US Navy Surface Warfare Center - Crane AND Group 25

AI MARITIME MANEUVERING: NAVAL SURFACE WARFARE CENTER INDIANA COLLEGIATE CHALLENGE

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OBJECTIVE

Autonomous vehicles allow for multiple systems and operations to operate independently from human intervention. Applications for such autonomous vehicles include cars, trucks, and boats that serve purposes in a variety of industries such as transportation, agriculture, and in the case of this project, defense. The development of this vessel is broken down into subsystems that are integrated together into a singular process. The team prioritized autonomous navigation and integration of computer vision for path planning.

Fig. 1: Final Design Boat

Competition Challenges

1) Gates Challenge (15pts)
Requires the LPV to autonomously navigate between two buoys, one red and the other green. Points are subtracted for touching either buoy.

2) Dodge Challenge (50pts)
LPV must wind through a path of stationary green buoys.

3) Evade Challenge (75pts)
LPV must avoid LiDAR detection while traveling between two gates.

4) Identify Challenge (40pts)
LPV must autonomously touch a randomly specified buoy based on its color.

5) Deploy Challenge (10pts) + 6) Receive Challenge (30pts)
Requires the LPV to successfully deploy a temperature sensor into the water, then demonstrate the ability to read its data. Points are awarded for reading the data from further away.

7) Launch Challenge (45pts)
A mortar shell-shaped object must be launched onto a designated floating target. Points are awarded based on minimizing distance from the target.

8) Recover Challenge (65pts)
LPV must recover contraband from the water without incurring damage.

9) Return Challenge (10pts)
The LPV must autonomously return to its original launch point.

CONCEPTS AND EXPERIMENTATION

The system utilizes an Nvidia Jetson mini-PC for high-speed onboard data processing, enabling efficient, responsive decision-making. The YOLO-based object detection model, running on the Jetson, was trained on over 5,000 images. The long-range LiDAR sensor creates a SLAM (Simultaneous Localization and Mapping) based map and works in tandem with the Oak and Zed cameras to identify, detect, and avoid obstacles. Using the location data and map, waypoints are planned while the boat is underway to complete the challenges. Each challenge is then completed independently for robustness. The primary application of this research is for defense and homeland security, protecting the United States' coasts from potential threats such as drug trafficking. An alternate application for this research could potentially be innovations in public and private transportation, as well as maritime transportation of goods.

