ODU RoboBoat 2016 Journal Paper

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***Abstract*— This paper is to document the scientific research and vehicle design of the RoboBoat. By documenting all research we track lessons learned for future team members. The RoboBoat Team at Old Dominion University has designed and developed an unmanned system to compete at the annual competition held by the Association Unmanned Vehicle Systems International (AUVSI). At this competition the primary mission is to navigate any obstacle the RoboBoat encounters. The team consists of Mechanical Engineering Technology (MET) students that intend to improve on the design and operability of the RoboBoat. The goal is to successfully complete all obstacles it shall encounter.**

I. Introduction

The RoboBoat designed at ODU is not just a project. The MET students have a goal and that is to build a proficient autonomous vehicle. The hull of the RoboBoat is a pontoon style that has the deck space and the buoyancy to effectively be outfitted with the latest technology. That technology consists of subsystems that are used to control the direction, speed, and time. Through many of our sea trails we have pinpointed the ideal setting and are enhancing the RoboBoat autonomy. Through collaboration we have fostered the passion to enhance the efficiency to build the most operable RoboBoat yet.

II. The Design

A. Initial Design Strategy

The blueprint was simple when it came to the overall design of the RoboBoat. Functionality and reliability was the objective in the design strategy. That objective originated the idea for a pontoon style RoboBoat. A pontoon has the buoyancy and the deck space to hold all critical electrical components. These components were equally distributed and the displacement was calculated. The material of the hull frame is aluminum making the hull rigid and easy to transport. The pontoon hull is hollow and accessible for weights to be added for better balance in the water. Figure 1 shows the design of the RoboBoat.

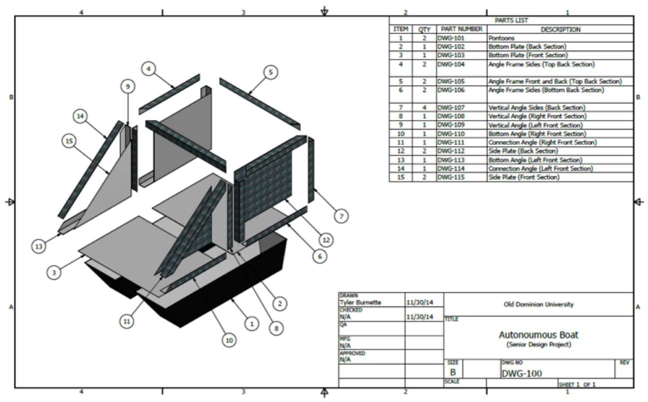

Fig 1. Shows the design of the pontoon style RoboBoat.

Due to the limited number of working hours to prepare it was necessary to have easy access to fix issues when they arise. A considerable amount of our time at the beginning of the course was spent on making our RoboBoat functional. The box where we stored our critical electrical components was overhauled. We choose a standard 10-gallon plastic bin as our housing, which is commonly used to store items at home. The top of the bin was fitted with hinges on one end in order to easily access the programmable logic controllers, Arduino microcontroller, and electrical input components. We made it easily accessible to replace components if necessary with the greatest amount of ease in mind.

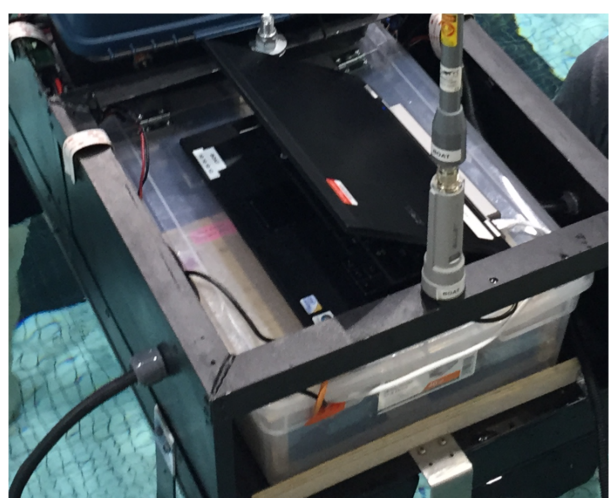
Fig. 2 shows our box that we used to store our electrical components.

The reliability of the RoboBoat was reviewed and changes were made at the beginning to make all electrical connections watertight. Also, we sealed the entire vessel with Flex Seal in order to alleviate any water seeping into the pontoons needed to keep the vessel afloat. Another issue was transportation; it was crucial that we were able to effectively transport the RoboBoat for testing. We decided to construct a wooden shipping container that would surround our boat while in transport. We started with half-inch thick half-inch thick plywood and cut out our sides. Then using 2x4 wood boards we built a frame that would create a stable fixture to attach the plywood to. This allowed us to attach each side together using screws in the 2x4 boards which strengthened the overall enclosure. We are working on a hinged top for the box now so that we are able to close off the boat to weather elements such as rain and wind in a case of emergency. This will allow for safe travel with our RoboBoat no matter the weather conditions. It also provides higher security measures.

