1. Abstract

The Underwater Robotics Club at NC State returns to RoboSub 2018 with a new strategy and a new robot to accomplish it. Through analyzing the success of top performing teams at previous RoboSub competition, the team has developed a strategy focused around the tasks that utilize the acoustics system. To accomplish this the mechanical and electrical teams coordinated a redesign which resulted in Seawolf 7, the latest robot for the club which has several creative systems within it. Finally, the club systematically tested the robot and the new systems with both simulations and in water testing to ensure that we can successfully accomplish our strategy at RoboSub 2018.

2. Competition Strategy

The strategy that the Underwater Robotics Club at NC State is bringing to RoboSub 2018 revolves around the acoustic tasking. Acoustic tasking has seen a growing presence in the last few years of the competition, and the increase in the number and significance of these acoustic tasks makes it an attractive area of focus for our team. This focus is increased further when studying previous competition strategies of the most successful competitors, all of whom perform well in the acoustics tasking. With our current focus on acoustics, the team hopes to somewhat mimic the more successful team strategies to improve our own outcomes.

Our focus on the acoustic tasks stems also from the fact that the acoustic tasks have changed the least from our previous competition attendance. Due to a complete electrical and mechanical redesign for the robot this year, our team decided to focus on acoustics over vision processing and build on the already solid acoustics foundation we have used in years past. We believe this ensures the best chance of success for our robot during the competition. Given the limited software team resources, it was decided that a vision processing-focused approach would not allow enough time for full development and thorough testing as would be required to be adequately prepared for competition.

Given the acoustic approach, the robot will attempt four tasks during its competition run. The robot will use its three orthogonal thrusters sets (oriented for x, y, and z-axis) to maneuver through the gate, as well as through the first path. The robot will then move into the open water and use a hydrophone array to locate the pinger for either the roulette wheel or the cash in depending on random pinger order. The move into open water is a safety factor to avoid possible collision with other task objects. At the roulette wheel, the robot will use its pneumatics system to drop markers onto the wheel. At the cash in, the robot will surface on the platform. While acoustics are used to navigate the robot to these tasks, vision processing will be used to complete the tasks. There are cameras on the front and bottom of the robot to perform the vision processing.

3. Design Creativity

There are several systems within Seawolf 7 that feature creative designs. The new frame designed by the mechanical team heavily utilizes 3D printing to create unique part designs for systems such as the torpedo launcher or the marker dropper. As part of the electrical redesign, a modular electrical system was made by the electrical team which helps solve some of the issues the club has had with past electrical systems.

As mentioned, the mechanical team has heavily utilized 3D printing with the mechanical design of Seawolf 7. While some of the more prominent benefits of 3D printing is the fast turnaround time and low cost compared to traditional manufacturing, it also allows for an increased flexibility in part design and reduction on the number of sub-assemblies on the vehicle. Throughout the designs a balance between the creativity, ease of printing the part, and the ease of replacing or repairing the part if it breaks had to be found. As mentioned, one of the tasks the club plans to attempt is the roulette wheel which requires a dropper. By using 3D printing to manufacture both the dropper mechanism as well as the markers we were able to rapidly iterate and improve the design. This allowed us to quickly reach a design that was compact and operated reliably. This allows for Seawolf 7 to attempt the roulette wheel task without the risk of the dropper mechanism failing to successfully drop the marker.

Another creative design in Seawolf 7 is the modular electrical system. After years of using a hard to troubleshoot set of electrical boards, the electrical team decided to create a modular system that splits the various functions of the previous electrical boards into individual systems which communicate over a shared backplane board. This design decision allows each system to be tested individually which simplifies troubleshooting and repairing damaged boards while also allowing the individual systems, such as the power conversion or sensors board, to be upgraded without needing to replace the entire electrical system. This change also shifted the complexity of the electrical system from encompassing the entire system, to a simple overall system made up of more complex subsystems.

4. Experimental Results

The club performed multiple test over the spring semester and the summer. To balance testing and design engineering, we aimed to test once a month and spent the rest of the time that month designing and engineering new things for the test. By testing every month, the club is able to validate the improvements made during the past month.

