Robotics Association at Embry-Riddle

Hasan Akpunar, Brooke Wolfram, Austin Haeberlen, Chandra Teja Tiriveedhi, Stephen Cronin

Embry-Riddle Aeronautical University

I. Abstract

Embry-Riddle Aeronautical University is using the BlueROV2 platform which has been converted into an Autonomous Underwater Vehicle (AUV) for the 2019 Association for Unmanned Vehicle Systems International (AUVSI) Foundation RoboSub Competition. The goal of using the BlueROV2 platform is so the team can focus on further advancing the understanding of deep learning code for vision, without the struggles of having to design and build a new platform.

II. Competition Strategy

This year's Robotics Association at Embry-Riddle (RAER) RoboSub team comprises of seven new members. Many factors were considered when deciding the design and complexity of the competition platform. The biggest limiting factor was that all the team members are freshmen with limited experience of AUV's. The team's strategy for this year's season was to focus on gaining knowledge of important vision software, including learning how to utilize machine learning to achieve accurate object detection. To gain this knowledge of software, it was decided to go with an off-the-shelf sub, the BlueRov2 in this case. The advantages this would grant the team is the ability to solely on software without having to worry about hardware limitations. The drawbacks of the BlueRov2 is that the platform was limited in the complexity of tasks it can perform due to limited hardware space. Ultimately, it was decided that this problem could be ignored for this season. The main goal was to create a reliable base for the software team to expand upon in the upcoming season. Because of this, the only attempted tasks were to go through the gate and bump the buoys. It was believed that with the combined experience of newer team members, this would be a challenging yet accomplishable task.

One part of the competition that the team attempted to do was the pre-qualification video. This would have brought the team bonus points for completing the maneuver as well as less time spend trying to qualify at competition. The main strategy of the team was to use dead reckoning and trust the stabilization and accuracy of the motors. A simple script was set up to have the sub go down for "x" number of seconds, then move forward "x" number of seconds, etc. While the team got very close to completing the maneuver, due to slight differences due to human error, every attempt varied slightly, and the maneuver was never fully executed. It is believed that with more time, there would have been the option to fine tune the script as well as utilize the vision code in the attempts to complete this maneuver.

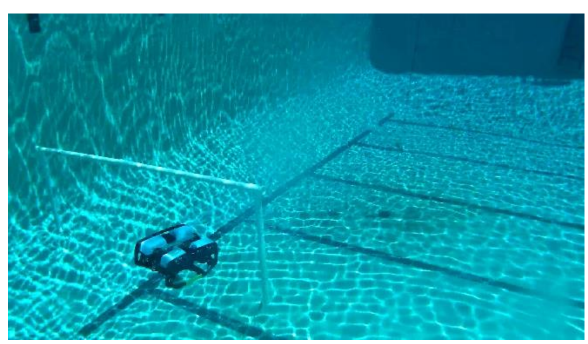

Figure 1: One of the teams Pre-Qualification Video attempts

III. Design Creativity

In the beginning of the season, there were many design ideas being thrown around but as mentioned before, it was ultimately decided to use the BlueRov2 platform. The reason for rejecting these designs were mainly due to lack of experience and knowledge of the mechanical team. Although many of the mechanical team members were part of the FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition, designing AUV's are a much harder challenge than designing FIRST Robotics platforms.

One hardware challenge that was encountered was the integration of an emergency stop. There were many ideas presented such as a toggle switch or a button, but it decided against them. The toggle switches required too much force to use and it was believed that the divers would have trouble using them. The team decided against buttons because of possible disconnects if the AUV bumped into something. The final design was very unique but also very functional. It consisted of a magnetic switch inside a Blue Robotics ROV light. This was done to utilize the thick cable that the ROV light had. This enabled the team to use a thicker cable that was less prone to breaking. A nut was then installed outside of the ROV light and a magnet was used attached to a cable as an emergency stop. If the AUV needs to be stopped, the cord will be pulled, lifting the magnet off the nut and cutting the connection with the magnetic switch, turning the AUV off.

Figure 2: The Emergency Stop System

Arguably, the most challenging hurdle that the team faced was the software. While utilizing the BlueRov2 had many benefits, one of the downsides was the onboard computer. Because of the way the BlueRov2 is set up, the team had to use a Raspberry Pi 3B+ in conjunction with a Pixhawk IMU. The easiest to control the movement of the AUV was through emulating joystick inputs. While this was an unorthodox way of controlling the AUV, it meant that the team was able to utilize the advantages of Ardusub such as stabilization, depth hold, and heading hold. The vision code was relatively simple deep learning. Only one of the team members has had previous experience with software so it proved to be a challenge to get vision processing working. Ultimately, it meant that some of the other members had to learn how to use Python and TensorFlow. In the end, the vision and deep learning code was created following a simple TensorFlow and Python 3.6 tutorial. Although this code may be very basic for this season, the team is planning on advancing it in the upcoming seasons.

