John Deere Team 56

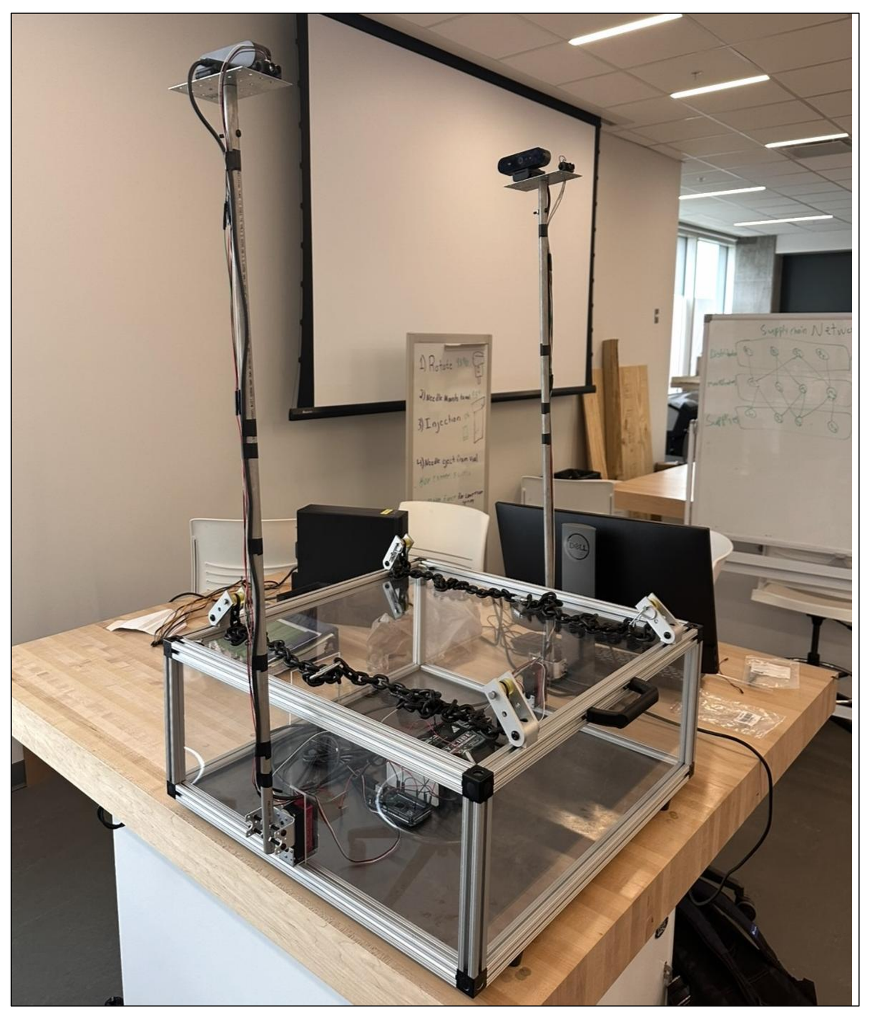
Conveyor Preventative Maintenance

Team Members: Tristan Ehman, Ryan Elmore, Joshua Kim, Patrick Berger
Mentor: Ralph Munguia

Purdue University
Polytechnic Institute

OBJECTIVE

The objective of our project is to create a computer vision machine learning system that notifies the client when weld cracks and failures occur. The system should be compatible with the current track system at John Deere for seamless implementation and have self-sufficient power that lasts for the entire conveyor ride.



