The Design and Development of Roboboat

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***Abstract*—Wilson is a fully autonomous vehicle designed by the Seminole Coast team for the 2019 Roboboat competition. This is the first competition that Seminole Coast has entered. This report focuses on how the team will attempt to tackle the challenges they participate in. It also gives an analysis on the conceptualization, timeline, and construction of the boat frame as well as how the individual parts are setup and organized. An outline of the timeline is also given to give readers an idea of the time frame, challenges and obstacles that the team had when working on this project.**

I. Introduction

This is the first year that the Seminole Coast team, consisting of Florida State's Panama City Campus (FSU-PC)and Gulf Coast Sate College, has participated in the RoboBoat competition. After several months of testing and problem-solving, the team was able to come up with solutions for many of the problems faced in regards to navigation and construction of the boat. This was all achieved despite Hurricane Michael, a Category 5 hurricane, which halted all work on the project and caused several delays in the last three months of 2018. Despite this, the team rebounded and was able to come up with a fully-functional boat, ready for the competition, as seen in the following sections.

II. Competition Strategy

As stated in the introduction, this is the first year for Seminole Coast's Team to participate in this competition. This presented some rather unique challenges. Because the team has had no previous experience in this competition, it is imperative that multiple rounds of testing are performed to make sure the boat and the system are optimized.

A. Challenge 1: Mandatory Autonomous Navigation

The team will begin by performing in the mandatory autonomous navigation. This challenge will demonstrate the team's ability to perform autonomously. The goal of this challenge is to simply maintain a straight heading autonomously. Once the boat is set in the water at the correct spot, the boat will maintain the same heading through both sets of gates.

B. Challenge 2: Speed Challenge

The team will most likely not be participating in this challenge. This is due largely to time constraints. The team felt it best to focus the other tasks mentioned in this report to do well. However, the team is confident in boat's ability to perform in this challenge as the design of the boat is light and maneuverable.

C. Challenge 3: Automatic Docking

Challenge 3 presents a different type of design complexities to the competition that the other challenges do not have. Underwater acoustic detection was considered to be too much for the team to tackle, and the team chose not to participate in this task. It was determined that there was not enough time to focus on detection and programming for this task and that the team was better off spending resources and time on the tasks that focused on vision. Thus the team will not be participating in this challenge this year.

D. Challenge 4: Raise the Flag

The team did not have the resources or time to participate in this challenge nor a drone. It was deemed best to focus on the tasks that were somewhat related to the parts of autonomy already working with the boat. Trying to participate in a challenge that required a drone and the ability to communicate with one proved to be too much this year. Initially Seminole Coast had hoped to participate in this event, however, after Hurricane Michael it became clear that the team needed to focus on making sure the vision and autonomous system worked well with navigation aspects of the boat.

E. Challenge 5: Find the Path

This challenge is the main focus of the Seminole Coast team. Once autonomous navigation is workable with their system, they are ready to begin complex path-planning. First, the team has uses programming so that the camera picks up the initial center buoy. This info is sent to the Jetson TX2. From here, the Pixhawk can make a determination about heading and speed. Once the loop is complete around the center buoy, the boat will use a similar process to detect an opening to exit (which can be the same one it entered according to the rules). Besides simply being able to run the boat autonomously, the team decided that this task was one that they would be best suited to compete in.

F. Challenge 6: Return to Dock

The team does hope to be able to complete this task. However, as of the time the report was submitted, it was unclear how far the team would get in being able to complete this task. Although not all of the tasks will still be completed, the team knows that it can still get points if they can finish this task.

