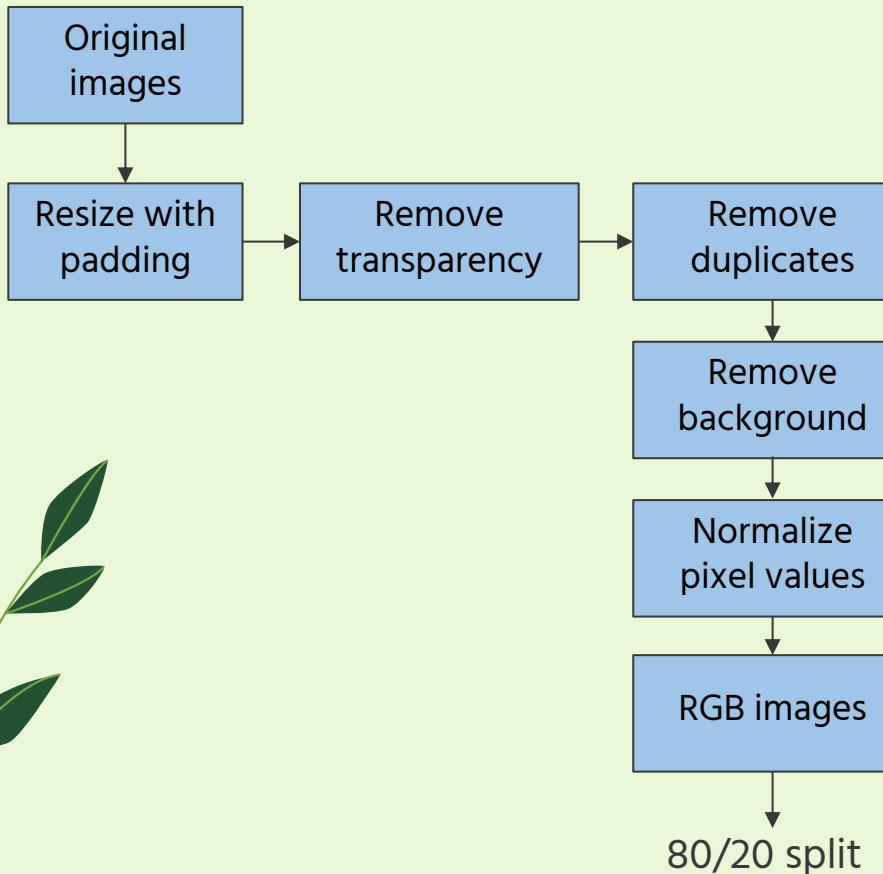
224 x 224 image size allow models to process the data more efficiently

### Color Palette

RGB, many pretrained models were trained using color images



# Data Pipeline: Preprocessing



Ex. Metal container



Ex. Plastic bottle



**Cardboard**



**Battery**



**Laptops**



# HOW WE OVERCAME UNUSABLE IMAGES

We manually removed mislabeled images, improving model performance:

- Single object or multiple objects of the same material
- Remove mixed materials
- Remove people

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# Modeling Approach



# **Modeling Techniques that we explored...**

**Class weight  
adjustments**

**Regularization  
Techniques**

**Hyperparameter  
Tuning**

**Transfer  
Learning**

**Ensemble  
Modeling**

**Model  
Checkpointing**

# Primary Evaluation Metric: Macro F1 Score

## PRIMARY METRIC

We used Macro F1 score for model selection and evaluation.

## HOW DOES IT WORK?

Macro F1 takes the F1 scores of each class and averages them, treating all classes equally.

## WHY MACRO F1?

Our dataset class distribution doesn't mirror real-world usage.

We ensure equal weight for each class with Macro F1 Score.