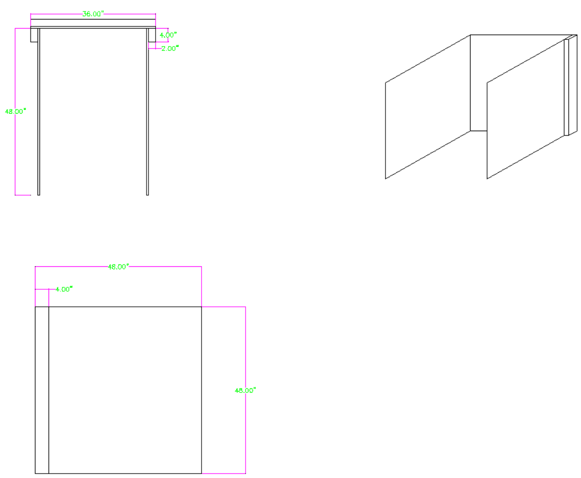

Fig. 3 The design of the transportation container.

One design change came about during testing. We noticed the back antenna was suffering from vibrations. That antenna is a critical element to our autonomously by allowing us to remotely access the on board computer. Thus the team configured a few stabilizing bracket to reduce the vibrations.

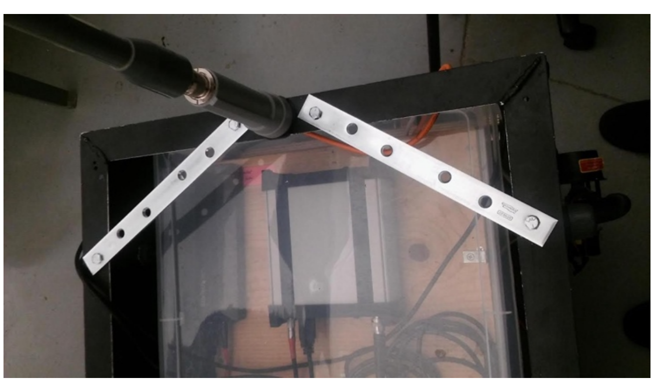

Fig. 4 Shows the stabilizing bracket

B. Autonomous Design

The autonomous design processes employs computer vision to navigate the obstacle course. Sensors are used to detect objects, distances, and its location. That information determines the boats direction and thrust throughout the obstacle course. The computer vision programing is written in NI LabView and Python utilizing OpenCV and (DLIB) libraries. The vision code incorporates YCbCr threshold color detection and HOG SVM detectors. Ultrasonic Sensors and LIDAR are used for object detection. Ultrasonic sensor data is output through Arduino and is coded in NI LabView programming language. The LIDAR data is outputted to the navigation code and is coded in NI LabView programming language.

The entire RoboBoat is run through LabView programming. The program utilizes various vi inputs to create a web effect for operating the entire vessel. Individual programs were assembled to create very simple commands such as “move forward,” and then these programs were interlaced to create more complex commands such as “move forward then stop and turn.” These commands build on each other creating more complex programs. The vehicle contains numerous sensors to aid in navigating courses. The first sensor attached and modified was the LIDAR Lite v2, which is a Class 1 laser, used to detect distance and angle of deviation from center. The component is easily interfaced with an integrated circuit or pulse width modulation. Using the LIDAR Lite did not, however, solve the problem of seeing everything in front of the vehicle. The LIDAR Lite was then mounted on a servomotor interfaced with pulse width modulation to control the speed and angles at which it operates. The LIDAR Lite was then programmed to take measurements of each object it sees over a 130° range and processes the two closest objects it sees, one on the port side of center line and another on the starboard side.

The programming of the LIDAR Lite and servo was all accomplished through Arduino programming which utilizes NI LabView coding. These outputs are then ran through LabView at which point they are commanded to dictate the angle and direction of the best approach. What makes our program a little more unique is that the outputs from LIDAR Lite not only dictate the attack angle and distance, but also the angle it will need to achieve in order to go normal between the two buoys. In other words the boat will accelerate forward, stop and run the LIDAR Lite, then shoot these values through the preprogrammed LabView files. These files take the four data points given from the LIDAR Lite and Arduino program and convert them into three new values: the angle to the center of the buoys, the distance needed, and also the angle needed once that distance is achieved to go directly straight through the buoys gates. This extra value allows the boat to maintain a straight course the field as it passes through the buoys.

C. Power

The power distribution is a 12 V battery that powers the fuse box. Inside the box we have the programmable logic controllers, Arduino microcontroller, and electrical input components. Originally, the original battery provided 10 amp-hours and weighed 6 pounds; the new battery weighs 2 lbs and is a 28 amp-hour battery. Also, if we needed more amp-hours we can install a few batteries in parallel to increase the amp-hour rating to around 45 to 50. We have a meter on the fuse box itself that monitors the battery usage. Also, on top of the fuse box is our kill switch. When actuated it will kill all the power from the motors and the actuators.

