



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

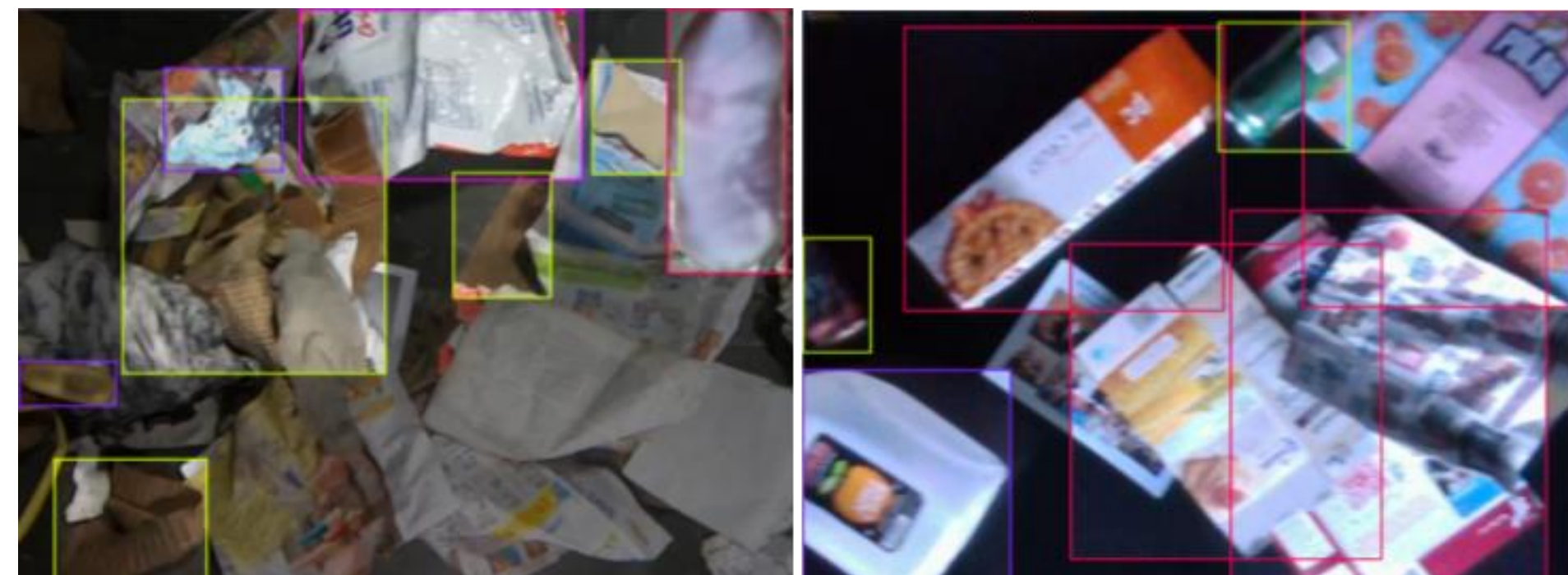


Figure 1: ZeroWasteAug [1] (left) and Sagamore Lab (right)