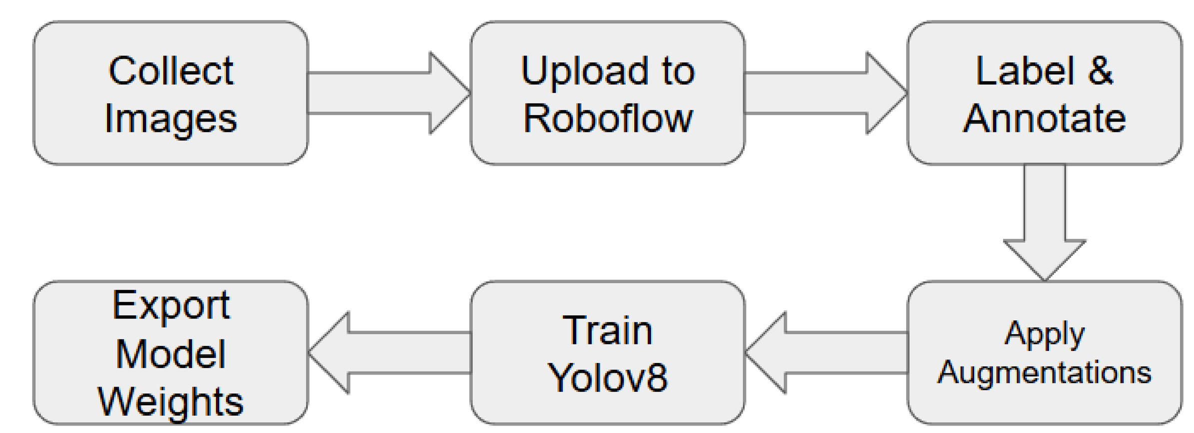

Fig. 2: Computer Vision Training Pipeline

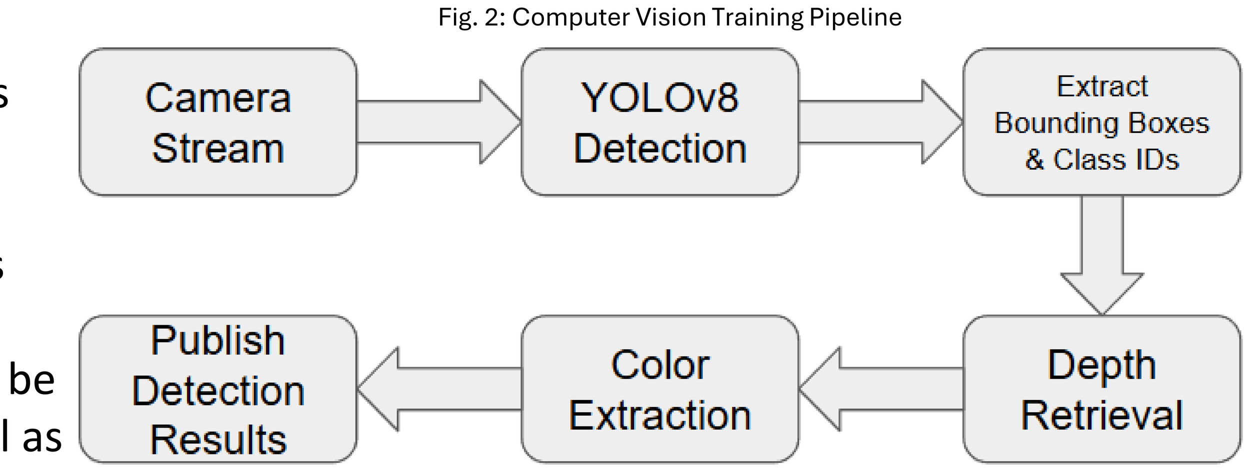

Fig. 3: Computer Vision Inference Pipeline

REQUIREMENTS AND FINAL DESIGN

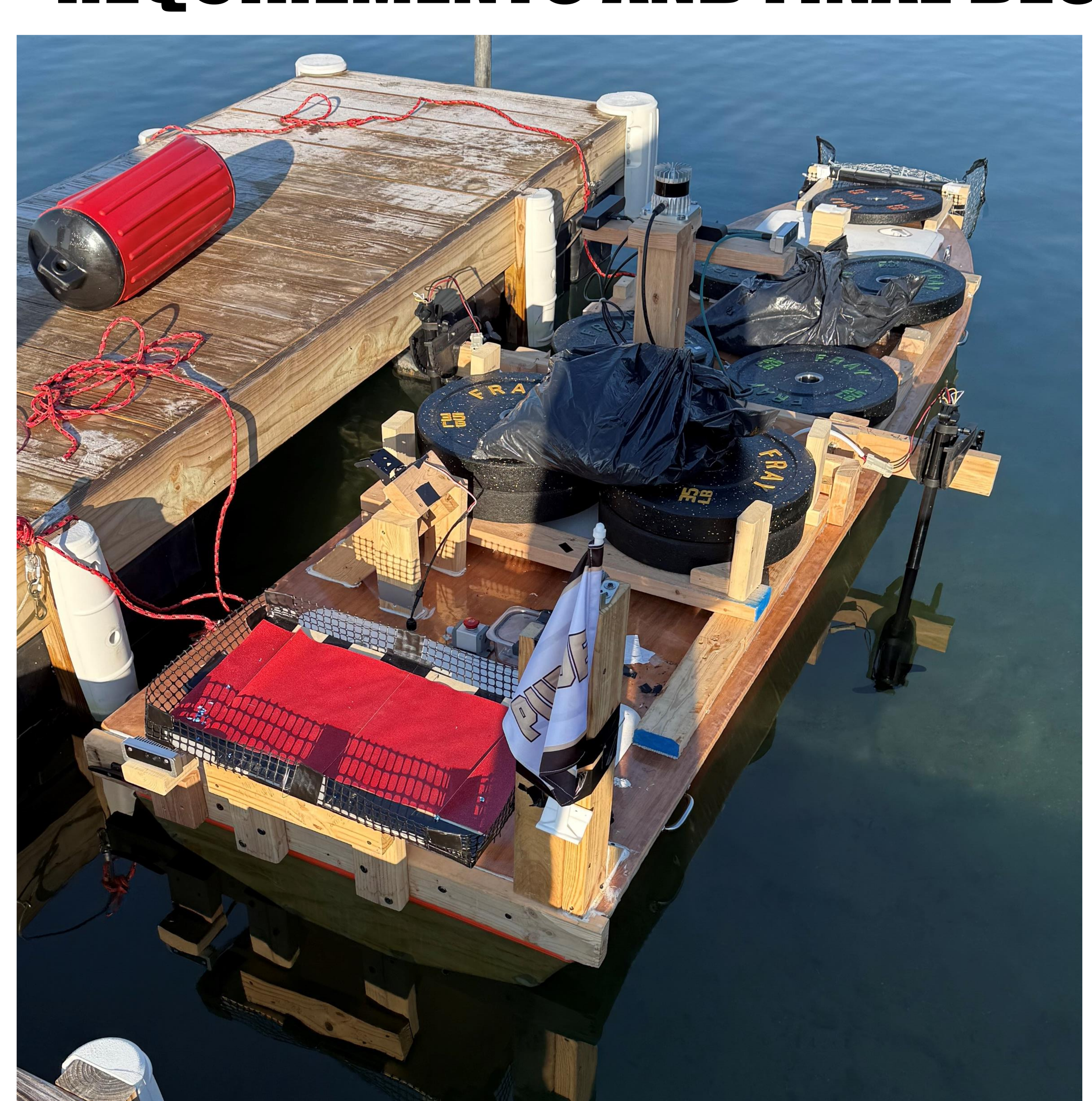

Fig. 3: Final Design Boat

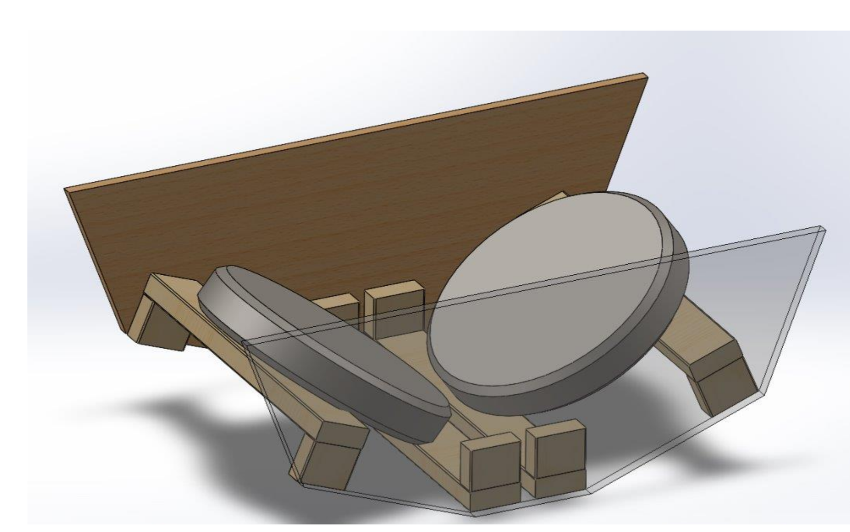

Fig. 4: Interior Boat Frame with Weights

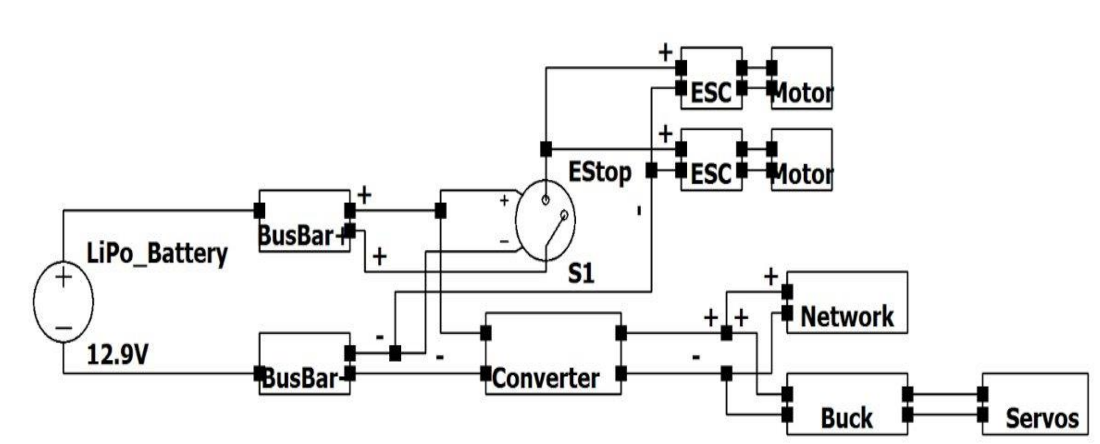

Fig. 5: LiPo Battery Power Schematic

Initial real-world testing occurred in the lab and on a lake with less ideal conditions than prior lab tests. Each sub-team conducted internal tests, reporting results as success or failure and noting integration feasibility. Once confident in the boat's readiness, the team conducted integration tests at Lake Harner in Lafayette, IN. These tests focused on system-wide performance rather than individual components. Simulated challenges, such as gates and slalom, were used to debug and optimize the entire system, ensuring cohesive functionality under real-world conditions.

