College of Engineering
MICHIGAN STATE UNIVERSITY

AMPROBOTICS®

Surplus Store and Recycling
managing waste as a resource

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Maximizing Use & Efficiency of Robotic Sorting Technology

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Introduction

AMP Cortex [1] is a powerful robot arm and vision system that sorts recyclable materials in place of human sorters at MSU's Surplus Store and Recycling Center (SSRC) [2].

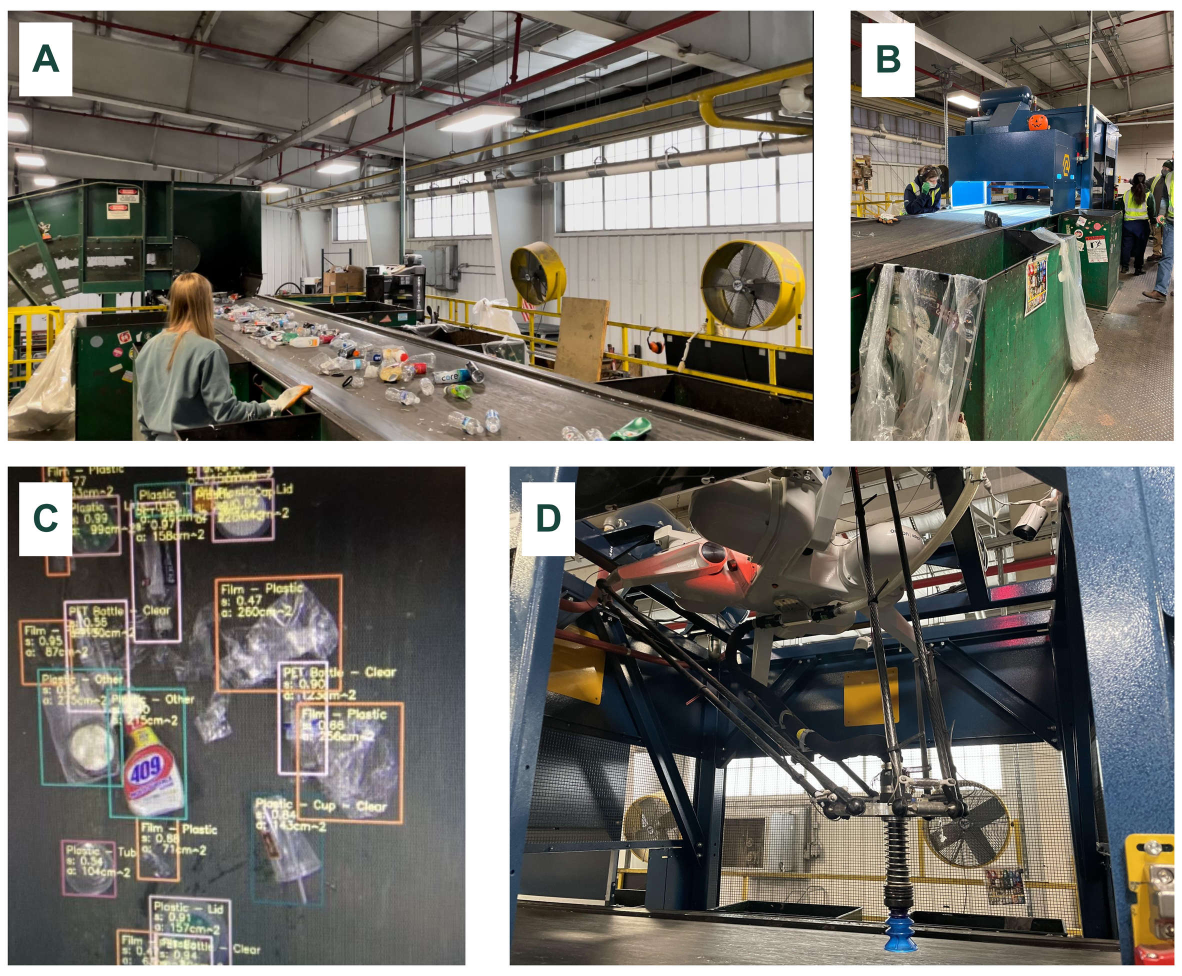


Figure 1: AMP Cortex system integration at the SSRC. (A) Conveyor line leading up to the Cortex. (B) Cortex system. (C) Screen capture of the Neuron System. (D) Robotic sorting arm.