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

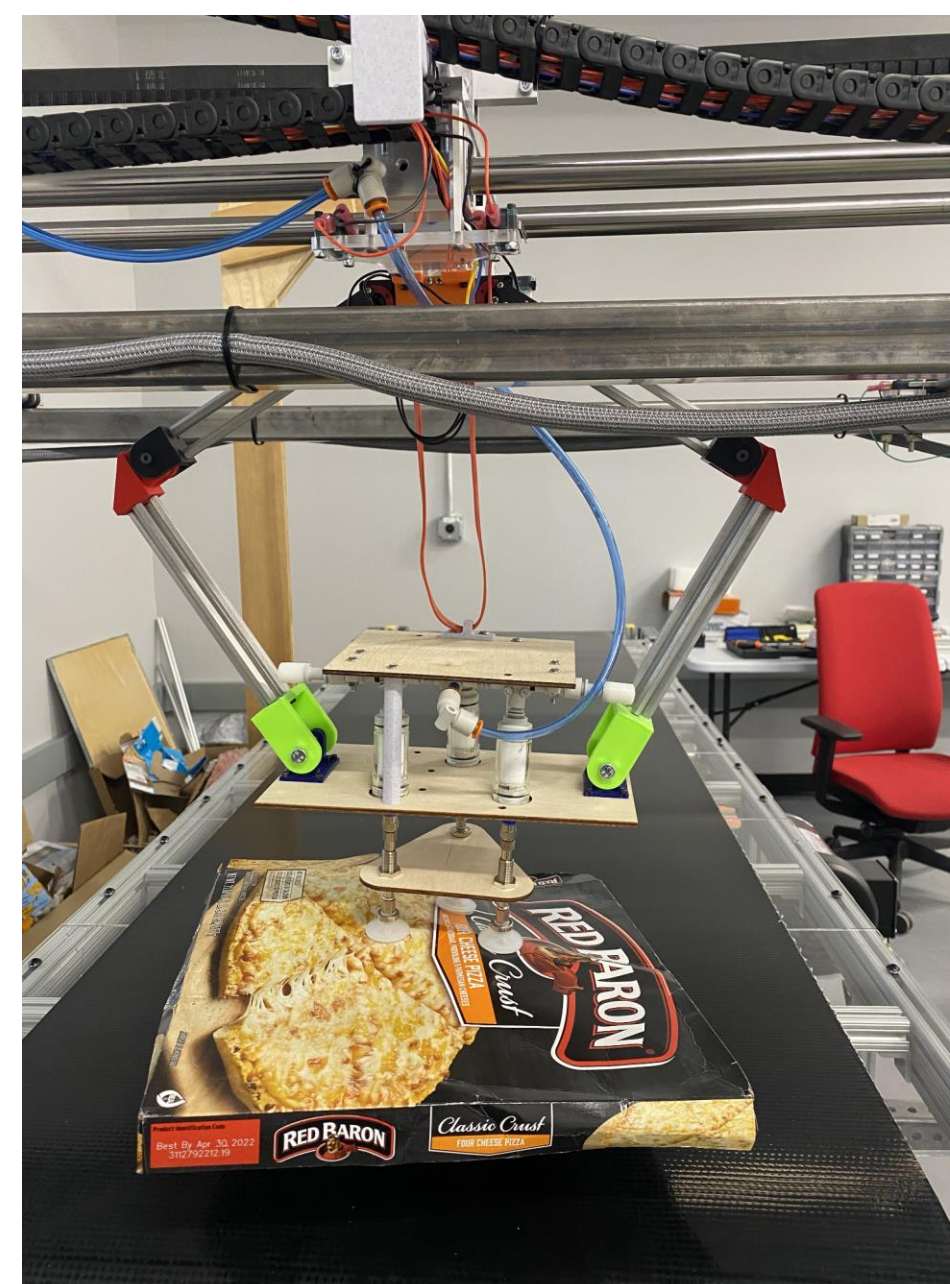


Figure 3: Robotic Arm



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