# Model Experiments

	Train Accuracy	Train Macro F1	Test Accuracy	Test Macro F1
<b>Majority Baseline</b>	0.120	0.010	0.120	<b>0.010</b>
<b>CNN – rembg, grayscale</b>	0.986	0.830	0.680	<b>0.600</b>
<b>ResNet50 – rembg, augmented</b>	0.890	0.930	0.810	<b>0.770</b>
<b>VGG16 – rembg, non-augmented</b>	0.986	0.701	0.750	<b>0.680</b>
<b>ViT – rembg, non-augmented</b>	0.916	0.897	0.918	<b>0.896</b>
<b>Boosted 8 Transfer Learning Models</b>	0.724	0.657	0.609	<b>0.515</b>

# Our final model (ViT) balanced performance and efficiency

## ■ Accurate

The ViT model yielded the highest validation macro f1 score of 90%

## ■ Efficient

Total training and evaluation time was ~2 hours, an indicator of speed of prediction for unseen data

### Test Evaluation Metrics

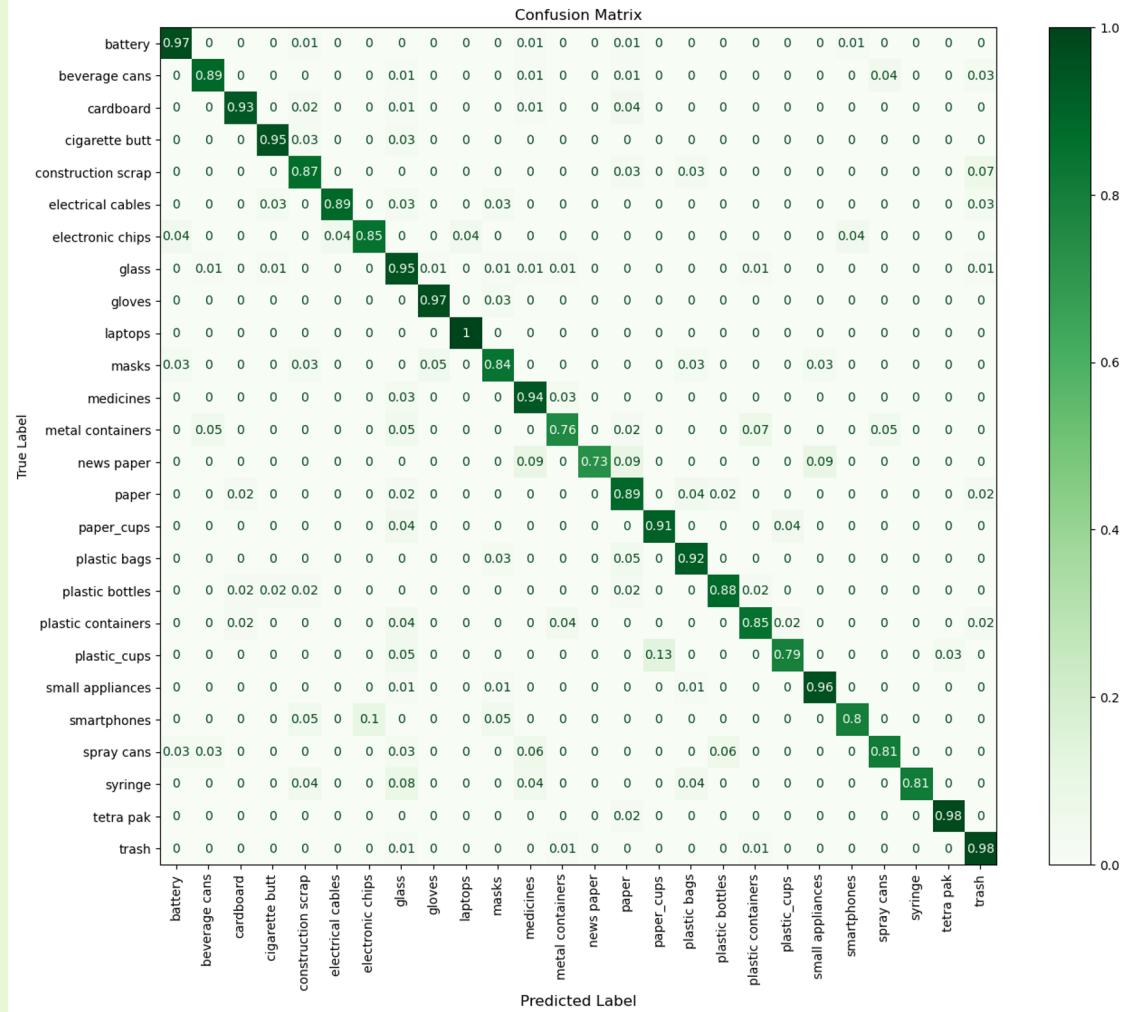
- **Accuracy:** 92%
- **Macro F1:** 90%
- **Precision:** 91%
- **Recall:** 89%

