Joint Capstone Project in Electrical and Mechanical Engineering

Autonomous Surface Vessel

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Sponsor: USCGA Department of Engineering

Abstract

The ASV capstone project focuses on creating a vessel that can autonomously complete RoboBoat's six maritime challenges. We have continued with the hull design completed by prior capstone groups. The ASV has integrated a PD heading controller, when paired with an IMU sensor, can maintain a desired heading. A desired heading is derived from our onboard GPS and a waypoint position where the two locations are compared via Python code to find the heading and distance between the two locations. Our group has used this as a basis for allowing the ASV to travel in a rectangular path. Future goals include utilizing ComputerVision, creating a UAV landing pad, and creating a path planning algorithm.

Background

Autonomous Vessel Fleets

The maritime industry has seen an increasing growth in the advancements of autonomous technology onboard vessels. Companies such as Maersk Line envision future autonomous cargo fleets, operating across oceans without the need for crews.

U.S. Coast Guard Implementation

The US Coast Guard also has tested the concept of autonomy, utilizing a 29' Response Boat with an autonomous helm system installed to research future self-sufficient law enforcement vessels. With the USCG acting as a regulatory partner for the marine domain, understanding the future of technology plays an instrumental role in enforcing the rules of the seas.

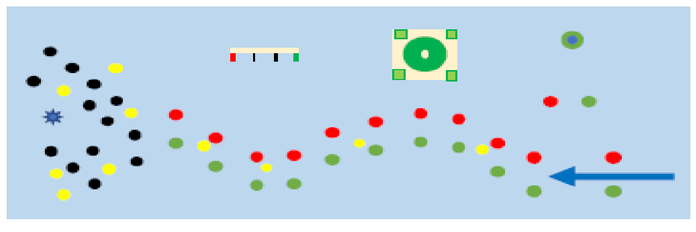
Maersk Line Future Ships (Maritime Executive)

USCG R&D 29' RBS-II (US Coast Guard)

Objective

RoboNation's RoboBoat competition, which is comprised of six maritime based challenges that must be completed without any human input, with a weight restriction no >140lbs. Challenges include:

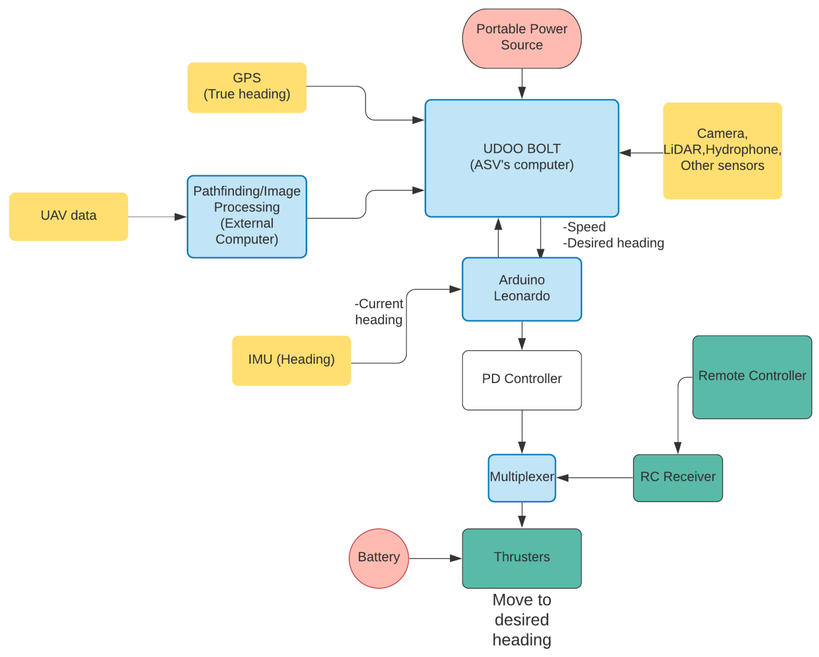
- Navigable channel
- Obstacle avoidance
- Acoustic docking
- Obstacle field
- Speed gate
- Payload delivery



Course Diagram (RoboNation)

System Design

The hull utilized from previous capstone teams consists of a catamaran design, with the vessel's control electronics box supported between the twin hulls by metal framing. Our team has since implemented sensor upgrades and performed necessary vessel repairs using modified designs to improve the safety and quality of the vessel for pool and open-water testing of the ASV's current status.



System Design Block Diagram

Our design utilizes several different computing devices that allow us to perform tasks vital to the project and competition such as:

- Data acquisition
- Sensor use
- Acquiring/maneuvering desired heading
- Remote controlling

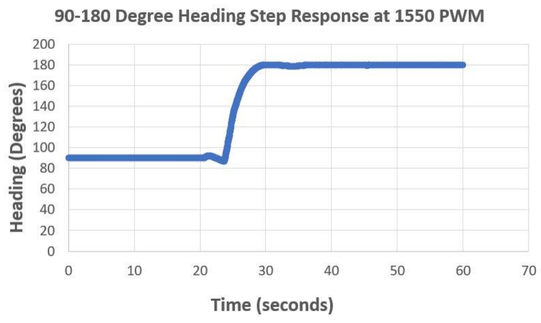
Sensors/Computing

- Adafruit BNO055 Absolute Orientation Sensor
- Adafruit Ultimate GPS Breakout v3
- UDOO Bolt V8 (Onboard Computer)
- Arduino Leonardo (built into UDOO Bolt)

UDOO Bolt (shop.udoo.org)

Navigation and Control

The ASV incorporates a PD controller that allows the vessel to continuously correct its heading by error correction as our navigation algorithm. We then utilize a nested PD controller to derive desired headings from position errors.

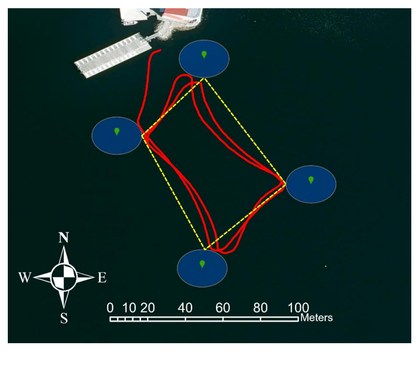


Heading 90° Turn Step Response

Fall Semester Results

Our team designed a surface vessel with the ability to navigate remotely and autonomously to waypoints via GPS coordinates. The vessel also has potential to allow for more advanced modules to be integrated for more complex tasking. We conducted three separate tests: float tank, pool, and Thames River. The most recent testing on the Thames River allowed us to see the implementation of our onboard GPS which allowed the ASV to track defined waypoints and follow a "box pattern."

ASV Fall 2021 Design (Photo: 1/c Patrick Raymond)



Thames Testing "Box Pattern"