Instance Segmentation of Polymer Flakes through Hyperspectral Imaging

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Introduction

- Plastic packaging materials produce a very large amount of waste.
- In 2018 alone, more than 360 million tons of plastic was produced worldwide. [1]
- With 62 million tons of waste in the European Union, only 15.16% of which was recycled, equivalent to 9.4 million tons. [1]
- Recycling plastics is proven to be a viable option when it comes to managing, decreasing or even partially solving this 'plastic crisis' . [2]
- The goal of this work is to implement instance segmentation to have a per-pixel segmentation of the different types of polymer plastics.

Materials and Methods

- The dataset is created using a Specim FX17 NIR camera.
- The dataset consists of 72 Hyper Spectral Images of PS and PE plastic flakes.
- Each image contained only one class.
- The images are annotated using supervise.ly.
- The Mask R-CNN architecture [3] is used to analyse Hyper Spectral Images.
- A convolutional layer has been added to on top of the Mask R-CNN architecture to handle 224 band Hyper Spectral Images (Apposed to 3 channel RGB images).

Abstract

With the increase of plastic waste being produced each year, effective recycling becomes more important. Our research looks to aid in just that. By combining the Mask R-CNN with a convolutional layer, we were successfully processing Hyper Spectral Images of different polymer types. Our promising results concreted that Mask R-CNN is capable of processing hyper spectral images and while doing so, create accurate instance segmentations.

Figure 1. The Specim FX17 camera and setup as in the Circular Plastics Lab in the progress of recording a sample.

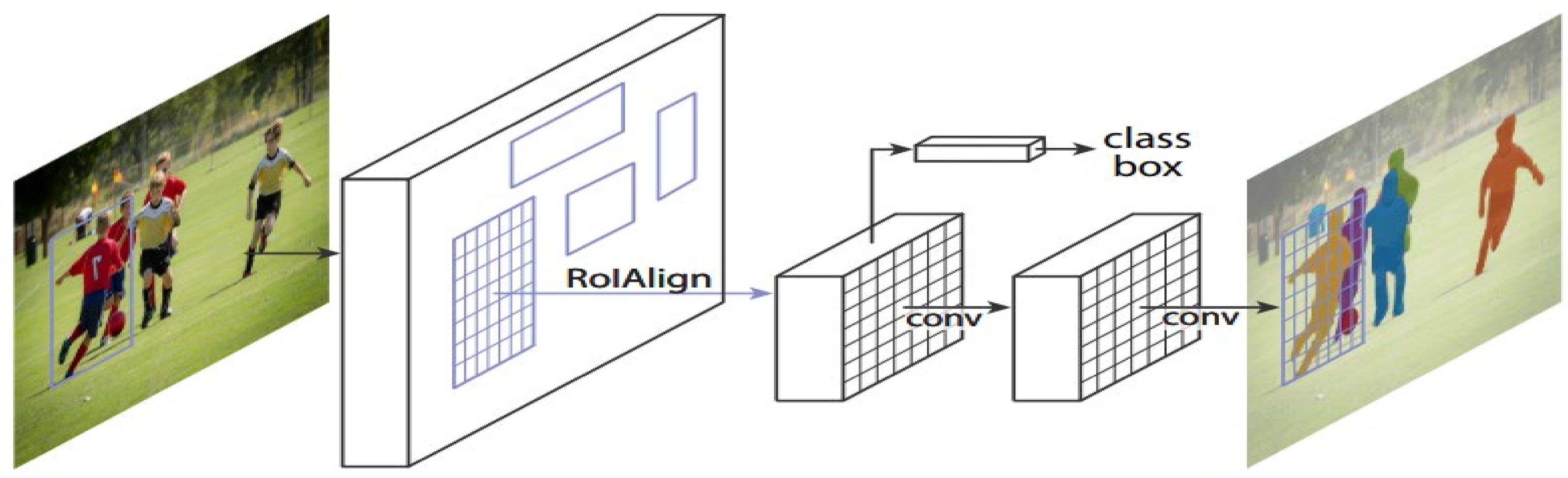

Figure 2. The Mask R-CNN model for instance segmentation. It has a two-stage pipeline with an RPN (Region Proposal Network) in the first stage. The second stage consists of classification and bounding box regression and, in parallel, production of a binary mask for each Region of Interest [3].

