

WASTEWIZARD

Efficient Waste Sorting through Computer Vision

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MEET OUR TEAM



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PROBLEM OVERVIEW

We produce **2 billion metric tons** of solid waste globally per year^[1] 75% of America's waste is recyclable, but we only recycle 32%^[2].

The US throws away **\$11.4 billion** in recyclable packaging annually^[3].

Material Recovery Facility (MRF) workers must sort through potentially hazardous waste^[4]. The US is **#1** in waste-per-capita, producing **12%** of global waste production despite being 4% of global population^[5].

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

Image Source

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...

> ∧ ≜_⇒ Paper

Waste

Plast

Waste Management Facility

Equip with AI-based computer vision for enhanced:

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

PROJECT IMPACT

Individuals

\rightarrow 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.^[3]

Environment

\rightarrow Save resources

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

We can reduce landfill waste to 28 million tons annually.^[4]







Step 1: Users Upload Photo(s)

Step 2: Computer Vision Real-time image classification

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

File Upload	Results	Learning Center	About
	Welcome,	Eco-Sorcerer!	
	Let's G	iet Started	
	For accurate and reliable ret 1. Background: Ensure your object has 2. Object Placement: Place only one o 3. Lighting: Use lighting to avoid shad 4. Focus: Make sure the object is in foc	bject in full view in the center of the image frame.	
	Upload up to '	10 waste item images:	
	·	files here or	

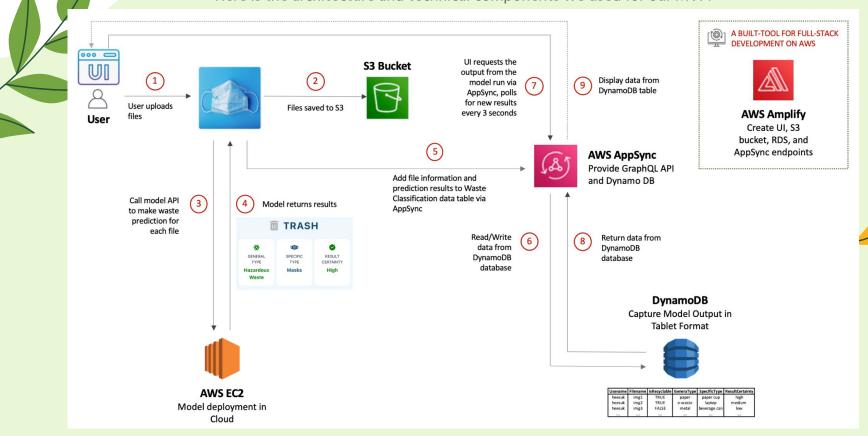
Minimum Viable Product (MVP)

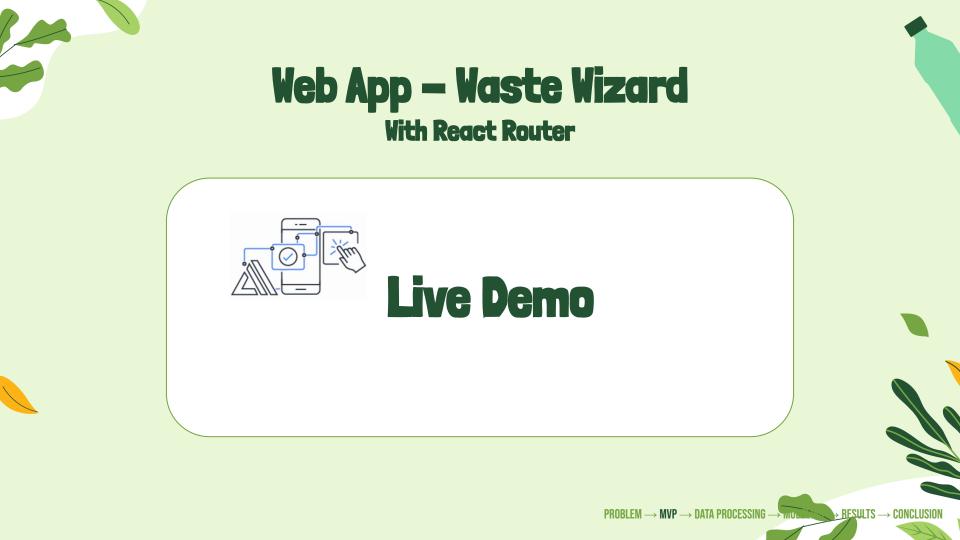
MVP Addresses Key Question:

How can I recycle this item?

Data Flow Diagram

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





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

03 Data **Exploration &** Preprocessing



DATASETS

TrashBox

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

Kaggle: waste_pictures

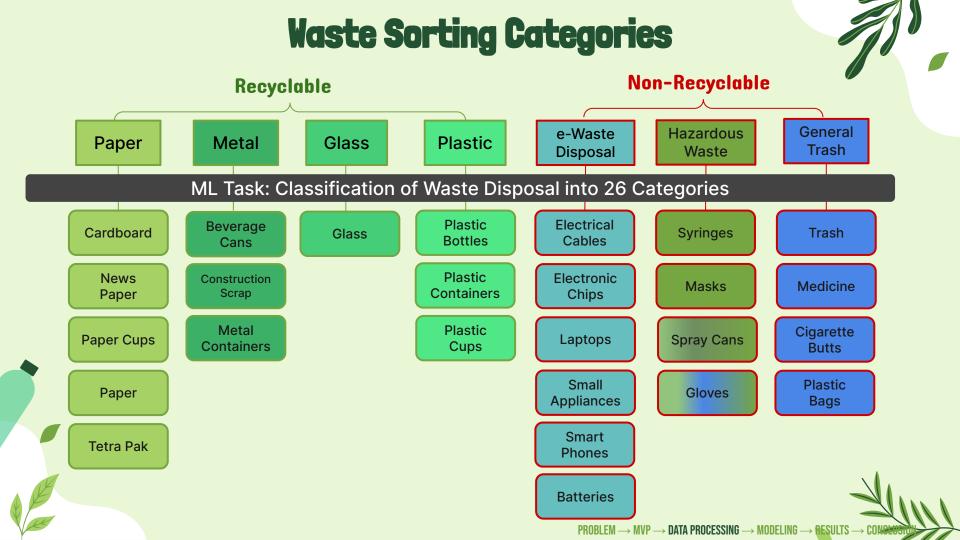
Supplemental images (.jpg) for trash and battery class

- 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







EDA FINDINGS:

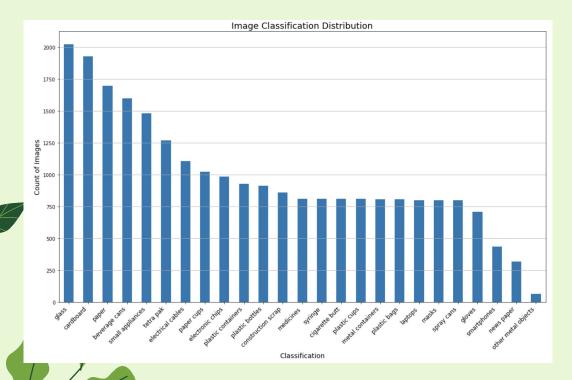


Image Shape

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

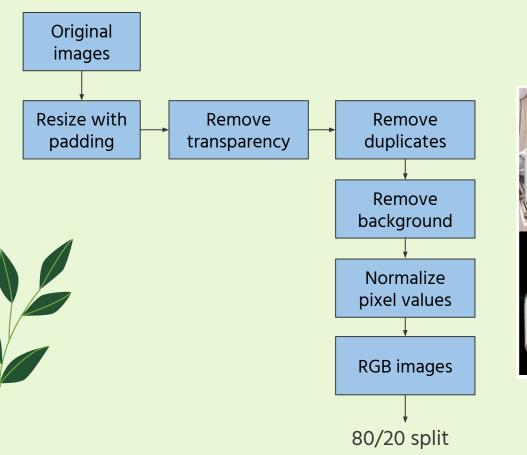
Image Size

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

$\mathsf{PROBLEM} \to \mathsf{MVP} \to \mathsf{DATA} \ \mathsf{PROCESSING} \to \mathsf{MODELING} \to \mathsf{RESULTS} \to \mathsf{CONCLUSION}$















Laptops







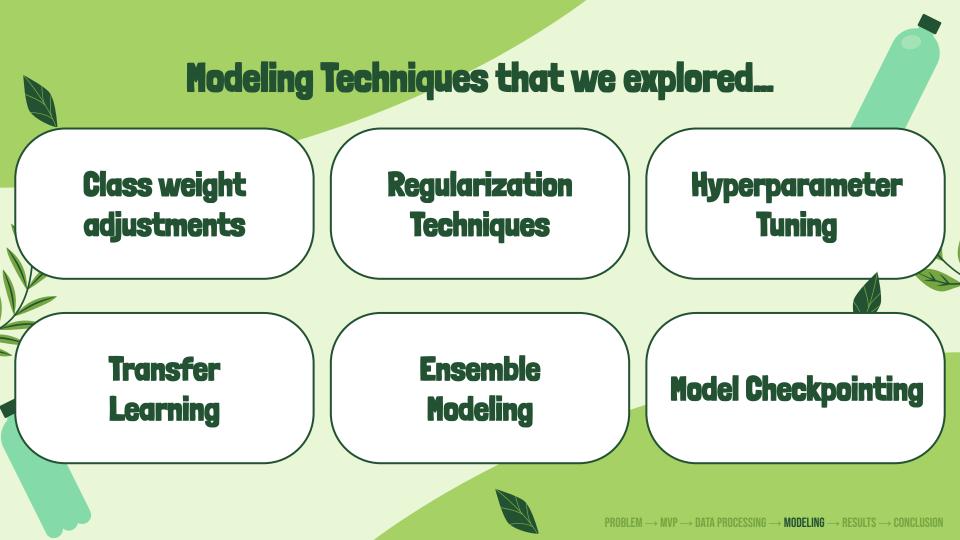
HOW WE OVERCAME UNUSABLE IMAGES

We manually removed mislabeled images, improving model performance:

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



04 Modeling Approach





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.







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

 $\mathsf{PROBLEM} \to \mathsf{MVP} \to \mathsf{DATA} \ \mathsf{PROCESSING} \to \mathsf{MODELING} \to \mathsf{RESULTS} \to \mathsf{CONCLUSION}$

