Maximizing Use & Efficiency of Robotic Sorting Technology

ECE 480 Design Team 16

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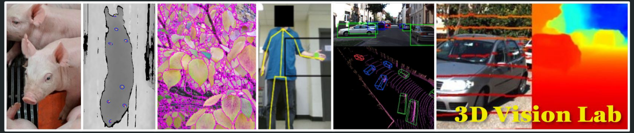
Mr. Dave Smith, *MSU Surplus Store & Recycling Center*

Facilitator:
Dr. Daniel Morris, *Michigan State University*



Introduction

- The MSU Surplus Store recycled over 2800 tons of recyclable commodities in 2019.
- Most commercial factories have a fully automated sorting process; MSU doesn't.
- Recently, MSU purchased an AMP Cortex for improvements in safety and efficient.
- **Currently, the AMP Cortex's is not being maximized.**
- **Work to get student hands off of the line.**

MSU's AMP Cortex

Introduction

Objectives

1. Optimize the use of the AMP Cortex Robot at MSU's SSRC
2. Design additions to the chutes to decrease spillover and downtime
3. Determine the burden depth of the recyclables on the line

Objective 1

Operations

Austin Anthony

- Develop recommendations for MSU's SSRC that:
  - Maximize the use of the robotic sorting technology
  - Increase the number of picks per minute performed by the robot

Increasing the Efficiency of the AMP Cortex

- AMP Robots ideally operate at 80 ppm
- The AMP Cortex at MSU is currently operating around 50 ppm
- The two variables explored that impact the pick per minute rate: Pick Priority and Manual Presorting
- Our technical approach to explore what increases the pick per minute rate was to carry out 1L controlled experiments

AMP Cortex Robot [1]

Experiment Results

- Higher priority to most likely to be encountered
- Taller items presorted closer to the chute

Objective 2

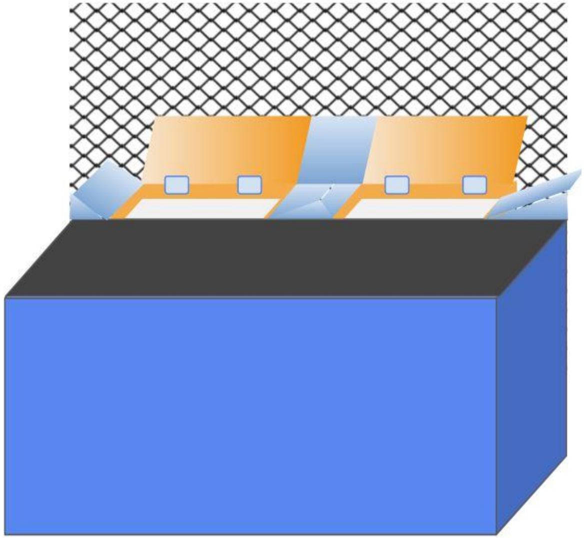
Chute Shields

Katie Albus

- Design chute shields to:
  - Prevent ricochetting
  - Prevent clogging
  - Prevent spillover

Technical Approach - Chute Shields

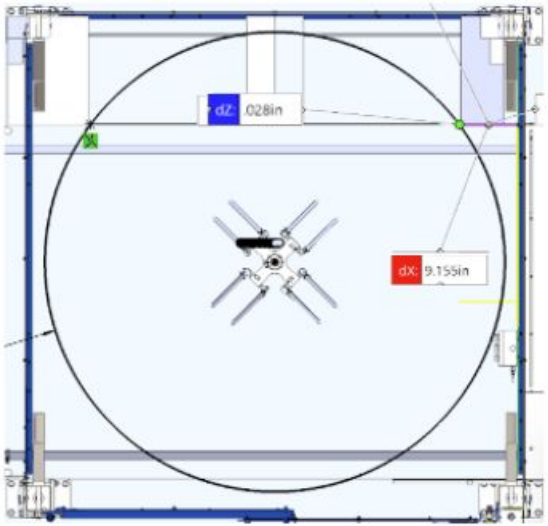
Proposed Method



Prototyped Method

- Initial prototype remained very similar to the proposed chute shield design
  - No back panel between the hinged chute shields

