Technical Design Report- 2019 RoboBoat

CU robotics Club

Earl Potters John Biegel Andrew Zhu

Abstract—This paper documents the design and development of the CU Robotics surface vehicle made for the 2019 RoboBoat competition. The design report will cover the initial strategy for completing the various competition courses which include systems for the onboard electronics and computer algorithms. In response to unforeseen problems and lack of resources, the plan had to be revised and necessary components took precedence over superfluous auxiliary sensors. The paper will detail the challenges faced leading up to competition and the solution implemented to handle them.

I. INTRODUCTION

CU RoboBoat is a new student organization that was inspired by advisor David Pasley, who was a contender and advisor in the RoboBoat competitions. The team has had no prior experience with designing and building robotic platforms and in part from inexperience, has encountered initial phase challenges. In summary, the report will examine the process our team has had to put in for being able to compete in the 2019 competition. As a side note, we are very excited to be able to participate in this event.

II. COMPETITION STRATEGY

Since the team is relatively new, we have gone with course by course implementation starting from the navigation challenge up to follow the leader challenge. The first section will provide insight into how the team plans on accomplishing these challenges followed by an in depth analysis on what role various subsystems will take part.

A. Vehicle design approach

The vessel being used for the competition is the 2017 Embry Riddle Floating Point IV trimaran design based on the United States Navy's USS Independence(LCS 2). The vessel donated comprises of a lightweight and spacious design that is both robust and agile. The boat is composed of wood which is coated in 2 layers of fiberglass to ensure strength, rigidity and water proofing of the platform; additional, two layers of water proof paint with lacquer have been added. The platform has three mounting areas for GPS, LiDAR and Camera that mount smoothly giving full range of visibility and manoeuvrability.

Figure 1: Floating Point IV [1]]

B. Electrical systems

Onboard the vessel, the electronic box houses a PCB board that manages all of our systems. The main component on the board is the Teensey 3.5 developer microcontroller which does all the computations and processing. Other components are the Wiznet850 io which provides a compact-sized network module that includes TCP/IP & Ethernet jack; the 8-channel PWM FeatherWing board; a pololu RC relay allows for a remote E-stop of Blue Robotics T200 Thrusters ; and a GPS connector. A external GPS mouse is used to collect GPS coordinates and compassing heading necessary for way-point navigation. In addition to the board, communications from the ground station and the platform is done using an Ubiquiti M5 omni-antenna, which speaks to the Ubiquiti M5 Bullet inside the platform. The antenna communicates at 5.8 GHz with the ground station in order to avoid signal loss and interference. The system is also capable of long range command control which allows the platform to be monitored and send in control adjustments.

C. Computer software & Autonomous Navigation

The boat utilizes C code and Arduino Libraries that are specifically tailored for the various hardware components in use. The GPS mouse uses a TinyGPS++ library from Arduiniana for parsing NMEA data streams provided by the GPS module. The compass component uses an arduino Library for the QMC5883L magnetometer/compass module to the Wiznet850 io uses a Ethernet library do comunicate witht the Teensey using UDP comunications. Waypoint navigation will be our main method of moving to desired locations.. A future improvement would be to change the software to the ROS (Robot Operating System) architecture to improve modularity and robustness.

Figure 2: Blue Robotics T200 thrusters [2]

III. Design Creativity

Our team has never before competed in the Roboboat competition and, beginning in September, 2018, our work was started from scratch with extremely limited manpower. For this reason, the capabilities of our boat have been implemented with an emphasis on thrift and simplicity.

The hull of our boat is a hand-me-down from Embry-Riddle's Roboboat team. By reusing their old hull, we bypassed an enormous number of working hours and challenges that would otherwise have taken weeks or months to design and implement. While we plan on designing our own hull in the future, the Embry-Riddle donation has given us a platform to develop and experiment with the electrical and mechanical systems necessary for our boat to operate autonomously. Furthermore, our PCB control board is a control board from a remote control truck. It had all of the capabilities we need to compete on the level we want, so we took it and repurposed it to control our boat.