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

													Con	fusio	n M	latrix											
	battery -	0.97	0	0	0	0.01	0	0	0	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0.01	0	0	0	0
	beverage cans -	0	0.89	0	0	0	0	0	0.01	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0.04	0	0	0.03
	cardboard -	0	0	0.93	0	0.02	0	0	0.01	0	0	0	0.01	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0
	cigarette butt -	0	0	0	0.95	0.03	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
¢	onstruction scrap -	0	0	0	0	0.87	0	0	0	0	0	0	0	0	0	0.03	0	0.03	0	0	0	0	0	0	0	0	0.07
	electrical cables -	0	0	0	0.03	0	0.89	0	0.03	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
	electronic chips -	0.04	0	0	0	0	0.04	0.85	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0
	glass -	0	0.01	. 0	0.01	0	0	0	0.95	0.01	0	0.01	0.01	0.01	0	0	0	0	0	0.01	0	0	0	0	0	0	0.01
	gloves -	0	0	0	0	0	0	0	0	0.97	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	laptops -	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	masks -	0.03	0	0	0	0.03	0	0	0	0.05	0	0.84	0	0	0	0	0	0.03	0	0	0	0.03	0	0	0	0	0
	medicines -	0	0	0	0	0	0	0	0.03	0	0	0	0.94	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0
True Label	metal containers -	0	0.05	0	0	0	0	0	0.05	0	0	0	0	0.76	0	0.02	0	0	0	0.07	0	0	0	0.05	0	0	0
Irue	news paper -	0	0	0	0	0	0	0	0	0	0	0	0.09	0	0.73	0.09	0	0	0	0	0	0.09	0	0	0	0	0
	paper -	0	0	0.02	0	0	0	0	0.02	0	0	0	0	0	0	0.89	0	0.04	0.02	0	0	0	0	0	0	0	0.02
	paper_cups -	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0.91	0	0	0	0.04	0	0	0	0	0	0
	plastic bags -	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0.05	0	0.92	0	0	0	0	0	0	0	0	0
	plastic bottles -	0	0	0.02	0.02	0.02	0	0	0	0	0	0	0	0	0	0.02	0	0	0.88	0.02	0	0	0	0	0	0	0
	plastic containers -	0	0	0.02	0	0	0	0	0.04	0	0	0	0	0.04	0	0	0	0	0	0.85	0.02	0	0	0	0	0	0.02
	plastic_cups -	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0.13	0	0	0	0.79	0	0	0	0	0.03	0
	small appliances -	0	0	0	0	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0.01	0	0	0	0.96	0	0	0	0	0
	smartphones -	0	0	0	0	0.05	0	0.1	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0
	spray cans -	0.03	0.03	0	0	0	0	0	0.03	0	0	0	0.06	0	0	0	0	0	0.06	0	0	0	0	0.81	0	0	0
	syringe -	0	0	0	0	0.04	0	0	0.08	0	0	0	0.04	0	0	0	0	0.04	0	0	0	0	0	0	0.81	0	0
	tetra pak -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0.98	0
	trash -	0	0	0	0	0	0	0	0.01	0	0	0	0	0.01	0	0	0	0	0	0.01	0	0	0	0	0	0	0.98
		battery	beverage cans	cardboard	cigarette butt	construction scrap	electrical cables	electronic chips	glass	gloves	laptops -	masks	medicines	ptontainers .	news paper	paper	paper_cups	plastic bags	plastic bottles	plastic containers	plastic_cups	small appliances	smartphones	spray cans	syringe	tetra pak	trash

0.8

- 0.6

- 0.4

0.2

- 0.0

Our model was successful in many cases:

- Classes with >=97% correct
 - **Laptops**: 100%
 - **Tetra Pak**: 98%
 - **Trash**: 98%
 - Battery: 97%
 - **Gloves**: 97%



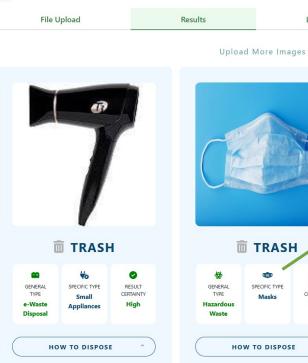


But there is room for improvement...

- 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

 $\mathsf{PROBLEM} \to \mathsf{MVP} \to \mathsf{DATA} \ \mathsf{PROCESSING} \to \mathsf{MODELING} \to \mathsf{RESULTS} \to \mathsf{CONCLUSION}$





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.



RESULT

Learning Center



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

 $PROBLEM \rightarrow MVP \rightarrow DATA PROCESSING \rightarrow MODELING \rightarrow RESULTS \rightarrow CONCLUSION$

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

3. OTHER FEATURES: mobile app, locationspecific guidance

2. INTEGRATING CONTINUOUS MODEL LEARNING



1. OPTIMIZING MODEL INFERENCE TIME



Our Mission

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



For more info:

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



Logo generated with Bing AI Designer

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