Daytona Beach Homeschoolers

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***Abstract*— This document describes the Daytona Beach Homeschooler's entry to the RoboBoat 2017 competition. Topics in this document include: design strategy, vehicle design, results from testing, and outreach.**

I. Introduction

The Daytona Beach Homeschoolers were initially a group of three middle schoolers. This year, two of the initial members, Abigail and Nick, are in 11th grade and recently began dual enrollment at Daytona State College. Being in college now combined with the late release of the rules made it hard to get any work done on the boat this year. After the release of the rules the team picked up an advisor who helps the team, Stephen.

II. Design Strategy

The boat will navigate the course using a Raspberry Pi based autopilot called the Navio2. As for the course, the speed gate will be accomplished by using waypoint navigation and vision processing. The autonomous navigation task will use the same processes as the speed gate. Find the Path will be done using vision processing, wall following, and obstacle avoidance. Docking will use hydrophones to identify which docking bay has the correct pinger, allowing the boat to dock in the bay after locating the pinger. A small tethered UAV with a camera will then be launched and recovered autonomously. to identify the number on the 7-segment display. The boat will then dock in the second bay

III. Vehicle Design

A. Lessons Learned from Design Iterations

The boat needs to be smaller and flat-bottomed. Last year's boat was so large it wouldn't fit through doors without turning it sideways. It also had issues last year with hobby-horsing, the boat would constantly rock back and forth when moving forwards. This was caused by the shape of the boat's pontoons. Last year's boat was also slow, encouraging the team to increase the voltage given to the motors from 12V to 14V for more power.

The team also learned that the navigation system needs to time-out if the boat is unable to reach a waypoint. This became an issue last year when trying to use waypoint navigation for the docks. The boat would hit the dock and begin to move it while trying to reach the waypoint, even though it had already reached the dock.

B. Vision

Abigail worked on vision processing of dock targets for the Robotics Association at Embry Riddle's RobotX team. The algorithm developed and tested for the RobotX project will be reused for the RoboBoat team. The algorithm developed consisted of the following steps: taking out a color plane to make the color the boat is trying to identify the darkest in the image, thresholding the greyscale image to remove lighter colored parts of the image, removing blobs that are too big or too small to be a target, and finally identifying the shape using multi-scale template matching. For the RobotX team this was all done in LabVIEW and used for identifying targets on the dock, so the code will be remade using Python and OpenCV.

Another two methods of identifying the 7-segment display and buoys in the water that the team will be learning about are neural nets and machine learning. This will be done in MATLAB.

C. Control System

A Raspberry Pi based autopilot will be used for navigation. DroneKit by 3D Robotics will be used to get the values and information from the autopilot. All high-level control of the platforms will be written in Python. A laptop held on the boat will control the boat, UAV, and handle processing of vision as well as sonar data.

D. This Year's R&D

This year, the boat will be both small and flat-bottomed. It will be MIG welded as opposed to TIG because of the size and shape of the metal unique to the team this year. It will be completely waterproof, and will have an access hatch that will allow the boat to be submersible.

In last year's boat, the team had many issues they needed to address. One such issue was the boat's tendency to rock in a way that concerned the team. So, the team decided to try a flat-bottom boat design to eliminate this issue. Another issue was the lack of buoyancy on the pontoons

The boat had flotation issues because it had more weight than expected. The team also initially tested in a saltwater pool while the competition is held in a freshwater lake. They didn't expect the boat to be so low in the water and so they decided to add foam for flotation. The team also had control issues last year which caused the boat to move slowly. This year's new design will fix this issue so the boat will be able to move at a faster pace than last year's entry.

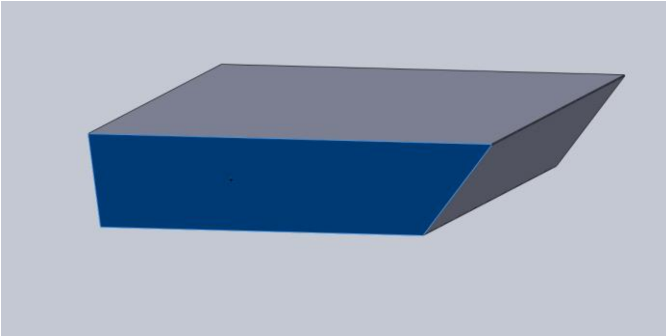

Figure 1 CAD model of this year's boat design

The above picture is of a CAD model of this year’s design. This was made by Nick as he also made the boat. Through these processes, the issues that were in our boat’s mechanical design last year are now obsolete.