III. Boat Design

A. Conceptualization

The goal for the boat design this year was to develop a firm understanding of the requirements of our boat and the solutions that other teams had come up with. After researching robotic boat designs, our team noticed a consistent pattern. Most were catamaran style, with individually fabricated pontoons held together with aluminum rails and boxes to house the electronics. While this design allows for a more modular approach, it also increases the resulting weight. In order to account for this, we opted to go with a single integrated design that brings the pontoons, rails, and electronics housing all together into one coherent hull. The figure below shows the final dimensions the integrated catamaran design (Fig. 1). Due to the Seminal-Coast alliance, our team had access

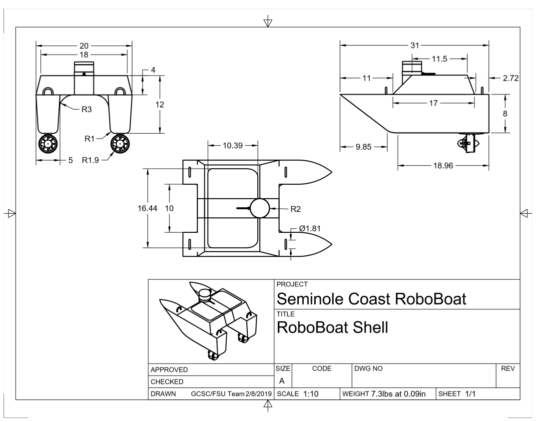

Fig. 1. Hull Drawing

to the composites lab at Gulf Coast, where the boat was manufactured. The hull is out of carbon fiber, in order to manufacture the lightest, but also strongest, boat possible.

B. Design Creativity

After sketching out the idea and its dimensions, the boat was modeled using the 3D design software in Autodesk Fusion360.This allowed the team to have a rough estimate of the final weight of the boat, around 28-30lbs. With this in consideration, the team opted for a maximum load capacity of 60.15lbs and a superstructure just big enough to account for the inclusion of the electronic components. The next step was to modify the design to include a set location for the LiDAR. A scale model was printed to test balance and center of gravity. The final rendering is shown in the figure below, (Fig. 2). The team was satisfied with the results and able to move onto the next step, bringing the digital design into the real world. Due to limited resources, time, and budgetary restrictions, the team came up with an innovative manufacturing process. Using the Slicer add-in for Fusion360, the design was sliced into quarter

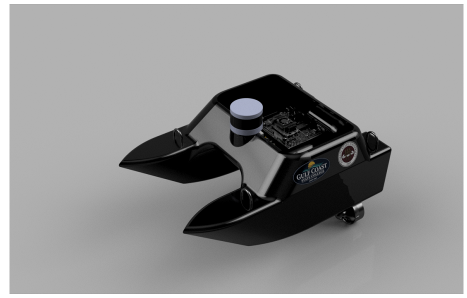

Fig. 2. Fusion360 rendering

inch increments. With the resulting DXF files, it then laser cut each layer of our boat out of quarter inch insulation foam. A picture of the foam model, (Fig. 3), is included on the following page. To allow for easy removal of the foam after

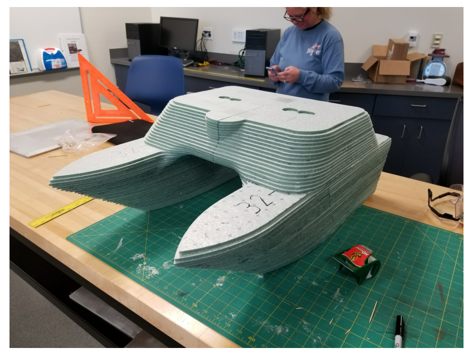

Fig. 3. Sliced Foam Model

the layup of fiber, each layer was connected with wooden dowels, toothpicks, and a light layer of glue on the outside edge. The next step was to smooth out the external texture of our foam model to allow for smooth adhesion of each piece of fiber to the foam. To do this, each offset was filled with a layer of fairing compound, then sanded smooth. Then, to allow for easy removal of the plug from the inside of the hull, the outside of the foam was coated with a layer of appliance epoxy, then a layer of wax. The next task was to set forth on the layup of fiber. The team started with a single layer of fiberglass in order to get acquainted with the process of hand lay-up and then shifted to two full layers of carbon fiber. After all the layers were adhered to the model, the foam was pulled out of the inside of the hull. With the pontoons complete, the next focus was on how to mount the two T200 thrusters to the bottom of each pontoon. The team machined a piece of aluminum with holes that matched the dimensions of the 3D printed motor mounts. Then the team laser cut a piece of acrylic with holes cut to the same dimensions but in a hex shape that was custom made to fit the size of two hex nuts (Fig. 4). After that the aluminum and acrylic were adhered together, embedding the hex nuts in place permanently. After drilling out the motor mount holes in the bottom of our pontoons, the motor mounts were aligned with the holes on the inside of each pontoon. Each mount was covered with a generous coat