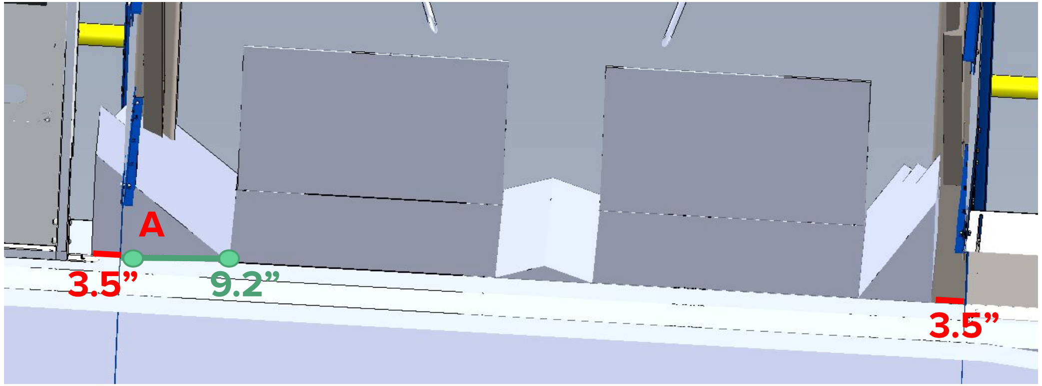
Design Iterations - Chute Shields

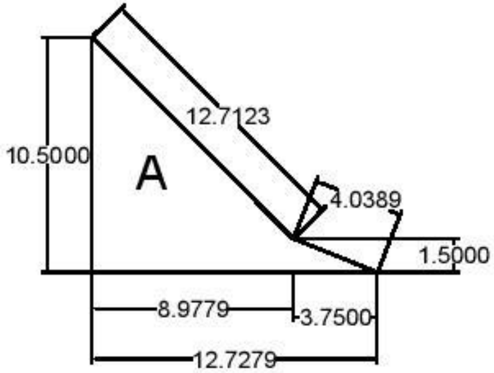


Prototyped Method

- Working zone of 72” diameter
- Must remain under 1.5” maximum

Design Iterations - Chute Shields





- 3.5” difference between AMP Robotics design and the actual installation
- Working zone intersects the conveyor line at 9.2”
- Redesigned the upstream diverter to accommodate the height maximum
  - Changed to a variable sloped design

