Robotics for Recycling Industry

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Abstract

We designed an autonomous system which is capable of detecting and removing recycled materials from a conveyor belt using deep learning object localization and classification as well as a bi-directional arm with pneumatic suction cups. We also created our own dataset to train our deep learning model and a user interface to correct it during operation. Our project's goal is to help innovate material recovery facilities' sorting methods required to separate materials before they can be recycled.

Dataset

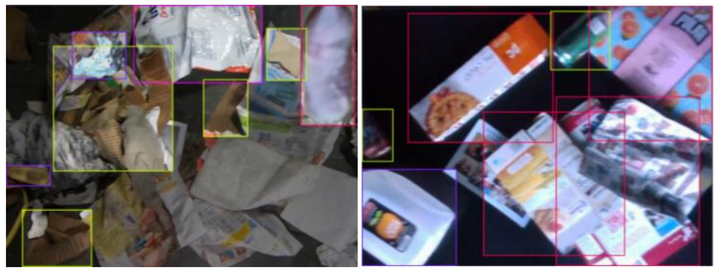

Figure 1: ZeroWasteAug [1] (left) and Sagamore Lab (right)

Model & Training

Model	Size	All (AP)	Card-board (AP)	Metal (AP)	Rigid Plastic (AP)	Soft Plastic (AP)
Faster R-CNN	800 MB	65.45	72.59	65.66	51.60	71.94
YOLOV5	14 MB	68.80	73.40	71.30	56.90	73.50

Table 1: Results on Sagamore Lab test images, model pre-trained on ZeroWasteAug and fine-tuned on Sagamore Lab dataset

Waste Sorting System

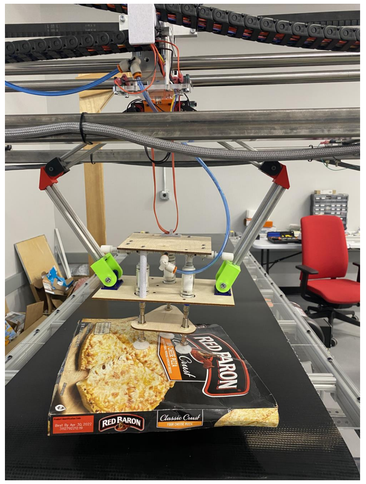

Figure 3: Robotic Arm

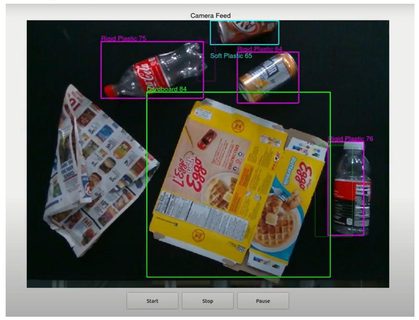

Figure 4: GUI

- **Vacuum gripper**
- **YOLOv5 object detection model**
- **GUI for human robot interaction**
- **Kalman filter combines predictions**

Human Robot Interaction

- **Create, edit, & delete bounding boxes and classifications**
- **Pause camera feed to draw annotations**
- **Start & stop detection system**

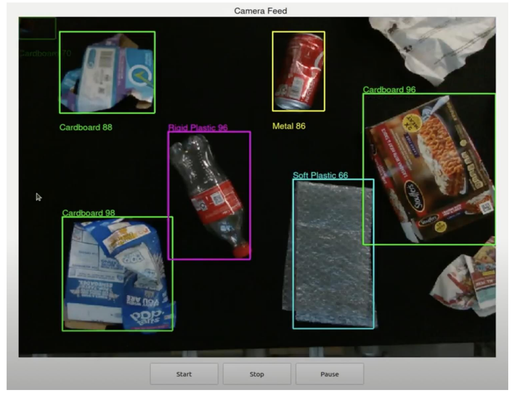

Figure 5: GUI

Vacuum Gripper Design

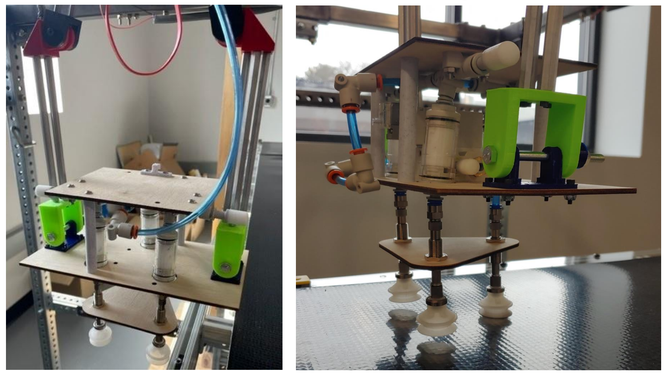

Figure 6: Front and side view of gripper design

- **A new gripper was designed to pick up flat pieces of cardboard**
- **Vacuum gripping was chosen and proved most reliable**

Results

Trial	3 objects without HRI	3 objects with HRI	6 objects without HRI	6 objects with HRI
Detected Total	15 (75%)	20 (100%)	16 (80%)	20 (100%)
Hit Total	13 (87%)	19 (95%)	13 (81%)	17 (85%)
Picked Up Total	11 (85%)	16 (84%)	11 (85%)	14 (82%)
Accuracy	55%	80%	55%	70%

Table 2: Experimental results for 20 rounds of each trial type. In each round the specified number of objects, including one piece of cardboard, were placed on the belt

ROS

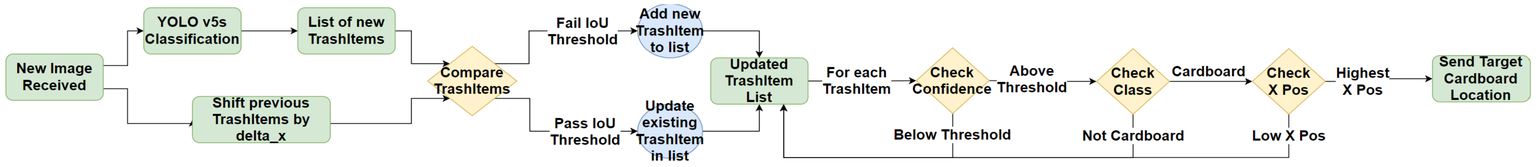

Figure 3: Flowchart for object tracking

Conclusion

- **Successfully created a prototype waste sorting system**
- **Human aid provides valuable feedback to improve system accuracy**
- **Vacuum gripping has more possibilities than just flat pieces of cardboard**
- **Future work might utilize multiple active robots and grippers specialized toward different materials**

[1] Bashkirova, D., Abdelfattah, M., Zhu, Z., Akl, J., Alladkani, F. M., Hu, P., Ablavsky, V., Calli, B., Bargal, S. A., Saenko, K.. ZeroWaste Dataset: Towards Automated Waste Recycling. In CoRR, vol. abs/2106.02740, arXiv preprint arXiv:2106.02740v3, 2022.