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IV. Experimental Results

All testing testing was done at the pool located at the fitness center at Embry-Riddle. The pool proved to be useful, as the deep end was about 15 feet, similar to the depth of the TRANSDEC. The team was not able to get much testing done until the end of the season, due to the pool being closed for the winter. Unfortunately, because of busy schedules and pool times, there was much less testing time than the team expected. Although the team did not get to test often, when testing occurred there was lots of valuable data gained in the process. The team gained valuable experience as to how AUV's and ROV's handle underwater. This information will prove critical in the upcoming season when starting to design a new platform.

V. Acknowledgements

We would like to thank our faculty advisors, Dr. Butka, Dr. Hockley, Dr. Coyle, and Dr. Currier along with various upper classmen for their advice and direction in getting our code to run properly. We would also like to thank the fitness center staff and the lifeguards for always being accommodating to our testing schedule. We would also like to thank Embry-Riddle's College of Engineering for their long-term support of the project.

Appendix A: Expectations

Subjective Measures			
	Maximum Points	**Expected Points**	**Points Scored**
Utility of team website	50	50	
Technical Merit (from journal paper)	150	100	
Written Style (from journal paper)	50	50	
Capability for Autonomous Behavior (static judging)	100	80	
Creativity in System Design (static judging)	100	20	
Team uniform (static judging)	10	10	
Team Video	50	50	
Pre-Qualifying Video	100	0	
Discretionary points (static judging)	40	0	
Total	650	360	

Performance Measures			
	Maximum Points	**Expected Points**	**Points Scored**
Weight	See Table 1 / Vehicle		
Marker/Torpedo over weight or size by <10%	Minus 500 / marker	0	
Gate: Pass through	100	100	
Gate: Maintain fixed heading	150	150	
Gate: Coin Flip	300	0	
Gate: Pass through 60% section	200	0	
Gate: Pass through 40% section	400	400	
Gate: Style	+100 (8x max)	0	
Collect Pickup: Crucifix, Garlic	400 / object	0	
Follow the “Path” (2 total)	100 / segment	0	
Slay Vampires: Any, Called	300, 600	300	
Drop Garlic: Open, Closed	700, 1000 / marker (2+ pickup)	0	
Drop Garlic: Move Arm	400	0	
Stake through Heart: Open Oval, Cover Oval, Sm Heart	800, 1000, 1200 / torpedo (max 2)	0	
Stake through Heart: Move lever	400	0	
Stake through Heart: Bonus - Cover Oval, Sm Heart	500	0	
Expose to Sunlight: Surface in Area	1000	0	
Expose to Sunlight: Surface with object	400 / object	0	
Expose to Sunlight: Open coffin	400	0	
Expose to Sunlight: Drop Pickup	200 / object (Crucifix Only)	0	
Random Pinger first task	500	0	
Random Pinger second task	1500	0	
Inter-vehicle Communication	1000	0	
Finish the mission with T minutes (whole + factional)	Tx100	0	

Appendix B: Component Specifications

Component	Vendor	Model / Type	Specs	Cost (If New)
Buoyancy Control	Lab Equipment	Foam and Lead	N/A	N/A
Frame	Blue Robotics	BlueROV2	DPE frame, Aluminum flanges/endcaps	N/A
Waterproof Housing	Blue Robotics	Blue Robotics acrylic enclosures.	4 inch – Electronics 3 inch - Battery	N/A
Waterproof Connectors	Blue Robotics	Tether Connector	N/A	N/A
Thrusters	Blue Robotics	T200	See Blue Robotics website	N/A
Motor Control	Blue Robotics	Basic 30A ESC	See Blue Robotics website	N/A
High Level Control	N/A			
Actuators	N/A			
Propellers	Blue Robotics	T200 Propellers	N/A	N/A
Battery	Blue Robotics	Lithium-Ion Battery	14.8V, 18Ah	N/A
Converter	N/A			
Regulator	N/A			
CPU	Raspberry Pi 3B+			
Internal Comm Network	N/A			
External Comm Interface	ArduSub			
Programming Language 1	Python 3.6			
Programming Language 2	N/A			
Compass	Blue Robotics	3-DOF Magnetometer (On the PixHawk)	N/A	N/A
Inertial Measurement Unit (IMU)	Blue Robotics	PixHawk	N/A	N/A
Doppler Velocity Log (DVL)	N/A			
Camera(s)	Blue Robotics	N/A	N/A	N/A
Hydrophones	N/A			
Manipulator	N/A			
Algorithms: Vision	TensorFlow			
Algorithms: Acoustics	N/A			
Algorithms: Localization and Mapping	N/A			
Algorithms: Autonomy	TensorFlow			
Open Source Software	TensorFlow, LabelImg, Python			
Team Size (Number of People)	7			
HW/SW expertise ration	N/A			
Testing time: Simulation	N/A			
Testing Time: In-water	20 Hours			