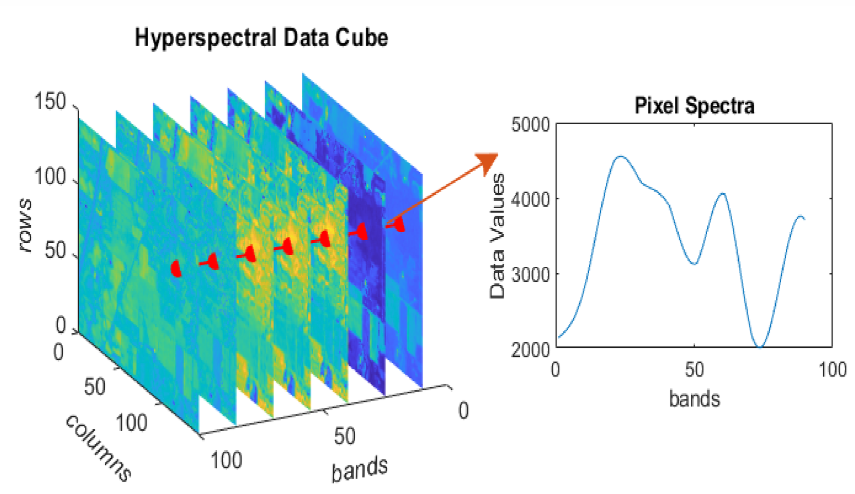

Figure 3. An example visualization of a hyperspectral data cube and the spectrum for a given pixel [4]

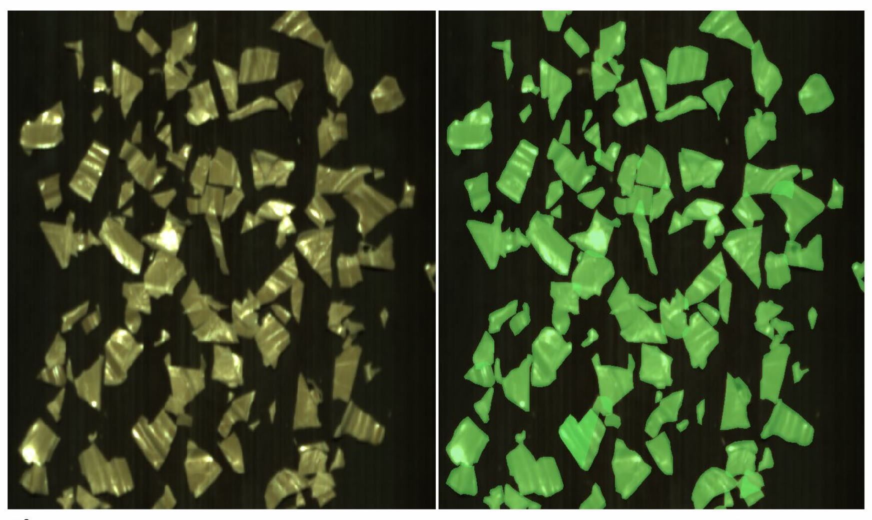

Figure 4. An image of the dataset being annotated. Each polymer flake gets its own polygon.

