Technical Design Report- 2018 RoboBoat

Georgia Tech Marine Robotics Group

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***Abstract*—This paper documents the design and development of the modifications to the Marine Robotics Group autonomous surface vehicle made for the 2018 AUVSI RoboBoat competition. Modifications include new replacement pontoons as well as a heat management system for the onboard electronics and computers. These were made in response to problems or potential problems the team observed during last year's competitions. The same software stack used for autonomy and simulation has been updated to account for the new vehicle as well as the new competition tasks. With a familiar set of competition tasks, the team is excited to build upon their existing knowledge in order to obtain as many points as possible during this year's competition.**

I. Competition Strategy

In many ways, the 2018 RoboBoat vehicle shares features with the 2017 RoboBoat platform. Modularity became a key focus in the design of the 2017 vehicle as a result of the sudden failure of the 2016 platform. The team realized that building a reliable and easily repairable hardware configuration is a wise investment of time and resources. This benefits the team in both the short term, as during the week of competition, the team is out of the lab environment and has very limited resources at Daytona Beach. In the long term, as the team hopes that the 2018 platform can be used and iterated upon instead of making major revisions or even new vehicles every year.

A. Major Design Trade-offs

One of the greatest strategic strengths of the 2017 vehicle – the 53 lb, 2700 watt-hour battery (exact specifications are detailed in Appendix A) – was preserved for the 2018 vehicle. The team maintains that the seemingly over-sized battery allows the team to maximize both valuable in-water testing time, minimize time wasted and risk of damage associated with getting the boat in and out of the lake, and reduce operational complexities. However, maintaining such a heavy-weight battery on the boat results in two problems. The first is the lower thrust-to-weight ratio; the second is physical point reduction in the competition. As can be seen in Fig. 1, there are points to be earned if the vehicle is under 110 lbs, and points will be deducted if the vehicle is over 110 lbs. Considering that the battery is 53 lbs, in order to gain points in this category, the rest of the boat must weigh at most 57 lbs. Without any weight reduction measures last year, our vehicle lost against every competing team in this category. To minimize the costs of this weight trade-off, the new set of pontoons designed for the 2018 vehicle contains less than a quarter of the heavy aluminum extrusion railing used in the 2017 pontoons, a significant contributer of weight. The pontoons themselves are also 50 percent lighter than last year's pontoons.

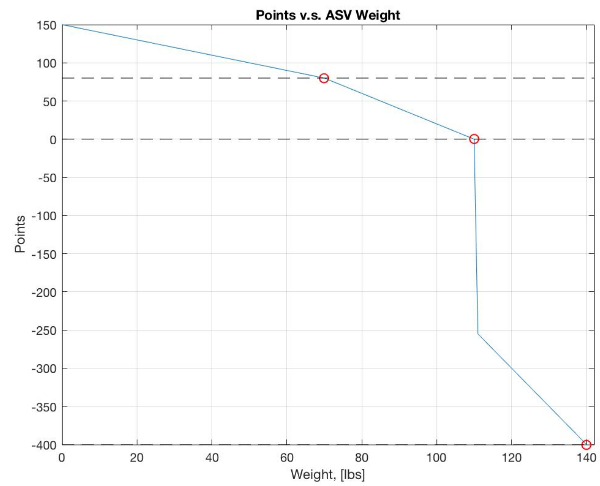
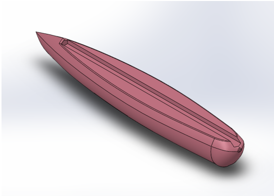


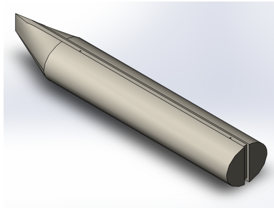
Fig. 1: Weight points to be earned

B. Pontoon Redesign Strategy

The team took advantage of the modularity designed in the 2017 vehicle and was able to build a brand new set of pontoons for the 2018 vehicle. The team had realized that last year's pontoons had a lot of curvature that made it hard to perform their layup, resulting in a number of unsightly rough areas. In direct response, the team designed pontoons that made it easier to apply fiberglass, epoxy, resin, and hardener. Only one layer of fiberglass was used, instead of the four layers used last year, as the team realized that additional layers produce diminishing returns to the strength and rigidity of the pontoons. These pontoons were also designed to increase buoyancy by displacing more water volume near the bottom of the pontoon instead of having more volume near the middle of the pontoon as done in the previous year's pontoon design. This simplification of pontoon curvature is shown in Fig. 2. These design considerations, coupled with the previously mentioned weight reduction effort, should result in a faster vehicle which the team hopes will result in higher scores in tasks such as the Speed Challenge.



(a) 2017 Pontoon Design



(b) 2018 Pontoon Design

Fig. 2: A comparison of the two different pontoon approaches

C. Task Confidence

This year, the team was smaller compared to past years, and therefore had very limited collective hours to work on the vehicle. Outlined below is the team's confidence in the various autonomy tasks, based on both simulation results, as well as last year's vehicle's performance.