With the limited manpower on our team (only two permanent members), it was necessary to take every opportunity to reduce the number of hours spent developing, designing, troubleshooting, etc.. The Embry-Riddle hull and the repurposed control board are prime examples of time saved by the effective use of available resources. These examples also demonstrate our team's emphasis on simplicity. Rather than develop any complex or novel system, we rely heavily on prebuilt components that can be easily integrated into our existing system.

For instance, Arduino's built in libraries have been critical in integrating the various components we use for communication with shore and communication with the ESC's that power our motors. The idea is: if there is already a solution to our problem, we don't need to re-solve the problem, we can implement the existing solution instead. This strategy has been perhaps paramount in the operations of our team and certainly defines our approach to this year's competition.

IV. Experimental Results

To balance technical work with testing, the team usually allocates one full day every week to test in-water all of the capabilities that were developed during that week. The team will be on this once-a-week testing schedule for the two months prior to the competition. As the team is new and is using an unfamiliar platform, a majority of early testing was spent learning about the dynamics of the boat, as well as setting up RC control and basic autonomy. The team is planning to have capabilities for the Autonomous Navigation and Speed Challenge tasks tested by the competition, and will be testing for the other three challenges during the pre-qualifying runs.

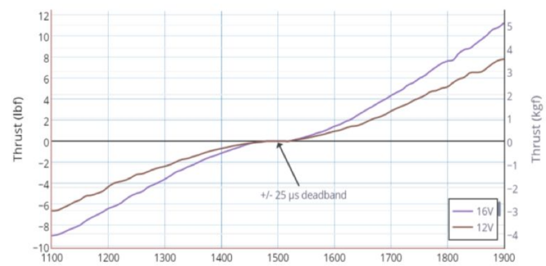

Figure 3: Thrust vs PWM input [2]

V. ACKNOWLEDGEMENT

The CU RoboBoat team would like to thank CU for facilitating our club and giving us support. Additionally, we would like to thank our advisor David Pasley for helping out with technical challenges and giving us essential guidance. Finally, we thank roboNation for hosting this marvelous event and are extremely excited to participate!

V1I. REFERENCES

[1] Floating Point IV paper , https://www.robonation.org/sites/default/files/EmbryRiddle_2016_RoboBoat_Journal.pdf

[2] Blue Robotics, http://www.bluerobotics.com

Appendix A

Component	Vendor	Model/Type	Specs	Cost (if new)
ASV Hull form/platform	Embry Riddle	Trimaran	2.5 x 5 x 2 feet	UNKNOWN
Waterproof connectors				
Propulsion	Blue Robotics	T200	https://www.bluerobotics.com/store/thrusters/t200-thruster/	$169 X 3 = $507
Power system	L&E Battery (LND) LND4S7090	LiPo battery Pack	14.8V 7000mAh 4S Cell 90C	$94.99 X 2 = $189.98
Motor controls	HobbyKing	ESC:HobbyKing 30A Boat ESC 3A UBEC	30A	$14.67 X 2 = $29.34
CPU	PJRC	Teensey 3.5	https://www.pjrc.com/store/teensy35.html	$24.25
Teleoperation	Turnigy	RC:Turnigy 9X 9Ch Transmitter w/ Module & iA8 Receiver (Mode 2) (AFHDS 2A system)	https://www.ne...&gclsrc=aw.ds	$82.75
Compass & GPS	SparkFund	GPS Mouse - GP-808G (72 Channel)	https://www.sp...10.1554253465	$37.95
Algorithms	Arduino Libraries			
Autonomy	Waypoint Nav			
Team Size (number of people)	3 people			
Expertise ratio (hardware vs. software)	1:1			
Testing time: simulation	0			
Testing time: in-water	3-5			
Programming Language(s)	C/C++			