This project aims to improve the sorting system by decreasing the potential hazards that the workers and robot might face through three major objectives:

1. Increase the efficiency of the Cortex system through changes to the operations at the SSRC.
2. Decrease downtime for cleaning by the addition of chute shield components.
3. Develop a depth sensing mechanism to improve efficiency of the robot and indicate hazards.

1. Operations

The Cortex system allows users to set priority on a 5-point likert scale from lowest to highest. This project explored manipulating the priority to match and reverse the order of the recyclable materials most commonly encountered. Additionally, due to problems with collisions between materials on pick attempts, pre-sorting the line by height of the object was explored.

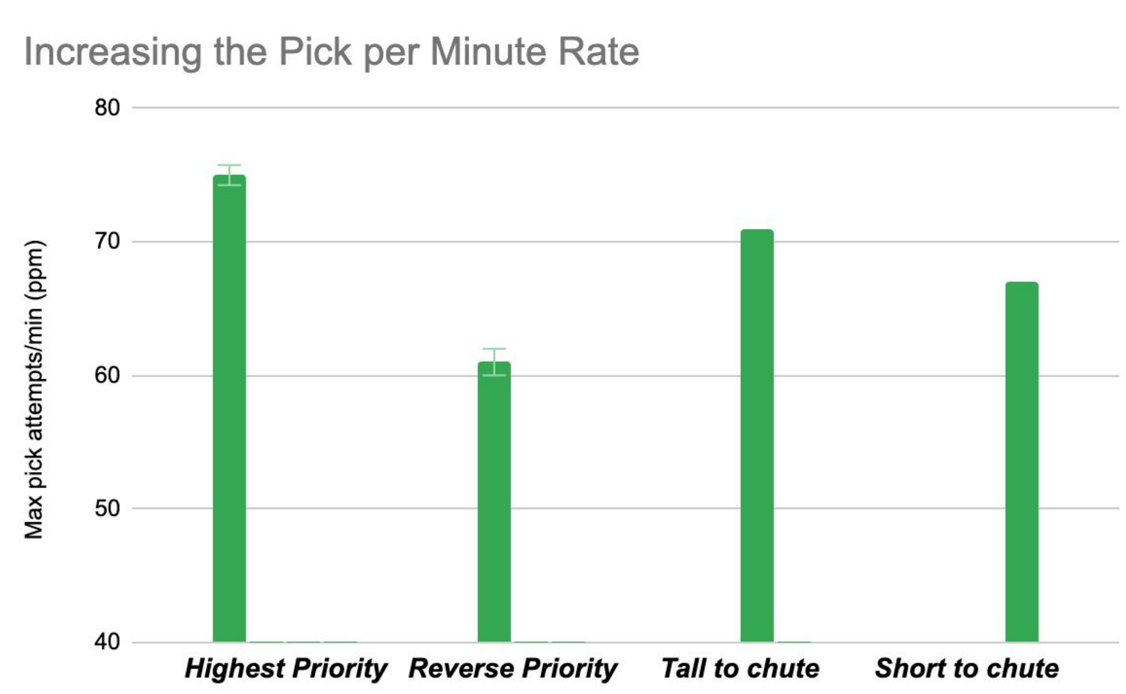


Figure 2: Maximum picks per minute (ppm) of 1 L of unsorted material for priority and presorting experiments.

Assigning higher priorities to plastics that the robot is on average more likely to encounter yields a higher ppm rate. Moving taller recyclable materials closer to the side of the chutes yields a slightly higher ppm rate.

2. Chute Shields

Material previously lodged between chute openings and the cage leading to downtime for cleaning out the cage (Fig 3). Non-targeted material also spilled over into chute openings causing contamination.