Acknowledgements

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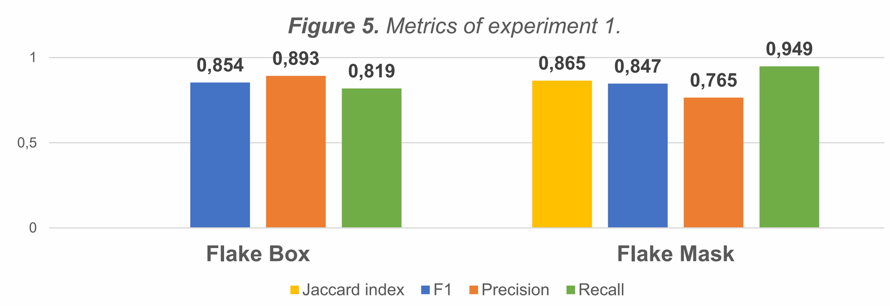
Experiments and Results

Experiment 1:
We changed the classes of all the flakes to generic class 'Flake' in order to test if the networks were able to detect just the flakes in the images.

Experiment 2:
We trained, validate and test the mask R-CNN network on the large dataset to see how well the network can classify different polymer type and create good instance masks.

Experiment 3:
We trained , validate and test the mask R-CNN network on the half of the large dataset to see how well the network performs using small amount of data.



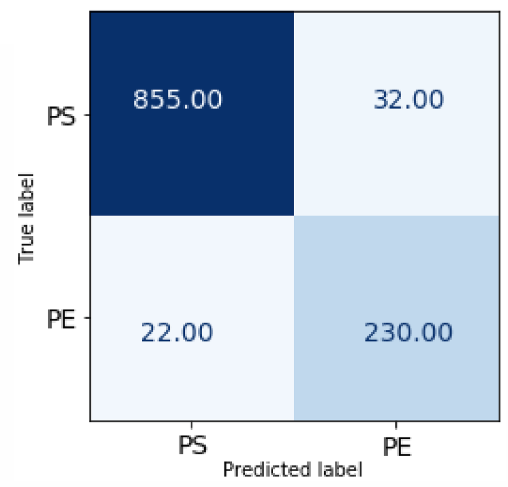
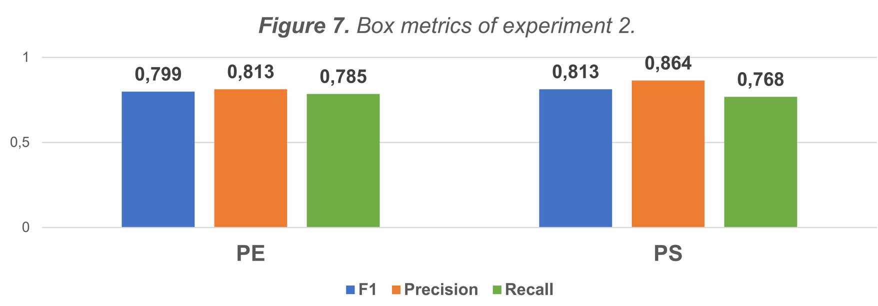
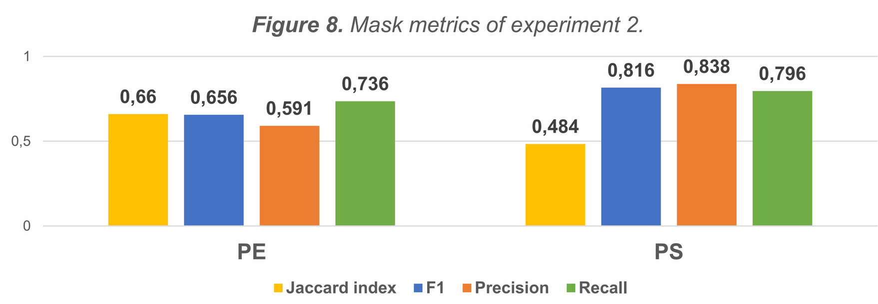


Figure 6. Confusion matrix for experiment 2.