### Best Hyperparameters:

- **learning\_rate:** 2.003e-05
- **num\_train\_epochs:** 12
- **per\_device\_train\_batch\_size:** 9
- **weight\_decay:** 0.00027797

# Our model was successful in many cases:

- Classes with  $\geq 97\%$  correct
  - **Laptops:** 100%
  - **Tetra Pak:** 98%
  - **Trash:** 98%
  - **Battery:** 97%
  - **Gloves:** 97%





## But there is room for improvement...

- Classes with < 80% correct:
  - **Plastic Cups:** 79%
    - 13% misclassified as paper cups
  - **Metal Containers:** 76%
    - Misclassified as plastic containers, beverage cans, glass, and spray cans
  - **Newspaper:** 73%
    - Misclassified as medicines, paper, small appliances
    - Items on newspaper



Upload More Images



TRASH

GENERAL TYPE e-Waste Disposal	SPECIFIC TYPE Small Appliances	RESULT CERTAINTY High
----------------------------------	-----------------------------------	--------------------------

## HOW TO DISPOSE ^

STEPS TO PROPERLY DISPOSE OF  
small appliances:

1. Determine if the small appliance is still functional.
2. If working, consider donating the appliance to a charitable organization or thrift store.
3. If not working or outdated, take the appliance to a local electronic waste recycling facility for proper disposal.



TRASH

GENERAL TYPE Hazardous Waste	SPECIFIC TYPE Masks	RESULT CERTAINTY High
---------------------------------	------------------------	--------------------------

## HOW TO DISPOSE ^

STEPS TO PROPERLY DISPOSE OF  
masks:

1. If the mask is clean and unused, it can be reused or donated if appropriate.
2. If the mask is contaminated or no longer usable, dispose of it in the regular trash.
3. Follow hazardous waste disposal guidelines provided by local authorities if the mask is contaminated with hazardous materials.

# Interpretable Insights

Target users can use model outputs to address the problem:

## Model Classification Output

Informs users about the waste item's material composition

## Result Certainty

Shows users our certainty in the item's classification, (low, medium, high), derived from the prediction's softmax score

## Waste Disposal Suggestion

Nudges users towards correct waste disposal actions for specific waste items

# TOP 3 TECHNICAL CHALLENGES



## Addressing Data Quality

Manual image cleanup and label correction



## Balancing Resource Constraints

AWS credits, training runtimes, development bandwidth



## Adapting to New Technologies

Learned many new libraries: React for full-stack app and AWS for model deployment



# FUTURE ROADMAP ITEMS

**1. OPTIMIZING MODEL  
INFERENCE TIME**

**3. OTHER FEATURES:  
mobile app, location–  
specific guidance**

**2. INTEGRATING  
CONTINUOUS  
MODEL LEARNING**



# Our Mission

Revolutionize waste management through AI-driven solutions, promoting a culture of sustainability and empowering eco-conscious communities for a healthier planet.

# APPENDIX



For more info:

<https://wastewizard-mids.webflow.io/>



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