# Identifying Littered Waste with a CNN

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## The Problem

We litter in almost every environment!

- Inadequately disposed of waste kills wildlife and contributes to respiratory issues and other health problems
- Over 300,000 tons of plastic estimated to be littered each year in just the US
- Habitat Destruction
- Biological Harm
- Interfere with Human Activity



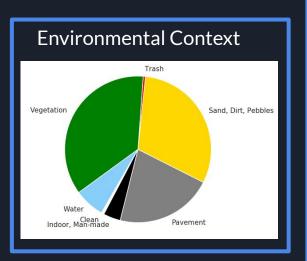
https://www.epa.gov/trash-free-waters/impacts-mismanaged-trash

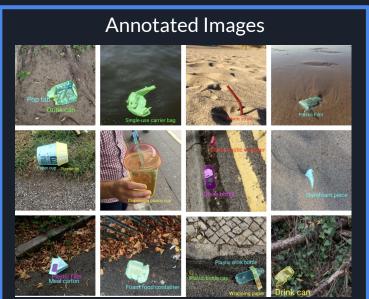
## Our solution

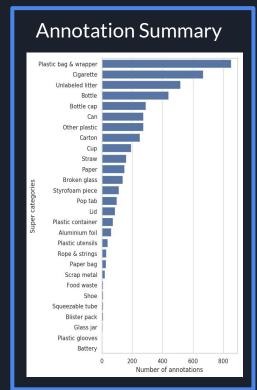
- Use a Convolutional Neural Network Architecture to identify the presence of litter in an image
- Ultimately, we hope that our work can be built upon to use robots that will autonomously and appropriately clean up litter

## Our Dataset: Trash Annotations in Context (TACO)<sup>[1]</sup>

❖ 1500 Images with 4784 annotations from 60 categories and 20 super categories







## Original COCO JSON Data!

#### Over 30,000 items!

```
annotation{
  "id"
                        : int.
  "image id"
                        : int.
  "category id"
                        : int.
  "segmentation"
                        : RLE or [polygon],
  "area"
                        : float.
  "bbox"
                        : [x,y,width,height],
  "iscrowd"
                        : 0 or 1.
categories[{
                        : int.
  "name"
                        : str.
  "supercategory"
                        : str.
}]
```

"info": {"vear": 2019, "version": null, "description": "TACO", "contributor": null, "url": null, "date created" . "height": 2049, "file name": "batch 1/000006.jpg", "license": null, "flickr url": "https://farm66.staticflickr.co null, "flickr 640 url": "https://farm66.staticflickr.com/65535/33978196618 632623b4fc z.jpg"}, {"id": 1, "width" flickr url": "https://farm66.staticflickr.com/65535/47803331152 ee00755a2e o.png", "coco url": null, "date captu" 47803331152 19beae025a z.jpg"}, {"id": 2, "width": 1537, "height": 2049, "file name": "batch 1/000010.jpg", "lice 40888872753 08ffb24902 o.png", "coco url": null, "date captured": null, "flickr 640 url": "https://farm66.static "height": 1537, "file name"<sup>.</sup> "hatch 1/000019.jpg", "license": null, "flickr url": "https://farm66.staticflickr.co null, "flickr 6 Follow link (ctrl + click) m66.staticflickr.com/65535/47803331492 b8c0e5aafe z.jpg"}, {"id": 4, "width": flickr url": "https://farm66.staticflickr.com/65535/33978199868 88ee160849 o.png", "coco url": null, "date captu 33978199868 1bc379170a z.jpg"}, {"id": 5, "width": 2049, "height": 1537, "file name": "batch 1/000047.jpg", "lice 33978200068 c6eed416ac o.png", "coco url": null, "date captured": null, "flickr 640 url": "https://farm66.static height": 2049, "file name": "batch 1/000055.jpg", "license": null, "flickr url": "https://farm66.staticflickr.co" null, "flickr 640 url": "https://farm66.staticflickr.com/65535/47803332212 0ff13e5eb1 z.jpg"}, {"id": 7, "width": flickr url": "https://farm66.staticflickr.com/65535/33978202498 effbca58ef o.png", "coco url": null, "date captu 33978202498 ef6d507616 z.jpg"}, {"id": 8, "width": 1537, "height": 2049, "file name": "batch 1/000005.jpg", "lice 47803335992 9c58683430 o.png", "coco url": null, "date captured": null, "flickr 640 url": "https://farm66.static height": 2049, "file name": "batch 1/000007.jpg", "license": null, "flickr url": "https://farm66.staticflickr.cq" null, "flickr 640 url": "https://farm66.staticflickr.com/65535/47855505601 a81c3ba8de z.jpg"}, {"id": 10, "width" flickr url": "https://farm66.staticflickr.com/65535/40888877173 855795c875 o.png", "coco url": null, "date capt 40888877173 734cec88e1 z.jpg"}, {"id": 11, "width": 1537, "height": 2049, "file name": "batch 1/000014.jpg", "lid 47066066634 c50443ca0c o.png", "coco url": null, "date captured": null, "flickr 640 url": "https://farm66.staticf height": 1537, "file name": "batch 1/000048.jpg", "license": null, "flickr url": "https://farm66.staticflickr.co" null, "flickr 640 url": "https://farm66.staticflickr.com/65535/47803337262 4965d5608b z.jpg"}, {"id": 13, "width" flickr url": "https://farm66.staticflickr.com/65535/47066067064 84c534d654 o.png", "coco url": null, "date captu 47066067064\_b7ca7a114d\_z.jpg"}, {"id": 14, "width": 1537, "height": 2049, "file name": "batch 1/000056.jpg", "lic 47803337932 3b5ba10c22 o.png", "coco url": null, "date captured": null, "flickr 640 url": "https://farm66.static height": 2049. "file name": "batch 1/000058.jpg". "license": null. "flickr url": "https://farm66.staticflickr.cd"