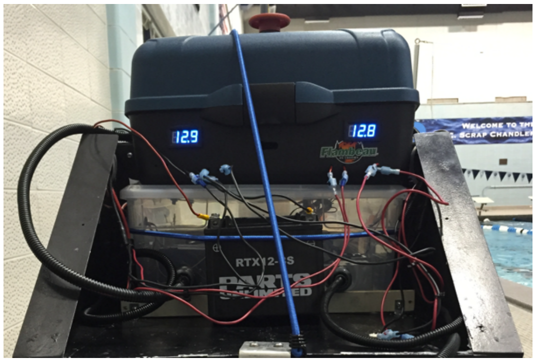

Fig. 5 shows the fuse box.

D. Propulsion

The propulsion consists of four fixed thrust propellers. The propellers are located on all four sides of the boat controlling the direction and the speed. The RoboBoat controls the direction and the speed by regulating the voltage to the motor by Pulse Width Modulation signals. These signals control all power operations to its desired setting.

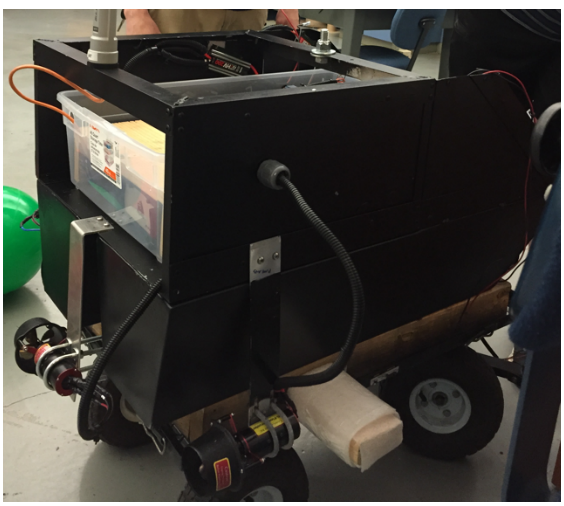

Fig. 6 Shows the Starboard and Aft propellers on the RoboBoat.

E. Testing

The majority of testing of the RoboBoat has been conducted at a recreational pool. This type of testing is beneficial for calibrating the motors to maintain a straight course as the boat maneuvers through water. We found it to be much easier to conduct these types of tests indoor as the wind and various elements tended to skew the performance of the vehicle. Pond testing has been conducted, as well. This type of testing focuses more on the overall performance of the individual systems by being able to utilize the LIDAR Lite. The LIDAR Lite could not be used in the pool due to the high edges being read as close objects. The boat tended to veer unexpectedly when it detected these values.

Fig. 7 Pond testing the RoboBoat.

F. Lessons Learned

During the first pond testing conducted with the vehicle an unexpected issue arose concerning the inverters onboard the vessel. All of the sudden power was lost to the remote connection antenna and the boat seized to move. After pulling it out of the water it was discovered that the inverter has a built in fail-safe that commands it to disconnect power once the input voltage drops below roughly 10.5 volts. This was a major issue due to the fact that everything on board must be powered during operation. The solution we came to was to install a much longer lasting battery. The current battery placed on the vehicle is a roughly 10 pound 12-volt battery with a 30 Amp hour life span. Comparing this to the previous batteries on board which only ran for 5 Amp hours this allows us to alleviate the need to charge batteries, as well as physically replace them, much simpler.

Another lesson learned dealt with the LIDAR Lite system. When using the system indoors the data that is assembled came back flawlessly, however, once outside the data showed that it was unable obtain values for objects in front of it. This was deduced to be caused by a sort of “noise interference” due to the sunlight. As the sun’s rays hit the barrels used a buoys for testing it was unable to register an object was present. What compounded the issue was its default distance was set to one centimeter meaning it would read that as the closest distance overall. This was overcome by coding the Arduino program to not include any value lower than a specified distance, therefore counteracting any interference the unit may encounter.

A simpler issue encountered during pool testing was the difficulty in aligning the vessel straight. It seems easier said than done to have a boat sit perfectly still in the water as a program is being readied to run. A low intensity laser was mounted to aid in indoor testing. It allowed us to see the exact vector the boat was taking both before launch and during the launch process.

Currently, we are having issues with the front and back motors. We are trying to determine if it is an electrical issue or manufacture.

G. Summary

Overall, we have had a few obstacles to overcome in a short period of time. In just six weeks we have completely changed the functionality of the boat for the better. We have made it significantly more reliable and easier to work on. After we completed the overhaul we began testing. During testing we encountered many issues and have confidently worked through them. Together we have made the changes necessary to make it the most capable RoboBoat yet to compete in the AUSVI RoboBoat competition in July.

H. References

[1] 2016 Final RoboBoat Tasks and Rules. N.p.: n.p., 28 Apr. 2016. PDF

[2] Zubaly, R. B. Applied Naval Architecture. Centreville, MD: Cornell Maritime, 1996. Print.