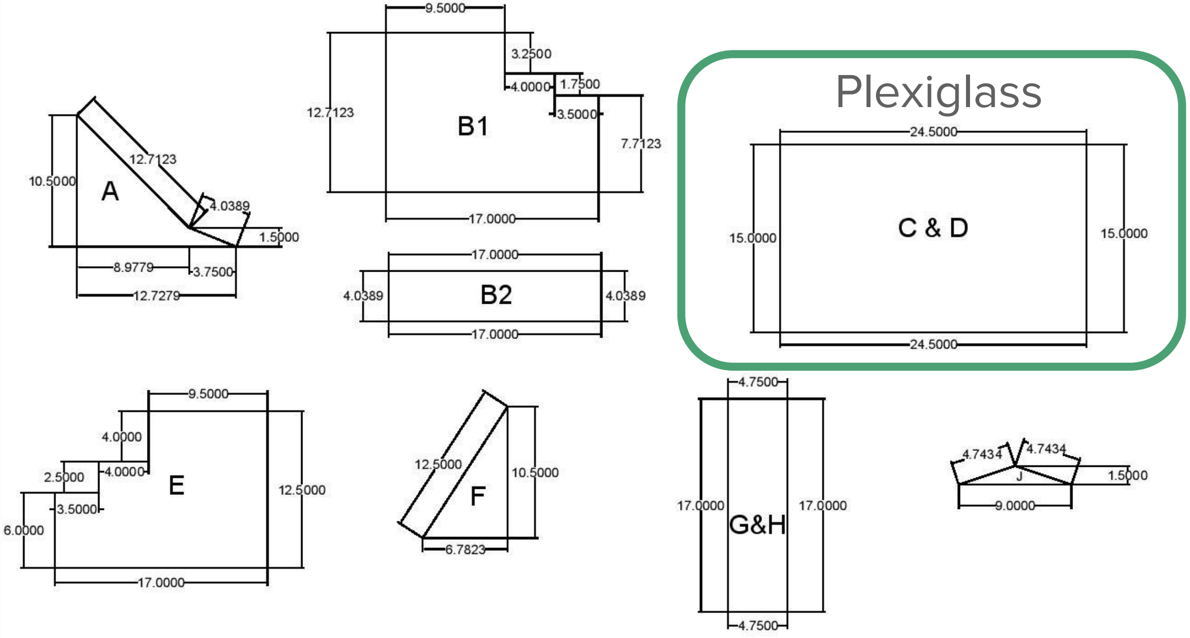
Testing - Chute Shields

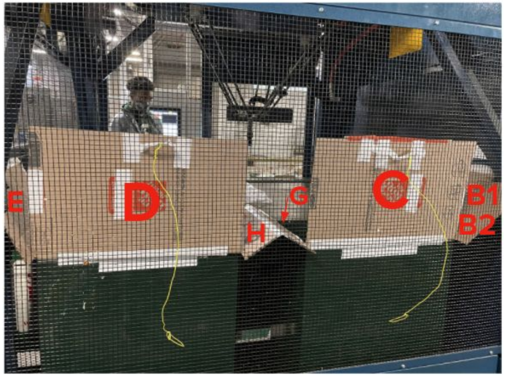
Before the prototype

After the prototype

- Reduction of the clogged material after installation of the prototype shields
- Ability to close the hinges reduced spillover into the chute openings