Figure 3: Clogged material around chute openings.

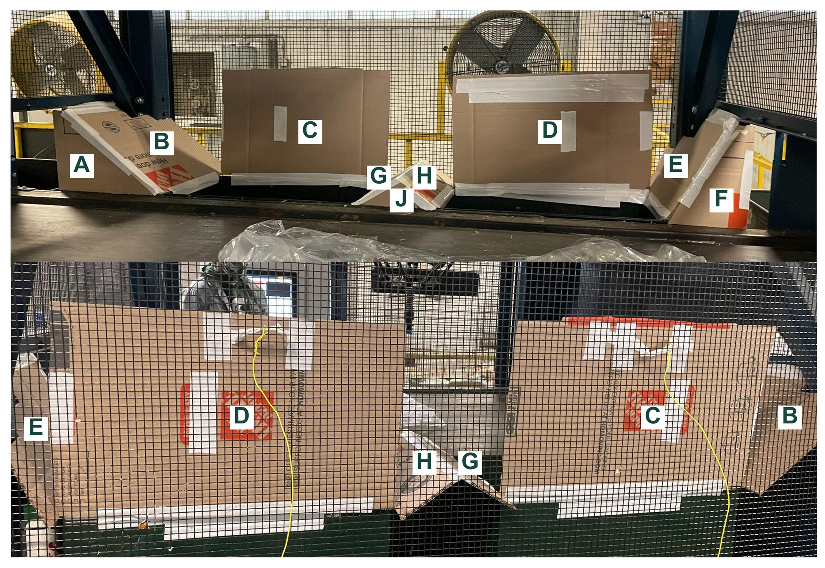


Figure 4: Prototyped chute shield components out of corrugated board and duct tape as installed at the SSRC.

Prototyped components in Fig. 4 block the gaps between the chute openings and cage. Components C and D are on hinges to prevent spillover when the robot is off.

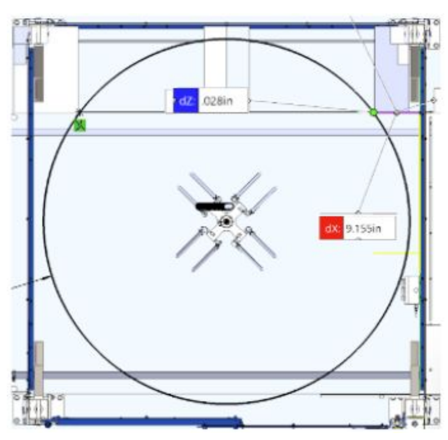


Figure 5: Working zone of the robotic arm.

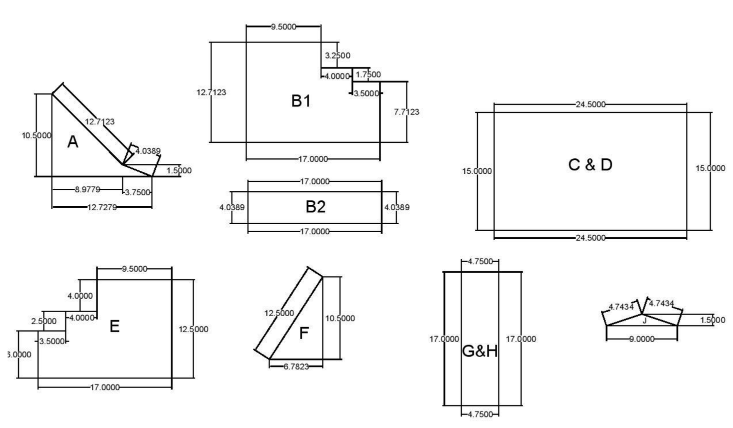


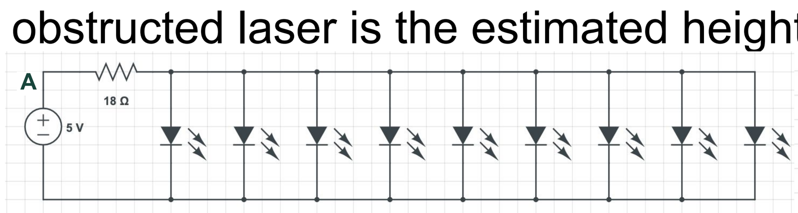
Figure 6: Final component dimensions for steel and plexiglass chute shields.