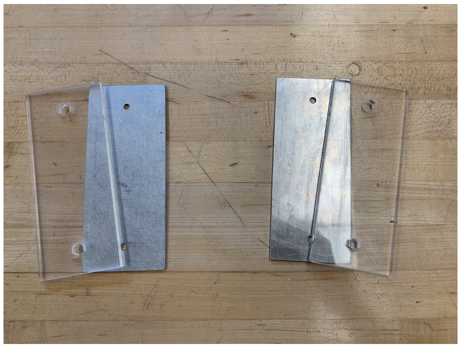

Fig. 4. Aluminum and Acrylic

of carbon fiber and epoxy resin to ensure a fully watertight hull. This method of mounting the motors allows for easy attachment and removal of the thrusters without compromising the integrity of the hull. The result of this design is a rigid and durable custom made shell, with an incredibly low weight at only six pounds. Finally, the carbon fiber lid and inner electronics platform were manufactured and attached using the necessary u-bolts. Following this the boat was finalized with a custom paint job. In order to account for varying positions of weight in our boat, the team opted to use our batteries as ballasts inside each pontoon, securing them with industrial grade velcro strips which allows for easy repositioning of each battery inside the pontoons.

IV. Experimental Results

Seminole Coast began working on roboboat in August of 2019. The team originally consisted of about 20+ people, and the team planned to have RC boat testing in the water by the end of the year. The conceptualization and brainstorming continued through the end of September. However, all progress on the boat completely stopped during the beginning of October due to Hurricane Michael. Hurricane Michael was a Category 5 hurricane that stopped progress on the boat for the rest of the year. Many of the team members had to leave the team for one reason or another. The remaining participants decided to begin the project again at the beginning of the new year. The testing for the thrusters began around March. After a few test runs, the calibration for the thrusters was fixed. The team ran into some issues with ESC controllers when testing the thrusters initially. Of course, the tests were all performed using remote control and not autonomy, as this allowed for a controlled environment. When the design of the boat was ready around March and further digital tests were performed, Gulf Coast State College allowed the team to test the boat in the water at their pool. At the time of testing the boat was strictly remote control yet this still gave great insight into what the team's next steps needed to be. From this testing the team discovered the boat's maximum speed was capped due to the thrusters sucking in air. Adding more weight was a suitable solution for this problem. The team was able to decide how to best distribute this weight as well. The thrusters are powerful for the size of the hull so the weight distribution needed to be more towards the bow of the boat. The remote kill switch worked very well at close distances yet it struggled at the maximum length of the pool, 50 yards. After further testing the team came to the conclusion that the inconsistency in the remote control switch was due to interference. With remote control testing out of the way, implementing the autonomous features was straightforward as a lot of this had already been worked on. Thus testing could resume for the rest of may and the beginning of June leading up to the competition, where the team would do test-runs similar to the challenges that they decided to compete in.

Acknowledgment

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APPENDIX

Component	Vendor	Description
T200 thruster	Blue Robotics	thrusters
R3	Blue Robotics	Uses Arduino
Pixhawk	supplied by team member	gps unit (driver)
Jetson TX2 Board	Nvidia	.
Zed Stereo Camera	Zed	Uses open CV
Real sense T265	Intel	AND
E Stop	E Stop	Kill switch
10000mAh 4s	Turnigy	Battery
ac/dc 400W charger	Maxamps	4 port charger
Digital Battery Tester	Dork7	Battery monitor
Programming Languages	c++, python, ros	.
Team Size	10 people	all undergraduate students