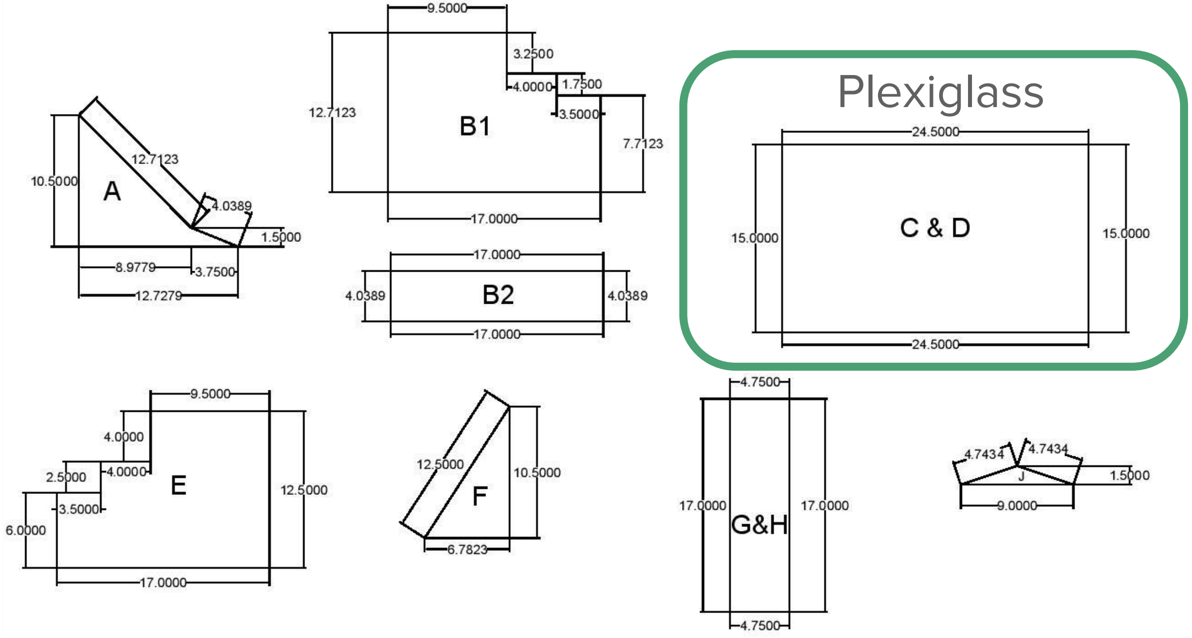
Next Steps - Chute Shields





- Order materials
- Cut steel components
- Weld to the chute openings

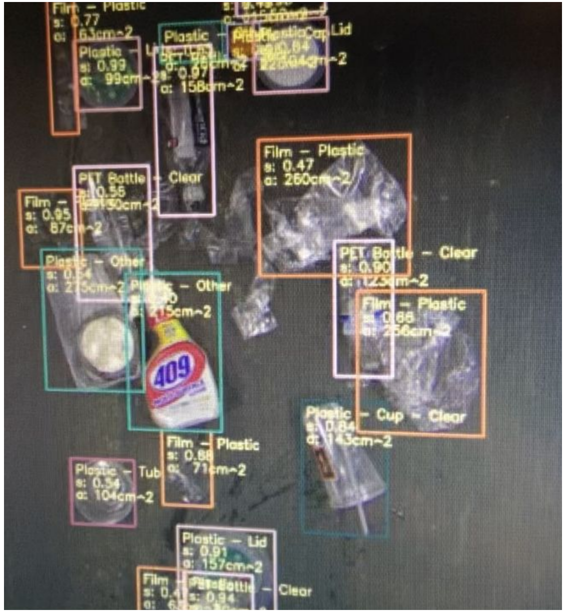
Next Steps - Chute Shields



- Prevent scratching and rattling against the cage
  - Reduce dimensions of steel components by ¼”
  - Pad edge with foam

Objective 3

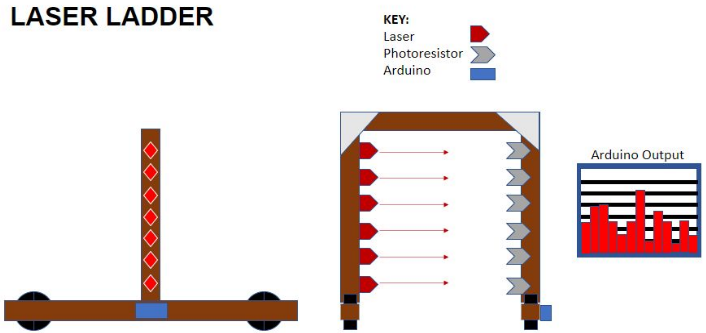
Burden Depth



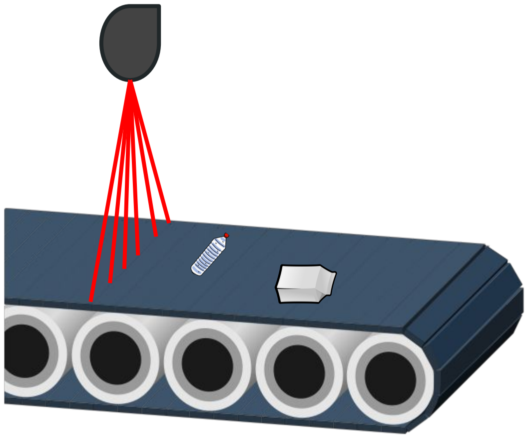
Hardware:
Jarrett Blumke & Sepehr Rahgozar
Software/Interfacing:
Jacob Honer & Sam Church

- Design and prototype a sensor system that:
  - obtains a depth estimate of the recyclable on the line
  - is real-time
  - has high accuracy
  - can be used to redirect the robotic arm trajectory