To prevent harm to the robotic arm within the working region (72" diameter), the height of chute shield components remain under 1.5". Component A in Fig. 6 is variably sloped to accommodate this constraint.

3. Depth Sensing

To prevent unintended collisions with the Cortex arm and with other recyclables on the line, two depth sensing methods were explored: Laser Ladder and LiDAR.

Laser Ladder consists of a set of 9 lasers and a set of 9 corresponding photoresistors. The highest non-obstructed laser is the estimated height of the object.



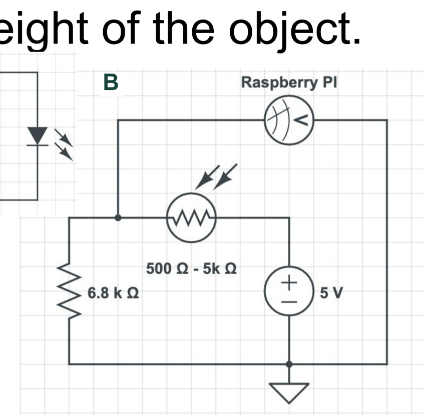


Figure 7: (A) The Laser Ladder transmitter circuit. (B) The Laser Ladder receiver circuit.

Figure 8: Wiring of the Laser Ladder.

The LiDAR method uses the Slamtec A1M8 RPLidar sensor and interfaces with a Raspberry Pi. 1D depth scans are translated into heights off of the ground and concatenated to create 2D depth maps (Fig. 9).

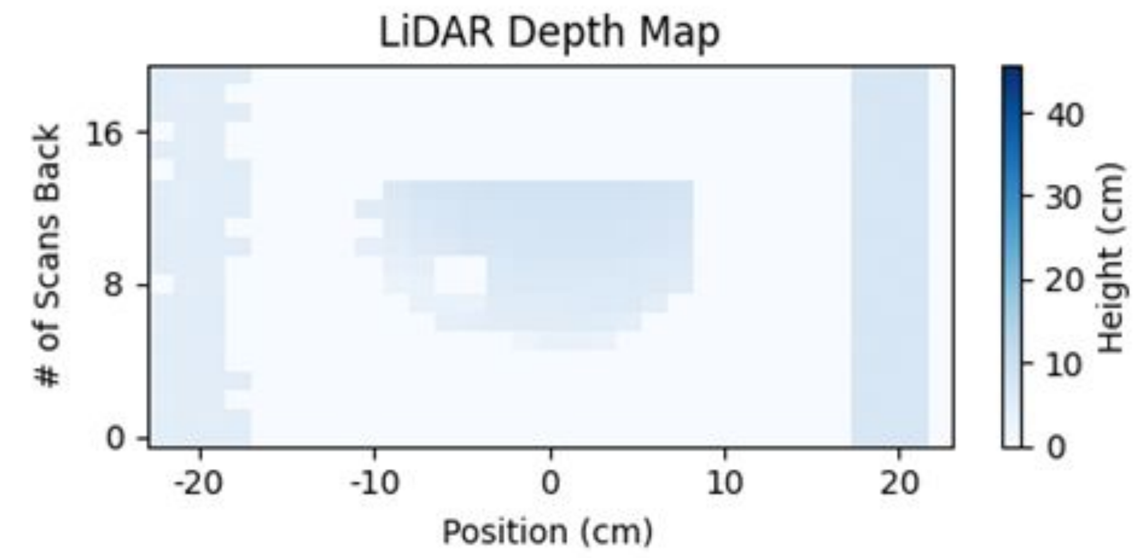


Figure 9: 2D depth map of a bottle of dish detergent.