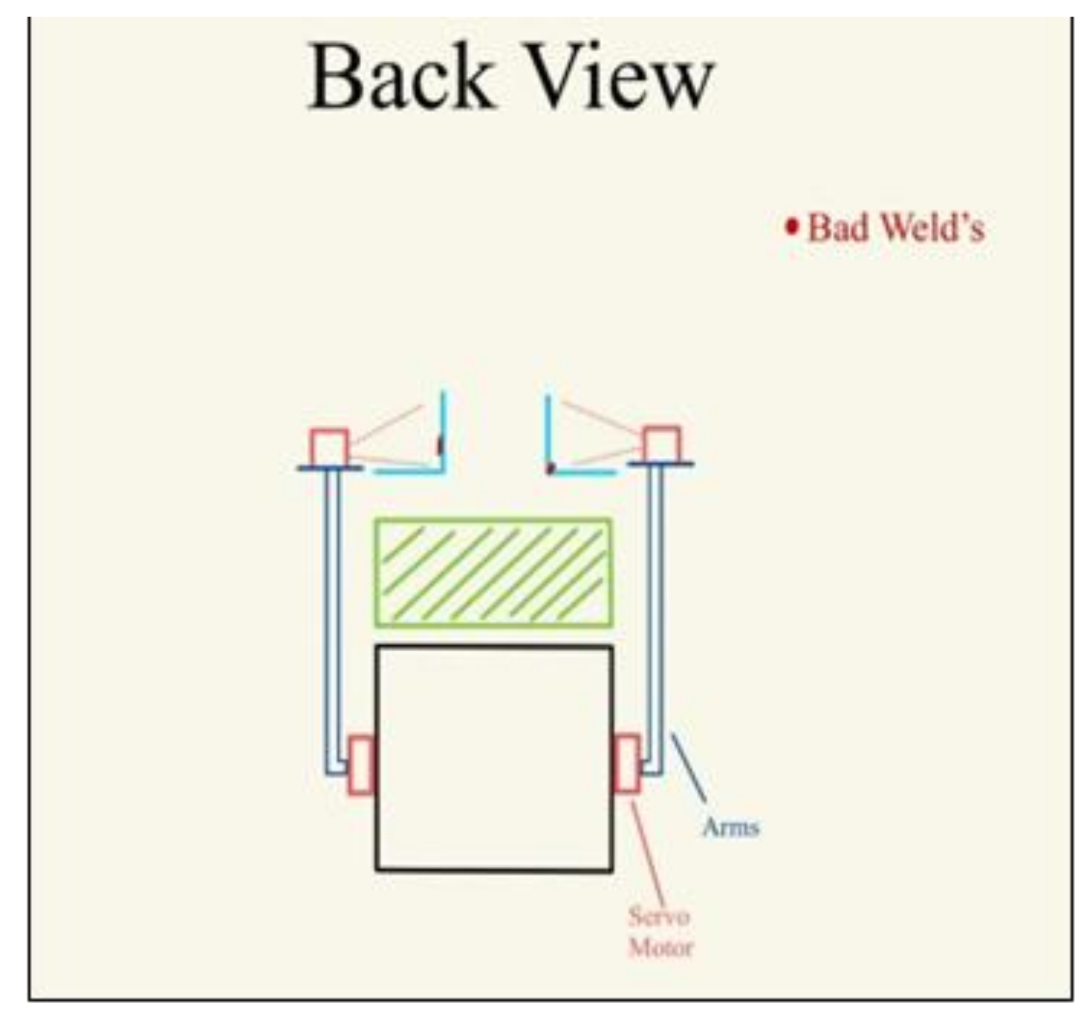
CUSTOMER PROBLEM AND BACKGROUND

Currently, John Deere does not utilize any automated systems for preventive maintenance at its manufacturing plant. Instead, maintenance checks are performed manually on an annual basis, relying heavily on human labor. This traditional approach has proven to be inefficient, often resulting in unplanned production downtime and increased operational costs. More critically, it poses safety risks due to the need for personnel to inspect and service heavy overhead equipment.

In recent observations, the plant has experienced recurring weld-related issues, including fractures and structural failures, which present both safety hazards and potential disruptions to manufacturing output. While solenoid failures have also been noted on occasion, these incidents are generally less frequent and pose minimal safety concerns in comparison to the weld defects. The lack of a predictive or condition-based maintenance strategy leaves the facility vulnerable to preventable failures and operational inefficiencies.