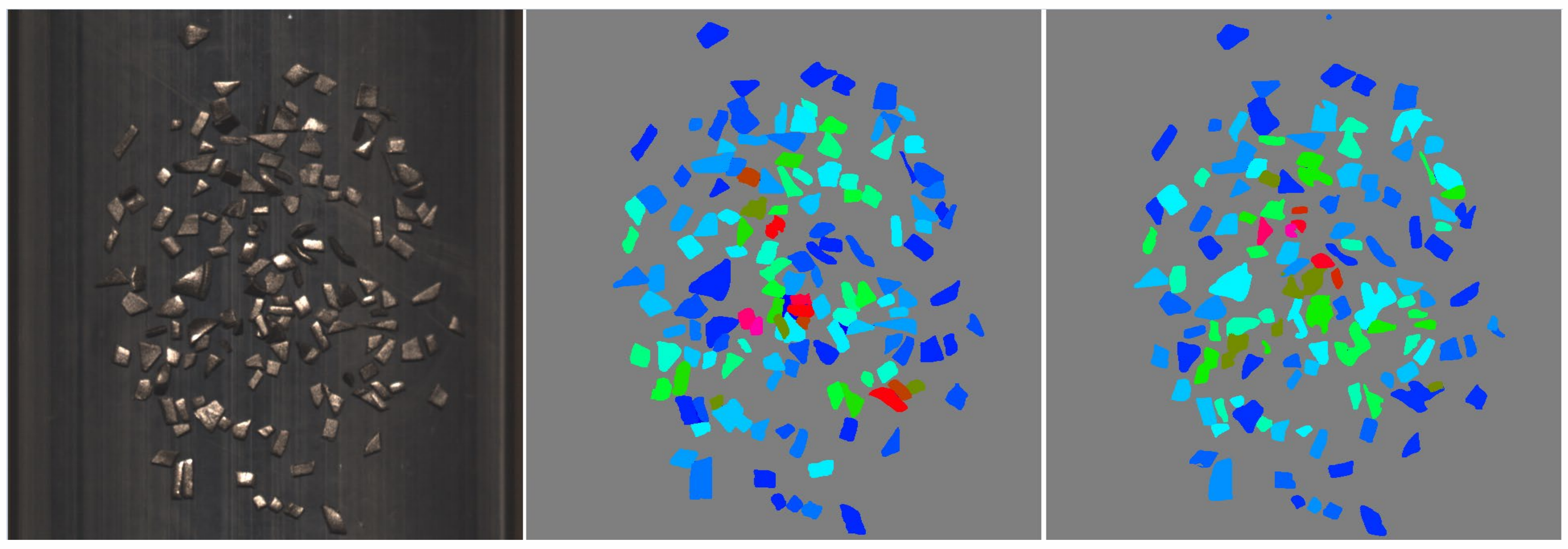
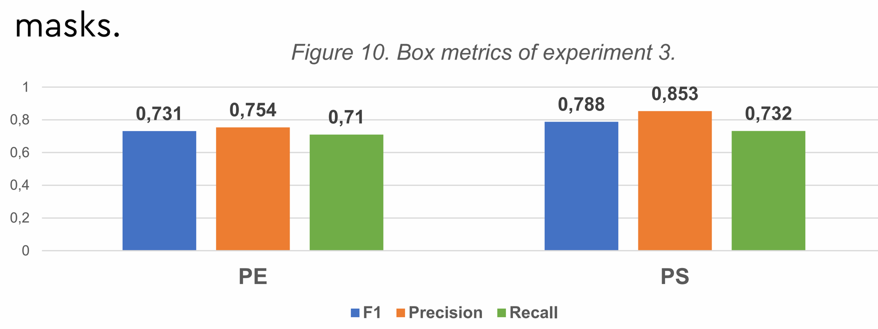
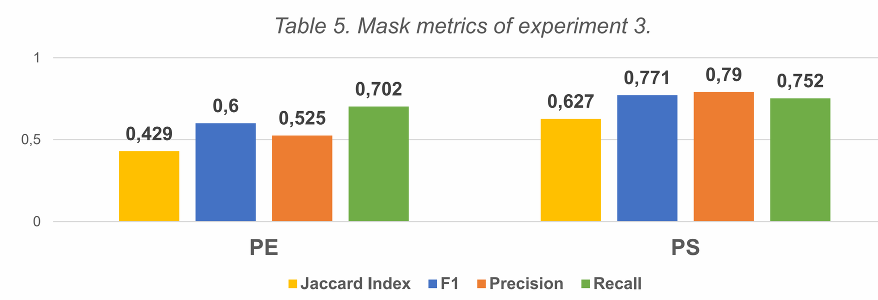


Figure 9. Instance segmentation results of experiment 2. LTR: 'RGB' representation – Target masks – Result masks.