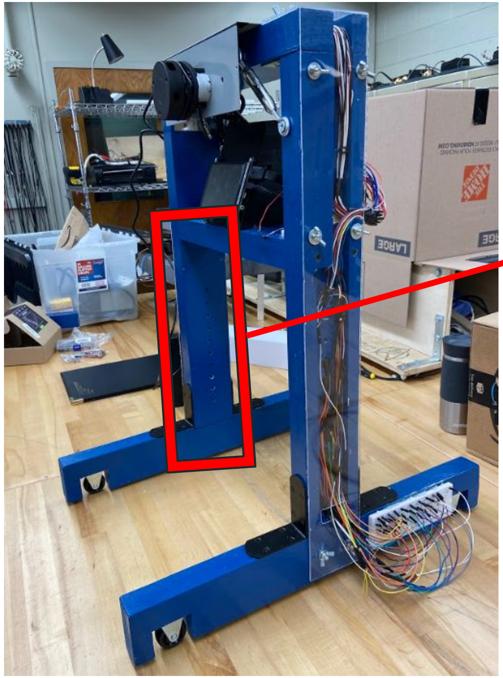
Technical Approach 1
Laser Ladder

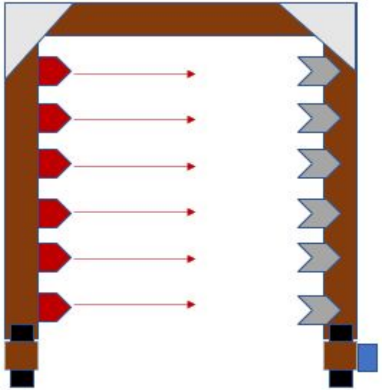


Technical Approach 2
LiDAR Sensor



Technical Approach 1 - Laser Ladder

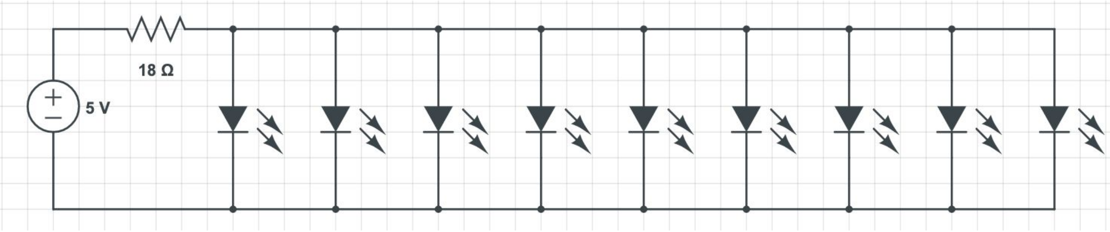




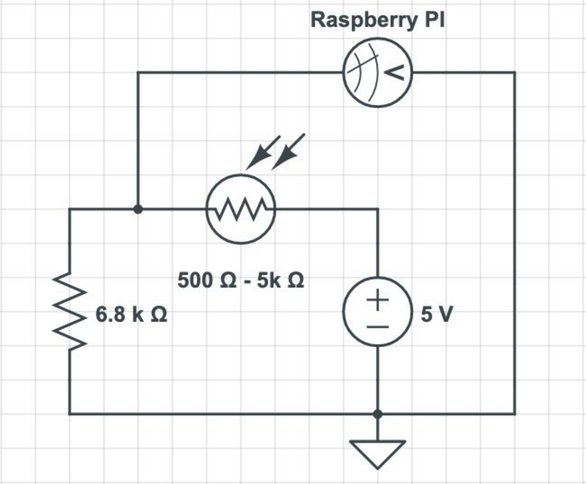
- Uses Laser Diodes and Photoresistors to collect depth data.
  - Could be implemented as a safety system
  - Not as accurate as other solutions (LiDAR)

Technical Approach 1 - Laser Ladder (Circuitry)