IV. Experimental Results

The team is using DroneKit software in the loop to simulate missions. This is to figure out what values and information the autopilot needs without directly using the autopilot. The team is also doing simple vision processing tests of the docking targets. Not much testing is needed in this area because they are reusing the code Abigail created while working on RobotX. There have also been several flights of the UAV, however not much testing has been done regarding the UAV because of how late the rules came out.

The team has also done hydrophone testing.

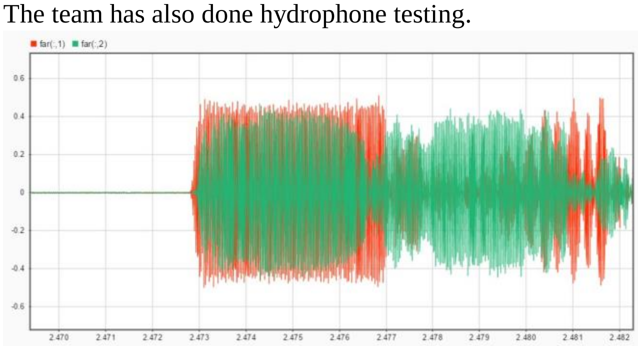

Figure 2 The red signal represents the left hydrophone, the green signal represents the right

The above is an image of measured sonar pinger pulses from 15 meters away. The red signal shows a good received pulse that is 4 ms long, the green signal shows the pulse received from the adjacent hydrophone. This signal shows the effect of reflections, which make it difficult to determine the timing of the signals.

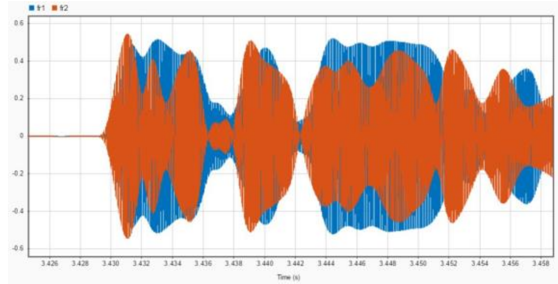

Figure 3 The blue signal represents the right hydrophone, the red signal represents the left

Figure 2 shows the measured sonar pinger pulses directly centered in front of the boat. Numerous reflections can be seen that affect the amplitude of the signals making it difficult to determine when a pulse begins and ends. These reflections are caused by pool walls, the bottom of the pool, and the surface of the water. The reflections are worst when the pinger is near the surface of the water.

V. Outreach

This year the team presented to the IEEE Daytona Beach Section for the fourth year in a row. They also presented the work they had accomplished on their boat at XPONENTIAL 2017. A large unmanned vehicle conference hosted by the AUVSI foundation. While there, the team gave two presentations on what they had done last year. Explaining last years’ course and how they approached the problems that came up.

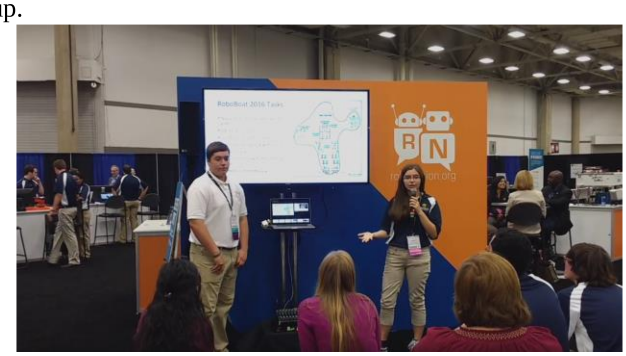

Figure 4 Nick and Abigail presenting at XPONENTIAL 2017

Also at XPONENTIAL are the RoboTours. These are tours given to high school and middle school students, touring them around the conference. Nick and Abigail presented to many different groups of children who came by, guided by RoboTour guides

Figure 5 A RoboTour guide introducing Abigail and Nick

VI. Conclusion

This year the team will be highlighting their new boat design. It is a vast improvement from the year before and much easier to work with. The team is planning to attempt all competition tasks and use the knowledge gained from RoboBoat 2016, as well as RobotX, to succeed.