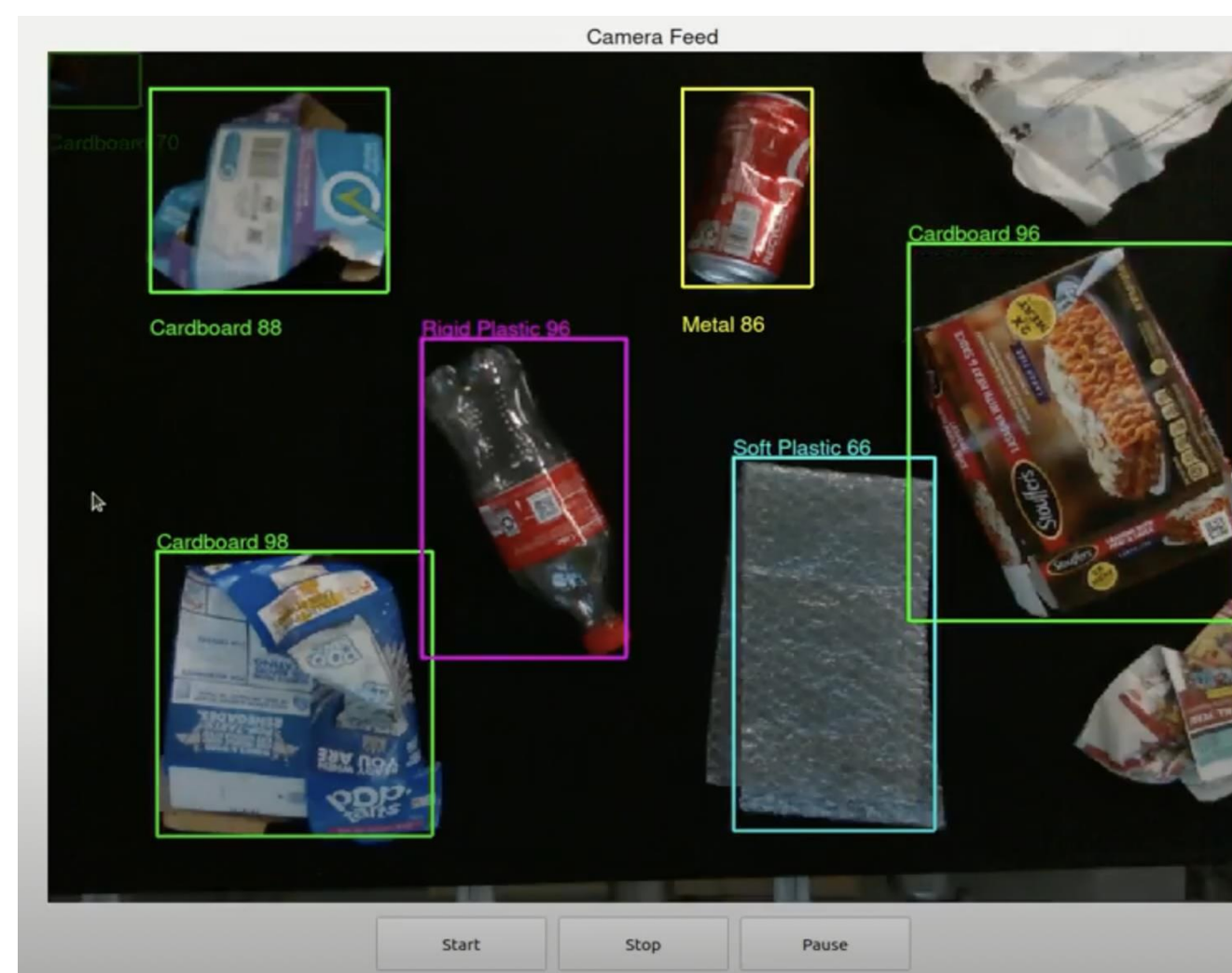


Figure 5: GUI

Vacuum Gripper Design

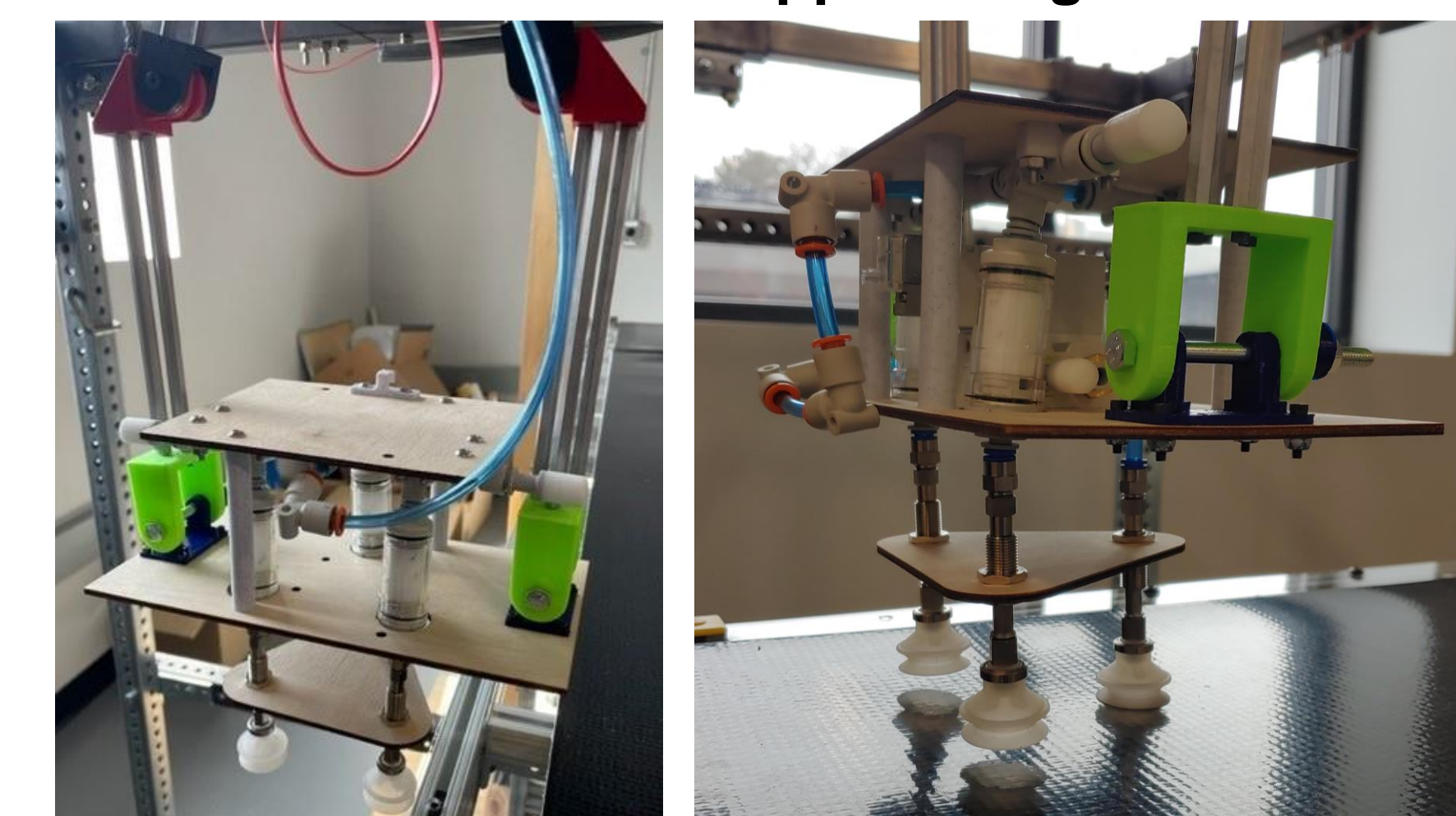


Figure 6: Front and side view of gripper design

- 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

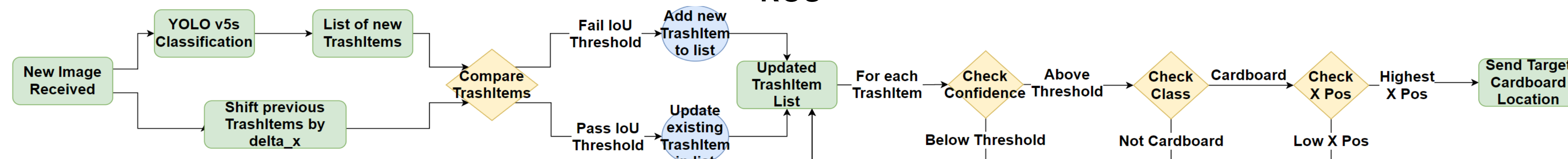


Figure 3: Flowchart for object tracking

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