WASTE OBJECT DETECTION AND CLASSIFICATION

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Introduction

We want to educate users to be more mindful of recycling throwaway items, so that we can reduce the contamination at the source. We use pictures of different throwaway items from [6] and train a classifier to output a label which is a type of the object.

Related work

Object detection and classification approaches for throwaway items is a well studied topic. Yang and Thung and Chu et al. use a AlexNet [4] like architectures, and have very poor accuracy. [6], their classifier was confused between plastic and glass categories.
To have more robust classification we experiment with different classifiers namely ResNet by He et al. Because of the skip connection mechanism in [3] we find that the ResNet worked the best.

Dataset and Features

We use TrashNet yang2016classification dataset as the baseline which has 400 images in each of 6 different labelled classes (Glass, Paper, Cardboard, Plastic, Metal, Trash).We augment this dataset by flipping, rotation, and generate a collage by

- Placing images at random and explicitly

Fig. 1: Collages with images at random locations

- Learning where to place the images

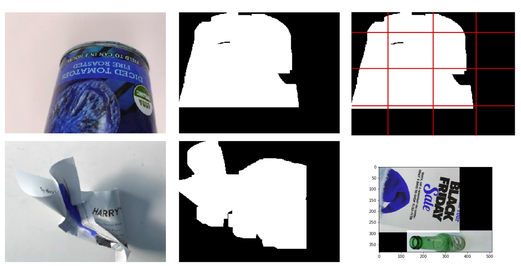

Fig. 2: Learning Collages

$$collage_{loss} = \frac{intersection}{union} \quad (1)$$

- Blending Images using GP-GAN [5]

Fig. 3: Blending Images with GP-GAN

Classification and Localization Methods

- Hybrid approach to Transfer Learning [2]
  - Start with pretrained weights, and add BatchNorm and Dense Layers on the top.
  - Freeze the base layers, and train with a higher learning rate for few epochs.
  - Unfreeze the base layers, and train with lower learning rate.
- Fine-tune with Faster R-CNN Network
  - We used Faster R-CNN network with Inception V2 trained on MSCOCO dataset as the baseline.
  - Conducted experiments by fine tuning it with TrashNet dataset with hand annotated bounding boxes, randomly generated collages, collages with images at 4 quadrants and their bounding boxes.

Experiments and Results

- Hybrid Transfer Learning for Classification

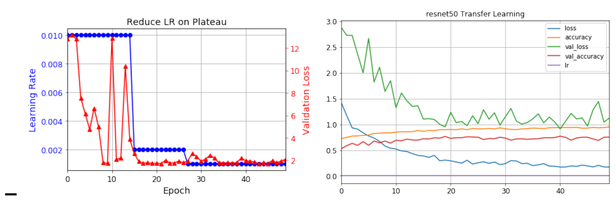

Fig. 4: Learning Rate Schedule

	$lr_1 = 0.01, lr_2 = 0.01$	$lr_1 = 0.001, lr_2 = 0.001$	$lr_1 = 0.01, lr_2 = 0.0001$
Precision	0.15	0.06	0.18
Recall	0.91	0.16	0.19
F1-Score	0.10	0.07	0.18

- The confusion matrix for Hybrid Transfer Learning is below

	cardboard	glass	metal	paper	plastic	trash
cardboard	**10**	2	4	9	2	8
glass	1	**6**	7	9	5	7
metal	6	7	**5**	8	4	8
paper	7	8	7	**6**	3	10
plastic	8	9	6	8	**4**	14
trash	4	6	9	7	4	**16**

- Fine-tune with Faster R-CNN network for Object Detection

LR	0.0002 (TrashNet)	0.0002 (Collage)	0.00002 (Collage)	0.000002 (Collage)
Loss	0.436	1.214	1.442	1.452
Precision	0.816	**0.842**	0.697	0.7
Recall	0.565	**0.878**	0.791	0.793
F1-Score	0.668	**0.859**	0.708	0.743

	cardboard	glass	metal	paper	plastic	trash
Precision	0.97	0.76	0.81	0.90	0.84	0.77
Recall	0.99	0.82	0.86	0.90	0.87	0.8
F1-Score	0.98	0.79	0.83	0.9	0.85	0.78

Experiments and Results

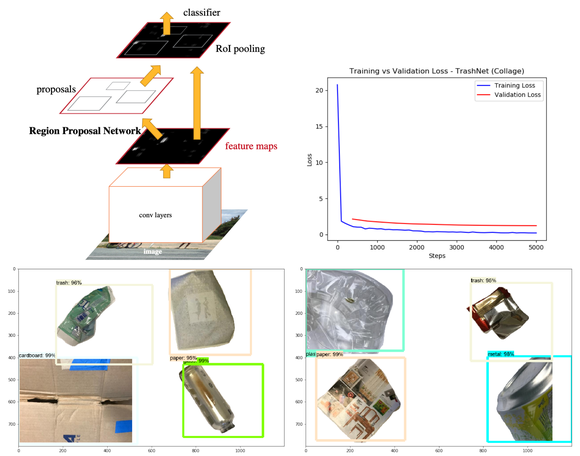

Fig. 5: Train Validation Loss and Object Detection Results for Fine-tuning Faster RCNN with TrashNet collages

Discussions

The Hybrid training requires two learning rates, and is harder to train. We also choose not to useGP-GANs because the GAN blending blurs the features of the image,and hurts the performance.Fine tuned Faster R-CNN returned good object detection results for learning rate 0.0002.

References

[1] Yinghao Chu et al. “Multilayer hybrid deep-learning method for waste classification and recycling”. In: *Computational Intelligence and Neuroscience* 2018 (2018).

[2] Aurélien Géron. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*. O’Reilly Media, 2019.

[3] Kaiming He et al. “Deep residual learning for image recognition”. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016, pp. 770–778.

[4] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E Hinton. “Imagenet classification with deep convolutional neural networks”. In: *Advances in neural information processing systems*. 2012, pp. 1097–1105.

[5] Huikai Wu et al. “Gp-gan: Towards realistic high-resolution image blending”. In: *Proceedings of the 27th ACM International Conference on Multimedia*. ACM. 2019, pp. 2487–2495.

[6] Mindy Yang and Gary Thung. “Classification of trash for recyclability status”. In: *CS229 Project Report* 2016 (2016).