- Speed Challenge - The 2017 vehicle was able to complete this challenge consistently autonomously. The team is hopeful that the hardware redesign and weight reduction will result in a vehicle that performs this challenge in less time, and, as a result, earns more points.
- Find The Path - As in the speed challenge, the 2017 vehicle was able to perform this task with high confidence. The team will approach this task with the same software approach used in year's past.
- Follow the Leader - Due to the fact that the vehicle's primary vision system is LIDAR-based, the 2017 variant of this task was extremely difficult for the vehicle to perform consistently. This was based on difficulty assessing flag lettering using the web cam. Since the 2018 task does not involve flag identification, the team is optimistic that they will be able to correctly identify and follow the flag and will give an honest attempt at this challenge.
- Automated Docking - This task is considered very difficult by the team and involves a lot of systems that do not provide an advantage on other tasks. Due to limited time, the team has decided to forgo heavy emphasis on this task. The team believes that they will be able to correctly identify where the pinger is located via hydrophone and complete the first portion of the task. However, the second portion of the task that involves the flying UAV has yet to be proven out in the field and the team accepts the risk of not earning points associated with this task during the competition.

II. Design Creativity

As a result of moving the RoboBoat competition from Virgina to Florida, the team unexpectedly experienced thermal management issues onboard the vehicle in 2017. The Intel NUC Windows PCs were observed to be throttling themselves to prevent overheating which resulted in poor PC responsiveness while out on the lake. In order to prevent this problem from repeating itself this year, the team decided to design a cooling system. A reduction of temperature of even 4-5 °C would benefit the units on board. The team does not have the expertise to utilize a system that relies on refrigerant, and significant environmental impact may occur if the refrigerant is improperly handled and spills into the lake. Therefore, the team designed a system of thermoelectric coolers (TECs) (shown in Fig. 3), heat-sinks, and computer case fans to dissipate heat outside the electronics casing. The team is aware that TECs tend to be less efficient than their refrigerant-based counterparts. However, the team is willing to try this subsystem out during the completion. If the team finds it consumes too much power for the thermal benefits, the team plans to disconnect the subsystem entirely.

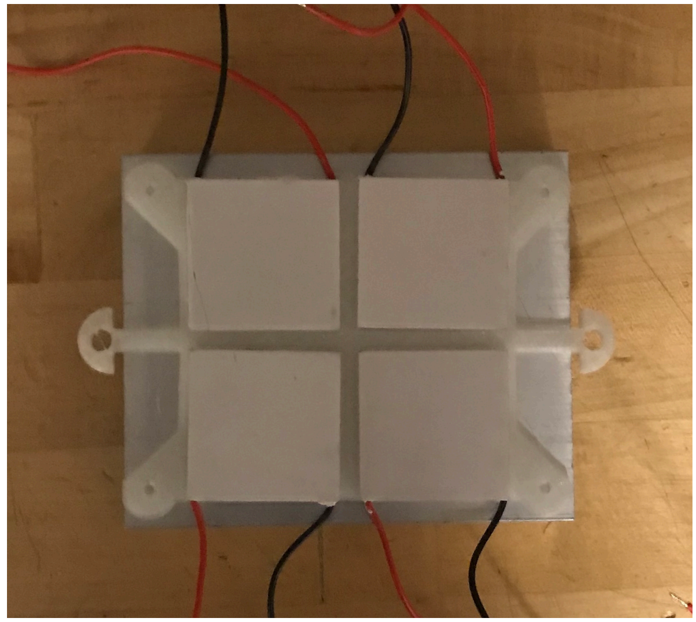


Fig. 3: An array of four TECs attached to a heatsink

III. Experimental Results

It is often difficult balancing vehicle development and testing; however the team has maintained their simulation-based approach to testing during the school year. Testing out on the water is a significant investment of time, so the team prefers to develop and test path-planning within the simulation environment and then fine-tune during the competition week. However, baseline tests with the new pontoon design have been performed, and the team knows that this new configuration provides a platform that is at least as fast as last year as well as about 20 lbs lighter. The experimental strategy for early pre-qualifying runs include validating performance of the thermal management system, the team's ability to locate the pinger for the Automated Docking Challenge, and lastly the team's ability to perform Follow the Leader. These three items are difficult to simulate and would specifically benefit from real-world validation. Therefore, it is paramount to get in-water testing of all tasks and verify simulation results during the pre-qualifying runs at Daytona Beach.

Acknowledgment

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References

[1] S. Siefert, Georgia Tech Roboboat 2016, https://www.youtube.com/watch?v= fAYEVduLsGI
[2] Robonation, Rules and Task Descriptions Version 1.2, May 24, 2018
[3] Robonation, RoboBoat 2017 Scoresheet

Appendix A

Component	Vendor	Model/Type	Specs	Cost (if new)
ASV Hull form/platform				
Waterproof connectors				
Propulsion				
Power system				
Motor controls				
CPU				
Teleoperation				
GPS				
Intertial Measurement Unit (IMU)				
Doppler Velocity Logger (DVL)				
Camera(s)				
Hydrophones				
Aerial vehicle platform				
Motor and propellers				
Power system				
Motor controls				
CPU				
Camera(s)				
Autopilot				
Algorithms				
Vision				
Acoustics				
Localization and mapping				
Autonomy				
Team Size (number of people)				
Expertise ratio (hardware vs. software)				
Testing time: simulation				
Testing time: in-water				
Inter-vehicle communication				
Programming Language(s)				