1) Laser Connection Diagram



2) Photoresistor Detection Diagram

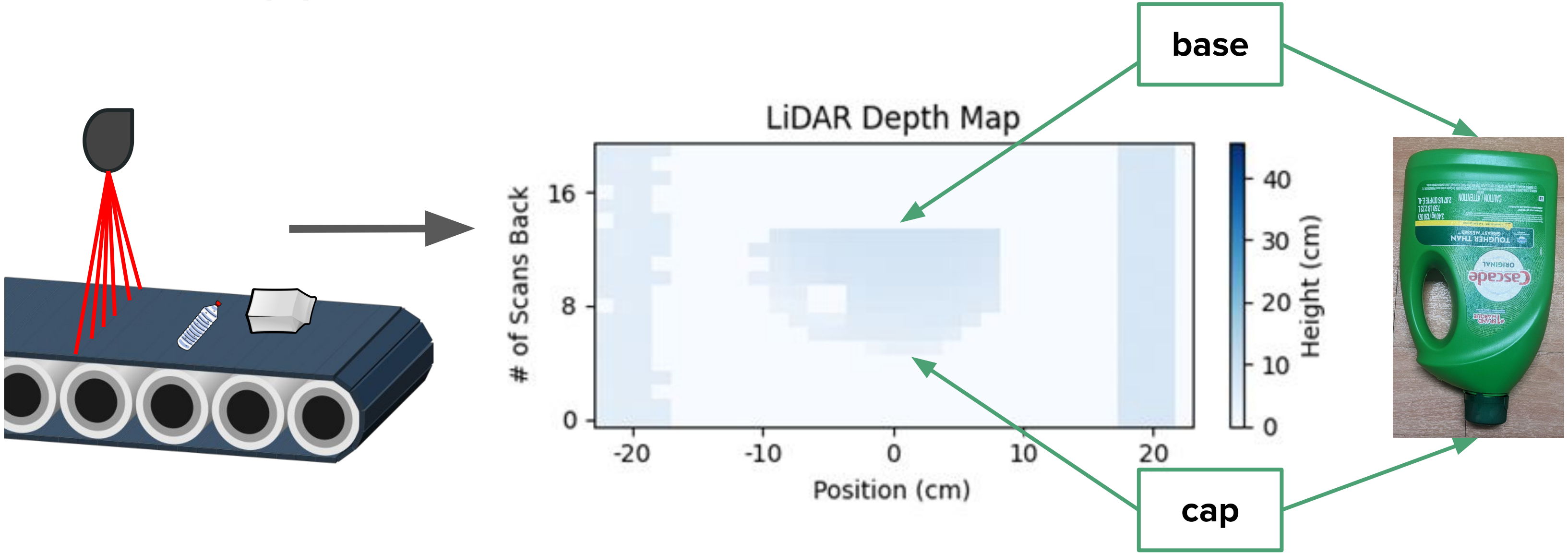


GPIO Voltage Detection:

Less 1 V = LOW (0)

Greater 2.5 V = HIGH (1)

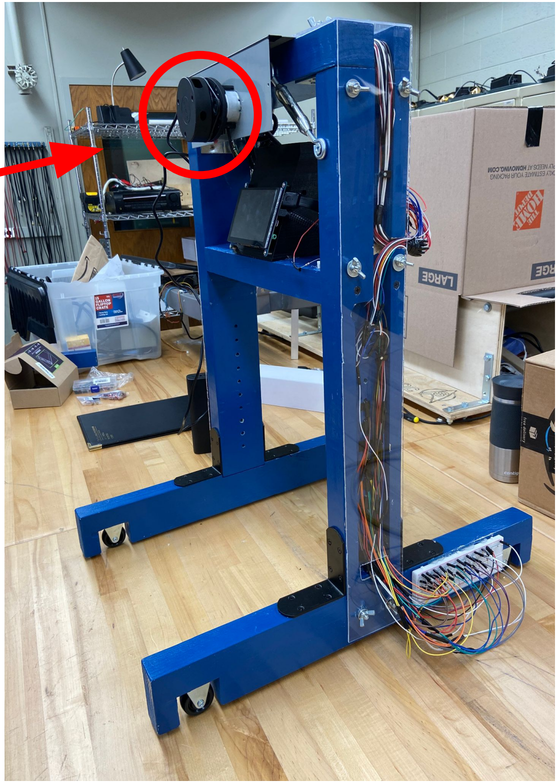
Technical Approach 2 - LiDAR Sensor



- Use LiDAR sensor to generate real-time depth mapping
- High accuracy, higher cost compared to the Laser Ladder
- Struggles with clear plastics