## Original COCO JSON Data!

• Multiple Sub-Data Sections with id, image\_id as join points.

#### The Environmental Background Sub-Dataset of Images from JSON

```
"scene_categories": [{"id": 0, "name": "Clean"}, {"id": 1, "name": "Indoor,
Man-made"}, {"id": 2, "name": "Pavement"}, {"id": 3, "name": "Sand, Dirt, Pebbles"}
, {"id": 4, "name": "Trash"}, {"id": 5, "name": "Vegetation"}, {"id": 6, "name":
"Water"}]}
```

```
{"image_id": 116, "background_ids": [5, 6]}, {"image_id": 117, "background_ids":
[5]}, {"image_id": 118, "background_ids": [5, 6]}, {"image_id": 119,
"background_ids": [1]}, {"image_id": 120, "background_ids": [2]}, {"image_id":
121, "background_ids": [2]}, {"image_id": 122, "background_ids": [2]},
{"image_id": 123, "background_ids": [2]}, {"image_id": 124, "background_ids": [2]},
{"image_id": 125, "background_ids": [2, 3]}, {"image_id": 126, "background_ids":
[2, 3]}, {"image_id": 127, "background_ids": [2, 3]}, {"image_id": 128,
"background_ids": [2]}, {"image_id": 129, "background_ids": [2, 3]}, {"image_id":
130, "background_ids": [2]}, {"image_id": 131, "background_ids": [2]},
{"image_id": 132, "background_ids": [2]},
{"image_id": 133, "background_ids": [3]}}
```

## Data Processing: Custom JSON Data Subset

#### Steps Implemented [Python]

- Read in and Parse Through Annotations
- For each Image
  - Using Image\_Id, BBox\_ID
    - Obtain Image Info, Trash Bounding Boxes,
       Environment Info
- Export to our Custom JSON Dataset!

```
{"data_subset": [{"image_id": 1498, "flickr_url": "https://farm66.staticflickr.com/65535/48693804538_6aa092c617_o.png", "filename": "batch_9/000098.jpg", "og
_width": 1824, "og_height": 4000, "scene_id": [2], "bboxes": [[517.0, 127.0, 447.0, 1322.0], [1.0, 457.0, 1429.0, 1519.0], [531.0, 292.0, 1006.0, 672.0], [63
```

## Data Processing: ROI Box Creation

Problem: We only have images with trash in them- No images without trash!

#### Solution:

- For Each Image
  - ➤ Obtain ROI (Regions of Interest) Boxes
    - Boxes around Trash Objects :
      - Implemented Algorithm to expand annotated Trash Boundaries without overlapping
    - Boxes containing no Trash Objects:
      - Implemented Algorithm to Randomly Choose Boxes that don't overlap with any of the annotated Trash Objects

## Final ROI Dataset Example Images

1500 Original Trash Images

9231 New ROI Images

4843 Images with Trash

4388 Images without Trash



Trash Present.



Trash NOT Present.



Trash Present.

## Final ROI Dataset Example - Same Image\_ID



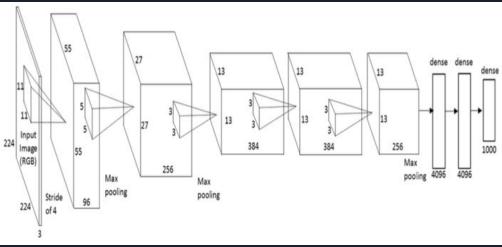
Trash NOT Present.



Trash Present.

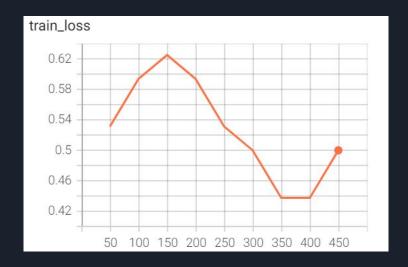
## Our Network

- We used transfer learning with a pre-trained Alexnet as a feature extractor for our vision model
- Take features from Alexnet output and use ReLU activation & a Linear layer



## Results

- Adam optimizer with learning rate of 0.001
- Ran for 11 epochs
- We achieved 56% accuracy



## Conclusions

- Accuracy was not as good as we expected it to be
- Creation of the custom augmented dataset might have resulted in mislabeling and anomalies
- Feature extraction with Alexnet may not be suited to the task
- The plot of training loss suggests that the model architecture can be used to classify images of trash