Most of the testing done this year was focused on the acoustics system. The test followed our process from prototype system to robot ready program. The testing began in October, when long cables were used to connect hydrophones in the pool to an oscilloscope outside of the pool. During this test a PVC pipe structure was used to hold the pinger at a known distance from the hydrophones. Having the hydrophones at a set distance from the robot gave an expected result for the localization software. Using an oscilloscope, meant the best possible data was being gathered. Thus, the best scenario for the system was created and tested. The test ran successfully, and the data proved our concept for localizing the acoustic pinger.

The next test involved using a pocket oscilloscope that fits in the hull of our robot to capture the hydrophone data. If the oscilloscope could not be configured to accurately sample the pinger using the manufacturer’s GUI then it would unlikely that the oscilloscope would sample the ping when controlled by club written software. In addition, the manufacturer’s GUI made it easier to change configurations on the fly, in order to see what worked best for capturing acoustics data. This test allowed us to validate the performance of the pocket oscilloscope for the acoustic system.

The following test involved using the program written by the team to control the pocket oscilloscope and collect data. Success in this test mean that once the system was placed into the robot, the program would accurately tell the robot where the pinger is in the pool in relation to itself.

To insure success at the pool tests, the team made test plans and performed a dry run before every pool test. Running through the plan before going to the pool allowed us to find errors in our plan and ensure a successful pool test. Part of the dry run involved creating a simulation of the pool environment. For example, for the acoustic system, a signal generator was used to represent the pinger signal when dry running in the lab.

5. Acknowledgements

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We would also like the thank our faculty advisor, Dr. John Muth, for his continued support of the club.

6. References

No outside sources were used in the paper.

Appendix A: Component Specifications

Featured below is Table 1 which contains the list of components used in Seawolf 7 for the RoboSub 2018 competition.

Table 1: Component Specifications

Component	Vendor	Model/Type	Specs
Frame	Custom		Laser cut acrylic and 3D printed PLA parts
Waterproof Housing	Custom		Custom aluminum endcaps with double o-ring seals
Waterproof Connectors	Fischer	103,104, and 105 series	
Thrusters	Seabotix	SBT150	Brushed Thrusters
Motor Control	Polulu	High-Power Motor Driver 18v15	
High Level Control	Digikey	ATX Mega 32A4U	
High Level Control	Digikey	ATX Mega 16D4	
Actuators	SMC	C85N8-10T	
Battery	Turnigy	6s 5000mAh Lipo	
Regulator 1	TI	PTN78020W	6A Switching Regulator
Regulator 2	ST	L7809	Positive Voltage Regulator
Regulator 3	TI	TPS54231	Step-Down Buck Regulator
CPU	Intel	i7-2710QE	
Internal Comm Network		FTDI	Serial to USB
External Comm Interface		Ethernet	
Programming Language 1		Python	
Programming Language 2		C	
Inertial Measurement Unit (IMU)	Sparkfun	SEN-10736	
Camera(s)	Microsoft	LifeCam 720p	
Hydrophones			
Algorithms: vision	OpenCV		
Algorithms: acoustics	numpy		
Open source software	OpenCV	2.4	
Team Size			31
HW/SW expertise ratio		Mechanical, Electrical, Software	12, 9, 9
Testing time: simulation			30 hours
Testing time: in-water			20 hours

Appendix B: Outreach Activities

The Underwater Robotics Club at NC State works to give back through community outreach on all levels, from events focused on elementary and middle school students all the way up to events at NC State University for our fellow students. This leads to a variety of outreach events; however, a few demonstrative events are given below.

- Math Science Education Network, Students in Programming, Robotics and Computer Science - November 3rd, 2017. Providing a hands-on NXT robotics lesson to underserved youth, demonstrating how STEM careers are attainable for these students and providing a sense of ownership over their own education.
- College Connections - January 9th, 2018. Running a booth to new NC State Students showing how URC can promote strong engineering fundamentals.
- Engineering Open House - March 17th, 2018. Demonstrating Seawolf to prospective NC State students promoting robotics and problem solving.
- Lunch & Learn - May 4th, 2018. A “TED” style presentation to industry professionals showing off URC’s iterative design process.