RoboBoat 2021: FSU PC Technical Design Report
Seminole Coast

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Abstract- In preparation for the 2021 RoboBoat competition, the team communicated with the previous RoboBoat team to see what challenges and setbacks they faced. Based on this information, we were able to design our boat hull to the needs of other team members and make sure to avoid any design flaws found in the past. We ultimately decided to use a catamaran hull design to give us more space for component placement as well as give good spacing for thruster placement. We planned to use carbon fiber for the hull material, however due to time constraints we were not able to fabricate the boat in time for the competition. We instead printed a 3-D model of our boat at a 1/16 volume scale. We also see the need for a Lidar tilting mechanism and are actively working on designing it.

Introduction

The goal of this project is to design and construct a robotic boat capable of autonomously executing tasks defined by the RoboBoat competition. Originally, the competition was held in-person and all boats had the opportunity to compete in any of the course. Due to Covid-19, this year's competition will be held online and will not require that the boat be able to complete the courses, however teams must still adhere to the 2021 RoboBoat rules to constrain their designs. Instead, teams have three submission opportunities: Videos, Technical Design Report, and a website. The main goal of this year's competition is to show the progress each team is making and better prepare themselves for the face-to-face competition next year. The work for this project was split up between the mechanical engineers and the electrical engineers, with the mechanical side consisting of hull design and fabrication and the electrical side consisting of programming and wiring components.

Planning Phase

This section discusses the organization of the team, and the course strategy that led to how we design and fabricate the boat.

A. Team Organization

The team was divided into two distinct groups: Mechanical Engineers and Electrical Engineers. The Mechanical division primarily focused on hull design and fabrication, while the electrical division focused on integration of electrical components and software. The two teams had to make sure they communicated effectively.

B. Course Strategy

Our core course strategy is to ensure our boat is proficient in obstacle avoidance. This way we can focus on the courses that are centered around avoiding obstacles, such as the mandatory navigation channel, the obstacle channel, the obstacle field, and the speed gate. The other courses will also be attempted however our focus for our design is completing obstacle avoidance centered courses.

Design Process

This section discusses the two groups design strategy/goals and methods of validation.

A. Electrical Engineering Team Strategy

The Electrical team primarily focused on the autonomy of the boat. The team focused on integrating the LiDAR, GPS, and the camera. This team also worked on the power distribution and the safety concerns such as the kill switch and the E-kill switch.

a. Power and Safety

The Power distribution like the previous team. There was a lot of collaboration with the individual that was responsible for the previous system. That individual educated this team on how the power distribution was done before and gave some advice on how to improve the system. This team took his advice and working on the improvements required for the challenges this year.

This year's team is using four thrusters which requires a bigger power supply. There will be two batteries to power the whole system compared to the three-battery system from the last team. There will be a voltage bus system in place to easily connect the necessary sensors and devices.

The safety part is primarily the kill switch combo. Both the physical and remote kill switches will be set up in series to kill all the motors. The is a 1.5-inch red button for the physical on board kill switch. The remote kill switch will be a double throw relay paired with an Arduino. The Arduino will receive a signal from the remote, and it will flip the relay to transfer the power to a voltage sensor. This sensor will be used for the light bar to determine status of the boat.

b. LiDAR, GPS, and Camera.

The LiDAR, GPS, and camera are going to be used for object detection and navigation. The GPS is the VectorNav system, the LiDAR is the Ouster LiDAR, and the camera is a Logitech webcam. The sensors are subject to change depending on the team's capabilities. The camera will be controlled by a Jetson TX2. This is so the team can use the Yolo Darknet machine learning algorithm which recommends using Opencv with Cuda. Cuda requires an Nvidia graphics card. The TX2 comes standard with all of these. The LiDAR and the GPS will be controlled by a second on board computer. This computer will be either the Jetson Xavior or a Nuc, which ever will work best with the sensors. The autonomy will be pulled together using ROS. The team decided to use ROS2 however, it appears that Nvidia does not support ubuntu 20.04, which is required to use ROS 2. Therefore, the team will be using ROS 1 for the autonomy integration.

B. Mechanical Engineering Team Strategy

The last team to compete from our school had problems with their boat flipping due to the size and weight distribution of the boat. Our team aims to learn from the challenges they faced and find ways to avoid those problems. We plan to do this by using a stable hull design, carefully adjusting component placement and weight distribution, and adjusting thruster placement.

a. Hull Design

The hull design we decided to go with was the catamaran. This hull design gives ample storage space for component placement. Because of the available room, we will be able to attach 4 thrusters on the boat (2 along each pontoon). This boat also gives us optimum stability and sits tall in the water. The 2019 RoboBoat team made a boat with the same hull design. However, they had a couple errors pertaining to their boat. The first thing is that their boat was not long enough resulting in the front of the boat being too light. Also, their thrust force was too much. Therefore, when they accelerated, their boat ended up flipping and not being able to compete. We decided to correct those mistakes in making sure our boat is long enough and will have enough weight at the front. Also, we added 4 thrusters to the boat (2 in the front and 2 in the rear), this allows the thrust force to be distributed more evenly and allow the bow of the boat to not come too far out of the water.

Figure 1: Boat Render

b. Hatch Design

The previous RoboBoat team stressed to us the importance of having easy access to the components inside the boat. In previous years either the whole top of the boat had to be disassembled or there was little room to move around or take out components. Because of this, our team set the hatch design as one of our top priorities.

Essentially, the lid of the hatch sits in a groove on the top of the boat lid and will be sealed with silicone. There will also be latches connecting the hatch and boat hull to hold the hatch down. With these measures in place the hatch should be waterproof and keep the components from getting wet or damaged in the event that the boat gets water on top of it or flips over in the water. The hatch should also be big enough to allow easy access to all components without the need to disassemble the hull.

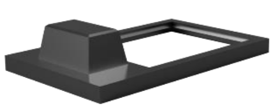

Figure 2: Boat Lid

c. LiDAR Tilting Mechanism

To ensure that the boat senses everything adequately we decided that being able to tilt the LiDAR would be a beneficial endeavor. By tilting the LiDAR we would be able to adjust the sensor on the fly, and be able to use it in the best configuration for our hull design.

d. Propulsor Attachment

In the case of a propulsor failing, how it is attached is an important aspect of how hard it is to fix. We have developed a hot swap propulsor attachment that allows for us to easily change propulsors in the event they fail. A track is mounted to the hull, and the propulsor is mounted to a fin on the track, if the need to change the component arises, we simply slide it off the track and mount a new propulsor.

e. Prototyping

Before finalizing the design with our theoretical values, we decided to make a 3D printed 1/16 volume scale model. By doing so, it allowed us to see a physical representation of how the full-scale model would float and allow us to scale down our weights and more easily see how component distribution would affect how the boat would float. It was 3D printed out of PLA in three parts, the hull, the hatch, and the hull lid. The scaled down component weights were represented by lead fishing weights at the appropriate scaled weight.

Figure 3: Prototype Floating