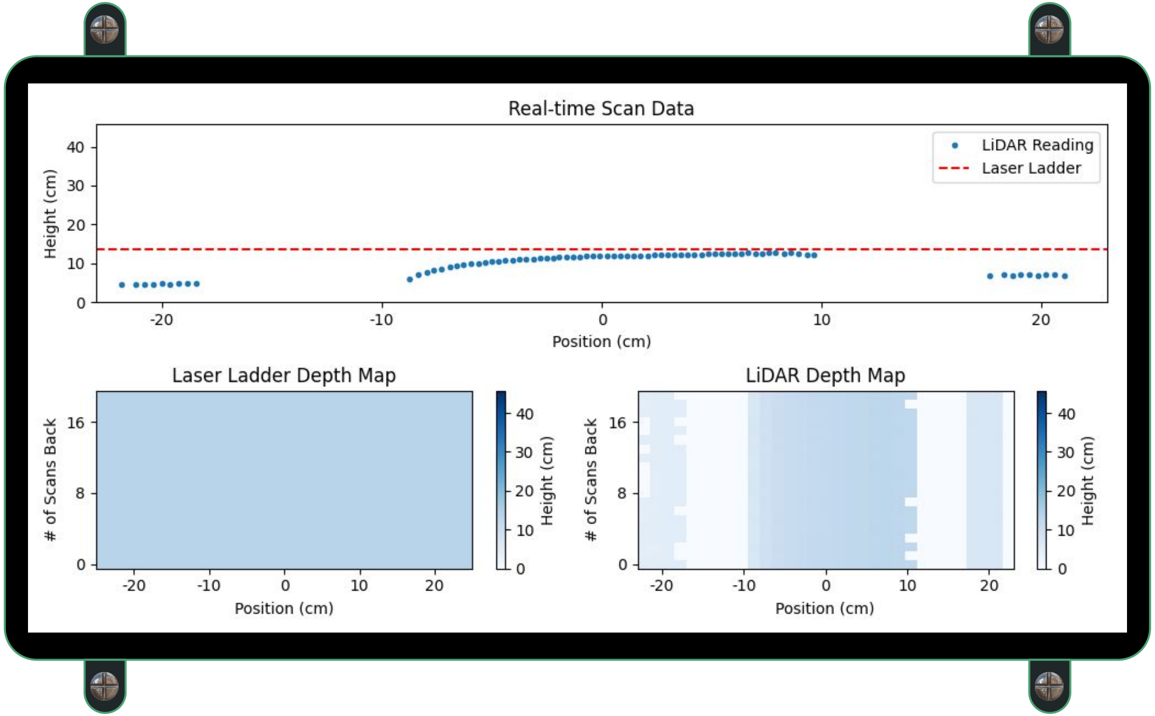
Technical Approach 2 - LiDAR Sensor

Slamtec RPLIDAR A1M8 [2]



- Up to 10 Hz
- Resolution < 1% of actual distance
- 8000 Samples/s

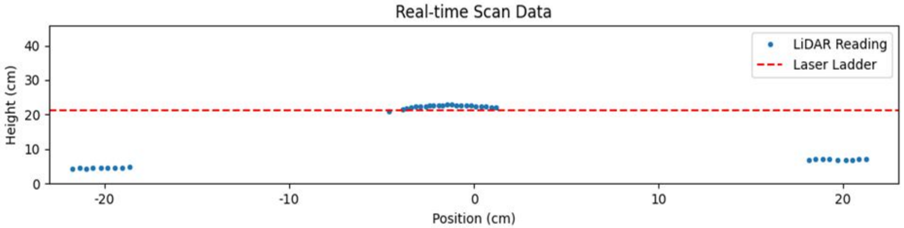
Technical Approach 2 - LiDAR Sensor Software