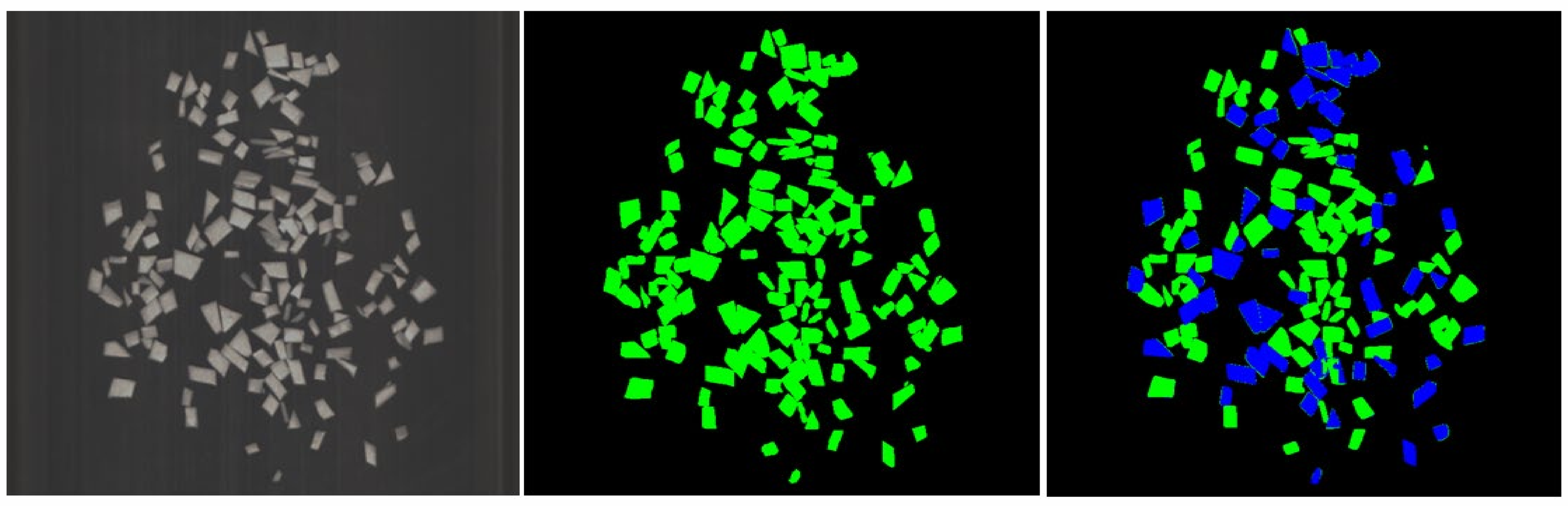


Figure 12. Segmentation results of experiment 2 with the classification results. We can clearly see that classification is not accurate as the target is only one class. LTR: 'RGB' representation – Target mask – Result mask.

Conclusions

- Mask R-CNN in combination with a convolutional layer for dimensionality reduction are shown to be able to process Hyper Spectral Images.
- The Instance mask results are promising as shown by the Jaccard Index in experiment two and by visually inspecting figure 9.
- The classification results are promising but could be improved upon. As shown in figure 12.
- Using a smaller dataset for training, validation and testing, has shown to be able to reach comparable results as to a bigger dataset.

References

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[2] Angeli Mehta. The plastic sorting challenge. 2020
[3] Kaiming He, Georgia Gkioxari, Piotr Dollár, and Ross B. Girshick. Mask R-CNN. CoRR, abs/1703.06870, 2017.
[4] mathworks.com. Hyperspectral data cube and a pixel spectra.