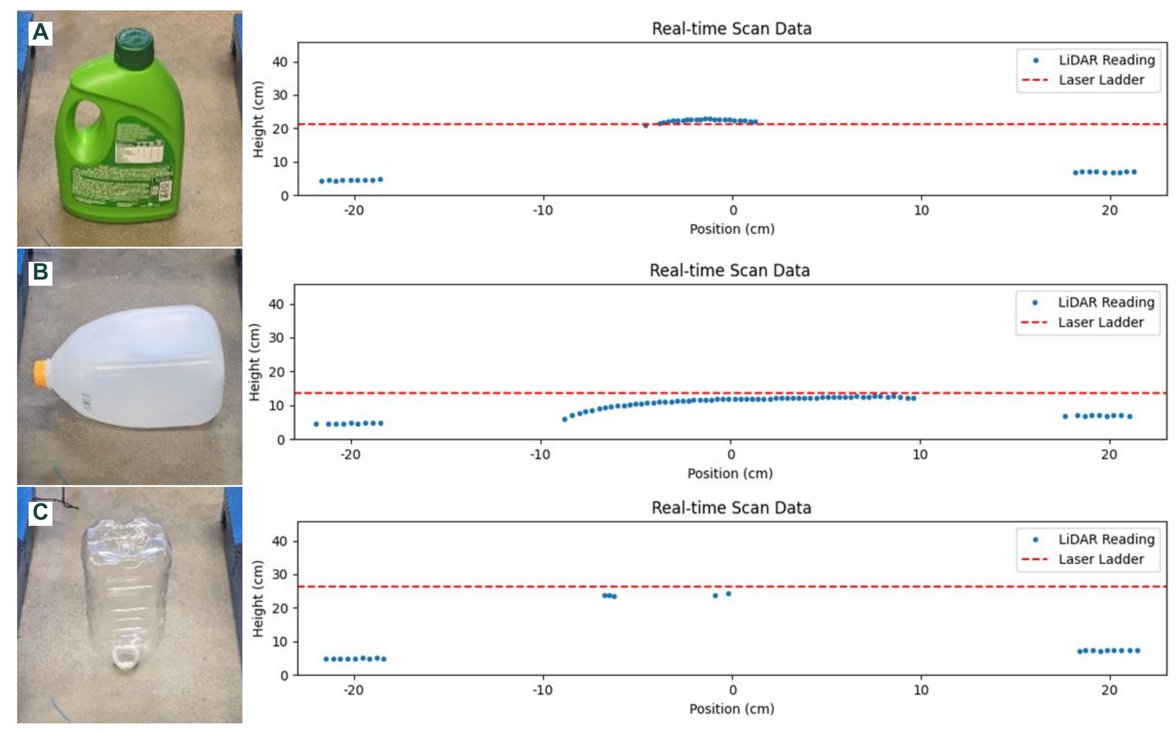


Figure 10: Scan of the (A) opaque object, (B) translucent object, (C) transparent object.

The LiDAR system is able to detect correct heights for objects that are opaque or translucent. For transparent objects, the results were much less accurate.

The Laser Ladder system has marginally more consistent readings for transparent objects, but it only detects highest object and is limited by laser spacing.

Conclusion

Through this project we were able to successfully assist the SSRC identify methods to increase sorting efficiency, implement a design for chutes to reduce spillover and downtime, and provide a prototype to estimate depth for future integration into the Cortex Neuron system.

Future Work

Future work includes investigations into more variables for improving the ppm rate of the robotic sorting system such as the suction cup replacement schedule and the plastics in each bunker. The steel and plexiglass chute shields should be implemented and tested. Integration of the depth sensing methods in the AMP system should also be explored.

References

[1] AMP Robotics. [Online]. Available: https://www.amprobotics.com/. [Accessed: 04-Feb-2022].
[2] "MSU recycling," MSU Recycling Center. [Online]. Available: https://msurecycling.com/. [Accessed: 04-Feb-2022]

Acknowledgements

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