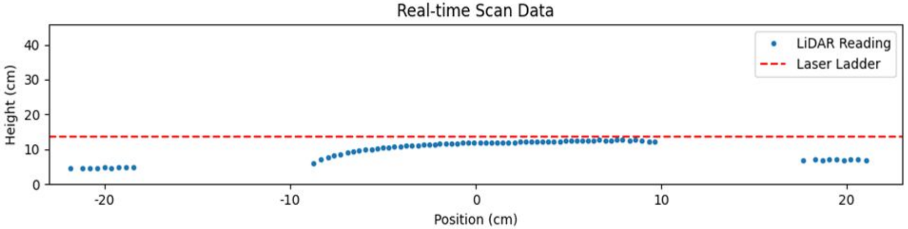


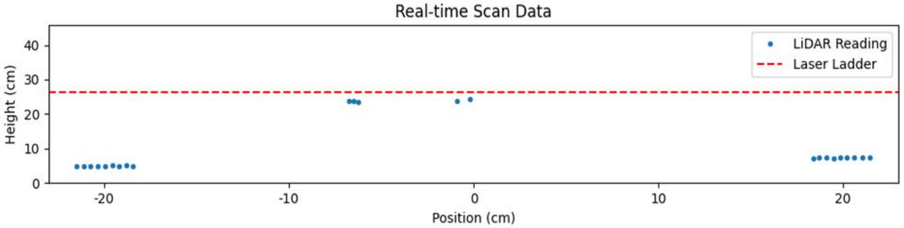
One C++ program to handle both Laser Ladder and LiDAR Sensor

- Slamtec's LiDAR SDK [3]
- Matplotlib for C++ [4]
- GPIO for Raspberry PI [5]

Performance Results - Burden Depth







Testing light transmission:

- opaque - good
- translucent - good
- transparent - struggles

Future Improvements - Burden Depth

- Evaluate necessity of transparent object burden depth
- Look into solutions performing better on transparent objects
    - e.g., ultrasonic sensors
- Test depth sensing on recycling line
- Interface with AMP Cortex System
    - Integrate depth information into machine learning
- LiDAR Sensor
    - Increase rotation rate to 10 Hz
    - Process readings on separate thread from visualization
- Laser Ladder
    - Better height resolution (decrease distance between lasers)

Project Budget

Part	Cost
Computing power/required equipments	$289.63
Laser Ladder structure components	$62.45
Accessories	$33.46
Total	**385.54**

Demo

Thank you! Questions?

References

[1] https://www.amprobotics.com/ampcortex

[2] https://www.slamtec.com/en/Lidar/A1

[3] Slamtec (2021) rplidar_sdk (Version 2.0.0) [Source code].

https://matplotlib-cpp.readthedocs.io/en/docs/index.html#.

[4] Evers, Benno (2021) matplotlib-cpp [Source code].

https://matplotlib-cpp.readthedocs.io/en/docs/index.html#.

[5] abyz (2021) pigpio [Source code]. https://abyz.me.uk/rpi/pigpio/index.html.

Next Steps - Chute Shields

Name	Part Number	Quantity	Cost per item	Total Cost
800 lbs. Capacity Zinc Plated Steel Tie-Down Ring	3076T35	2	1.08	2.16
Extra-Flexible Coated Wire Rope—Not for Lifting	8923T517	1	1.47	1.47
Mortise-Mount Entry Door Template Hinges	1494A43	4	7.60	30.40
High-Strength Grade 8 Steel Hex Head Screws	91268A503	2	9.23	18.46
Low Carbon Steel Sheet	6544K17	2	37.10	74.20
				$126.69

Technical Approach 1 - Laser Ladder

- Benefits:
  - Cost-efficient
    - Used 8% of the total cost
  - Easy to diagnose
  - Could be implemented as a safety system

- Drawbacks:
  - Not as accurate as other solutions (LiDAR)
  - Requires recalibration if the surrounding light changes