TESTING RESULTS

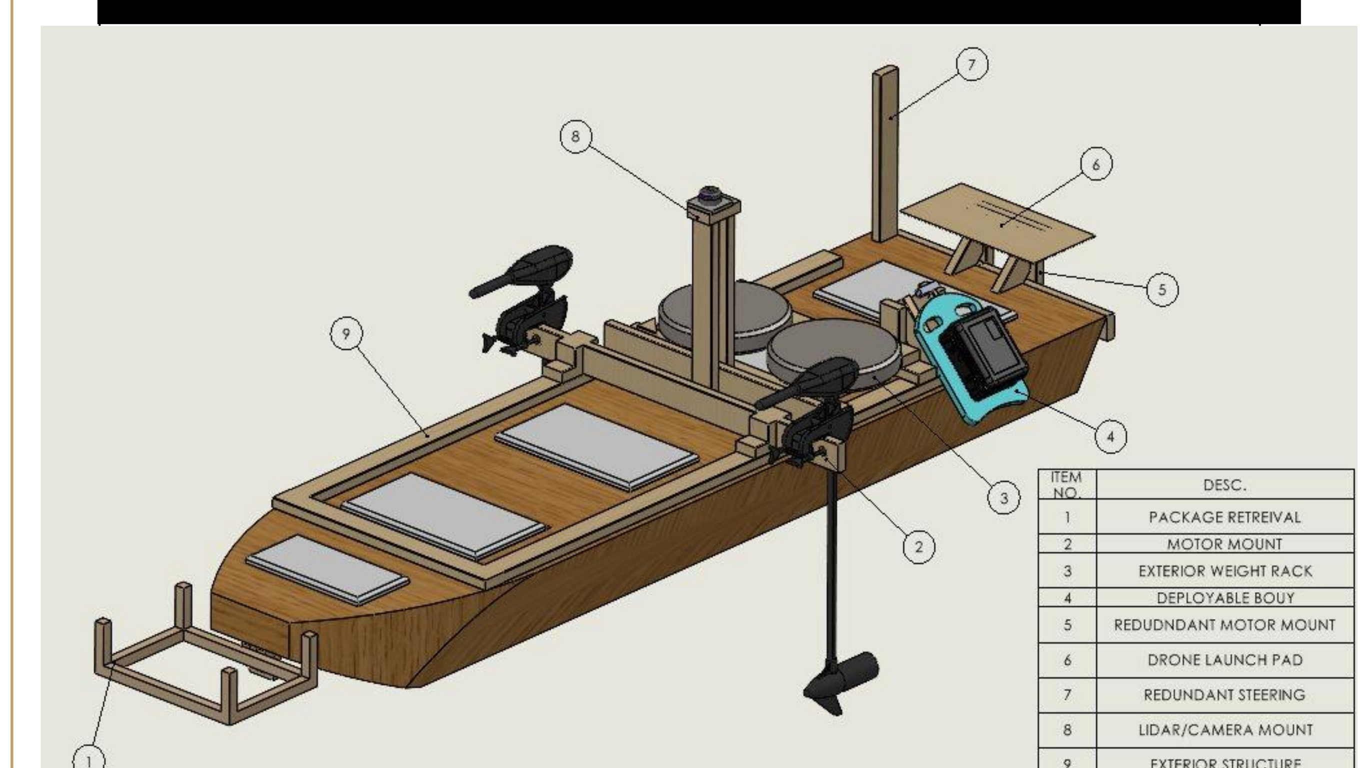

Fig. 6: Comprehensive CAD Drawing of LPV

CONCLUSION AND RECOMMENDATIONS

The Purdue Autonomous Boat Project complete the competition in second place at Pokagon State Park behind Notre Dame. The boat was able to complete all the challenges during the competition. Recommendations for future teams working on the Autonomous Boat Project is to improve the Autonomous ability of the boat. During the competition, the Machine Learning was having localization issues and boat had to be controlled manually due to the boat had trouble navigating and moving by itself. Due to the issues with the localization of the boat, it is recommended that future teams do not use the current LIDAR or use a better LIDAR to improve localization. Overwise the boat was physically able to maneuver and do the tasks required of it.