CONCEPTS AND EXPERIMENTATION

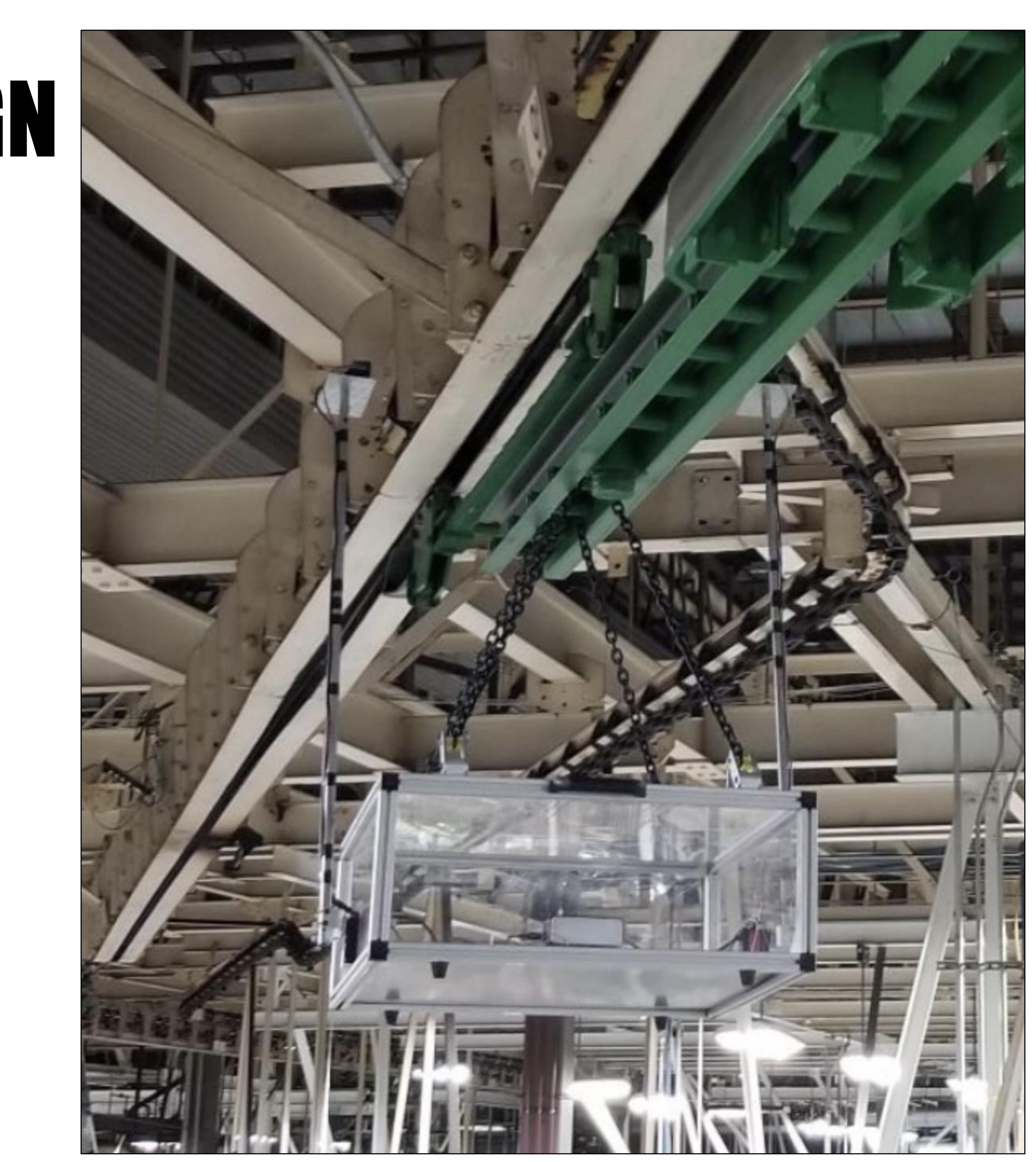
Our first iteration consisted of a platform like base to mount all systems and electronics. This base would be attached to a preexisting system so it can travel with the conveyor. This plan implemented vibration detection sensors, cameras, and distance detection sensors on two wide but flat arms that bend in towards the center. With a battery for power paired with a computer system, a weld detection program would run and send notifications to the users at John Deere. Our team then revised this iteration to improve mounting points and the addition of an arm on the bottom for easier installation. After experimentation, our team met with John Deere and determined these iterations would not fit within the given part window. Our team then developed a new prototype idea which consisted of a box connected to the conveyor via chains with LIDAR sensors, lights, and cameras at the top. With this new prototype idea, our team began construction on the system that is seen today.



REQUIREMENTS AND FINAL DESIGN

The requirements for our system included being self-sustaining for several hours while roaming the track, the ability to automatically move the arms to avoid collisions, and the integration of machine learning-based weld detection software. Our team was able to meet all of these requirements with the final design shown to the right.

The final design features an 80/20 frame with a sheet metal bottom and non-metal, laser-cut sides and top, creating a fully enclosed system resistant to dust. Attached to the frame, our team installed one arm on each side, each housing a camera, two lights, and a LIDAR sensor. Servos were integrated into the design to enable the arms to move out of the way automatically, using data from the LIDAR sensors to detect and avoid obstacles.



TESTING RESULTS

When tested, our product worked a little differently as expected. Our cameras were not able to take the most optimal photos due to the servos being loose, causing the arms to be in lower angles. The camera was also too sensitive when detecting cracks. The LIDAR sensors worked well when objects were detected. The battery life was better than expected, but there were some power draw issues related to the Arduino.

CONCLUSION AND RECOMMENDATIONS

Our final product consists of two cameras, two LIDAR sensors, four LEDs, two Arduinos, one Raspberry Pi 5, and two battery packs. It is capable of detecting cracks using the cameras and saving the images to the Pi's local storage. The pictures gathered during testing revealed that our system was able to detect cracks accurately. However, due to the nature of the factory environment, many objects were mistakenly detected as cracks. The arm system of our project worked somewhat as expected. However, due to the servo motors coming loose, the arm was tilted and was unable to move properly to avoid certain obstructions.

We recommend that John Deere replace our servo motors with more robust and higher-quality ones. This would greatly increase the reliability and accuracy of the system. We also suggest that our sponsor implement a method to transfer images from the Pi to their own database for further analysis.